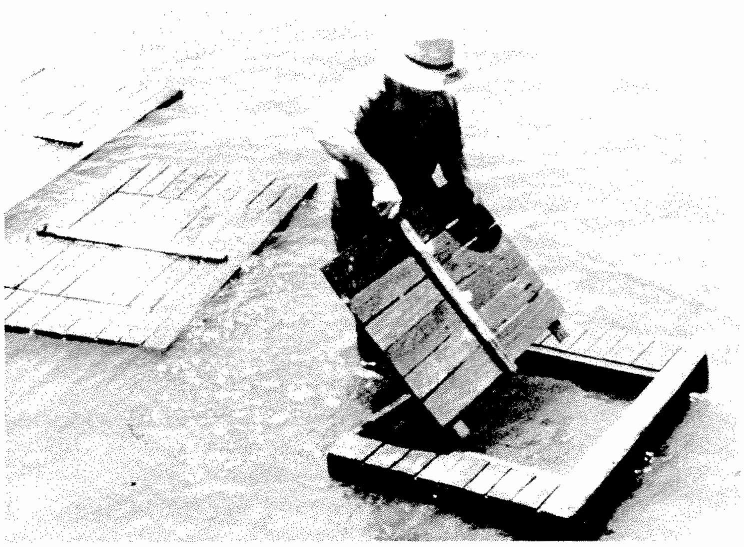
A Profile of the

BLUE CRAB FISHERY

of the Gulf of Mexico



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A PROFILE OF THE BLUE CRAB FISHERY OF THE GULF OF MEXICO

(Completion Report —— Contract No. 000–010)

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by

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CONTENTS

1. INTRODUCTION

The blue crab (*Callinectes sapidus* Rathbun) fisheries have become increasingly more important in the Gulf states. Reported landings for the Gulf in 1980 were in excess of 40 million pounds* with an ex-vessel value approaching $10 million*. In addition to the commercial hard-crab fishery, there exists a substantial recreational fishery and an expanding fishery for soft crabs.

Variations in the abundance of crabs due to environmental factors and disease, use of more efficient gear, increased fishing effort, and the economic condition of the market are reflected in historical blue crab catches. The fishery in Mississippi and Alabama has been relatively stable with each state reporting from 1.5 million to 2 million pounds annually. Louisiana continues to be the largest producer in the Gulf, supplying raw product to Texas, Mississippi, and Alabama plants. Landings for Louisiana have fluctuated widely although reported landings from 1975 to 1980 have not approached the 1973 landings of 23 million pounds. Florida Gulf coast landings have remained relatively stable at 13 million pounds after declining from 21 million pounds in 1965 to 9 million pounds in 1968. Landings in Texas continue to increase; approaching 9 million pounds in 1980.

Reported landings for hard and soft crabs are at best poor estimates of the annual catch. Many of the crabs going to out-of-state buyers, the general public and to the restaurant or retail trade go unreported; also data on the recreational fisheries are lacking. In his review of the blue crab fishery of the Gulf of Mexico, Moss (1982) noted that the statistical reporting system is so ***uniformly*** bad that only trends and cycles can be identified. "There is no doubt that 1973 and 1977 were excellent crab years . . . and that the summer months and early fall are the most productive [seasons]. There is [also] no doubt that Louisiana produces the most crabs . . . but does it harvest 16 million pounds live weight or 60?" Roberts and Thompson (1982) estimated the 1980 crab catch from Lakes Pontchartrain and Borgne to be 9.8 million pounds as compared to a reported catch of 1.5 million pounds. Even if landings data were accurate their use as an index of adult stock abundance can be misleading. Moss (1981) noted that blue crab landings do not necessarily reflect populations, but may merely reflect economic fluctuations. Lyles (1976) and Meeter et al. (1979) also suggested that socio-economic variables may influence blue crab landings. The need for accurate landings data and catch/effort data is evident in all sectors of the fishery.

While much is known concerning the life history of the blue crab in the Gulf of Mexico, many questions remain unanswered. The relationships between density-dependent and density-independent factors and species specific estuarine populations levels are still unresolved. Estuarine species respond to a multiplicity of physical, chemical, biological, and anthropogenic variables and the influence of these variables on estuarine populations is poorly understood. Physical factors affecting larval recruitment, the distribution of early crab stages in the estuary, as well as the chemical and biological parameters which affect the survival of both larvae and juveniles need investigation. Nothing is known of the distribution of blue crab zoeae in offshore waters and the mechanisms of larval transport. Estimates are lacking on natural and fishing mortality. The influence of parasitic infections (particularly *Loxothylacus texanus*) on subsequent levels of harvestable blue crabs is unknown.

It is the purpose of this profile to present a synopsis of existing information on the biology of and the fishery for blue crabs in the Gulf of Mexico.

*Unless otherwise noted, all statistical data presented in either the text or tables are from *Fishery Statistics of the United States* and *Current Fishery Statistics,* both published by the National Marine Fisheries Service.

2. DESCRIPTION OF THE RESOURCE

2.1 Zoogeographic Distribution

The genus *Callinectes* belongs to the family Portunidae which contains approximately 300 extant species. *Callinectes* is a warm-water genus whose poleward distribution appears to be limited by summer temperatures. According to Norse (1977) no species occur regularly in waters where peak temperatures fail to approach 20°C. The separation of the east and west Atlantic populations of *C. marginatus* into two species brings the number of valid species in the genus to 15 (Manning and Holthuis 1981); three are found in Pacific waters with the remaining twelve species distributed throughout the Atlantic and adjacent seas (Table 1).

According to Williams (1974), eight species are found in the Gulf of Mexico; *C. bocourti* A. Milne Edwards, *C. danae* Smith, *C. ornatus* Ordway, *C. exasperatus* (Gerstaecker), *C. marginatus* (A. Milne Edwards), *C. sapidus* Rathbun, *C. similis* Williams, and *C. rathbunae* Contreras.

Callinectes marginatus, C. exasperatus and *C. danae* are known from the southernmost portion of the Gulf, bordering the Caribbean (Figures 1, 2 and 3, respectively). *Callinectes ornatus* occurs off central Florida through the southern Gulf to Yucatan (Figure 4). Extraterritorial occurrences include *C. bocourti* recorded from Biloxi Bay, Mississippi (Perry 1973) (Figure 2) and *C. marginatus* from Louisiana waters (Rathbun 1930) (Figure 1). The blue crab *C. sapidus* and lesser blue crab *C. similis* show Gulfwide distribution (Figures 2 and 3, respectively).

Though all species of *Callinectes* are edible (Williams 1974, Norse and Fox-Norse 1982), *C. sapidus* is the most economically important species. Greatest reported commercial landings of blue crabs generally occur north of 28° N latitude. Within this area, *C. sapidus* is common in tidal marsh estuaries characterized by soft mud substrata and waters of moderate salinity.

Vegetative, sedimentary and physical descriptors for major Gulf estuarine systems are presented in Tables 2 through 6. The percent contribution to individual state commercial landings by estuarine system is also shown. Major estuarine systems for each state are shown in Figures 5 through 9.

TABLE 1. Distribution of *Callinectes* species (from Williams 1974).

Species	Distribution	Species	Distribution
	ATLANTIC	*C. maracaiboensis*	Confined to the Lago de Maracaibo estuarine system, roughly 120 km wide by 215 km long, extending from Bahia del Tablazo emptying into Golfo de Venezuela in north, through Estrecho de Maracaibo southward into Lake proper.
*C. marginatus**	Off southern Florida through Caribbean Sea to south central Brazil off Estado de Sao Paulo; Bermuda and Cape Verde Islands; Senegal to central Angola. A recent record from North Carolina is regarded as a temporary range extension.	*C. amnicola* (= *latimanus*)	Baie de Saint-Jean ($19^{\circ}27'$N, $16^{\circ}22'$W), Mauritania, to Cabinda, Angola.
C. similis	Off Delaware Bay to Key West, Florida; northwestern Florida around Gulf of Mexico to off Campeche, Yucatán.	*C. sapidus*	Occasionally Nova Scotia, Maine, and northern Massachusetts to northern Argentina, including Bermuda and the Antilles; Oresund, Denmark; the Netherlands and adjacent North Sea; southwest France (found twice); Golfo di Genova; northern Adriatic; Aegean, western Black, and eastern Mediterranean seas.
C. pallidus (= *gladiator*)	West Africa from Baie de Saint-Jean, $19^{\circ}27'$N, $16^{\circ}22'$W, Mauritania, to Baia do Lobito, Angola.		
C. ornatus	Bermuda; North and South Carolina through southern Florida;northwestern Yucatán to Estado de Saio Paulo, Brazil.		
C. danae	Bermuda; southern Florida and eastern side of Yucatán Peninsula to Estado de Santa Catarina, Brazil.		**PACIFIC**
C. exasperatus	Bermuda; Veracruz, Mexico; southern Florida to Estado de Santa Catarina, Brazil.	*C. toxotes*	Cabo de San Lucas, Baja California, to extreme northern Peru; extraterritorial, Juan Fernandez.
C. bocourti	Jamaica and British Honduras to Estado de Santa Catarina, Brazil; extraterritorial occurrences in southern Florida and Mississippi, USA (both mature males).	*C. bellicosus*	San Diego, California, to Bahiá Almejas (southeastern extension of Bahiá Magdalena) Baja California; La Paz Harbor around Golfo de California to Topolabampo, Sinaloa, Mexico.
C. rathbunae	Mouth of Rio Grande, Texas–Mexico border to southern Veracruz, Mexico.	*C. arcuatus*	Los Angeles Harbor, California, to Mollenda, Peru; Galápagos Islands.

*Manning and Holthuis (1981) suggest that the west Atlantic and east Atlantic populations of *C. marginatus* should be considered separate species, with *C. marginatus* (A. Milne Edwards, 1861) retained for the east Atlantic species and the name *C. larvatus* Ordway, 1863 assigned to the west Atlantic species.

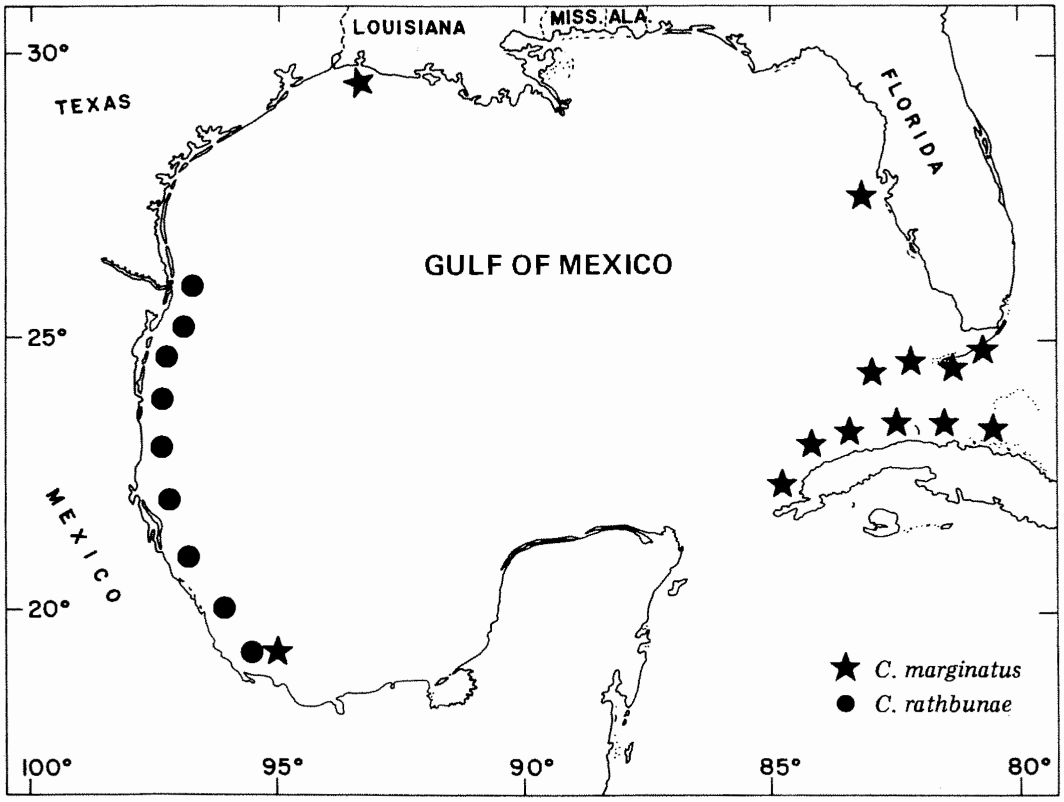

Figure 1. Distributions of *C. marginatus* and *C. rathbunae* in the Gulf of Mexico (modified from Williams 1974).

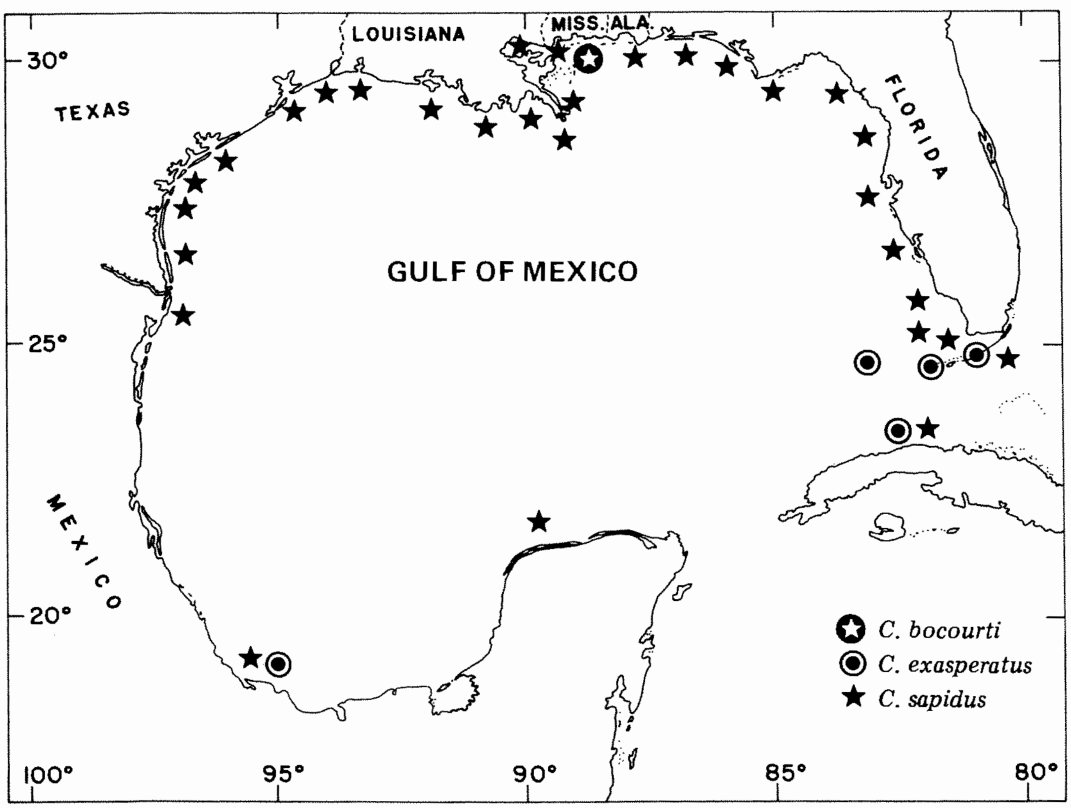

Figure 2. Distributions of *C. bocourti, C. exasperatus* and *C. sapidus* in the Gulf of Mexico (modified from Williams 1974).

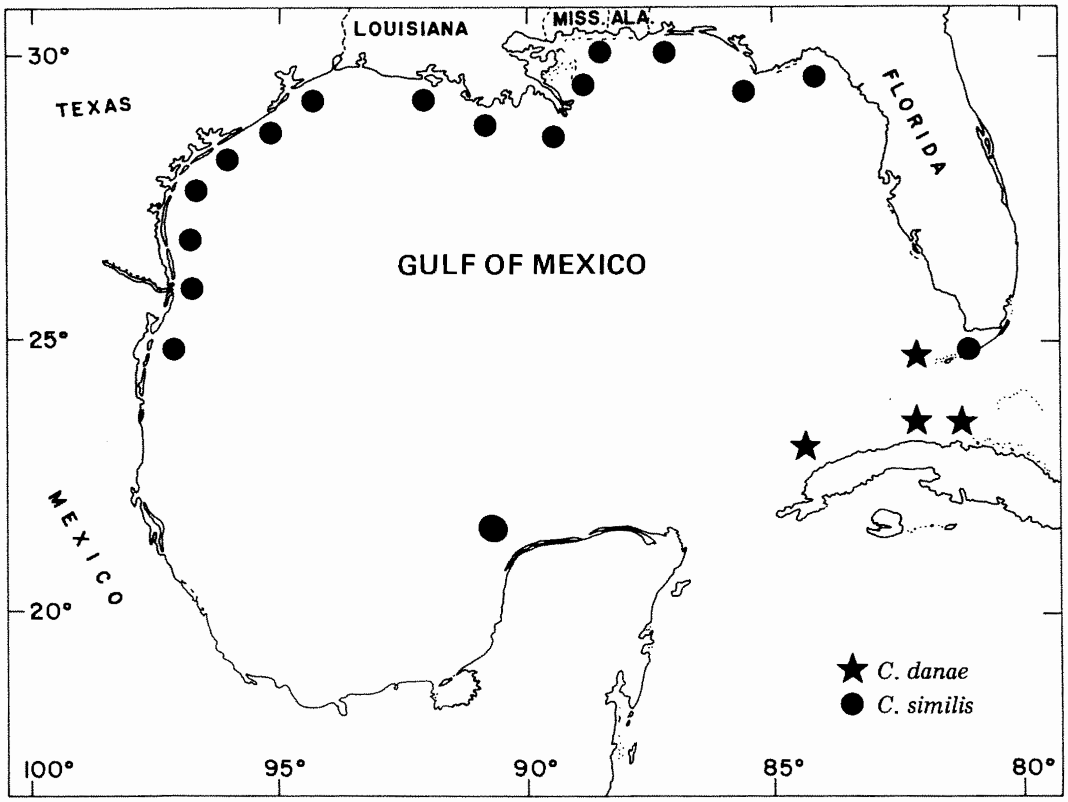

Figure 3. Distributions of *C. danae* and *C. similis* in the Gulf of Mexico (modified from Williams 1974).

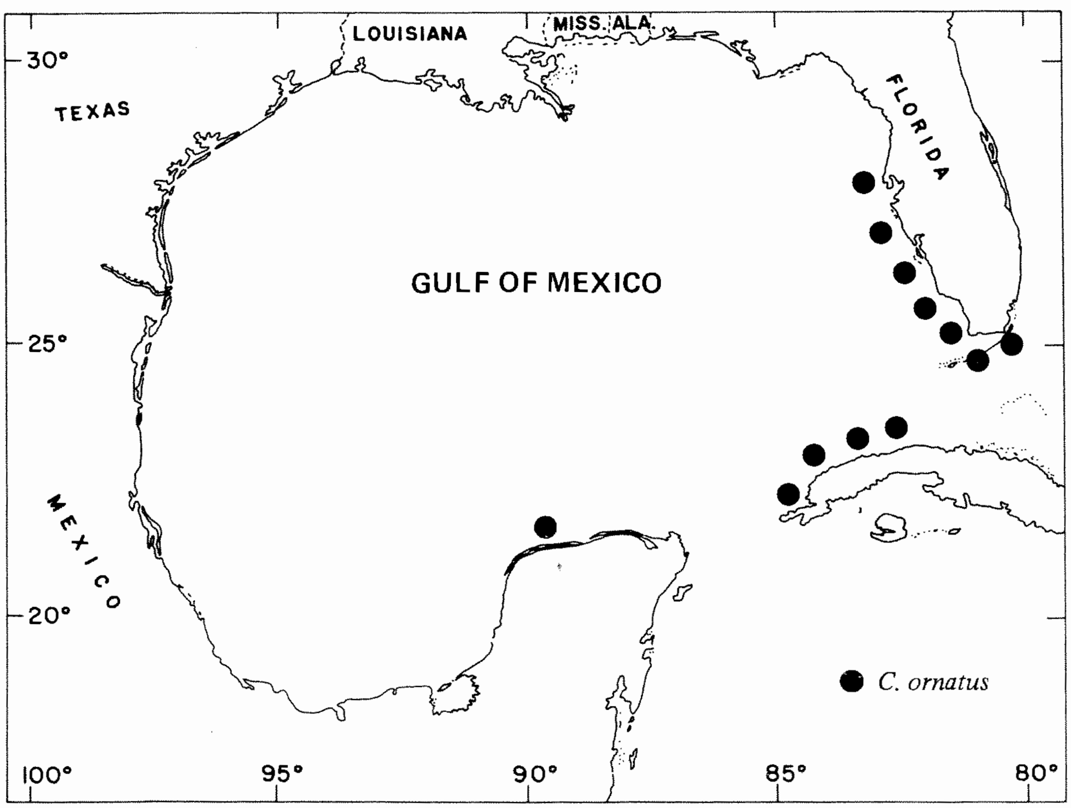

Figure 4. Distribution of *C. ornatus* in the Gulf of Mexico (modified from Williams 1974).

TABLE 2. **Vegetative, physical and sedimentary characteristics of Alabama estuarine systems and percent contribution to reported commercial landings.**

Hydrologic Unit	Tidal Marsh (hectares)	Submerged Vegetation (hectares)	Sediment Type[3]	Surface Area[3] (hectares)	Drainage Area[3] (km^2)	River Discharge[3] (ℓ/sec)	Percent Contribution[4] to State Landings
Mobile Bay	1,333[1]	2,024[3]	Sand, Clay, Mud	107,030	113,995	1,947,329	20.0
Mississippi Sound	5,369[2]	NA*	Sand, Clay, Mud	37,516	259	NA	57.0
Perdido Bay	434[3]	NA	Sand, Clay, Mud	6,989	2,637	26,539	0.2

*Data not available = NA.

[1]Source: Stout, J. P. 1979. Marshes of the Mobile Bay estuary: Status and evaluation, pp. 113–121. *In:* H. Loyacano and J. Smith (eds.), *Symposium on the Natural Resources of the Mobile Estuary, Alabama.* MASGP–80–022.

[2]Source: Stout, J. P. & A. A. de la Cruz. 1981. Marshes of Mississippi Sound: State of Knowledge, pp. 8–20. *In:* J. K. Kelly (ed.), *Symposium on Mississippi Sound.* MASGP–81–007.

[3]Source: Crance, J. H. 1971. Description of Alabama estuarine areas–Cooperative Gulf of Mexico Estuarine Inventory. *Alabama Mar. Res. Bull.* 6:1–85.

[4]Source: Swingle, W. E. 1976. Analysis of commercial fisheries catch data for Alabama. *Alabama Mar. Res. Bull.* 11:26–50.

TABLE 3. **Vegetative, physical and sedimentary characteristics of Florida estuarine systems and percent contribution to reported commercial landings.**

Hydrologic Unit	Tidal Marsh/ Mangrove Swamp[1] (hectares)	Submerged Vegetation[1] (hectares)	Sediment Type[1]	Surface Area[1] (hectares)	Drainage Area[1] (km^2)	River Discharge[1] (ℓ/sec)	Percent Contribution[2,3] to West Coast Landings
Escambia Bay	3,510	769	Sand, Sand/shell	51,005	14,315	268,402	< 1.0
Choctawhatchee Bay	1,139	1,251	Sand, Sand/shell, Mud	34,924	11,525	204,810	< 1.0
St. Andrew Bay	4,476	2,684	Sand, Silt, Clay	27,972	NA*	NA	4.4
St. Joseph Bay	345	2,560		17,755			< 1.0
Apalachicola Bay	8,621	3,795	Sand covered with silt and clay	68,788	47,818	768,123	7.6
Apalachee Bay	22,529	9,518	Sand	24,817	7,552	90,822	20.8
Suwanee Sound and Waccasassa Bay	25,560/354	13,030	Sand	35,618	26,304	322,760	22.1
Tampa Bay	699/7,088	8,450	Sand, Sand/clay, Clay/silt	110,338	3,398	43,530	1.9
Sarasota Bay	95/1,463	3,079	Sand, Sand/shell	14,061	160	2,285	0.0
Charlotte Harbor	3,678/9,500	9,463	Sand/shell, Mud/shell	49,290	5,174	55,739	6.4
Caloosahatchee River	687/1,203	293	Sand/shell	15,180	699	29,934	< 1.0
Florida Bay	4,916/14,932	103,849	Coral, Sand/shell, Sand/mud	225,631	NA	NA	< 1.0

*Data not available = NA.

[1]Source: McNulty, J. K., W. N. Lindall, Jr. and J. E. Sykes. 1972. *Cooperative Gulf of Mexico Estuarine Inventory and Study, Florida: Phase 1, Area Description.* NOAA Tech. Rept. NMFS Circ. 368:1 -126.

[2]Source: Steele, P. 1982. A synopsis of the biology of the blue crab *Callinectes sapidus* Rathbun in Florida. *Proc. Blue Crab Colloquium,* Oct. 18–19, 1979, Biloxi, Mississippi. Gulf States Marine Fisheries Commission 7:29–35.

[3]Dixie-Taylor Counties–23.7%, Pasco-Citrus Counties–11.5%.

TABLE 4. Vegetative, physical and sedimentary characteristics of Louisiana estuarine systems and percent contribution to reported commercial landings. (The size and complexity of Louisiana estuaries did not permit the use of a single classification scheme.)

Hydrologic Unit	Tidal Marsh[1] (hectares)	Hydrologic Unit	Submerged Vegetation[2] (hectares)	Sediment Type[3]
Lakes Maurepas, Pontchartrain and Borgne; Chandeleur and Breton Sounds	189,804	Lakes Maurepas and Pontchartrain	8,094 (north shore of Lake Pontchartrain only)	Clayey Silt Silty Clay Sand
Active Mississippi River Delta	27,115	Lake Borgne, Brenton Sound	NA*	Silty Clay Clayey Silt
Barataria Basin	164,308	Barataria Bay	NA	Clayey Silt Sand
Timbalier-Terrebonne Bays, Caillou Bay	219,347	Timbalier-Terrebonne Bays	NA	Sandy Silt Clayey Silt Sand
Atchafalaya Bay	23,877	Lake Mechant, Caillou Lake	NA	Clayey Silt Sand, Clay
Cote Blanche-Vermilion Bays	100,770	Vermilion-Atchafalaya Bays	NA	Clayey Silt Silty Clay
Mermentau River,[2] White and Grand Lakes	121,410[2]	Calcasieu, White and Sabine Lakes	NA	Clayey Silt Silty Clay
Calcasieu and Sabine Lakes[2]	106,436[2]			

Hydrologic Unit	Surface Area[2] (hectares)	Hydrologic Unit	Drainage Area[4] (km^2)	Hydrologic Unit	Percent Contribution[5] to State Landings Hard/Soft
Lake Maurepas	23,549	Pearl River	22,454	Lakes Maurepas and Pontchartrain	14.0/46.0
Lake Pontchartrain	159,503	Lakes Maurepas, Pontchartrain and Borgne; Chandeleur and Breton Sounds	14,394	Lake Borgne, Chandeleur and Breton Sounds	10.0/00.0
Lake Borgne	69,357				
Chandeleur Sound	233,918	Mississippi River	336,492	Barataria Bay	22.0/53.0
Breton Sound	79,050	West Mississippi River Delta, including drainage into Barataria Bay, Timbalier-Terrebonne Bays, Caillou Bay, Atchafalaya Bay, Cote Blanche-Vermilion Bays	248,417	Timbalier-Terrebonne Bays	8.0/00.0
Mississippi River and Active Delta	46,268			Lake Mechant, Caillou Lake	14.0/00.0
Barataria and Caminada Bays, Little Lake	28,571			Vermilion-Atchafalaya Bays	14.0/00.0
Lakes Barre, Raccourci, Timbalier-Terrebonne Bays	69,052	Mermentau River	9,896		
		Calcasieu River	9,780	Calcasieu, White and Sabine Lakes	14.0/00.0
Caillou Bay and Lake, Four League Bay, Lakes Mechant and Pelto	35,722	Sabine River	54,244		
Atchafalaya Bay	54,505				
Cote Blanche-Vermilion Bays	118,909				
White and Grand Lakes	33,745				
Calcasieu Lake	17,318				
Sabine Lake	22,606				

*Data not available = NA.

[1]Source: Wicker, K. M. 1980. Mississippi deltaic plain region ecological characterization: a habitat mapping study. A user's guide to the habitat maps. *U.S. Fish Wildl. Serv.*, Office of Biol. Ser. FWS/OBS-79/07.

[2]Source: Perret, W. S., et al. 1971. *Cooperative Gulf of Mexico estuarine inventory and study, Louisiana, Phase I, Area description:* pp. 1–38. Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana.

[3]Source: Barrett, B. B., et al. 1971. *Cooperative Gulf of Mexico estuarine inventory and study, Louisiana, Phase III, sedimentology*, pp. 131–191. Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana.

[4]Source: Sloss, R. 1971. Drainage area of Louisiana streams. U.S. Dept. Interior Geological Survey, Water Resources Division, Basic Records Report 6.

[5]Based on NMFS data for 1980.

TABLE 5. Vegetative, physical and sedimentary characteristics of Mississippi estuarine systems and percent contribution to reported commercial landings.

Hydrologic Unit	Tidal Marsh[1] (hectares)	Submerged Vegetation[2] (hectares)	Sediment Type[3]	Surface Area[4] (hectares)	Drainage Area[4] (km^2)	River Discharge[4] (ℓ/sec)	Percent Contribution[5] to State Landings
Pascagoula River	11,281		Sandy and Muddy Sandy Deposits	53,110	24,346	430,464	NA*
Biloxi Bay	4,683		Sandy and Muddy Sandy Deposits	60,896	1,735	38,232	NA
St. Louis Bay			Sandy and Muddy Sandy Deposits	66,568	291	41,347	NA
	9,927						
Pearl River			Sandy and Muddy Sandy Deposits	22,335	3,521	365,328	NA
Mississippi Sound South of Intracoastal Waterway	860 Barrier Islands	1,970	Sand Mud				NA

* Data Not Available = NA

[1] Source: Eleuterius, L. N. 1973. The marshes of Mississippi. *In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi, pp. 147–190.

[2] Source: Eleuterius, L. N. and G. J. Miller. 1976. Observations on seagrasses and seaweeds in Mississippi Sound since Hurricane Camille. *J. Miss. Acad. Sci.* 21:58–63.

[3] Source: Otvos, E. G. 1973. Sedimentology. *In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi, pp. 123–137.

[4] Source: Christmas, J. Y., Jr. 1973. Area description. *In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi, pp. 1–71.

[5] Source: Majority of catch taken from Mississippi Sound (personal communication, Hermes Hague, NMFS).

TABLE 6. Vegetative, physical and sedimentary characteristics of Texas estuarine systems and percent contribution to reported commercial landings.

Hydrologic Unit	Tidal Marsh (hectares)	Submerged Vegetation (hectares)	Sediment Type	Surface Area (hectares)	Drainage Area (km^2)	River Discharge (ℓ/sec)	Percent Contribution[23, 24] to State Landings
Sabine Lake	NA*	NA	Mud, Silt, Shell[2]	22,605[2]	53,421[14]	434,424[1]	11.8
Galveston Bay	93,624[1]	7,323[1]	Mud, Shell, Clay[3], Sand	143,170[7]	51,958[15]	317,098[20]	29.4
East Matagorda Bay	NA	NA	Mud, Sand[1]	15,300[1]	NA	NA	11.4
West Matagorda Bay	48,552[1]	2,848[1]	Mud, Shell, Clay,[1] Sand	98,920[1]	10,713[16]	85,616[1]	
San Antonio Bay	10,115[1]	6,615[1]	Silty Clay, Mud,[4] Sand, Shell	47,800[8]	26,563[17]	53,907[21]	21.6
Aransas Bay	18,207[1]	1,669[1]	Mud, Sand[1]	55,652[1,9]	6,800[18]	3,022[1]	20.9
Corpus Christi Bay	NA	NA	Mud, Sand[1]	50,505[8,10,11]	44,963[18]	25,368[11]	1.4
Upper Laguna Madre	NA	NA	Sand, Silt, Shell[5]	41,014[1,12]	7,752[19]	NA	0.5
Lower Laguna Madre	NA	NA	Sand, Silt, Clay[6]	73,983[13]	3,193[19]	3,100[22]	2.4

* Data Not Available = NA.

[1]Source: Diener, R. A. 1975. *Cooperative Gulf of Mexico estuary inventory and study-Texas: area description.* NOAA Tech. Rept., Nat. Mar. Fish. Serv., Circ. 393. 129 pp.

[2]Source: Wiersema, J. M., and R. P. Mitchell. 1973. Sabine power station ecological program. Vol. 2. TRACOR, 6500 TRACOR Lane, Austin, Texas. 54 pp.

[3]Source: Benefield, R. L. and R. E. Hofstetter. 1976. Mapping of productive oyster reefs–Galveston Bay, Texas. Texas Parks and Wildlife Dept., Austin. (unpublished manuscript)

[4]Source: Texas Parks and Wildlife Department. 1975. Fishery resources of the San Antonio Bay system and factors relating to their viability–preliminary draft. Texas Parks and Wildlife Dept., *Coastal Fish.* 116 pp.

[5]Source: Simmons, E. G. 1957. Ecological study of the Upper Laguna Madre of Texas. *Publ. Inst. Mar. Sci., Univ. Tex.* 4(2):156–200.

[6]Source: Shepard, P., and A. Rusnak. 1957. Texas bay sediments. *Publ. Inst. Mar. Sci. Univ. Tex.* 4(2):5–13.

[7]Source: Fisher, W. L., H. H. McGowen, L. F. Brown, Jr. and C. G. Croat. 1972. Environmental geologic atlas of the Texas coastal zone–Galveston-Houston area. Bureau of Economic Geology. Univ. Tex., Austin, Tex. 91 pp.

[8]Source: Collier, A., and J. W. Hedgpeth. 1950. An introduction to the hydrography of tidal waters of Texas. *Publ. Inst. Mar. Sci. Univ. Tex.* 1(2):120–194.

[9]Source: Heffernan, T. L. 1972a. An ecological evaluation of some tributaries of the Aransas Bay area. Texas Parks and Wildlife Dept., *Coastal Fish. Proj.* No. CE-1–1. 104 pp.

[10]Source: Hood, Donald W. 1953. A hydrographic and chemical survey of Corpus Christi bay and connecting water bodies. Texas A&M Research Foundation Project No. 40, Annual Report, Dept. of Ocean, Texas A&M University.

[11]Source: Stevens, H. R., Jr. 1959. A survey of hydrographic and climatological data of Corpus Christi Bay. *Tex. Game and Fish. Comm. Proj. Repts.* 1958–1959 (mimeo).

[12]Source: Breuer, J. P. 1957. An ecological survey of Baffin and Alazan Bays, Texas. *Publ. Inst. Mar. Sci., Univ. Tex.* 4(2):134–155.

[13]Source: Stokes, Gary M. 1974. The distribution and abundance of penaeid shrimp in the Lower Laguna Madre of Texas with a description of the live bait shrimp fishery. *Texas Parks and Wildlife Dept., Tech. Ser.* No. 15. 32 pp.

[14]Source: Texas Department of Water Resources. 1981. Sabine-Neches estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-116. 321 pp.

[15]Source: Texas Department of Water Resources. 1981. Trinity-San Jacinto estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-113. 411 pp.

[16]Source: Texas Department of Water Resources. 1980. Lavaca-TresPalacios estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-106. 325 pp.

[17]Source: Texas Department of Water Resources. 1980. Guadalupe estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-107. 344 pp.

[18]Source: Texas Department of Water Resources. 1981. Nueces and Mission-Aransas estuaries: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-108. 381 pp.

[19]Source: Texas Department of Water Resources. In Print. Laguna Madre estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. Draft Report.

[20]Source: Environmental Protection Agency. 1971. Pollution affecting shellfish harvesting in Galveston Bay, Texas. Div. Invest., EPA, Water Quality Office, Denver, Colorado. 98 pp.

[21]Source: Childress, R. E. Bradley, E. Hegen, and S. Williamson. 1975. The effects of freshwater inflows on hydrological and biological parameters in the San Antonio Bay system, Texas. Texas Parks and Wildlife Department, Coastal Fisheries Branch. 190 pp.

[22]Source: Bryan, C. E. 1971. An ecological survey of the Arroyo Colorado, Texas 1966–1969. *Texas Parks and Wildlife Dept., Tech. Ser.* No. 10, 28 pp.

[23]Average % of contribution for the period 1970–1979.

[24]Gulf of Mexico 0.6%.

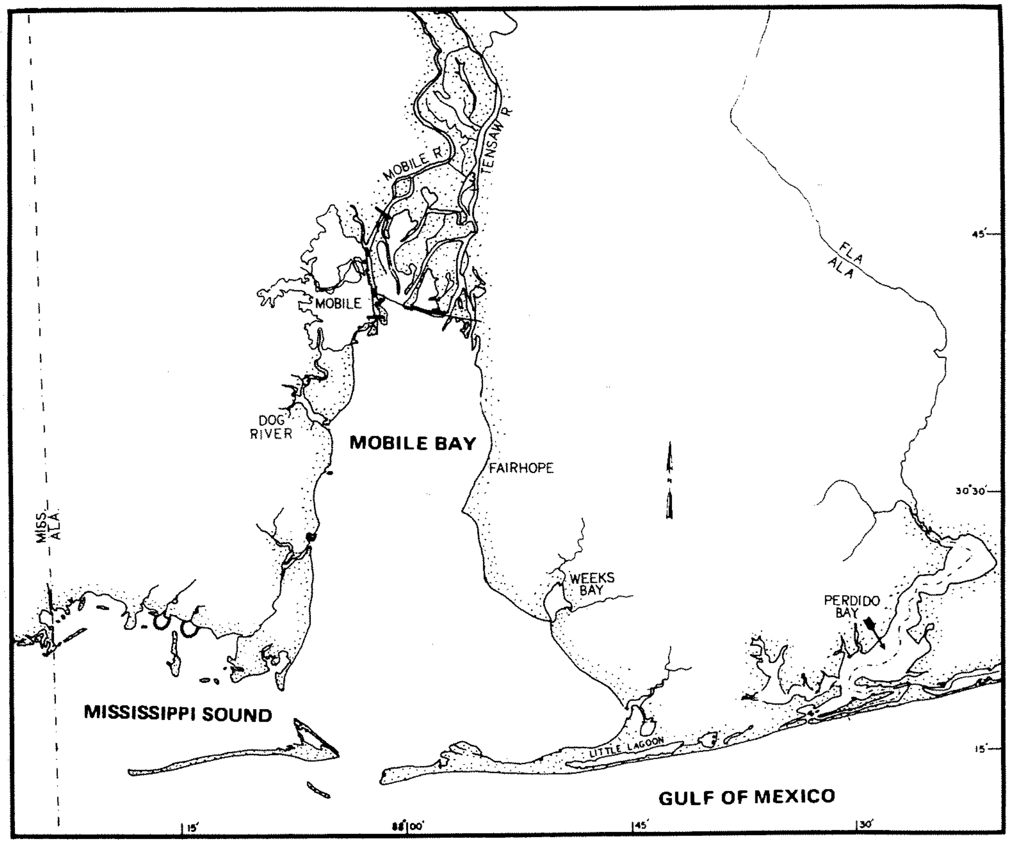

Figure 5. Major estuarine systems, Alabama.

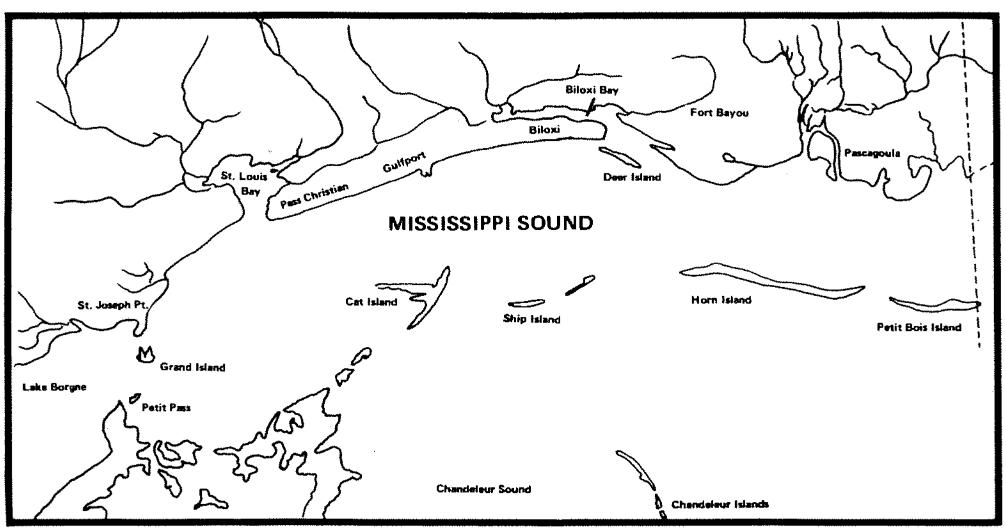

Figure 6. Major estuarine systems, Mississippi.

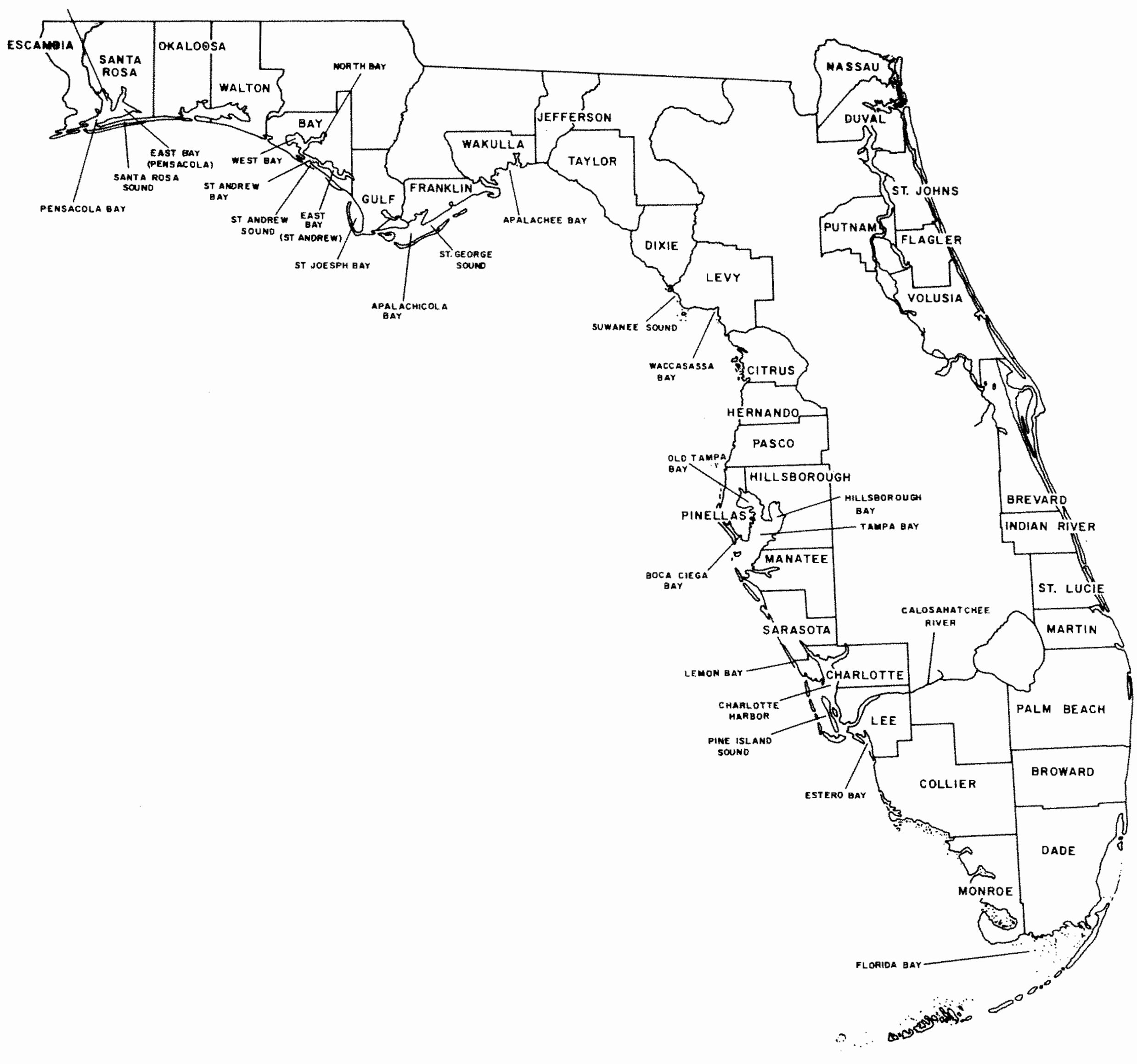

Figure 7. Major estuarine systems, Florida.

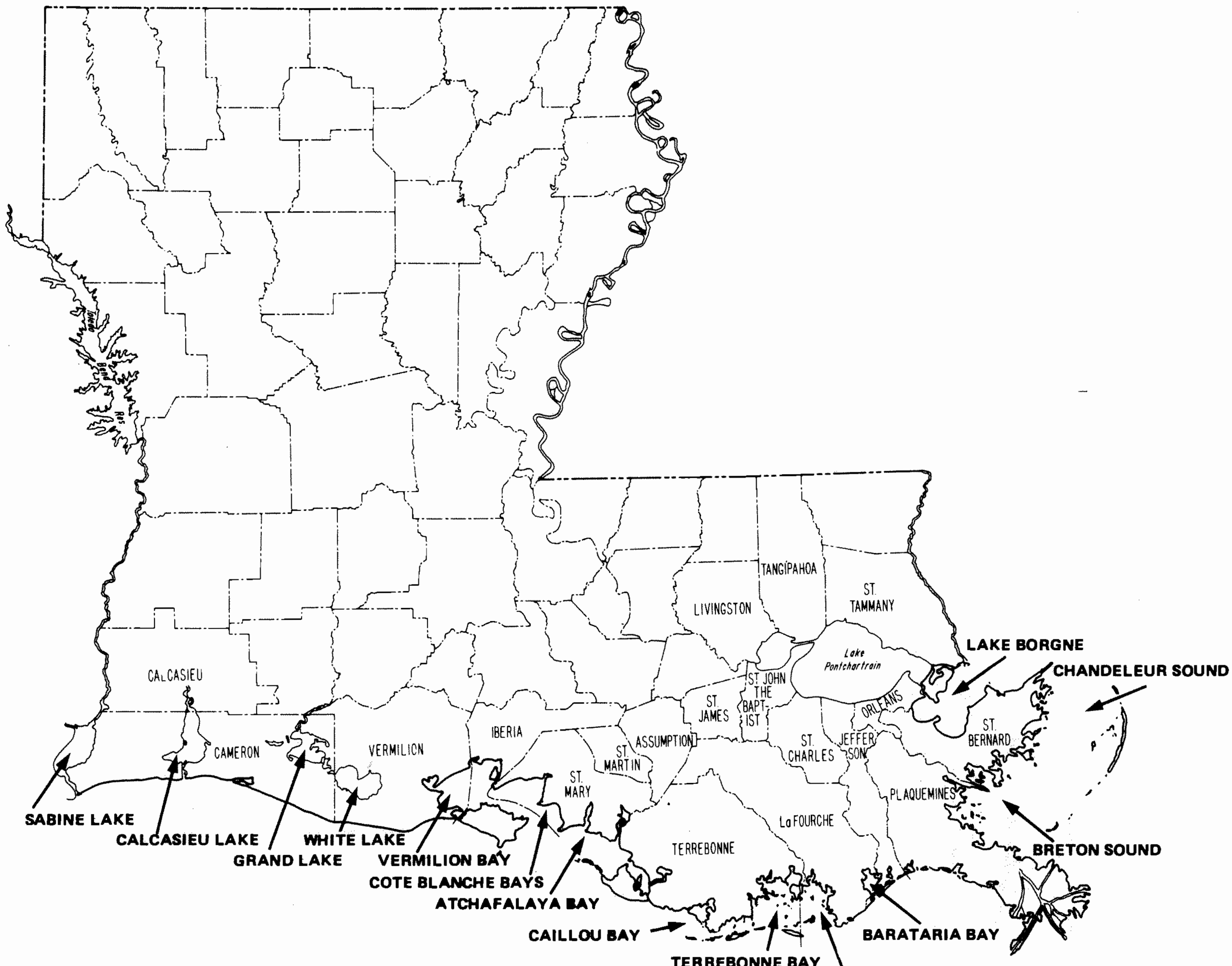

Figure 8. Major estuarine systems, Louisiana.

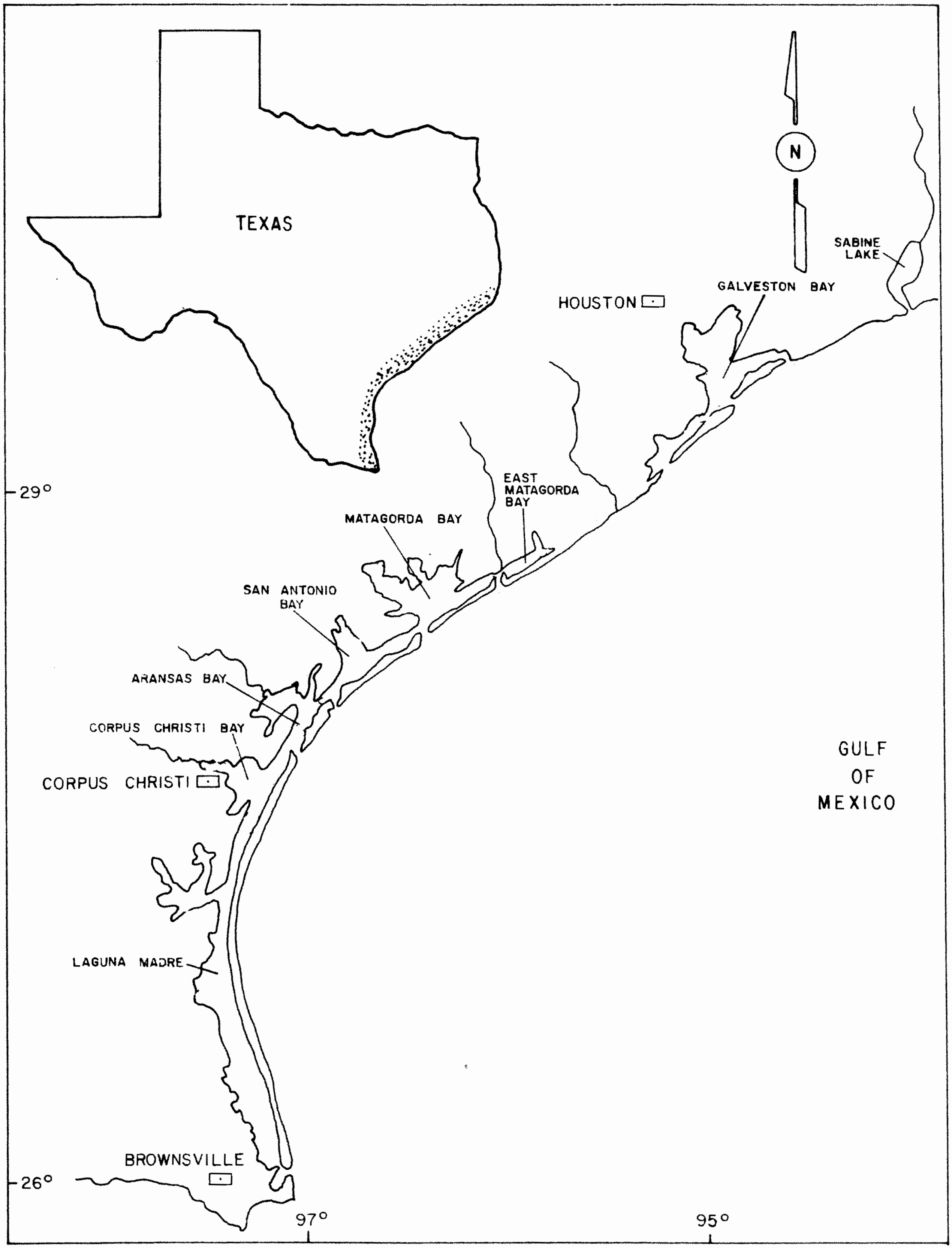

Figure 9. Major estuarine systems, Texas.

2.2 Life History

2.2.1 *Spawning*

Spawning of blue crabs in northern Gulf waters is protracted, with egg-bearing females occurring in coastal Gulf and estuarine waters in the spring, summer and fall (Gunter 1950, Daugherty 1952, More 1969, Adkins 1972a, Perry 1975). Additionally, Adkins (1972a) found evidence of winter spawning in offshore Louisiana waters based on commercial catches of "berry" crabs in December, January and February, and Daugherty (1952) noted that crabs in southern Texas may spawn year-round in mild winters.

For most marine animals mating and spawning are synonymous; however, in the case of the blue crab the two events occur at different times. Prior to her pubertal molt (in the female blue crab the cycle of growth and molting terminates with a final anecdysis), the female travels to brackish waters of the upper estuary to mate. The female mates in the soft shell state following her pubertal molt. Following insemination, the male continues to carry the female until her shell has hardened. Spawning usually occurs within two months of mating in the spring and summer. Females that mate in the fall usually delay spawning until the following spring. Sperm transferred to the female remain viable for a year or more and are used for repeated spawnings.

The fertilized eggs are extruded and attached to fine setae on the endopodites of the pleopods, forming an egg mass known as a "sponge," "berry," or "pom-pom." As many as two million eggs may be present in a single sponge. The sponge is initially bright orange, becoming progressively darker as the larvae develop and absorb the yolk. Prior to hatching, the sponge is black. The eggs hatch in about two weeks.

There has been some discussion in the literature concerning the existence of a prezoeal stage in *C. sapidus.* Robertson (1938), Churchill (1942), Truitt (1942) and Davis (1965) reported prezoeae emerging from the eggs. Time estimates for length of stay in the prezoeal stage ranged from one to three minutes (Davis 1965) to several hours (Robertson 1938). Sandoz and Hopkins (1944) and Sandoz and Rogers (1944) noted that larvae emerged as prezoeae only in response to adverse biological or environmental conditions. Costlow and Bookhout (1959) made specific reference to the lack of the prezoeal stage for *C. sapidus,* noting that the larvae emerged as zoeae. Additionally, Bookhout and Costlow (1974, 1977) do not mention a prezoeal stage for *Portunus spinicarpus* or *C. similis.*

Costlow and Bookhout (1959) reported seven zoeal stages and one megalopal stage for the blue crab. An eighth zoeal stage was sometimes observed though survival to the megalopal stage was rare. Development through the seven zoeal stages required from 31 to 49 days with the megalopal stage persisting from 6 to 20 days. In salinities below 20.1 ppt the larvae rarely survived the first molt.

2.2.2 *Larval Distribution and Abundance*

The larval life history of *Callinectes sapidus* in the Gulf of Mexico is poorly understood. Although Daugherty (1952), Menzel (1964) and Adkins (1972a) specifically discussed the distribution of blue crab larvae, the possibility of co-occurrence of the larvae of *C. similis* must be considered. The temporal and spatial overlap in spawning habits of the two species (Perry 1975), coupled with the difficulty in using the early morphological descriptions of *C. sapidus* from Atlantic specimens (Costlow and Bookhout 1959) to reliably identify Gulf blue crab larvae, suggest that published accounts of the seasonality of *C. sapidus* larvae are questionable. Recognizing the difficulty in separating the two species, King (1971), Perry (1975) and Andryszak (1979) did not differentiate between the larvae of *C. sapidus* and *C. similis.*

Perry and Stuck (1982a) noted that early stage *Callinectes* zoeae (I and II) were present in Mississippi coastal waters in the spring, summer and fall. Adkins (1972a) reported *C. sapidus* larvae present year-round in Louisiana, but did not separate the zoeal and megalopal stages. The sampling programs of Menzel (1964) and Andryszak (1979) were of limited duration with no seasonal distribution data available. Both Perry and Stuck (1982a) and Andryszak (1979) found only the early stage zoeae abundant nearshore.

Callinectes megalopae have been reported to occur throughout the year. Perry (1975) found megalopae in Mississippi Sound in all months with peak abundance in the late summer-early fall and in February. In Texas coastal waters, *Callinectes* megalopae have been found in all seasons (Daugherty 1952, More 1969, King 1971). King (1971) noted three waves of megalopae in Cedar Bayou, the first from January through March, the second in May and June, and the third in October.

Attempts to separate the larvae of *C. sapidus* from *C. similis*, using the characters developed by Bookhout and Costlow (1977) have been largely unsuccessful due to apparent morphological differences in larvae from the Gulf and Atlantic. Stuck, Wang and Perry (1981) provided characters useful in distinguishing the megalopae and early crab stages of the two species. Subsequent analysis of archived plankton samples from Mississippi and Louisiana coastal waters has furnished information on the seasonality of *C. sapidus* and *C. similis* megalopae in the northern Gulf (Stuck and Perry 1981). These authors found *C. similis* megalopae present in offshore waters adjacent Mississippi Sound throughout the year, peaking in abundance in February and March. *Callinectes sapidus* megalopae were rarely found in samples before May. Large numbers of *C. similis* megalopae were identified in February and March samples from Whiskey Pass, Louisiana. Perry (1975), based on the identification of first crabs reared from megalopae, reported a February occurrence of *C. sapidus.* Reexamination of these specimens found them to be *C. similis.* These data suggest that the reported winter peaks of *Callinectes* larvae in the northern Gulf are, in all probability, referable to *C. similis*.

Reports on the vertical distribution of *Callinectes* megalopae appear conflicting. Williams (1971), King (1971), Perry (1975) and Smyth (1980) reported *Callinectes* megalopae to be in greatest abundance in surface waters. In contrast, 96% of the *Callinectes* megalopae collected by Tagatz (1968a) and all of the megalopae collected by Sandifer (1973) were from bottom waters. Stuck and Perry (1981) found that portunid megalopae (*C. sapidus, C. similis* and *Portunus* spp.) showed no affinity for surface or bottom waters (Table 7). They noted that the majority of large catches of *C. sapidus* megalopae were taken on rising or peak tides, whereas the megalopae of *C. similis* and *Portunus* spp. were commonly collected on both rising and falling tides.

TABLE 7. Catch of major portunid taxa by depth.[1]

Depth	Taxa	Total Catch[2]	Total Standard Catch[3]	% of Standard Catch
Surface	*C. sapidus*	11,534	13,632.6	65.2
	C. similis	3,290	3,780.3	18.1
	Portunus spp.	2,467	3,493.5	16.7
	Total	17,291	20,906.4	100.0
Bottom	*C. sapidus*	12,637	18,048.4	75.9
	C. similis	1,106	1,377.1	5.8
	Portunus spp.	2,372	4,359.5	18.3
	Total	16,115	23,785.0	100.0

[1]From Stuck and Perry (1981).
[2]The sum of megalopae caught (number per 20-minute tow) from each sample.
[3]The sum of the standardized numbers (number per 1,000 m^3) of megalopae from each sample.

Little is known concerning mechanisms of larval transport and dispersal of blue crab zoeae in the northern Gulf. Based on the data of Menzel (1964), Andryszak (1979) and Perry and Stuck (1982a), it appears that development through the late zoeal stages (III through VII) takes place in offshore waters. At this time, the larvae are subject to currents and may be transported considerable distances. Recruitment of larvae back into coastal waters occurs during the megalopal stage. Oesterling and Evink (1977) proposed a mechanism for larval dispersal in northeastern Gulf waters in which blue crab larvae were transported distances of 300 km or more. If such transport mechanisms do exist in the Gulf, larvae produced by spawning females in one state may, in fact, be responsible for recruitment in adjoining states.

2.2.3 *Juvenile Distribution and Abundance*

Recruitment of blue crabs to Gulf estuaries occurs during the megalopal stage (More 1969, King 1971, Perry 1975, Perry and Stuck 1982b). The relationship between numbers of megalopae recruited and subsequent abundance of young crabs is not well defined. Perry and Stuck (1982b) noted that large catches of *C. sapidus* megalopae in August and September were usually followed by an increased catch of small crabs (10.0 to 19.9 mm) in October or November in Mississippi estuaries; however, inconsistencies between recruitment of megalopae and subsequent occurrence and abundance of juveniles were noted in the spring and summer in their samples. King (1971) found comparable population densities of juveniles between two years though recruitment was markedly different. Interpretation of his data is somewhat complicated by the taxonomic problems associated with the separation of *C. sapidus* and *C. similis* megalopae.

Young blue crabs show wide seasonal and areal distribution in Gulf estuaries. Livingston et al. (1976) found maximum numbers of blue crabs in Apalachicola Bay in the winter and summer noting that an almost "continuous succession" of young crabs entered the sampling area during the year. Perry (1975) and Perry and Stuck (1982b) found first crab stages in all seasons indicating continual recruitment to the juvenile population in Mississippi. In Lake Pontchartrain, Louisiana, Darnell (1959) noted recruitment of young crabs was highest in the late spring-early summer and in the fall.

Although juvenile crabs occur over a broad range of salinity, they are most abundant in low to intermediate salinities characteristic of middle and upper estuarine waters. Swingle (1971), Perret et al. (1971), Christmas and Langley (1973) and Perry and Stuck (1982b) determined the distribution of blue crabs (primarily juveniles) by temperature and salinity using temperature-salinity matrices. Both Perret et al. (1971) and Swingle (1971) found maximum abundance in salinities below 5.0 ppt (Table 8). In contrast, Christmas and Langley (1973) and Perry and Stuck (1982b) found highest average catches associated with salinities about 14.9 ppt in Mississippi (Table 8). Based on one year of bag seine data, Hammerschmidt (1982) found no direct relationship between catches of juvenile crabs and salinity in Texas. Although salinity influences distribution, factors such as bottom type and food availability also play a role in determining distributional patterns of juvenile blue crabs.

The importance of bottom type in the distribution of juvenile blue crabs is well established. More (1969), Holland et al. (1971), Adkins (1972a), Perry (1975), Livingston et al. (1976) and Perry and Stuck (1982b) all noted the association of juvenile blue crabs with soft, mud sediments. Evink (1976) collected the greatest number of individuals and biomass from mud bottoms and noted that blue crab biomass appeared to follow faunal food availability.

2.2.4 *Growth*

Newcombe et al. (1949) estimated the postlarval instars for male and female blue crabs to be 20 and 18, respectively. Assuming that the number of molts is fixed in blue crabs (Newcombe et al. 1949, Van Engel 1958),

TABLE 8. Distribution of *C. sapidus* by salinity intervals showing number of samples (above) and catch per sample (below).

Modified from:	Salinity (ppt) 0.0–4.9	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30+	Total
Swingle (1971)	41	15	14	19	33	18	18	179
	6.0	4.7	2.6	2.3	3.1	3.3	4.4	3.9
Perret et al. (1971)	197	185	263	278	182	82	12	1,199
	12.0	6.0	6.0	6.0	6.0	5.0	5.0	7.0
Christmas and Langley (1973)	134	87	110	99	145	169	74	818
	1.2	2.7	3.8	3.2	4.1	2.2	0.9	2.6
Perry and Stuck (1982b)	561	423	482	520	517	489	257	3,249
	7.6	7.8	7.1	8.3	5.9	3.0	2.7	6.3

the variability in the average size at which maturity is attained in the female coupled with the observations that unusually large blue crabs are found in low salinities suggests that environmental conditions influence the percentage increase in size per molt. Blue crabs in Chincoteague, Chesapeake and Delaware bays show an increase in size with decreasing environmental salinity (Porter 1955, Cargo 1958). The data of Newcombe (1945), Van Engel (1958) and Tagatz (1965, 1968a) also suggest a possible negative correlation of size with the salinity of the water in which growth occurs. Van Engel (1958) believed that the osmoregulatory mechanism was involved; differences in the levels of salt concentration between the crabs and their environment affected the uptake of water resulting in increased growth per molt. Haefner and Shuster (1964), in a study of the growth increments occurring during the terminal molt of the female blue crab under different salinity regimes, concluded that "within the parameters of the experiment, the salinity variation of the environment is not related to percentage increase in length at the terminal molt." Tagatz (1968b) also found that a decrease in salinity did not produce an increase in size and suggested that some factor other than salinity appeared to account for larger crabs in certain waters.

Growth of blue crabs is strongly affected by temperature. One of the more obvious effects of temperature on growth rate is the length of time required for crabs to reach maturity. Up to 18 months is necessary for maturation in Chesapeake Bay (Van Engel 1958), while blue crabs in the Gulf of Mexico may reach maturity within a year (Perry 1975, Tatum 1980).

In the laboratory, Leffler (1972) demonstrated that the molting rate (molts per unit of time) increased rapidly with increasing temperature from 13.0 to 27.0°C. This increase continued at a slower rate between 27.0 and 34.0°C and growth virtually ceased at temperatures below 13.0°C. The growth per molt was significantly reduced above 20.0°C. Thus while the molting rate increased with temperature, the number of molts necessary to attain a certain size also increased. If the maximum size a blue crab attains is assumed to reflect the growth per molt rather than the number of molts, environmental temperatures may, in part, be responsible for the variation in size at maturity.

Perry (1975) estimated growth by tracing modal progressions in monthly width-frequency distributions for crabs in Mississippi Sound. The estimated growth rate of 24.0 to 25.0 mm/month is somewhat higher than rates found in other Gulf estuaries. Adkins (1972a) found growth in Louisiana waters to be approximately 14.0 mm/month for young crabs, with slightly higher rates (15.0 to 20.0 mm/month) as crabs exceeded 85.0 mm in carapace width. Darnell's (1959) growth estimate of 16.7 mm/month for crabs in Lake Pontchartrain falls within the average reported by Adkins. More (1969) noted a growth rate of 15.3 to 18.5 mm/month in Texas. Plotting the progression of modal groups from February through August, Hammerschmidt (1982) reported higher growth rates for crabs in Texas (21.4 and 25.2 mm/month for seine and trawl samples, respectively) and attributed these rates to the use of seasonal rather than yearly data. Tatum (1980) found seasonal changes in the rate of growth of young blue crabs in Mobile Bay, Alabama. He observed monthly rates of 19.0, 10.0 and 5.0 mm for crabs recruited in April, August and December, respectively.

2.2.5 *Trophic Relationships*

Darnell (1958), while studying the food habits of fishes and invertebrates of Lake Pontchartrain, Louisiana, found blue crabs, mud crabs (*Rhithropanopeus harrisii*), unidentified crustacean pieces, molluscs, fish remains and detritus among the diet of *C. sapidus*. He noted that food differences between adults and young were not pronounced; however, as crabs exceeded 124.0 mm carapace width, molluscs became the dominant food item. The importance of molluscs in the diet has also been documented by Menzel and Hopkins (1956) and Tarver (1970). In an attempt to distinguish and clarify the fundamental nutritional relationships he observed in the Lake Pontchartrain estuary, Darnell (1961) reevaluated the data presented in his 1958 paper in the context of the total estuarine community. He found that most consumer species, the blue crab among them, did not conform to specific trophic levels and utilized alternate food sources from time to time depending upon availability. Successful species were opportunists whose food habits were governed by availability thus characterizing blue crabs as opportunistic benthic omnivores. Data from O'Neil (1949), Suttkus et al. (1953), and Tagatz and Frymire (1963) support this characterization. Heard (1982) described blue crabs as voracious feeders with a variable diet. He noted that in tidal marshes, fiddler crabs (*Uca* spp.) and marsh periwinkles (*Littorina irrorata*) were important components of the diet of blue crabs. Hamilton (1976) suggested that movement of periwinkles up marsh grass stalks with a rising tide may, in part, be an "escape" reaction to avoid predation.

Young and subadult blue crabs occur in estuarine waters throughout the year and are an important prey species for a variety of organisms. The clapper rail (*Rallus longirostris*), great blue heron (*Ardea herodias*) and several species of diving ducks are among the avian predators of blue crabs (Bateman 1965, Day et al. 1973, Stieglitz 1966, respectively). Mammalian predators include man and the raccoon. Important fish predators are listed in Table 9. Adkins (1972a) reported that triggerfish (*Balistes* spp.) have been observed attacking the egg mass of berried crabs in Louisiana coastal waters.

TABLE 9. Fish predators of the blue crab.

Species	Gunter (1945)	Darnell (1958)	Fontenot and Rogillio (1970)	Overstreet and Heard (1978a)	Overstreet and Heard (1978b)	Overstreet (Unpub. data– Gulf Coast Research Lab.)	Heard (Unpub. data– Gulf Coast Research Lab.)
Aplodinotus grunniens		X					
Archosargus probatocephalus	X	X	X			X	
Arius felis	X	X					
Bagre marinus	X						
Bairdiella chrysoura		X					
Caranx hippos						X	
Carcharhinus leucas							X
Cynoscion arenarius						X	
Cynoscion nebulosus	X		X			X	
Dasyatis americanus							X
Dasyatis sabina							X
Dasyatis sayi							X
Ictalurus furcatus		X					
Lagodon rhomboides		X					
Lepisosteus oculatus		X					
Lepisosteus spatula		X					
Lobotes surinamensis	X						
Micropogonias undulatus		X	X	X			
Micropterus salmoides		X					
Morone interrupta		X					
Opsanus beta							X
Paralichthys lethostigma		X				X	
Pogonias cromis	X		X			X	
Rachycentrum canadum						X	
Sciaenops ocellatus	X	X	X		X		
Sphyrna tiburo	X						

2.2.6 *Parasites and Disease*

Couch and Martin (1982) provided a synopsis of the protozoan symbionts and related diseases of blue crabs. Of the protozoans that utilize the blue crab as host, the amoeba *Paramoeba perniciosa* and the dinoflagellate *Hematodinium* were identified as lethal pathogens.

The history of the incidence of *P. perniciosa* along the eastern coast of the United States was reviewed by Couch and Martin (1982). This highly pathogenic amoeba is responsible for outbreaks of gray crab disease. Couch and Martin (1982) described *P. perniciosa* as an opportunistic parasite/pathogen of blue crabs and other Crustacea. To date, this organism has not been isolated from blue crabs in the Gulf of Mexico.

Hematodinium sp., a dinoflagellate found predominantly in the hemolymph, has been identified from *Callinectes sapidus* from the northern Gulf of Mexico (Couch and Martin 1982). The disease exhibits no external signs, although infected crabs are weak and lethargic. In heavily infected crabs, the dinoflagellates may be found in the musculature, gonads and hepatopancreas.

Other protozoans infecting the blue crab are the haplosporidan parasite *Urosporidium crescens* and the microsporidan pathogen *Ameson michaelis*.

Urosporidium crescens is a parasite of trematode metacercariae. Metacercariae of the microphallid trematode *Microphallus basodactylophallus* (as *Carneophallus basodactylophallus* [Perry 1975, Overstreet 1978]) are commonly infected by this hyperparasite in Gulf waters. The metacercariae are found in the hepatopancreas and musculature of blue crabs. With the maturation of the spores of *U. crescens*, the metacercariae become black. Metacercariae containing such spores cause the condition known as "buckshot" by crab fishermen. Crabs thus affected are also known as "pepper" crabs. According to Perkins (1971), rupture of the metacercaria is necessary for the release of the spores of *U. crescens* and this occurs after the death of the crab. He found no evidence that the trematode infection caused mortalities in crabs. Blue crabs infected with *U. crescens* pose problems to processors who must either pick around the cysts or discard the crab. According to Adkins (1972a), buckshot crabs are fairly common in Louisiana. More (1969) and Perry (1975) found infected metacercariae in crabs from Texas and Mississippi, respectively.

While *Ameson michaelis* is the more widely known microsporidan parasite of the blue crab, Couch and Martin (1982) reported that *A. sapidi* and *Pleistophora cargoi* have also been identified from muscle tissue of *C. sapidus*. *Ameson michaelis*, commonly found in blue crabs from Gulf and Atlantic waters (Sprague 1977), infects the musculature and is thought to cause lysis of the muscle tissue. Overstreet (1978) noted the occurrence of this species in crabs from lakes Pontchartrain and Borgne, Louisiana, and Mississippi Sound and diagramed the life cycle. Heavily infected crabs can be distinguished from healthy individuals by the chalky opaque appearance of the muscle tissue.

Heavy infestations of ectocommensal ciliate protozoans have been implicated in mortalities of blue crabs held in confinement (Couch 1966). Peritrichous ciliates of the genera *Lagenophrys* and *Epistylis* were identified from the gill lamellae of blue crabs from Chincoteague and Chesapeake bays and Couch (1966) suggested that severe infestations of these epibionts may interfere with respiration and contribute to mortality of crabs in holding or shedding tanks. Couch and Martin (1982) reported that the prevalence and intensity of infestation of *L. callinectes* in natural populations of *C. sapidus* in Chincoteague Bay increased through the spring and summer, peaking in August. He noted that this ciliate may be a seasonal factor affecting the survival of blue crabs, particularly at times when oxygen tension in the water is borderline.

A variety of cirripede symbionts are either ectocommensal or parasitic on blue crabs. Fouling species include the barnacles *Balanus venustus niveus* and *Chelonibia patula* (Overstreet 1978). Barnacle fouling of mature female blue crabs is common (Adkins 1972a, Perry 1975). Perry (1975) noted that large numbers of spent female crabs occasionally litter barrier island beaches in the northern Gulf and that these crabs are heavily fouled and parasitized. The pedunculate barnacle *Octolasmis muelleri* (as *O. lowei* [Perry 1975]) is found on the gills and in the gill chamber of *C. sapidus*. Infestations have been observed on male and female crabs from waters of high salinity with the incidence of occurrence greater on mature females (More 1969, Perry 1975). Overstreet (1978) noted that heavy infestations may interfere with respiration by decreasing the amount of available gill surface.

The barnacle *Loxothylacus texanus* is a true parasite of blue crabs in the Gulf of Mexico. The cypris larvae infect immature crabs during the molting process. Following a period of internal development, an externa or sac protrudes from beneath the abdomen of the crab. The externa contains the male and female gonads and serves as a brood pouch for the developing larvae. Rhizocephalan infection alters the secondary sex characteristics of the crab, causing the abdomen to appear as that of a mature female. There is some controversy in the literature as to the effect that rhizocephalan infection has on molting and growth. Reinhard (1956) reported that in infected crabs gonadal development is suppressed and that once the externa emerges, molting and growth cease. Overstreet (1978) observed that crabs with externae can molt but questioned whether this process was typical. The influence of rhizocephalan infection on blue crab stocks is of particular concern in Louisiana. Harris and Ragan (1970) reported that 43% of the blue crabs collected in May and June from two estuarine areas in Louisiana were infected with *L. texanus*. Adkins (1972b) found a direct correlation between temperature and percentage of infected crabs, with peak occurrence of the barnacle from July through September. In September 1971, 17.1% of the crabs taken in his samples were infected. More (1969), Adkins (1972b) and Ragan and Matherne (1974) found peak occurrence of the barnacle in higher salinities. According to Ragan and Matherne (1974) adult rhizocephalans cannot tolerate low salinity; maturing externae do not protrude and ones already protruding take on water and rupture. Blue crabs infected with *L. texanus* are becoming more prevalent in Mississippi coastal waters. Christmas (1969) noted that the rate of infection in the Sound was negligible in 1966. Perry (1975) reported that the barnacle was found on less than 1.0% of the crabs collected in 1971 and 1972, and Perry and Herring (1976) noted that 0.1% of the crabs taken in samples from October 1973 through September 1976 carried an externa or had a modified abdomen. Since these data were collected, the incidence of parasitism has risen to over 4.0% (Perry and Stuck 1982b). Additionally, parasitized crabs now show wider areal distribution in Mississippi Sound. From 1971 through 1976 catches of parasitized crabs were highest in the western portion of Mississippi Sound. Subsequently, infected crabs have been collected throughout local waters. Overstreet (1978) noted that over half of the crabs taken aboard a shrimp trawler in Mississippi Sound in July 1977 exhibited infections. Overstreet (1978) suggested that the "dwarf" or "button" crabs that appear seasonally in the commercial catch in Mississippi may be a result of sacculinid infection. Gunter (1950) observed that only 1.5% of the crabs collected in Aransas and Copano bays, Texas, were parasitized. Daugherty (1952), however, noted that 25.8% of the crabs collected near the southwestern end of Mud Island in Aransas Bay from 1947–1950 were infected. More (1969) found 8.0% and 5.8% infection rates in crabs examined from the lower Laguna Madre and upper Laguna Madre, respectively, with the incidence of infection never exceeding 1.0% in other Texas bays.

Carcinonemertes carcinophila, a parasitic nemertean, is common on the gills and egg masses of mature female crabs (More 1969, Perry 1975). Hopkins (1947) discussed the use of this worm as an indicator of the spawning history of *Callinectes sapidus.* Overstreet (1978) noted that while the blue crab is the usual host, it has been found on other portunids.

Digenetic trematodes of the family Microphallidae form an interesting group of parasites that often use a crustacean as a second intermediate host. In those species infecting the blue crab, a snail usually serves as the first intermediate host with a fish, bird or mammal serving as the final host. The cercariae (shed from the snail) enter the branchial chamber of the crab, attach to the gill lamellae and penetrate into the gill lumen. The circulatory fluid of the crab carries the cercariae to various parts of the body where they encyst (usually in the hepatopancreas and/or musculature). The encysted or metacercarial stage may or may not be visible depending upon the species. The metacercaria of *Levinseniella capitanea* are very large and easily seen, whereas the metacercariae of *Microphallus basodactylophallus* are not visible unless they are hyperparasitized by *U. crescens.*

Because the types of habitats in which these trematodes complete their life cycle are often quite specific, they have potential use as "biological tags" (Heard, Gulf Coast Research Laboratory, personal communication). In the northern Gulf of Mexico the life cycle of *L. capitanea* is completed in the high salinity marshes and baylets of the offshore barrier islands, thus the presence of the metacercariae of this species is an indication that the crab has spent time in the marsh habitats of these islands. Another example is *Megalophallus diodontis,* the metacercariae of which are found only in the gills of crabs that have spent all or part of their juvenile and/or adult life in high salinity turtle grass beds where the life cycle of this digenean is completed.

Perry (1975) and Overstreet (1978) found the metacercariae of *M. basodactylophallus* (as *Carneophallus basodactylophallus*) in blue crabs from the northern Gulf of Mexico. More (1969) and Adkins (1972a) reported a metacercaria similar to *Spelotrema nicolli* in blue crabs from Texas and Louisiana, respectively. Heard (1976) noted that the metacercariae observed by More and Adkins were in all probability *M. basodactylophallus* because *S. nicolli* is known only from New England (Cable and Hunninen 1940). The taxonomic status of several species of microphallids is in question (Heard, Gulf Coast Research Laboratory, personal communication). Deblock (1971) placed *Spelotrema* and *Carneophallus* in synonymy with *Microphallus.* Heard and Overstreet are currently reviewing the taxonomic status of those species from the southeastern United States which have been previously assigned to the genus *Carneophallus.*

Levinseniella capitanea was described from blue crabs from lower Lake Borgne and western Mississippi Sound by Overstreet and Perry (1972). The large metacercariae of this species appear as opaque, white cysts in the hepatopancreas, gonads or musculature. There are no published data on the prevalence of this species; Overstreet (Gulf Coast Research Laboratory, personal communication) reports it to occur with more frequency in crabs from Alabama and northwestern Florida.

Leeches (*Myzobdella lugubris*) are common on crabs from low salinity waters. Hutton and Sogandares-Bernal (1959) noted that *M. lugubris* may have been responsible for mortalities of blue crabs in Bulow Creek, Florida, although Perry (1975) and Overstreet (1978) found no evidence to suggest a harmful relationship.

A branchiobdellid annelid, *Cambarincola vitreus,* also infests blue crabs from low salinity and freshwater habitats. These small worms (2 to 3 mm long) are found in the gill chambers and on the external shell surface and apparently cause no harm to the crab (Overstreet 1978).

Microbial infections of blue crabs include the nonfatal bacteria responsible for "shell disease" and pathogenic species of *Vibrio*. Cook and Lofton (1973) in their study of the chitinoclastic bacteria associated with blue crabs and penaeid shrimp isolated one strain, *Beneckea* type I, from all necrotic lesions but noted that in all cases there was no penetration of the epicuticle by the bacteria.

Several species of *Vibrio* have been identified from blue crabs. Davis and Sizemore (1982) isolated bacteria taxonomically identical to *V. cholerae*, *V. vulnificus* and *V. parahaemolyticus* from blue crabs collected in Galveston Bay, Texas. Species of *Vibrio* were the predominant bacterial types in the hemolymph occurring in 50% of the crabs sampled in the summer. *Vibrio cholerae* and *V. vulnificus* were isolated from 3.5 and 9.0% of the crabs, respectively, with *V. parahaemolyticus* occurring in 30% of the study organisms. *Vibrio parahaemolyticus* and *V. vulnificus* were commonly isolated from the same crab, however, *V. parahaemolyticus* and *V. cholerae* were never found together.

Vibrio parahaemolyticus has caused mortalities in blue crabs and food poisoning symptoms in humans eating contaminated crabs (Overstreet 1978). Keel and Cook (1975) found *V. parahaemolyticus* in Mississippi coastal waters and related its prevalence to temperature and distance from land.

Gulf coast blue crabs were linked to an outbreak of human cholera in Louisiana in 1978. Evidence indicated that the outbreak was due to poor sanitary practices in home-prepared crabs, with no implication of commercially processed crab meat. Moody (1982) discussed zoonotic diseases associated with blue crabs and reviewed the history of the 1978 Louisiana cholera outbreak.

2.2.7 *Migration*

Tagging studies in the Gulf include those of More (1969), Perry (1975) and Oesterling and Evink (1977). Migrational patterns observed by More (1969) and Perry (1975) were typical of the onshore/offshore movements as characterized in previous studies (Fiedler 1930, Van Engel 1958, Fischler and Walburg 1962, Tagatz 1968a, Judy and Dudley 1970). Oesterling and Evink (1977) provided evidence of an along-shore movement of females in Florida coastal waters. Migratory patterns observed in their study demonstrated movement of females to sites north of their mating estuary with the Apalachicola Bay region appearing to be a primary spawning ground for crabs along the Florida peninsular Gulf coast. A hypothesis for redistribution of larvae to southwestern Florida involved transport of zoeae in surface currents associated with Apalachicola River flow and the Gulf of Mexico Loop Current.

2.2.8 *Mortalities*

Blue crab mortalities associated with chemical and biological pollutants, sediment, temperature, salinity and dissolved oxygen were discussed by Van Engel (1982). One of the most serious incidences of chemical pollution affecting the blue crab fishery occurred in Virginia and was associated with the release of the chlorinated hydrocarbon Kepone into the James River from the late 1950's to late 1975. Closure of the river to commercial fishing had a severe negative effect on the industry throughout the Chesapeake Bay. The annual mortality of young and adult blue crabs due to exposure to Kepone remains unknown, however, both commercial landings and juvenile crab abundance have been lower in the James River than in the York or Rappahannock rivers for the past 15 years (Van Engel 1982). Lowe et al. (1971) reported Mirex (closely related to Kepone) to be toxic to blue crabs either as a contact- or stomach-poison.

Low levels of dissolved oxygen not only cause mortality of blue crabs but also impede migration. Trap death due to anoxia is a serious problem in many areas. Tatum (1982) reported oxygen deficient bottom waters covered as much as 44% of Mobile Bay, Alabama, in the summer of 1971 with some area fishermen indicating as much as 75% of their catch dead. Low levels of dissolved oxygen in the deeper waters of Chesapeake Bay and associated tributaries during the summer months have also been implicated in trap death. Periodic "kills" of blue crabs following excessive freshwater runoff and the subsequent depletion of oxygen due to rapid decomposition of organic matter were reported by Van Engel (1982).

Other mortalities of blue crabs have been related to extreme cold or to sudden drops in temperature (Gunter and Hildebrand 1951, Van Engel 1978 [from Rhodes and Bishop 1979], Van Engel 1982, Couch and Martin 1982) and to red tides (Wardle et al. 1975, Gunter and Lyles 1979).

Mass mortalities of blue crabs occurred in South Carolina, North Carolina and Georgia in June 1966, and in South Carolina and Georgia in June 1967. While the pathogenic amoeba (*Paramoeba perniciosa*) was alluded to as a possible cause of the mortalities, there was some implication that pesticides may have been involved. According to Newman and Ward (1973) blue crab mortalities of greater and lesser magnitude have occurred during May and June with *Paramoeba* involved in the majority of the kills that were investigated.

Adkins (1972) and Perry (1975) reported large numbers of dead crabs periodically littered the beaches of Louisiana and Mississippi, respectively; observing that the vast majority of these crabs were heavily fouled, spent females.

3. DESCRIPTION OF THE FISHERY

3.1 Development of the Hard Crab Fishery

Information in this section was obtained from interviews with crab fishermen and processors.

The states bordering the Gulf of Mexico were more similar than disparate in the development of the blue crab fishery. The search for the earliest activity in each state has, thus far, ended at least one generation away from inception. Names, places and dates are extant in the minds of early fishermen, who entered an existing industry or in the evidence of heirs, and are subject to the limitations of retrospect.

The gaps in information and "foggy" dating in these early histories suggest that a more concerted effort be made to authenticate this fishery. Each state has crab stories to tell, but more confusing, each bay system, each fisherman and each crab plant also has a story to tell. As time passes the stories get more vague, dating fades and names are lost. The obvious inadequacies in the following sections enforce the need to learn and record what may soon be lost.

The blue crab fishery is characterized by the uniqueness of the product which, in itself, prevented fishery development until the advent of railroads. The importance of the coming of the railroads cannot be overemphasized in the development of markets for perishable items such as crab meat. Prior to rail travel, the fastest mode of transportation was by sailing schooner, with the trip from Biloxi, Mississippi, to New Orleans, Louisiana, requiring a full day. The onset of picking operations in the late 1920's heralded a new era of expansion for the fishery.

The earliest commercial fishery for blue crabs in the Gulf that could be documented through interviews existed in Florida in the 1880's. William H. Boyington and his son Jesse fished trotlines in Doyle and Whiskey George creeks, trading their crabs for farm products and staples in West Point (now Apalachicola).

3.1.1 Mississippi

Luke Dubaz, born in 1897 and of Yugoslavian descent, sailed with his parents and brothers from Pensacola, Florida, to Biloxi, Mississippi, in 1902. There he eventually entered the oyster fishery and crabbed and fished as a sideline. By the early 1920's, there were three fish houses picking crab meat for stuffed crab products. These were owned by Bill Cruso, Steve Papich and a man known only as Valpino. The Dubaz family bought Valpino's operation in the 1920's. A live market in Mobile, Alabama, bought 150- to 200-dozen live crabs per week from the Biloxi picking houses as well as from Lewis Johnson, who only shipped live crabs. The crabs were packed in moss, 8-dozen to an orange crate and shipped twice a week. The shippers received 20 cents per dozen. Markets quickly opened in Montgomery, Alabama, Washington, D.C. and Baltimore, Maryland.

Crabbers supplying the Biloxi crab houses fished 200-fathom trotlines, baited every few feet with beef lips and tripe at a cost of 3 to 8 cents per pound. Each crabber ran two or more lines at night from a rowed skiff. They reportedly harvested 1,200 to 1,500 pounds per day and were paid 10 cents per dozen. Pickers received 4 cents per pound of picked meat. Some of the pickers hand-dipped crabs in the shallows the night before, with a good catch being about 200 pounds per person.

3.1.2 Florida

Prior to 1930, the Florida blue crab fishery supplied a local, barter-type market where all the crab meat and crab meat products were consumed locally. "Seeb" Russell changed all that when he returned to Florida from Biloxi and reported that crab meat was being picked and shipped in large-scale operations. Arthur Tucker, from the Apalachicola-East Point area, investigated the report and began his own full-scale picking operation in Florida by spring of 1930. He packed crab meat in pint jars and shipped it to New York. This is the earliest report of crab meat produced for interstate shipment from Florida. The Tucker family still operates their seafood business to this date.

Florida crabbers fishing trotlines could harvest as much as 2,500 pounds per day on good days. Crabbers were paid 5 cents per dozen, translating to about $10.00 per day. Expenditures for the Florida crabber, as well as those for other Gulf states, were mainly for bait—two trotlines required about 100 pounds of bait.

Florida's blue crab fishery began to expand significantly after World War II due to the development of large-scale processing plants. Charles Barwick, Sr., started a picking plant in Panacea in 1949, and Herman Metcalf opened another between 1953 and 1954. During this post-war period, Ralph Newton added crab processing to his importing and seafood business. From 1963 to 1971 Newton was processing more than 2,000 pounds of product per day, requiring about 30,000 pounds of live crabs. Top production in Barwick's operation was 2,269 pounds per day, requiring 111 crabmeat pickers. The families of those mentioned above still operate several crab-processing facilities which provide the bulk of Florida Gulf coast crab meat entering eastern seafood markets.

3.1.3 Alabama

In Baldwin County, crabbers have been fishing since at least 1900, selling the live crabs in Mobile. The first crab shop in Baldwin County opened in 1947; the meat was canned and trucked to Bayou La Batre for sale. Bayou La Batre developed into a distribution center which now competes with Mobile. The first crab shop in Mobile County was opened in the early 1920's at Alabama Port. Crabs were brought in and boiled on the beach in 55-gallon drums which were cut lengthwise and set on four pipes in the ground. The cooked crab was taken into the plant, backed, washed at a hand pump and picked. The meat was packed fresh for shipment. Southern Fish Company, owned by Mr. Jess Jemison, was the first company in Mobile to distribute crab meat for intra- and interstate shipment.

3.1.4 Louisiana

Any early history of the Louisiana fishery presents a formidable challenge for the researcher. The type of evidence gathered from other Gulf states is available for Louisiana, but is scattered throughout a maze of wetlands, bays and estuaries. Early on, New Orleans grew into a major market for seafood products linking Houston, Texas, Mobile and Biloxi with inland centers. One of the first crab fisheries in the Gulf developed near New Orleans to supply the French Market and local restaurants. The first crabmeat plant was constructed in 1924 in Morgan City and, by 1931, there were seven more plants in the Morgan City/Berwick area. This time frame roughly corresponds with the onset of picking operations in most other Gulf states.

Louisiana now supplies live blue crabs to Baltimore, Maryland, and surrounding eastern cities. These crabs are shipped by airfreight, a practice which began in Louisiana. Verlon Davis, manager of Bo Brooks of Texas, has stated that Charles Turan of Turan Seafood in Metairie, Louisiana, was the first to ship live crabs by air.

Louisiana's vast fertile wetlands have provided a surplus of blue crabs over local demand. Since 1968, Louisiana has produced one third to one half of the total Gulf harvest. This surplus has historically been exported to other states. Mississippi and Alabama have consistently relied upon Louisiana crabs to keep their plants operating during years of low supply. Star Crab Company in Palacios, Texas, trucked crabs regularly from Hackberry, Louisiana, in the 1960's.

3.1.5 Texas

In the early 1900's, Homer Clark fished Galveston Bay, Texas, and shipped live crabs by the barrel to Houston via High Island and the Bolivar Peninsula. This is the earliest documented Texas crab fishery. Certainly, however, there must have been other crabbing operations supplying Houston restaurants and markets with Texas blue crabs. Owen Raby, now of Port O'Connor, Texas, fished and crabbed around Port Arthur, Texas, in 1914. He used trotlines with stagings every 3 to 6 feet baited with fresh fish. He sold his crabs to a man who stopped the Orange-to-Houston train and shipped the crabs live to Houston. Where this marketing chain ended is unknown.

The earliest documented crab-picking plant in Texas was built in 1958 in Palacios by a Mr. Willis. However, there are reports of a plant of earlier construction built in Flour Bluff. The owner was said to be a man from Mississippi whose name and history remain as vague memories.

Mr. Joseph [Preston?] Lowe (originally of Crisfield, Maryland, and later of Pascagoula, Mississippi) purchased the Palacios plant from Mr. Willis sometime after 1958. The plant was called Star Crab Company and Mr. Lowe bought crabs from Flour Bluff, Texas, to Hackberry, Louisiana. Joseph Lowe's death terminated an amazing career that began in Crisfield, Maryland, and profoundly affected the Gulf coast fishery. His wife, Ruby, continued to operate Star Crab Company which was eventually absorbed by Ed Collins Seafood.

Edmond Collins operated a shrimp cannery in Palacios in 1960. In 1966, he sold out and opened a seafood business which became Ed Collins Seafood in 1967. By 1970, he had built a hard crab processing plant capable of handling 25,000 pounds of crabs per day, adopting the first steam cooking and first pasteurizing process in Texas. He also led in the development of and promoted the legislation for regulations and inspection standards of Texas crab-processing plants.

Prior to the mid-1970's, blue crab production in Texas was severely limited due to the parochial marketing channels and low local demand for crab meat.

Bill Marsh of Marsh Seafood in Anahuac, Texas, reported a man named Glen Pearson began shipping crabs from Texas in the early 1970's. The receiver paid the freight charges. As air freighting became popular and east coast markets developed, Texas began to fully exploit its blue crab resources. This business now exports an estimated 20% of the reported landings in Texas at a wholesale price of about $1.00 per pound.

East coast "crab barons" soon took interest in Texas' productivity and invested in or bought out Texas processors. Verlon Davis, a Louisiana crab buyer, shipped live crabs to Baltimore, Maryland. He sold his interest to Bo Brooks of Baltimore who constructed a picking plant in Seadrift, Texas, in 1976. Mr. Davis continues to manage this plant. Ralph Newton, of Florida, took over South Bay Seafood in Aransas Pass, Texas, and renamed it Blue Sea. Ed Collins Seafood was purchased by a group of east coast crab buyers while a man named Mr. Dinardo opened up a crab house in Matagorda.

With the influx of new markets, increasing fishing pressure is being placed on the resource. Texas now provides over 20% of the Gulf coast production.

3.1.6 Regulatory Responsibility

Louisiana is the first of the Gulf states to assume responsibility for the quality of crab meat and crab meat products. One hundred years ago, in 1882, Louisiana passed food and drug legislation, predating the federal govenment. Since 1921 the Health Department has permitted and inspected crab plants with revision in 1950. The State

Sanitary Code, Chapter Six, now regulates seafood products.

In 1937 the Mississippi State Board of Health wrote crab meat regulations. In 1954 the Gulf States Shellfish Conference first met in Mississippi; the topics being crabmeat, crab products and interstate trade. In 1980 North and South Carolina began participating in the conference which now includes states from the Gulf and South Atlantic.

The Texas blue crab industry appealed to the legislature in 1969 for regulatory control including the licensing and inspection of plants to qualify for acceptance in interstate marketing. Presently this inspection and licensing is authorized by the Texas Department of Health.

Florida Department of Natural Resources assumed regulatory authority over the crab industry, writing regulations in 1977. Prior to that date, the production of crab meat was subject to State Health Department supervision.

Alabama also permits and inspects crab-processing plants.

3.1.7 Gear

The front beaches and back bays were surely a colorful sight at night in the 1800's as lanterns and torches lighted up the shallows. There the crabbers (both men and women) waded with hand-held dip nets, scooping up crabs and dropping them into towed skiffs, tubs, half-barrels or burlap sacks. The dip nets were long-handled with little webbing to facilitate removing the crab with a quick shake. When crabbing was good it was possible to dip 200 pounds a night. The hard crabs were kept for barter or for picked meat and the peeler crabs kept until they shed.

Crabbers used drop nets in deeper water that could not be waded. These were net-covered iron bar frames 18 inches square with a bait fastened to the middle of the webbing. Lines, attached to the frame, led to a float. Periodically, the drop net was raised and the crabs were placed in the skiff, probably in a moss- or brush-lined barrel. The trotline was found to be more effective in catching crabs and quickly replaced the drop net.

Trotlines were of two basic types. The earliest type consisted of a length of rope (mainline) to which were attached short (10-inch) lines at approximately 2-foot intervals. Bait was attached to the ends of these short lines (called snoods, drops, stagings or gangions) (Figure 10). When rollers or spools came into use with the advent of motor boats, the snoods were often abandoned as they easily became tangled in the roller; bait was then secured either in a slip knot in the mainline or tucked between the strands. A trotline with baits attached to the mainline is shown in Figure 11.

The bait varied, but beef lips and tripe were the most common. They were tough and durable. Chunks of salted eels were favored by some crabbers and were reported to be particularly effective for catching male crabs. Bait was constantly a problem; the lines had to be rebaited as needed after each use and then stored in a brine barrel in the bow of the skiff to preserve the cotton twine. As the bait became rank, the brine barrel began to develop a unique aroma. Sometimes the beef lips had to be boiled to remove them from the line. The whole gear was placed into a vat and boiled until the bait loosened up. If the bait was secured to the mainline with a slip knot, the line was strung around a tree or post and pulled in a sawing motion until the bait came loose and the slip knot gave way.

Most crabbers ran at least two lines, with some of the lines longer than a mile. The lines were run from a skiff which had been rowed to the crabbing grounds. Small outboard motors were not used in the Gulf until the 1950's. After the first line was set, the second was put out and the first run. If crabs were plentiful in a particular area, lines would be run until the supply was exhausted. Crabbers would then move the lines to more productive grounds.

To harvest the crabs, the crabber pulled his skiff along the set line, reaching out and dipping the crabs (feeding on the bait) into the boat. The dip net was constructed long enough to reach over the side of the skiff and into the water. The net was made of shallow webbing or chicken wire. Some nets were little more than tennis rackets used to bat the crabs off the bait and into the skiff. Most of the trotline fishing was done at night by lantern or in the early morning because the shadow of the skiff in clear water would "spook" the crabs and they would release the bait. The location of trotlines varied seasonally. The orientation of trotlines in an estuary was dependent upon tide (Van Engel 1962), season and geographic location (Jaworski 1972).

The arrival of the crab pot moved the blue crab fishery from a crab kitchen operation to the large-scale processing plant. The most vivid change took place in Florida after 1950. According to Bill Marsh, the crab pot was introduced in Panacea, Florida, by his cousin, Rose Bradshaw, and her husband, Leroy. From the reported landings and number of gear units (Tables 10 and 13) for the 1950's and 1960's, one can see that something spectacular happened in Florida and later in Louisiana that can be traced to the adoption of the crab pot. This is what enabled the large picking plants to expand; the new technology increased the supply of hard crabs beyond the capacity of local markets to consume them and the industry was forced to seek new marketing channels.

The only authenticated date on the arrival of the crab pot to the Gulf of Mexico is for Mississippi. Joseph Lowe brought the Chesapeake pots to Pascagoula in 1951, and they were placed in the water near Gautier. Emile DeSilva, of the Mississippi Marine Conservation Commission, picked up 200 of the pots, confiscating them as outlaw devices. A Justice of the Peace tried the case and instructed the Commission to return the pots to the water. Legality of the pot was based on the conclusion that the animal was not trapped but merely enticed by the bait and could leave

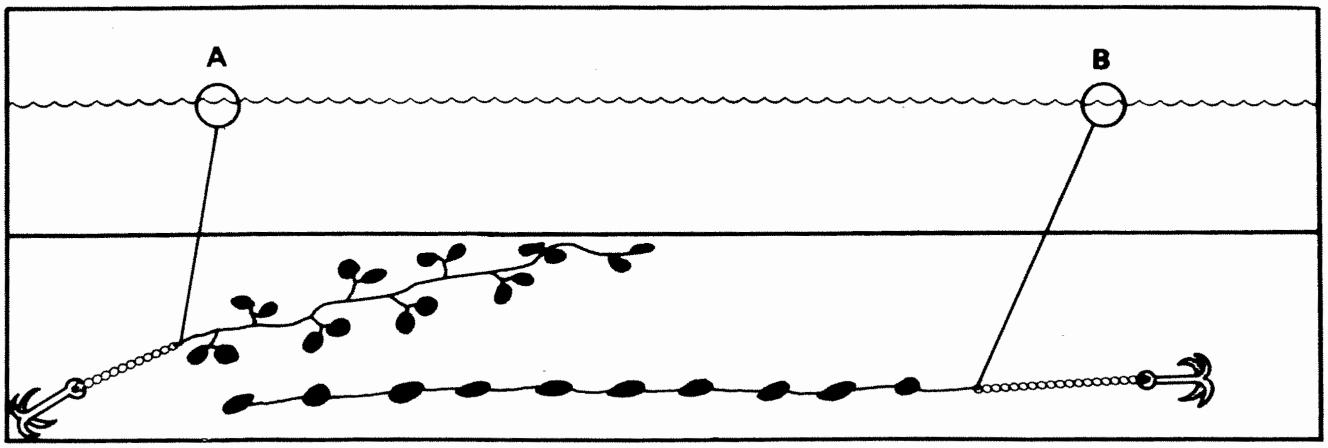

Figure 10. (A) Trotline with snoods. (B) Trotline with bait attached to mainline.

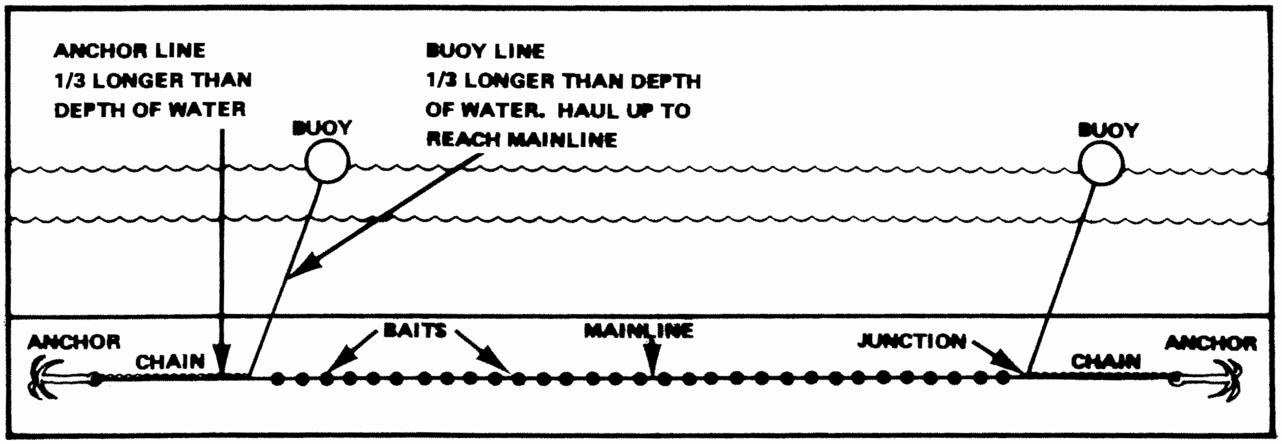

Figure 11. A trotline with baits attached to the mainline (from Floyd 1968).

as it entered. The term "pot" was coined to escape the connotation of trapping. Further details of this landmark case are reportedly a matter of public record and hopefully will be published.

It is not clear when the technology moved to Louisiana. However, both Alabama and Louisiana experienced difficulty in establishing pot fishing. Trotline fishermen felt that the more efficient pot was depleting the resource because their catch was decreasing. Another barrier to accepting the new technology was the capital investment required to purchase wire, floats, tools, and other necessary materials.

With legal precedence established in Mississippi, small skirmishes occurred between pot and trotline fishermen. Pots were stomped flat and float lines cut. Efficiency, however, won over tradition and Louisiana crabbers finally adopted the pot throughout the fishery by the 1960's.

The crab pot is a cubical shaped device constructed of 18 gauge, hexagonal mesh, galvanized wire fastened together with lacing wire, hog rings or "J" clips (Figure 12). Crabs enter through openings in the sides near the bottom. The number of openings is usually two, although some crabbers prefer four. The openings taper inward, leading the crab to a bait-well centered on the floor of the pot. The pot is divided into upper and lower chambers by means of a baffle which may arch from the floor over the bait-well and back to the floor or is tied into the sides in gull-wing fashion. Openings in the baffle permit the crabs to travel from the baited area to the upper chamber where they remain until removed.

Pot fishermen generally set their crab pots in a line. Each pot is fitted with a length of rope and a float. The crab pots are baited with any type of scrap fish (menhaden are the preferred bait) available at a reasonable price. They are usually run daily, early in the morning, but double runs during peak production months are not uncommon. Captured crabs are usually culled, sorted as to size, and placed in containers for sale. Sale generally takes place before noon to avoid heat-induced mortality.

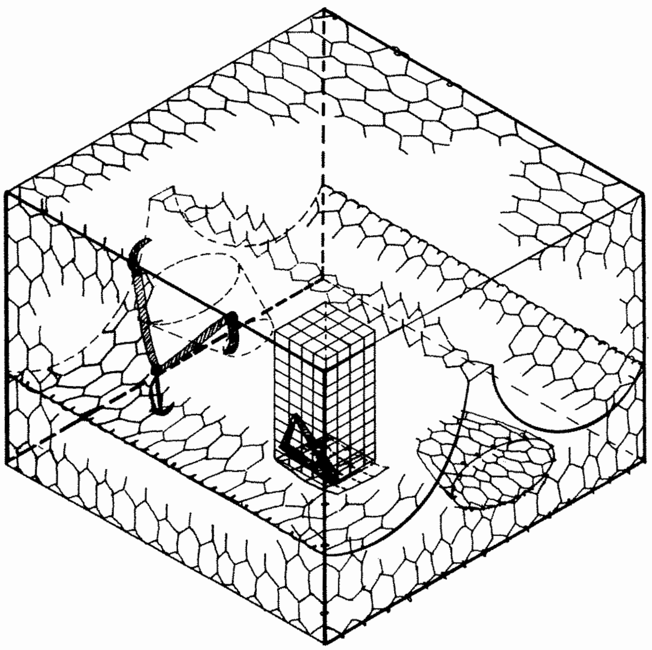

Figure 12. Commercial crab pot.

3.2 Development of the Soft Crab Fishery

Historically and presently, Louisiana has been the center for soft crab production in the Gulf of Mexico. According to Jaworski (1982) the soft and peeler crab fishery in the Gulf states developed along the northern shore of Lake Pontchartrain and in the area of the Rigolets, borrowing both terminology and shedding techniques from the Chesapeake Bay fishery. The fishery in the Barataria estuarine system, however, evolved quite differently. The discovery that peeler crabs could be harvested using the fresh willow branches (*Salix nigra*) designed to catch river shrimp and eels led to the development of a folk-oriented fishing technique (bush trotlines made of wax myrtle) still in use today (Figures 13–16).

The fishery in the other Gulf states relied on hard crab harvesting techniques.

3.3 Harvesting – Hard Crab Fishery

Knowledge of the exploitation rate of blue crabs by various user groups is essential for proper management of the resource. Total production figures for the blue crab fishery are difficult to obtain for a variety of reasons. The seasonal, supplemental nature of the fishery along with the wide distribution and easy accessibility of the resource contribute to the difficulty in identifying user density. Reported commercial landings are probably less accurate than similar data for other fisheries. Indeed, Roberts and Thompson (1982) observed that 60% of the hard crab landings from Lakes Pontchartrain and Borgne, Louisiana, moved through market channels not covered by government statistical surveys. Bootlegging, roadside vending, direct sale to fish markets and direct sales to the public also contribute to unreported landings (Moss 1982).

3.3.1 Trends in Landings by Year and State

Commercial blue crab landings from the Gulf of Mexico have been reported since 1880 (Table 10). The availability of these data prior to 1948 has not been consistent, however, the general trend indicates that total reported landings gradually increased from about 1 million pounds in the late 1800's to over 18 million pounds just prior to World War II. Louisiana contributed as much as 93% of the total Gulf landings during this period. Reported landings from almost all states rose significantly in 1945 and may be attributable to World War II veterans reentering the fishery. From 1948 to 1954, landings declined substantially in Alabama, Mississippi and Louisiana. Part of the decline in landings in these states from 1948–1949 was interpreted as a response by the fishermen to market conditions (Gulf fishermen were not willing to fish for crabs at a price that would allow competition with Chesapeake Bay crab meat [NMFS, Statistical Digest Number 25]), however, no explanation was available for the continued decline through 1954. During this period Florida was just beginning to expand its fishery and Texas was maintaining a small subsistance fishery.

Landings increased in all states in 1955, declined in 1956 and began a general increase through 1960. Florida, in 1960, was the leading producer of blue crabs on the Gulf coast, with Texas also reporting a large increase in blue crab landings. It was during these years that crab pots began to gain wide acceptance by the commercial fishermen. From 1962 through 1964, Gulf landings were substantially below the 35-million-pound levels recorded in 1960 and 1961. While the volume of catch in individual states varied, with the exception of Alabama, all states showed a general decline in harvest. Low Gulf landings in 1963 were attributed to decreases in catch in Louisiana and Texas due to unfavorable environmental conditions in those states as market conditions were good and the number of fishermen, craft and gear was nearly the same as in the previous year (NMFS Statistical Digest Number 57).

Following 1964, Alabama and Mississippi landings leveled off at about 1.6 million pounds while Florida fluctuated between 9 and 15 million pounds. Louisiana reported record landings of 23 million pounds during 1973 and leveled off at approximately 16 million pounds through 1980. Texas landings generally increased by about one-half million pounds from 1974 through 1980.

3.3.2 Seasonal Landings by State

Seasonal fluctuations in reported commercial landings are similar among all the Gulf states (Figure 17). Commercial crabbing generally begins in March or April as water temperatures rise above 15°C. Greatest commercial catches usually occur from May through August with June

Figure 13. Wax myrtle, *Myrica cerifera* (courtesy Lionel Eleuterius).

Figure 14. Bush trotline.

Figure 15. Running bushline.

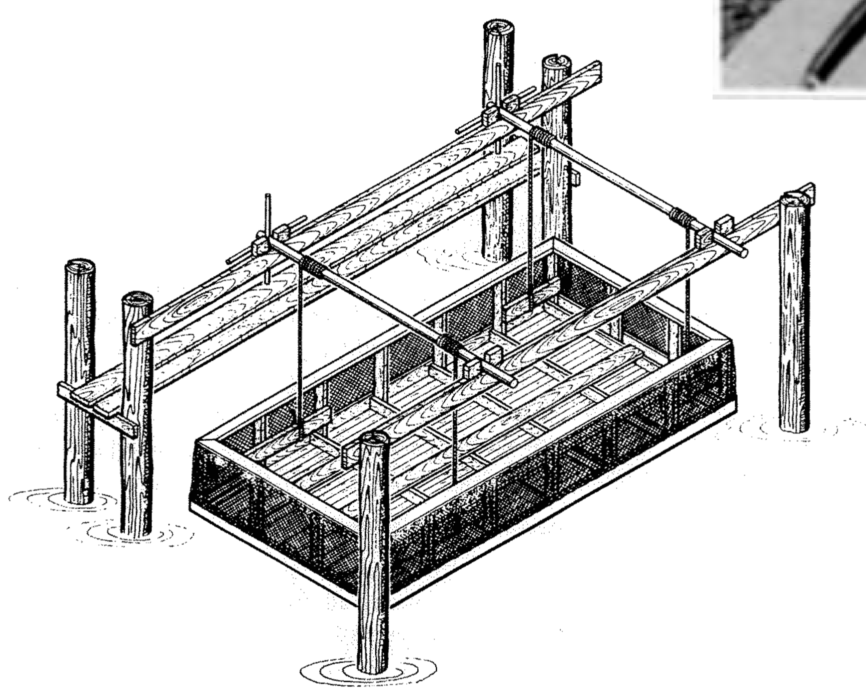

Figure 16. Live car, used for holding shedding crabs.

TABLE 10. **Historical hard-shell blue crab landing statistics, 1880–1980 (thousands of pounds; thousands of dollars).**

	Florida West Coast		Alabama		Mississippi		Louisiana		Texas		Total	
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1880	–	–	–	–	–	–	288	7	36	1	324	8
1887	(2)	(2)	(2)	(2)	38	1	837	13	111	4	(2)	(2)
1888	3	(1)	96	6	16	(1)	851	13	115	4	1,081	23
1889	–	–	–	–	48	1	842	14	189	5	1,079	20
1890	–	–	–	–	33	1	851	13	191	5	1,075	19
1891	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1892	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1895	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1897	6	(1)	24	1	132	3	1,459	13	138	4	759	21
1898	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1899	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1901	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1902	1	(1)	75	2	235	5	312	16	43	2	1,666	25
1904	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1905	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1908	2	(1)	246	6	380	10	244	8	199	5	1,071	29
1915	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1918	–	–	96	3	216	6	282	10	193	11	787	30
1919	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1920	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1921	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1922	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1923	–	–	84	3	435	11	312	8	109	9	940	31
1924	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1925	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1926	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1927	12	1	32	1	2,426	62	1,091	51	121	9	3,682	124
1928	7	1	102	4	1,518	40	2,320	78	300	12	4,247	135
1929	2	(1)	103	3	1,247	33	2,675	78	163	11	4,190	125
1930	4	(1)	80	1	673	11	4,186	63	29	1	4,972	76
1931	4	(1)	78	1	454	7	4,985	53	49	1	5,570	62
1932	4	(1)	70	1	320	5	5,878	57	45	1	6,317	64
1933	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1934	49	1	257	4	603	7	11,676	164	258	13	12,843	189
1935	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1936	821	12	997	14	2,011	30	12,576	168	320	8	16,725	232
1937	775	12	756	11	1,435	25	14,717	195	922	24	18,605	267
1938	1,104	16	511	8	1,016	17	10,533	106	971	24	14,135	171
1939	722	11	558	8	1,469	25	11,228	129	406	8	14,383	181
1940	1,170	16	1,381	28	1,488	26	14,062	172	252	6	18,353	248
1941	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1942	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1943	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1944	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1945	1,092	54	2,207	110	5,639	282	31,280	1,418	339	39	40,557	1,903
1946	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1947	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1948	(2)	(2)	2,373	119	5,503	275	21,110	608	526	34	29,512	(2)
1949	2,056	91	2,128	106	4,163	208	17,874	555	374	22	26,595	982
1950	684	27	599	26	4,040	202	13,106	599	387	30	18,816	884
1951	2,076	83	1,109	46	1,623	82	8,710	461	280	24	13,798	696
1952	1,984	89	655	39	1,726	86	7,334	314	338	24	12,037	552
1953	3,153	126	1,087	54	1,412	71	8,131	333	432	39	14,215	623
1954	2,903	145	972	49	1,256	68	7,085	294	379	26	12,595	582
1955	4,954	248	1,613	81	1,763	88	10,811	449	356	29	19,497	895
1956	3,728	180	725	36	1,979	99	9,402	433	195	20	16,029	768

TABLE 10 (Continued). Historical hard-shell blue crab landing statistics, 1880–1980 (thousands of pounds; thousands of dollars).

	Florida West Coast		Alabama		Mississippi		Louisiana		Texas		Total	
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1957	5,302	318	1,462	73	2,400	144	8,559	419	201	11	17,924	965
1958	8,693	461	1,182	56	2,124	123	9,336	402	570	51	21,905	1,083
1959	13,895	681	1,093	57	3,003	165	9,570	461	1,192	75	28,753	1,439
1960	18,648	895	499	26	2,812	169	10,050	497	2,867	177	34,876	1,764
1961	17,130	736	838	46	2,505	143	11,910	514	2,875	178	35,258	1,617
1962	10,356	487	634	35	907	55	9,523	463	4,473	289	25,893	1,329
1963	13,148	644	1,297	75	1,112	64	7,982	447	2,980	199	26,519	1,429
1964	14,068	843	1,762	110	1,286	82	5,692	379	2,484	175	25,292	1,589
1965	20,598	1,185	1,812	153	1,692	131	9,284	635	3,622	286	37,008	2,390
1966	16,547	912	2,183	182	1,457	105	7,986	537	2,778	228	30,951	1,964
1967	13,976	817	2,353	188	1,015	79	7,559	520	2,625	222	27,528	1,826
1968	9,008	674	1,980	159	1,136	108	9,551	807	4,084	329	25,759	2,077
1969	11,584	1,074	1,920	223	1,740	177	11,602	1,072	6,343	599	33,189	3,145
1970	14,786	1,076	1,407	144	2,027	193	10,254	928	5,525	509	33,999	2,850
1971	12,279	952	1,997	212	1,259	126	12,186	1,256	5,810	567	33,531	3,113
1972	10,673	959	1,613	195	1,362	169	15,083	1,777	6,464	653	35,195	3,753
1973	9,599	1,147	2,098	294	1,815	231	23,080	2,811	6,881	830	43,473	5,313
1974	10,134	1,280	1,826	284	1,667	227	20,640	2,701	6,088	832	40,355	5,324
1975	12,807	1,585	1,640	283	1,137	177	17,144	2,510	5,992	948	38,720	5,503
1976	12,048	1,966	1,299	281	1,335	268	15,211	3,061	6,668	1,179	36,561	6,755
1977	15,832	3,119	2,174	548	1,919	473	16,379	3,765	8,249	1,947	44,553	9,852
1978	11,679	2,235	2,009	458	1,940	423	15,207	3,189	7,470	2,004	38,305	8,309
1979	11,198	2,235	1,314	383	1,311	316	17,370	3,885	8,312	2,146	39,505	8,965
1980	11,263	2,392	1,557	464	2,748	690	16,342	3,874	8,953	2,456	40,863	9,876

(1) – less than 500 pounds or $500.00.
(2) – data not available.

or July as peak months. Reported landings then begin to decline along with water temperature. These general trends may shift slightly from month to month depending upon prevailing environmental and/or market conditions.

3.3.3 Percent Contributions – States to Gulf Landings ana Gulf to United States Landings

The percent contribution of each state to the total Gulf of Mexico blue crab landings from 1960–1980 is shown in Table 11. Prior to 1960, Louisiana led the Gulf coast in total reported landings. In 1959, Florida surpassed Louisiana and remained in the lead through 1967. Landings were roughly equal between these states from 1968 through 1971, however, Louisiana regained the lead in blue crab production in 1972 and remained there through 1980.

Prior to 1968, Texas contributed about 10% of the total Gulf landings. From 1968 through 1977, Texas landings contributed 15 to 18% of the total Gulf landings, increasing to 22% in 1980. Alabama and Mississippi each have contributed about 5% of the total Gulf landings consistently throughout the two decades.

The percent contribution of the total Gulf landings to the total U.S. landings for 1960–1980 are shown in Table 12. From 1962 through 1967, the Gulf states generally contributed less than 20% of the total U.S. landings. However, this contribution increased gradually to almost 35% in 1977. From 1978 through 1980, the Gulf contribution declined to about 25%.

3.3.4 Trends in Landings by Gear

Dominant commercial gear types used to harvest hard blue crabs in the Gulf are trawls, trotlines and crab pots. Annual reported blue crab landings by gear and state are shown in Table 13.

Reported landings of blue crabs taken in trawls have fluctuated widely. Although directed trawl fisheries for blue crabs exist, much of the fishing is seasonal and is, in many instances, related to economic conditions in other fisheries. Louisiana and Texas produced most of the trawl-caught crabs from 1948 through 1960, with Louisiana leading in later years. In Texas, landings of trawl-caught crabs have always been incidental to the shrimp fishery. Florida's trawl crab catch increased substantially in 1963 when a directed otter trawl fishery for crabs began. Gulf-wide landings from trawls were low and steady between 1948 and 1956, increasing to record levels in 1965. All states, except Alabama, experienced an increase from 1964–1965. Louisiana's landings alone increased by almost

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CONTENTS

1. INTRODUCTION

The blue crab (*Callinectes sapidus* Rathbun) fisheries have become increasingly more important in the Gulf states. Reported landings for the Gulf in 1980 were in excess of 40 million pounds* with an ex-vessel value approaching $10 million*. In addition to the commercial hard-crab fishery, there exists a substantial recreational fishery and an expanding fishery for soft crabs.

Variations in the abundance of crabs due to environmental factors and disease, use of more efficient gear, increased fishing effort, and the economic condition of the market are reflected in historical blue crab catches. The fishery in Mississippi and Alabama has been relatively stable with each state reporting from 1.5 million to 2 million pounds annually. Louisiana continues to be the largest producer in the Gulf, supplying raw product to Texas, Mississippi, and Alabama plants. Landings for Louisiana have fluctuated widely although reported landings from 1975 to 1980 have not approached the 1973 landings of 23 million pounds. Florida Gulf coast landings have remained relatively stable at 13 million pounds after declining from 21 million pounds in 1965 to 9 million pounds in 1968. Landings in Texas continue to increase; approaching 9 million pounds in 1980.

Reported landings for hard and soft crabs are at best poor estimates of the annual catch. Many of the crabs going to out-of-state buyers, the general public and to the restaurant or retail trade go unreported; also data on the recreational fisheries are lacking. In his review of the blue crab fishery of the Gulf of Mexico, Moss (1982) noted that the statistical reporting system is so ***uniformly*** bad that only trends and cycles can be identified. "There is no doubt that 1973 and 1977 were excellent crab years . . . and that the summer months and early fall are the most productive [seasons]. There is [also] no doubt that Louisiana produces the most crabs . . . but does it harvest 16 million pounds live weight or 60?" Roberts and Thompson (1982) estimated the 1980 crab catch from Lakes Pontchartrain and Borgne to be 9.8 million pounds as compared to a reported catch of 1.5 million pounds. Even if landings data were accurate their use as an index of adult stock abundance can be misleading. Moss (1981) noted that blue crab landings do not necessarily reflect populations, but may merely reflect economic fluctuations. Lyles (1976) and Meeter et al. (1979) also suggested that socio-economic variables may influence blue crab landings. The need for accurate landings data and catch/effort data is evident in all sectors of the fishery.

While much is known concerning the life history of the blue crab in the Gulf of Mexico, many questions remain unanswered. The relationships between density-dependent and density-independent factors and species specific estuarine populations levels are still unresolved. Estuarine species respond to a multiplicity of physical, chemical, biological, and anthropogenic variables and the influence of these variables on estuarine populations is poorly understood. Physical factors affecting larval recruitment, the distribution of early crab stages in the estuary, as well as the chemical and biological parameters which affect the survival of both larvae and juveniles need investigation. Nothing is known of the distribution of blue crab zoeae in offshore waters and the mechanisms of larval transport. Estimates are lacking on natural and fishing mortality. The influence of parasitic infections (particularly *Loxothylacus texanus*) on subsequent levels of harvestable blue crabs is unknown.

It is the purpose of this profile to present a synopsis of existing information on the biology of and the fishery for blue crabs in the Gulf of Mexico.

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*Unless otherwise noted, all statistical data presented in either the text or tables are from *Fishery Statistics of the United States* and *Current Fishery Statistics*, both published by the National Marine Fisheries Service.

2. DESCRIPTION OF THE RESOURCE

2.1 Zoogeographic Distribution

The genus *Callinectes* belongs to the family Portunidae which contains approximately 300 extant species. *Callinectes* is a warm-water genus whose poleward distribution appears to be limited by summer temperatures. According to Norse (1977) no species occur regularly in waters where peak temperatures fail to approach 20°C. The separation of the east and west Atlantic populations of *C. marginatus* into two species brings the number of valid species in the genus to 15 (Manning and Holthuis 1981); three are found in Pacific waters with the remaining twelve species distributed throughout the Atlantic and adjacent seas (Table 1).

According to Williams (1974), eight species are found in the Gulf of Mexico; *C. bocourti* A. Milne Edwards, *C. danae* Smith, *C. ornatus* Ordway, *C. exasperatus* (Gerstaecker), *C. marginatus* (A. Milne Edwards), *C. sapidus* Rathbun, *C. similis* Williams, and *C. rathbunae* Contreras.

Callinectes marginatus, C. exasperatus and *C. danae* are known from the southernmost portion of the Gulf, bordering the Caribbean (Figures 1, 2 and 3, respectively). *Callinectes ornatus* occurs off central Florida through the southern Gulf to Yucatan (Figure 4). Extraterritorial occurrences include *C. bocourti* recorded from Biloxi Bay, Mississippi (Perry 1973) (Figure 2) and *C. marginatus* from Louisiana waters (Rathbun 1930) (Figure 1). The blue crab *C. sapidus* and lesser blue crab *C. similis* show Gulfwide distribution (Figures 2 and 3, respectively).

Though all species of *Callinectes* are edible (Williams 1974, Norse and Fox-Norse 1982), *C. sapidus* is the most economically important species. Greatest reported commercial landings of blue crabs generally occur north of 28° N latitude. Within this area, *C. sapidus* is common in tidal marsh estuaries characterized by soft mud substrata and waters of moderate salinity.

Vegetative, sedimentary and physical descriptors for major Gulf estuarine systems are presented in Tables 2 through 6. The percent contribution to individual state commercial landings by estuarine system is also shown. Major estuarine systems for each state are shown in Figures 5 through 9.

TABLE 1. Distribution of *Callinectes* species (from Williams 1974).

Species	Distribution	Species	Distribution
	ATLANTIC	*C. maracaiboensis*	Confined to the Lago de Maracaibo estuarine system, roughly 120 km wide by 215 km long, extending from Bahia del Tablazo emptying into Golfo de Venezuela in north, through Estrecho de Maracaibo southward into Lake proper.
*C. marginatus**	Off southern Florida through Caribbean Sea to south central Brazil off Estado de Sao Paulo; Bermuda and Cape Verde Islands; Senegal to central Angola. A recent record from North Carolina is regarded as a temporary range extension.		
C. similis	Off Delaware Bay to Key West, Florida; northwestern Florida around Gulf of Mexico to off Campeche, Yucatán.	*C. amnicola* (= *latimanus*)	Baie de Saint-Jean (19°27′N, 16°22′W), Mauritania, to Cabinda, Angola.
C. pallidus (= *gladiator*)	West Africa from Baie de Saint-Jean, 19°27′N, 16°22′W, Mauritania, to Baia do Lobito, Angola.	*C. sapidus*	Occasionally Nova Scotia, Maine, and northern Massachusetts to northern Argentina, including Bermuda and the Antilles; Oresund, Denmark; the Netherlands and adjacent North Sea; southwest France (found twice); Golfo di Genova; northern Adriatic; Aegean, western Black, and eastern Mediterranean seas.
C. ornatus	Bermuda; North and South Carolina through southern Florida;northwestern Yucatán to Estado de Saio Paulo, Brazil.		
C. danae	Bermuda; southern Florida and eastern side of Yucatán Peninsula to Estado de Santa Catarina, Brazil.		**PACIFIC**
C. exasperatus	Bermuda; Veracruz, Mexico; southern Florida to Estado de Santa Catarina, Brazil.	*C. toxotes*	Cabo de San Lucas, Baja California, to extreme northern Peru; extraterritorial, Juan Fernandez.
C. bocourti	Jamaica and British Honduras to Estado de Santa Catarina, Brazil; extraterritorial occurrences in southern Florida and Mississippi, USA (both mature males).	*C. bellicosus*	San Diego, California, to Bahiá Almejas (southeastern extension of Bahiá Magdalena) Baja California; La Paz Harbor around Golfo de California to Topolabampo, Sinaloa, Mexico.
C. rathbunae	Mouth of Rio Grande, Texas–Mexico border to southern Veracruz, Mexico.	*C. arcuatus*	Los Angeles Harbor, California, to Mollenda, Peru; Galápagos Islands.

*Manning and Holthuis (1981) suggest that the west Atlantic and east Atlantic populations of *C. marginatus* should be considered separate species, with *C. marginatus* (A. Milne Edwards, 1861) retained for the east Atlantic species and the name *C. larvatus* Ordway, 1863 assigned to the west Atlantic species.

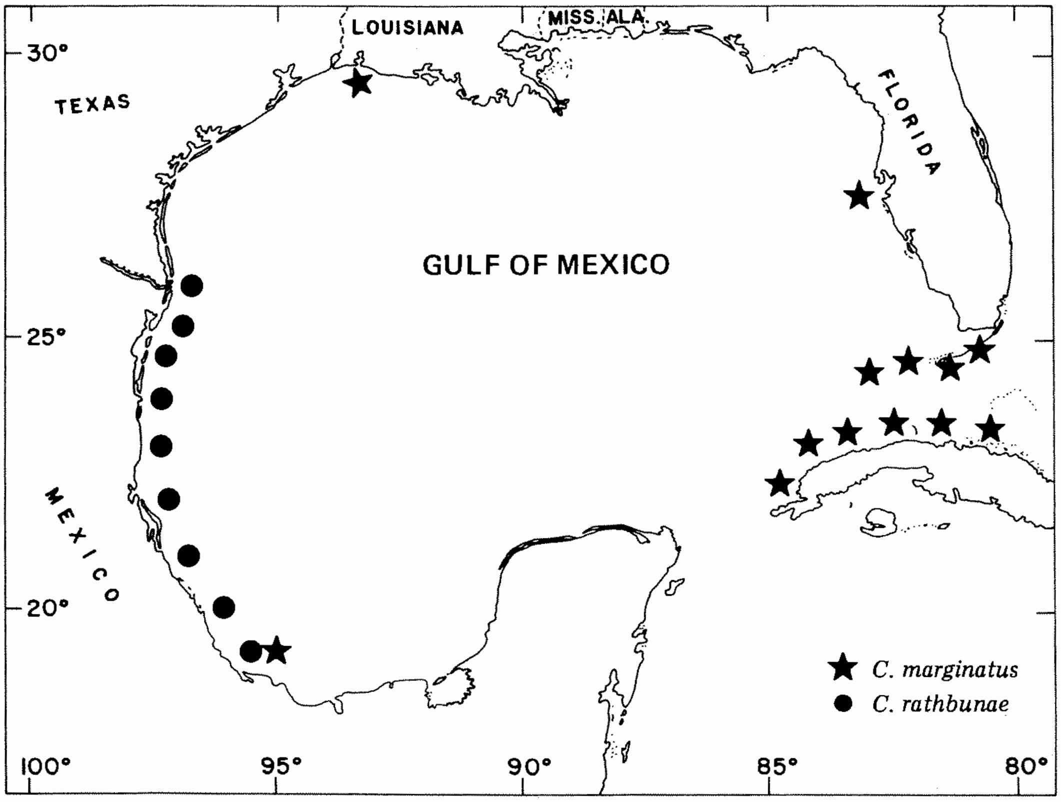


Figure 1. Distributions of *C. marginatus* and *C. rathbunae* in the Gulf of Mexico (modified from Williams 1974).

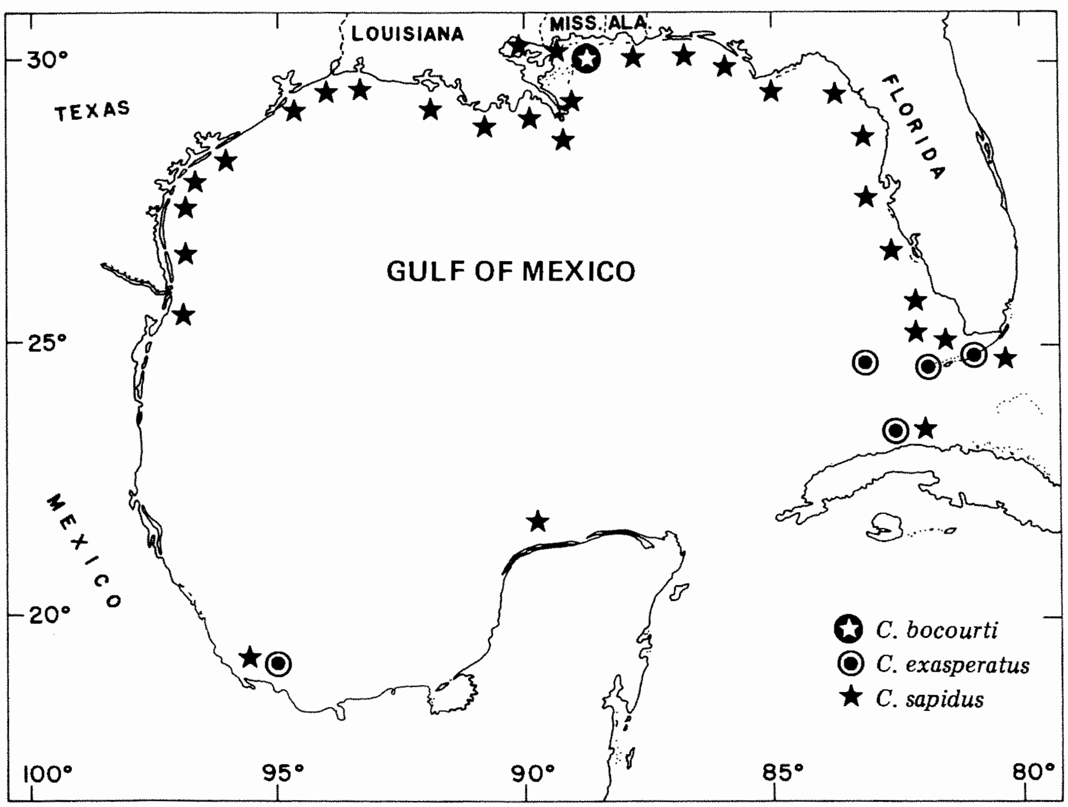


Figure 2. Distributions of *C. bocourti, C. exasperatus* and *C. sapidus* in the Gulf of Mexico (modified from Williams 1974).

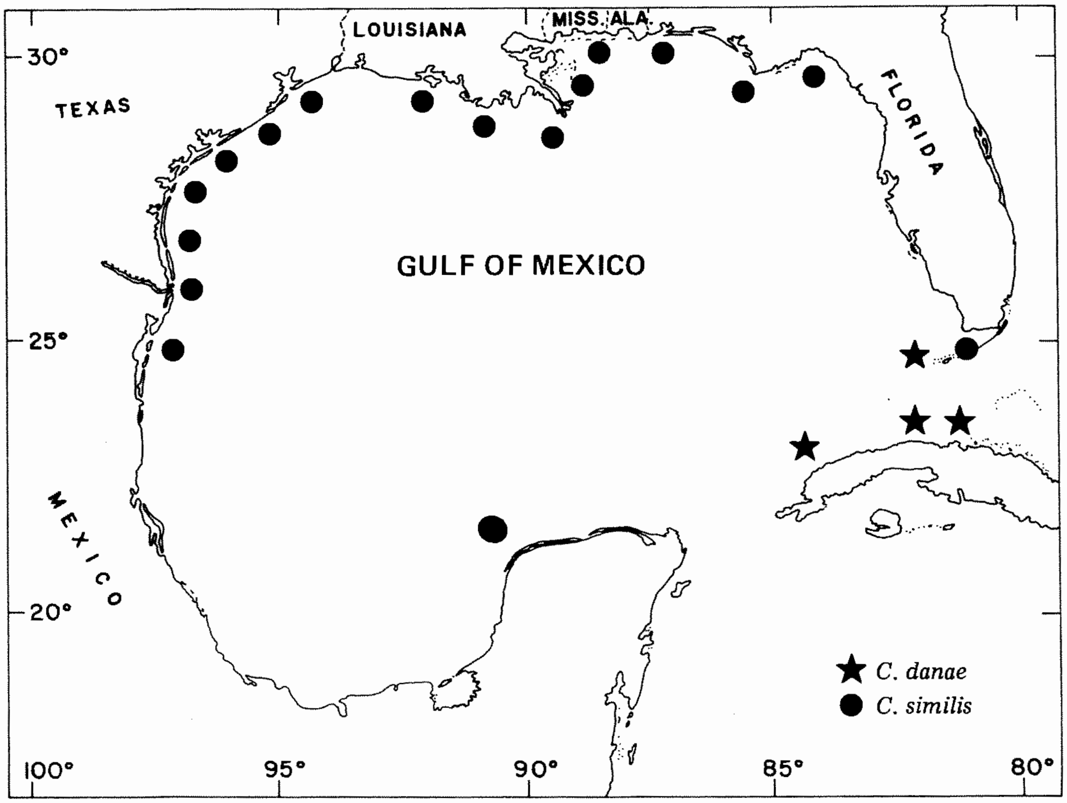


Figure 3. Distributions of *C. danae* and *C. similis* in the Gulf of Mexico (modified from Williams 1974).

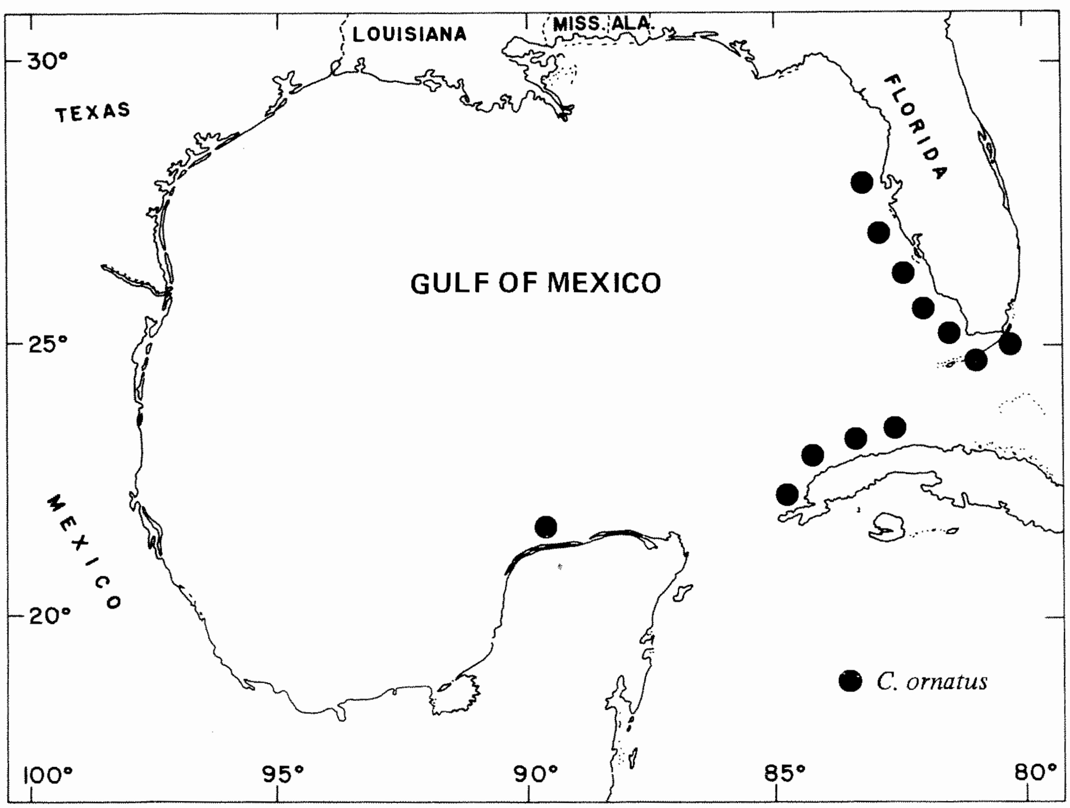


Figure 4. Distribution of *C. ornatus* in the Gulf of Mexico (modified from Williams 1974).

TABLE 2. **Vegetative, physical and sedimentary characteristics of Alabama estuarine systems and percent contribution to reported commercial landings.**

Hydrologic Unit	Tidal Marsh (hectares)	Submerged Vegetation (hectares)	Sediment Type[3]	Surface Area[3] (hectares)	Drainage Area[3] (km^2)	River Discharge[3] (ℓ/sec)	Percent Contribution[4] to State Landings
Mobile Bay	1,333[1]	2,024[3]	Sand, Clay, Mud	107,030	113,995	1,947,329	20.0
Mississippi Sound	5,369[2]	NA*	Sand, Clay, Mud	37,516	259	NA	57.0
Perdido Bay	434[3]	NA	Sand, Clay, Mud	6,989	2,637	26,539	0.2

*Data not available = NA.

[1]Source: Stout, J. P. 1979. Marshes of the Mobile Bay estuary: Status and evaluation, pp. 113–121. *In:* H. Loyacano and J. Smith (eds.), *Symposium on the Natural Resources of the Mobile Estuary, Alabama.* MASGP–80–022.

[2]Source: Stout, J. P. & A. A. de la Cruz. 1981. Marshes of Mississippi Sound: State of Knowledge, pp. 8–20. *In:* J. K. Kelly (ed.), *Symposium on Mississippi Sound.* MASGP–81–007.

[3]Source: Crance, J. H. 1971. Description of Alabama estuarine areas–Cooperative Gulf of Mexico Estuarine Inventory. *Alabama Mar. Res. Bull.* 6:1–85.

[4]Source: Swingle, W. E. 1976. Analysis of commercial fisheries catch data for Alabama. *Alabama Mar. Res. Bull.* 11:26–50.

TABLE 3. **Vegetative, physical and sedimentary characteristics of Florida estuarine systems and percent contribution to reported commercial landings.**

Hydrologic Unit	Tidal Marsh/ Mangrove Swamp[1] (hectares)	Submerged Vegetation[1] (hectares)	Sediment Type[1]	Surface Area[1] (hectares)	Drainage Area[1] (km^2)	River Discharge[1] (ℓ/sec)	Percent Contribution[2,3] to West Coast Landings
Escambia Bay	3,510	769	Sand, Sand/shell	51,005	14,315	268,402	< 1.0
Choctawhatchee Bay	1,139	1,251	Sand, Sand/shell, Mud	34,924	11,525	204,810	< 1.0
St. Andrew Bay	4,476	2,684	Sand, Silt, Clay	27,972	NA*	NA	4.4
St. Joseph Bay	345	2,560		17,755			< 1.0
Apalachicola Bay	8,621	3,795	Sand covered with silt and clay	68,788	47,818	768,123	7.6
Apalachee Bay	22,529	9,518	Sand	24,817	7,552	90,822	20.8
Suwanee Sound and Waccasassa Bay	25,560/354	13,030	Sand	35,618	26,304	322,760	22.1
Tampa Bay	699/7,088	8,450	Sand, Sand/clay, Clay/silt	110,338	3,398	43,530	1.9
Sarasota Bay	95/1,463	3,079	Sand, Sand/shell	14,061	160	2,285	0.0
Charlotte Harbor	3,678/9,500	9,463	Sand/shell, Mud/shell	49,290	5,174	55,739	6.4
Caloosahatchee River	687/1,203	293	Sand/shell	15,180	699	29,934	< 1.0
Florida Bay	4,916/14,932	103,849	Coral, Sand/shell, Sand/mud	225,631	NA	NA	< 1.0

*Data not available = NA.

[1]Source: McNulty, J. K., W. N. Lindall, Jr. and J. E. Sykes. 1972. *Cooperative Gulf of Mexico Estuarine Inventory and Study, Florida: Phase 1, Area Description.* NOAA Tech. Rept. NMFS Circ. 368:1 -126.

[2]Source: Steele, P. 1982. A synopsis of the biology of the blue crab *Callinectes sapidus* Rathbun in Florida. *Proc. Blue Crab Colloquium,* Oct. 18–19, 1979, Biloxi, Mississippi. Gulf States Marine Fisheries Commission 7:29–35.

[3]Dixie-Taylor Counties–23.7%, Pasco-Citrus Counties–11.5%.

TABLE 4. Vegetative, physical and sedimentary characteristics of Louisiana estuarine systems and percent contribution to reported commercial landings. (The size and complexity of Louisiana estuaries did not permit the use of a single classification scheme.)

Hydrologic Unit	Tidal Marsh[1] (hectares)	Hydrologic Unit	Submerged Vegetation[2] (hectares)	Sediment Type[3]
Lakes Maurepas, Pontchartrain and Borgne; Chandeleur and Breton Sounds	189,804	Lakes Maurepas and Pontchartrain	8,094 (north shore of Lake Pontchartrain only)	Clayey Silt Silty Clay Sand
Active Mississippi River Delta	27,115	Lake Borgne, Brenton Sound	NA*	Silty Clay Clayey Silt
Barataria Basin	164,308	Barataria Bay	NA	Clayey Silt Sand
Timbalier-Terrebonne Bays, Caillou Bay	219,347	Timbalier-Terrebonne Bays	NA	Sandy Silt Clayey Silt Sand
Atchafalaya Bay	23,877	Lake Mechant, Caillou Lake	NA	Clayey Silt Sand, Clay
Cote Blanche-Vermilion Bays	100,770	Vermilion-Atchafalaya Bays	NA	Clayey Silt Silty Clay
Mermentau River,[2] White and Grand Lakes	121,410[2]	Calcasieu, White and Sabine Lakes	NA	Clayey Silt Silty Clay
Calcasieu and Sabine Lakes[2]	106,436[2]			

Hydrologic Unit	Surface Area[2] (hectares)	Hydrologic Unit	Drainage Area[4] (km^2)	Hydrologic Unit	Percent Contribution[5] to State Landings Hard/Soft
Lake Maurepas	23,549	Pearl River	22,454	Lakes Maurepas and Pontchartrain	14.0/46.0
Lake Pontchartrain	159,503	Lakes Maurepas, Pontchartrain and Borgne; Chandeleur and Breton Sounds	14,394	Lake Borgne, Chandeleur and Breton Sounds	10.0/00.0
Lake Borgne	69,357				
Chandeleur Sound	233,918	Mississippi River	336,492	Barataria Bay	22.0/53.0
Breton Sound	79,050	West Mississippi River Delta, including drainage into Barataria Bay, Timbalier-Terrebonne Bays, Caillou Bay, Atchafalaya Bay, Cote Blanche-Vermilion Bays	248,417	Timbalier-Terrebonne Bays	8.0/00.0
Mississippi River and Active Delta	46,268			Lake Mechant, Caillou Lake	14.0/00.0
Barataria and Caminada Bays, Little Lake	28,571	Mermentau River	9,896	Vermilion-Atchafalaya Bays	14.0/00.0
Lakes Barre, Raccourci, Timbalier-Terrebonne Bays	69,052	Calcasieu River	9,780	Calcasieu, White and Sabine Lakes	14.0/00.0
Caillou Bay and Lake, Four League Bay, Lakes Mechant and Pelto	35,722	Sabine River	54,244		
Atchafalaya Bay	54,505				
Cote Blanche-Vermilion Bays	118,909				
White and Grand Lakes	33,745				
Calcasieu Lake	17,318				
Sabine Lake	22,606				

*Data not available = NA.

[1] Source: Wicker, K. M. 1980. Mississippi deltaic plain region ecological characterization: a habitat mapping study. A user's guide to the habitat maps. *U.S. Fish Wildl. Serv.*, Office of Biol. Ser. FWS/OBS-79/07.

[2] Source: Perret, W. S., et al. 1971. *Cooperative Gulf of Mexico estuarine inventory and study, Louisiana, Phase I, Area description:* pp. 1–38. Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana.

[3] Source: Barrett, B. B., et al. 1971. *Cooperative Gulf of Mexico estuarine inventory and study, Louisiana, Phase III, sedimentology*, pp. 131–191. Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana.

[4] Source: Sloss, R. 1971. Drainage area of Louisiana streams. U.S. Dept. Interior Geological Survey, Water Resources Division, Basic Records Report 6.

[5] Based on NMFS data for 1980.

TABLE 5. Vegetative, physical and sedimentary characteristics of Mississippi estuarine systems and percent contribution to reported commercial landings.

Hydrologic Unit	Tidal Marsh[1] (hectares)	Submerged Vegetation[2] (hectares)	Sediment Type[3]	Surface Area[4] (hectares)	Drainage Area[4] (km^2)	River Discharge[4] (ℓ/sec)	Percent Contribution[5] to State Landings
Pascagoula River	11,281		Sandy and Muddy Sandy Deposits	53,110	24,346	430,464	NA*
Biloxi Bay	4,683		Sandy and Muddy Sandy Deposits	60,896	1,735	38,232	NA
St. Louis Bay			Sandy and Muddy Sandy Deposits	66,568	291	41,347	NA
	9,927						
Pearl River			Sandy and Muddy Sandy Deposits	22,335	3,521	365,328	NA
Mississippi Sound South of Intracoastal Waterway	860 Barrier Islands	1,970	Sand Mud				NA

* Data Not Available = NA

[1]Source: Eleuterius, L. N. 1973. The marshes of Mississippi. *In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi, pp. 147–190.

[2]Source: Eleuterius, L. N. and G. J. Miller. 1976. Observations on seagrasses and seaweeds in Mississippi Sound since Hurricane Camille. *J. Miss. Acad. Sci.* 21:58–63.

[3]Source: Otvos, E. G. 1973. Sedimentology. *In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi, pp. 123–137.

[4]Source: Christmas, J. Y., Jr. 1973. Area description. *In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi, pp. 1–71.

[5]Source: Majority of catch taken from Mississippi Sound (personal communication, Hermes Hague, NMFS).

TABLE 6. Vegetative, physical and sedimentary characteristics of Texas estuarine systems and percent contribution to reported commercial landings.

Hydrologic Unit	Tidal Marsh (hectares)	Submerged Vegetation (hectares)	Sediment Type	Surface Area (hectares)	Drainage Area (km²)	River Discharge (ℓ/sec)	Percent Contribution[23, 24] to State Landings
Sabine Lake	NA*	NA	Mud, Silt, Shell[2]	22,605[2]	53,421[14]	434,424[1]	11.8
Galveston Bay	93,624[1]	7,323[1]	Mud, Shell, Clay[3], Sand	143,170[7]	51,958[15]	317,098[20]	29.4
East Matagorda Bay	NA	NA	Mud, Sand[1]	15,300[1]	NA	NA	11.4
West Matagorda Bay	48,552[1]	2,848[1]	Mud, Shell, Clay,[1] Sand	98,920[1]	10,713[16]	85,616[1]	
San Antonio Bay	10,115[1]	6,615[1]	Silty Clay, Mud,[4] Sand, Shell	47,800[8]	26,563[17]	53,907[21]	21.6
Aransas Bay	18,207[1]	1,669[1]	Mud, Sand[1]	55,652[1,9]	6,800[18]	3,022[1]	20.9
Corpus Christi Bay	NA	NA	Mud, Sand[1]	50,505[8,10,11]	44,963[18]	25,368[11]	1.4
Upper Laguna Madre	NA	NA	Sand, Silt, Shell[5]	41,014[1,12]	7,752[19]	NA	0.5
Lower Laguna Madre	NA	NA	Sand, Silt, Clay[6]	73,983[13]	3,193[19]	3,100[22]	2.4

* Data Not Available = NA.

[1]Source: Diener, R. A. 1975. *Cooperative Gulf of Mexico estuary inventory and study-Texas: area description.* NOAA Tech. Rept., Nat. Mar. Fish. Serv., Circ. 393. 129 pp.

[2]Source: Wiersema, J. M., and R. P. Mitchell. 1973. Sabine power station ecological program. Vol. 2. TRACOR, 6500 TRACOR Lane, Austin, Texas. 54 pp.

[3]Source: Benefield, R. L. and R. E. Hofstetter. 1976. Mapping of productive oyster reefs–Galveston Bay, Texas. Texas Parks and Wildlife Dept., Austin. (unpublished manuscript)

[4]Source: Texas Parks and Wildlife Department. 1975. Fishery resources of the San Antonio Bay system and factors relating to their viability–preliminary draft. Texas Parks and Wildlife Dept., *Coastal Fish.* 116 pp.

[5]Source: Simmons, E. G. 1957. Ecological study of the Upper Laguna Madre of Texas. *Publ. Inst. Mar. Sci., Univ. Tex.* 4(2):156–200.

[6]Source: Shepard, P., and A. Rusnak. 1957. Texas bay sediments. *Publ. Inst. Mar. Sci. Univ. Tex.* 4(2):5–13.

[7]Source: Fisher, W. L., H. H. McGowen, L. F. Brown, Jr. and C. G. Croat. 1972. Environmental geologic atlas of the Texas coastal zone–Galveston-Houston area. Bureau of Economic Geology. Univ. Tex., Austin, Tex. 91 pp.

[8]Source: Collier, A., and J. W. Hedgpeth. 1950. An introduction to the hydrography of tidal waters of Texas. *Publ. Inst. Mar. Sci. Univ. Tex.* 1(2):120–194.

[9]Source: Heffernan, T. L. 1972a. An ecological evaluation of some tributaries of the Aransas Bay area. Texas Parks and Wildlife Dept., *Coastal Fish. Proj.* No. CE-1–1. 104 pp.

[10]Source: Hood, Donald W. 1953. A hydrographic and chemical survey of Corpus Christi bay and connecting water bodies. Texas A&M Research Foundation Project No. 40, Annual Report, Dept. of Ocean, Texas A&M University.

[11]Source: Stevens, H. R., Jr. 1959. A survey of hydrographic and climatological data of Corpus Christi Bay. *Tex. Game and Fish. Comm. Proj. Repts.* 1958–1959 (mimeo).

[12]Source: Breuer, J. P. 1957. An ecological survey of Baffin and Alazan Bays, Texas. *Publ. Inst. Mar. Sci., Univ. Tex.* 4(2):134–155.

[13]Source: Stokes, Gary M. 1974. The distribution and abundance of penaeid shrimp in the Lower Laguna Madre of Texas with a description of the live bait shrimp fishery. *Texas Parks and Wildlife Dept., Tech. Ser.* No. 15. 32 pp.

[14]Source: Texas Department of Water Resources. 1981. Sabine-Neches estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-116. 321 pp.

[15]Source: Texas Department of Water Resources. 1981. Trinity-San Jacinto estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-113. 411 pp.

[16]Source: Texas Department of Water Resources. 1980. Lavaca-TresPalacios estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-106. 325 pp.

[17]Source: Texas Department of Water Resources. 1980. Guadalupe estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-107. 344 pp.

[18]Source: Texas Department of Water Resources. 1981. Nueces and Mission-Aransas estuaries: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-108. 381 pp.

[19]Source: Texas Department of Water Resources. In Print. Laguna Madre estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. Draft Report.

[20]Source: Environmental Protection Agency. 1971. Pollution affecting shellfish harvesting in Galveston Bay, Texas. Div. Invest., EPA, Water Quality Office, Denver, Colorado. 98 pp.

[21]Source: Childress, R. E. Bradley, E. Hegen, and S. Williamson. 1975. The effects of freshwater inflows on hydrological and biological parameters in the San Antonio Bay system, Texas. Texas Parks and Wildlife Department, Coastal Fisheries Branch. 190 pp.

[22]Source: Bryan, C. E. 1971. An ecological survey of the Arroyo Colorado, Texas 1966–1969. *Texas Parks and Wildlife Dept., Tech. Ser.* No. 10, 28 pp.

[23]Average % of contribution for the period 1970–1979.

[24]Gulf of Mexico 0.6%.

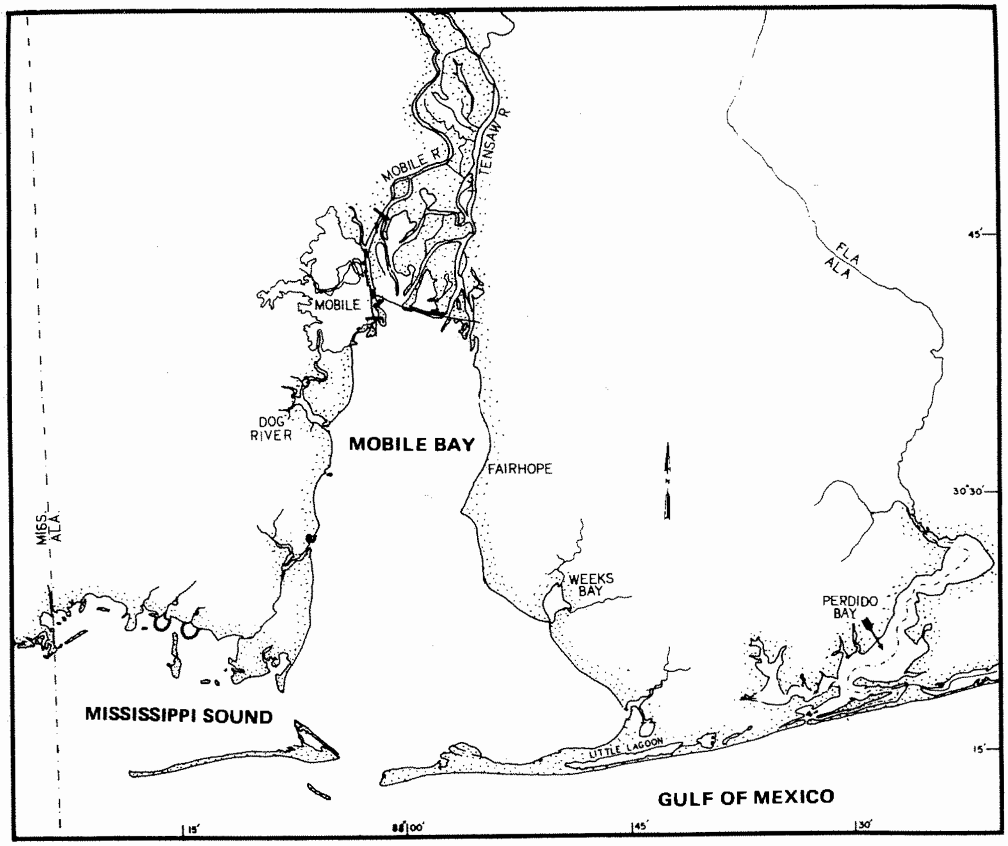


Figure 5. Major estuarine systems, Alabama.

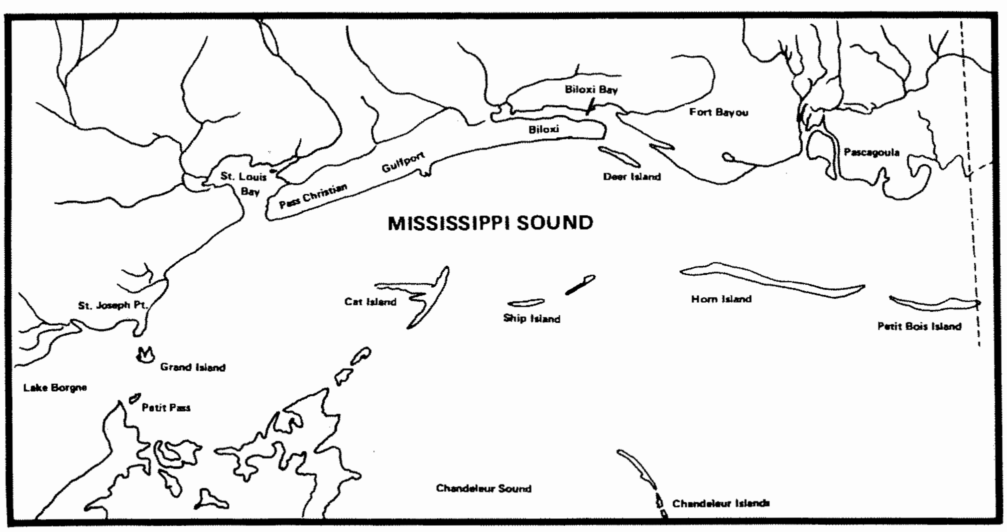


Figure 6. Major estuarine systems, Mississippi.

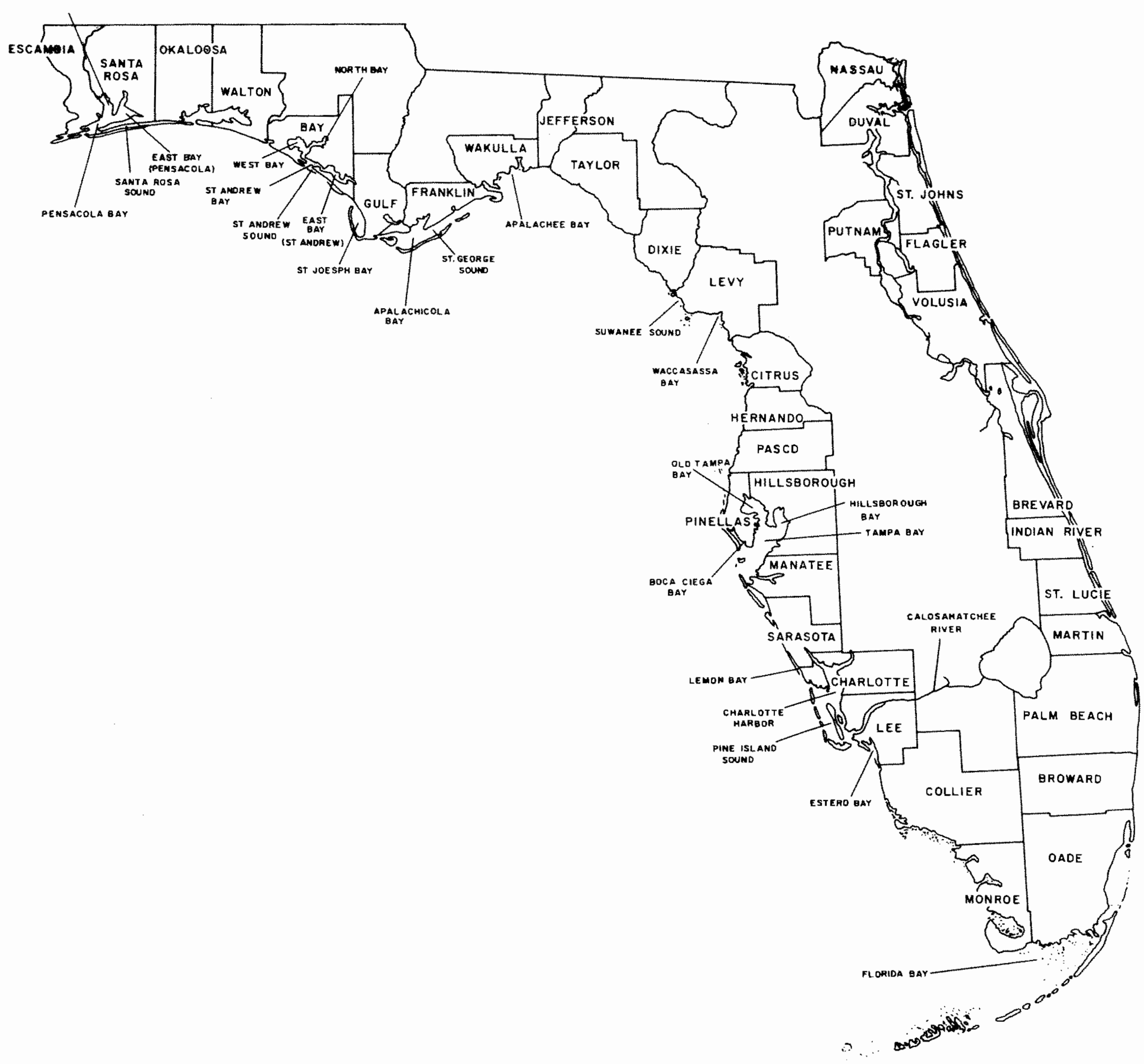


Figure 7. Major estuarine systems, Florida.

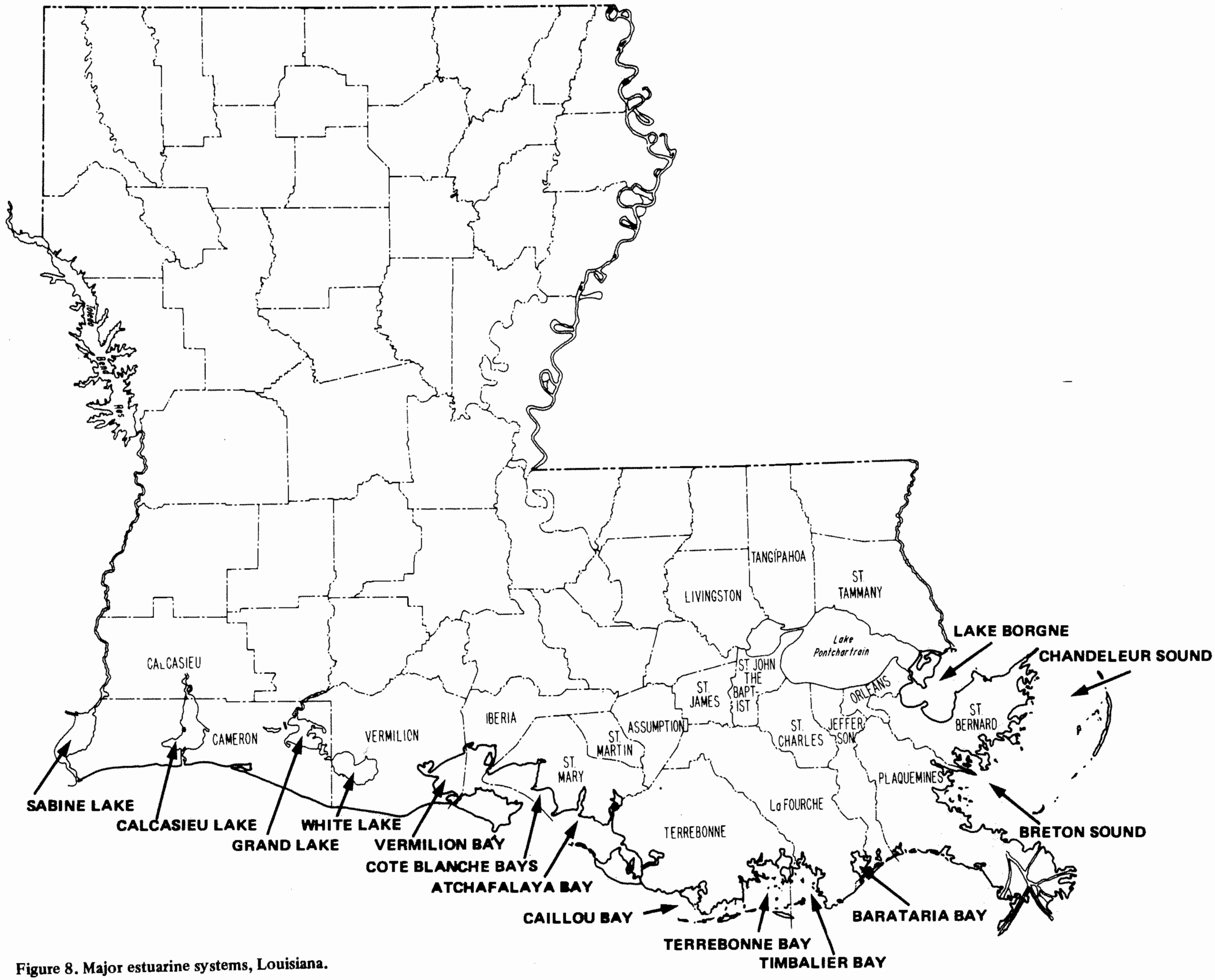


Figure 8. Major estuarine systems, Louisiana.

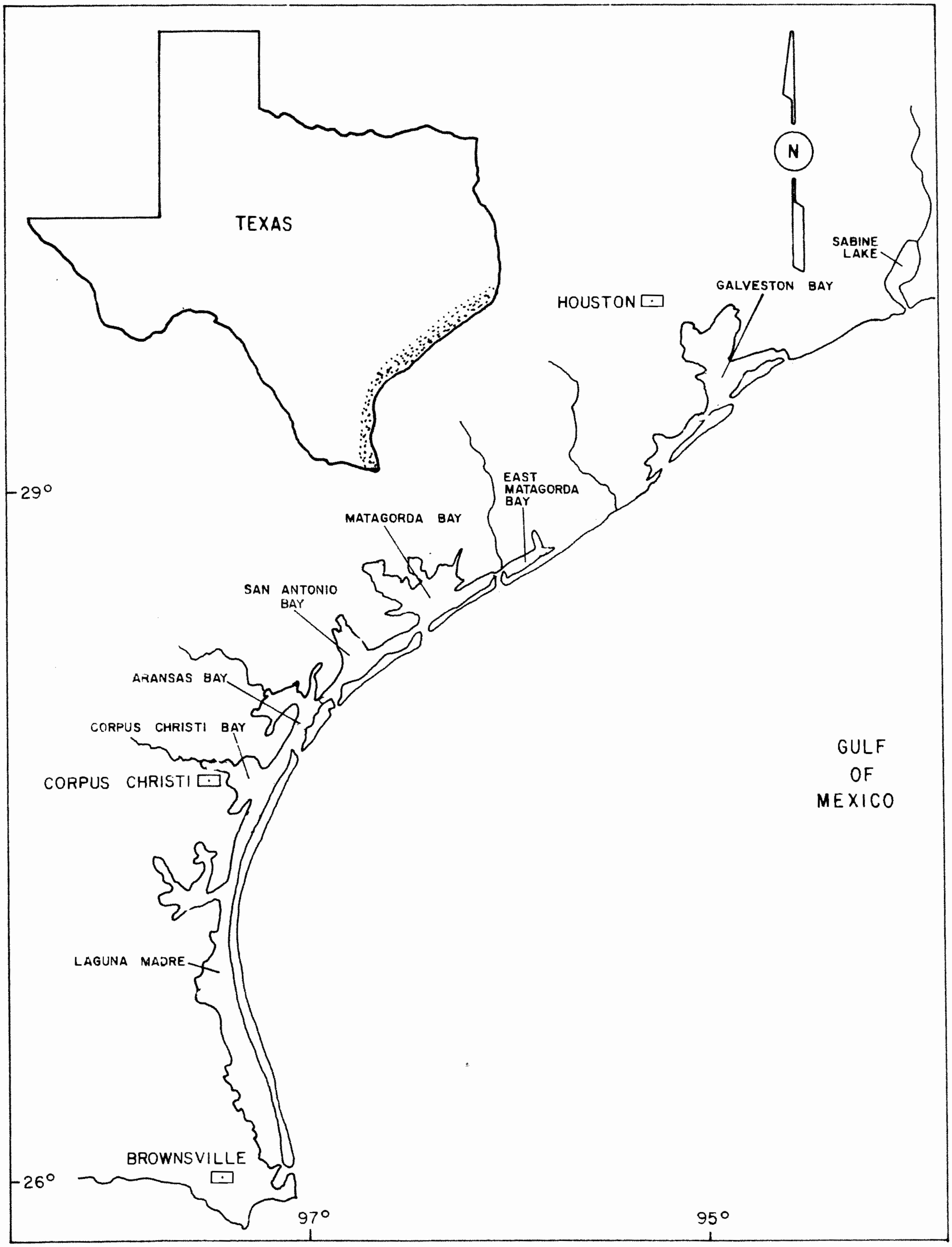


Figure 9. Major estuarine systems, Texas.

2.2 Life History

2.2.1 Spawning

Spawning of blue crabs in northern Gulf waters is protracted, with egg-bearing females occurring in coastal Gulf and estuarine waters in the spring, summer and fall (Gunter 1950, Daugherty 1952, More 1969, Adkins 1972a, Perry 1975). Additionally, Adkins (1972a) found evidence of winter spawning in offshore Louisiana waters based on commercial catches of "berry" crabs in December, January and February, and Daugherty (1952) noted that crabs in southern Texas may spawn year-round in mild winters.

For most marine animals mating and spawning are synonymous; however, in the case of the blue crab the two events occur at different times. Prior to her pubertal molt (in the female blue crab the cycle of growth and molting terminates with a final anecdysis), the female travels to brackish waters of the upper estuary to mate. The female mates in the soft shell state following her pubertal molt. Following insemination, the male continues to carry the female until her shell has hardened. Spawning usually occurs within two months of mating in the spring and summer. Females that mate in the fall usually delay spawning until the following spring. Sperm transferred to the female remain viable for a year or more and are used for repeated spawnings.

The fertilized eggs are extruded and attached to fine setae on the endopodites of the pleopods, forming an egg mass known as a "sponge," "berry," or "pom-pom." As many as two million eggs may be present in a single sponge. The sponge is initially bright orange, becoming progressively darker as the larvae develop and absorb the yolk. Prior to hatching, the sponge is black. The eggs hatch in about two weeks.

There has been some discussion in the literature concerning the existence of a prezoeal stage in *C. sapidus*. Robertson (1938), Churchill (1942), Truitt (1942) and Davis (1965) reported prezoeae emerging from the eggs. Time estimates for length of stay in the prezoeal stage ranged from one to three minutes (Davis 1965) to several hours (Robertson 1938). Sandoz and Hopkins (1944) and Sandoz and Rogers (1944) noted that larvae emerged as prezoeae only in response to adverse biological or environmental conditions. Costlow and Bookhout (1959) made specific reference to the lack of the prezoeal stage for *C. sapidus*, noting that the larvae emerged as zoeae. Additionally, Bookhout and Costlow (1974, 1977) do not mention a prezoeal stage for *Portunus spinicarpus* or *C. similis*.

Costlow and Bookhout (1959) reported seven zoeal stages and one megalopal stage for the blue crab. An eighth zoeal stage was sometimes observed though survival to the megalopal stage was rare. Development through the seven zoeal stages required from 31 to 49 days with the megalopal stage persisting from 6 to 20 days. In salinities below 20.1 ppt the larvae rarely survived the first molt.

2.2.2 Larval Distribution and Abundance

The larval life history of *Callinectes sapidus* in the Gulf of Mexico is poorly understood. Although Daugherty (1952), Menzel (1964) and Adkins (1972a) specifically discussed the distribution of blue crab larvae, the possibility of co-occurrence of the larvae of *C. similis* must be considered. The temporal and spatial overlap in spawning habits of the two species (Perry 1975), coupled with the difficulty in using the early morphological descriptions of *C. sapidus* from Atlantic specimens (Costlow and Bookhout 1959) to reliably identify Gulf blue crab larvae, suggest that published accounts of the seasonality of *C. sapidus* larvae are questionable. Recognizing the difficulty in separating the two species, King (1971), Perry (1975) and Andryszak (1979) did not differentiate between the larvae of *C. sapidus* and *C. similis*.

Perry and Stuck (1982a) noted that early stage *Callinectes* zoeae (I and II) were present in Mississippi coastal waters in the spring, summer and fall. Adkins (1972a) reported *C. sapidus* larvae present year-round in Louisiana, but did not separate the zoeal and megalopal stages. The sampling programs of Menzel (1964) and Andryszak (1979) were of limited duration with no seasonal distribution data available. Both Perry and Stuck (1982a) and Andryszak (1979) found only the early stage zoeae abundant nearshore.

Callinectes megalopae have been reported to occur throughout the year. Perry (1975) found megalopae in Mississippi Sound in all months with peak abundance in the late summer-early fall and in February. In Texas coastal waters, *Callinectes* megalopae have been found in all seasons (Daugherty 1952, More 1969, King 1971). King (1971) noted three waves of megalopae in Cedar Bayou, the first from January through March, the second in May and June, and the third in October.

Attempts to separate the larvae of *C. sapidus* from *C. similis*, using the characters developed by Bookhout and Costlow (1977) have been largely unsuccessful due to apparent morphological differences in larvae from the Gulf and Atlantic. Stuck, Wang and Perry (1981) provided characters useful in distinguishing the megalopae and early crab stages of the two species. Subsequent analysis of archived plankton samples from Mississippi and Louisiana coastal waters has furnished information on the seasonality of *C. sapidus* and *C. similis* megalopae in the northern Gulf (Stuck and Perry 1981). These authors found *C. similis* megalopae present in offshore waters adjacent Mississippi Sound throughout the year, peaking in abundance in February and March. *Callinectes sapidus* megalopae were rarely found in samples before May. Large numbers of *C. similis* megalopae were identified in February and March samples from Whiskey Pass, Louisiana. Perry (1975), based on the identification of first crabs reared from megalopae, reported a February occurrence of *C. sapidus*. Reexamination of these specimens found them to be *C. similis*. These data suggest that the reported winter peaks of *Callinectes* larvae in the northern Gulf are, in all probability, referable to *C. similis.*

Reports on the vertical distribution of *Callinectes* megalopae appear conflicting. Williams (1971), King (1971), Perry (1975) and Smyth (1980) reported *Callinectes* megalopae to be in greatest abundance in surface waters. In contrast, 96% of the *Callinectes* megalopae collected by Tagatz (1968a) and all of the megalopae collected by Sandifer (1973) were from bottom waters. Stuck and Perry (1981) found that portunid megalopae (*C. sapidus, C. similis* and *Portunus* spp.) showed no affinity for surface or bottom waters (Table 7). They noted that the majority of large catches of *C. sapidus* megalopae were taken on rising or peak tides, whereas the megalopae of *C. similis* and *Portunus* spp. were commonly collected on both rising and falling tides.

TABLE 7. Catch of major portunid taxa by depth.[1]

Depth	Taxa	Total Catch[2]	Total Standard Catch[3]	% of Standard Catch
Surface	*C. sapidus*	11,534	13,632.6	65.2
	C. similis	3,290	3,780.3	18.1
	Portunus spp.	2,467	3,493.5	16.7
	Total	17,291	20,906.4	100.0
Bottom	*C. sapidus*	12,637	18,048.4	75.9
	C. similis	1,106	1,377.1	5.8
	Portunus spp.	2,372	4,359.5	18.3
	Total	16,115	23,785.0	100.0

[1]From Stuck and Perry (1981).

[2]The sum of megalopae caught (number per 20-minute tow) from each sample.

[3]The sum of the standardized numbers (number per 1,000 m^3) of megalopae from each sample.

Little is known concerning mechanisms of larval transport and dispersal of blue crab zoeae in the northern Gulf. Based on the data of Menzel (1964), Andryszak (1979) and Perry and Stuck (1982a), it appears that development through the late zoeal stages (III through VII) takes place in offshore waters. At this time, the larvae are subject to currents and may be transported considerable distances. Recruitment of larvae back into coastal waters occurs during the megalopal stage. Oesterling and Evink (1977) proposed a mechanism for larval dispersal in northeastern Gulf waters in which blue crab larvae were transported distances of 300 km or more. If such transport mechanisms do exist in the Gulf, larvae produced by spawning females in one state may, in fact, be responsible for recruitment in adjoining states.

2.2.3 Juvenile Distribution and Abundance

Recruitment of blue crabs to Gulf estuaries occurs during the megalopal stage (More 1969, King 1971, Perry 1975, Perry and Stuck 1982b). The relationship between numbers of megalopae recruited and subsequent abundance of young crabs is not well defined. Perry and Stuck (1982b) noted that large catches of *C. sapidus* megalopae in August and September were usually followed by an increased catch of small crabs (10.0 to 19.9 mm) in October or November in Mississippi estuaries; however, inconsistencies between recruitment of megalopae and subsequent occurrence and abundance of juveniles were noted in the spring and summer in their samples. King (1971) found comparable population densities of juveniles between two years though recruitment was markedly different. Interpretation of his data is somewhat complicated by the taxonomic problems associated with the separation of *C. sapidus* and *C. similis* megalopae.

Young blue crabs show wide seasonal and areal distribution in Gulf estuaries. Livingston et al. (1976) found maximum numbers of blue crabs in Apalachicola Bay in the winter and summer noting that an almost "continuous succession" of young crabs entered the sampling area during the year. Perry (1975) and Perry and Stuck (1982b) found first crab stages in all seasons indicating continual recruitment to the juvenile population in Mississippi. In Lake Pontchartrain, Louisiana, Darnell (1959) noted recruitment of young crabs was highest in the late spring-early summer and in the fall.

Although juvenile crabs occur over a broad range of salinity, they are most abundant in low to intermediate salinities characteristic of middle and upper estuarine waters. Swingle (1971), Perret et al. (1971), Christmas and Langley (1973) and Perry and Stuck (1982b) determined the distribution of blue crabs (primarily juveniles) by temperature and salinity using temperature-salinity matrices. Both Perret et al. (1971) and Swingle (1971) found maximum abundance in salinities below 5.0 ppt (Table 8). In contrast, Christmas and Langley (1973) and Perry and Stuck (1982b) found highest average catches associated with salinities about 14.9 ppt in Mississippi (Table 8). Based on one year of bag seine data, Hammerschmidt (1982) found no direct relationship between catches of juvenile crabs and salinity in Texas. Although salinity influences distribution, factors such as bottom type and food availability also play a role in determining distributional patterns of juvenile blue crabs.

The importance of bottom type in the distribution of juvenile blue crabs is well established. More (1969), Holland et al. (1971), Adkins (1972a), Perry (1975), Livingston et al. (1976) and Perry and Stuck (1982b) all noted the association of juvenile blue crabs with soft, mud sediments. Evink (1976) collected the greatest number of individuals and biomass from mud bottoms and noted that blue crab biomass appeared to follow faunal food availability.

2.2.4 Growth

Newcombe et al. (1949) estimated the postlarval instars for male and female blue crabs to be 20 and 18, respectively. Assuming that the number of molts is fixed in blue crabs (Newcombe et al. 1949, Van Engel 1958),

TABLE 8. **Distribution of *C. sapidus* by salinity intervals showing number of samples (above) and catch per sample (below).**

Modified from:	Salinity (ppt) 0.0–4.9	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30+	Total
Swingle (1971)	41	15	14	19	33	18	18	179
	6.0	4.7	2.6	2.3	3.1	3.3	4.4	3.9
Perret et al. (1971)	197	185	263	278	182	82	12	1,199
	12.0	6.0	6.0	6.0	6.0	5.0	5.0	7.0
Christmas and Langley (1973)	134	87	110	99	145	169	74	818
	1.2	2.7	3.8	3.2	4.1	2.2	0.9	2.6
Perry and Stuck (1982b)	561	423	482	520	517	489	257	3,249
	7.6	7.8	7.1	8.3	5.9	3.0	2.7	6.3

the variability in the average size at which maturity is attained in the female coupled with the observations that unusually large blue crabs are found in low salinities suggests that environmental conditions influence the percentage increase in size per molt. Blue crabs in Chincoteague, Chesapeake and Delaware bays show an increase in size with decreasing environmental salinity (Porter 1955, Cargo 1958). The data of Newcombe (1945), Van Engel (1958) and Tagatz (1965, 1968a) also suggest a possible negative correlation of size with the salinity of the water in which growth occurs. Van Engel (1958) believed that the osmoregulatory mechanism was involved; differences in the levels of salt concentration between the crabs and their environment affected the uptake of water resulting in increased growth per molt. Haefner and Shuster (1964), in a study of the growth increments occurring during the terminal molt of the female blue crab under different salinity regimes, concluded that "within the parameters of the experiment, the salinity variation of the environment is not related to percentage increase in length at the terminal molt." Tagatz (1968b) also found that a decrease in salinity did not produce an increase in size and suggested that some factor other than salinity appeared to account for larger crabs in certain waters.

Growth of blue crabs is strongly affected by temperature. One of the more obvious effects of temperature on growth rate is the length of time required for crabs to reach maturity. Up to 18 months is necessary for maturation in Chesapeake Bay (Van Engel 1958), while blue crabs in the Gulf of Mexico may reach maturity within a year (Perry 1975, Tatum 1980).

In the laboratory, Leffler (1972) demonstrated that the molting rate (molts per unit of time) increased rapidly with increasing temperature from 13.0 to 27.0°C. This increase continued at a slower rate between 27.0 and 34.0°C and growth virtually ceased at temperatures below 13.0°C. The growth per molt was significantly reduced above 20.0°C. Thus while the molting rate increased with temperature, the number of molts necessary to attain a certain size also increased. If the maximum size a blue crab attains is assumed to reflect the growth per molt rather than the number of molts, environmental temperatures may, in part, be responsible for the variation in size at maturity.

Perry (1975) estimated growth by tracing modal progressions in monthly width-frequency distributions for crabs in Mississippi Sound. The estimated growth rate of 24.0 to 25.0 mm/month is somewhat higher than rates found in other Gulf estuaries. Adkins (1972a) found growth in Louisiana waters to be approximately 14.0 mm/month for young crabs, with slightly higher rates (15.0 to 20.0 mm/month) as crabs exceeded 85.0 mm in carapace width. Darnell's (1959) growth estimate of 16.7 mm/month for crabs in Lake Pontchartrain falls within the average reported by Adkins. More (1969) noted a growth rate of 15.3 to 18.5 mm/month in Texas. Plotting the progression of modal groups from February through August, Hammerschmidt (1982) reported higher growth rates for crabs in Texas (21.4 and 25.2 mm/month for seine and trawl samples, respectively) and attributed these rates to the use of seasonal rather than yearly data. Tatum (1980) found seasonal changes in the rate of growth of young blue crabs in Mobile Bay, Alabama. He observed monthly rates of 19.0, 10.0 and 5.0 mm for crabs recruited in April, August and December, respectively.

2.2.5 *Trophic Relationships*

Darnell (1958), while studying the food habits of fishes and invertebrates of Lake Pontchartrain, Louisiana, found blue crabs, mud crabs (*Rhithropanopeus harrisii*), unidentified crustacean pieces, molluscs, fish remains and detritus among the diet of *C. sapidus.* He noted that food differences between adults and young were not pronounced; however, as crabs exceeded 124.0 mm carapace width, molluscs became the dominant food item. The importance of molluscs in the diet has also been documented by Menzel and Hopkins (1956) and Tarver (1970). In an attempt to distinguish and clarify the fundamental nutritional relationships he observed in the Lake Pontchartrain estuary, Darnell (1961) reevaluated the data presented in his 1958 paper in the context of the total estuarine community. He found that most consumer species, the blue crab among them, did not conform to specific trophic levels and utilized alternate food sources from time to time depending upon availability. Successful species were opportunists whose food habits were governed by availability thus characterizing blue crabs as opportunistic benthic omnivores. Data from O'Neil (1949), Suttkus et al. (1953), and Tagatz and Frymire (1963) support this characterization. Heard (1982) described blue crabs as voracious feeders with a variable diet. He noted that in tidal marshes, fiddler crabs (*Uca* spp.) and marsh periwinkles (*Littorina irrorata*) were important components of the diet of blue crabs. Hamilton (1976) suggested that movement of periwinkles up marsh grass stalks with a rising tide may, in part, be an "escape" reaction to avoid predation.

Young and subadult blue crabs occur in estuarine waters throughout the year and are an important prey species for a variety of organisms. The clapper rail (*Rallus longirostris*), great blue heron (*Ardea herodias*) and several species of diving ducks are among the avian predators of blue crabs (Bateman 1965, Day et al. 1973, Stieglitz 1966, respectively). Mammalian predators include man and the raccoon. Important fish predators are listed in Table 9. Adkins (1972a) reported that triggerfish (*Balistes* spp.) have been observed attacking the egg mass of berried crabs in Louisiana coastal waters.

TABLE 9. Fish predators of the blue crab.

Species	Gunter (1945)	Darnell (1958)	Fontenot and Rogillio (1970)	Overstreet and Heard (1978a)	Overstreet and Heard (1978b)	Overstreet (Unpub. data– Gulf Coast Research Lab.)	Heard (Unpub. data– Gulf Coast Research Lab.)
Aplodinotus grunniens		X					
Archosargus probatocephalus	X	X	X			X	
Arius felis	X	X					
Bagre marinus	X						
Bairdiella chrysoura		X					
Caranx hippos						X	
Carcharhinus leucas							X
Cynoscion arenarius						X	
Cynoscion nebulosus	X		X			X	
Dasyatis americanus							X
Dasyatis sabina							X
Dasyatis sayi							X
Ictalurus furcatus		X					
Lagodon rhomboides		X					
Lepisosteus oculatus		X					
Lepisosteus spatula		X					
Lobotes surinamensis	X						
Micropogonias undulatus		X	X	X			
Micropterus salmoides		X					
Morone interrupta		X					
Opsanus beta							X
Paralichthys lethostigma		X				X	
Pogonias cromis	X		X			X	
Rachycentrum canadum						X	
Sciaenops ocellatus	X	X	X		X		
Sphyrna tiburo	X						

2.2.6 *Parasites and Disease*

Couch and Martin (1982) provided a synopsis of the protozoan symbionts and related diseases of blue crabs. Of the protozoans that utilize the blue crab as host, the amoeba *Paramoeba perniciosa* and the dinoflagellate *Hematodinium* were identified as lethal pathogens.

The history of the incidence of *P. perniciosa* along the eastern coast of the United States was reviewed by Couch and Martin (1982). This highly pathogenic amoeba is responsible for outbreaks of gray crab disease. Couch and Martin (1982) described *P. perniciosa* as an opportunistic parasite/pathogen of blue crabs and other Crustacea. To date, this organism has not been isolated from blue crabs in the Gulf of Mexico.

Hematodinium sp., a dinoflagellate found predominantly in the hemolymph, has been identified from *Callinectes sapidus* from the northern Gulf of Mexico (Couch and Martin 1982). The disease exhibits no external signs, although infected crabs are weak and lethargic. In heavily infected crabs, the dinoflagellates may be found in the musculature, gonads and hepatopancreas.

Other protozoans infecting the blue crab are the haplosporidan parasite *Urosporidium crescens* and the microsporidan pathogen *Ameson michaelis*.

Urosporidium crescens is a parasite of trematode metacercariae. Metacercariae of the microphallid trematode *Microphallus basodactylophallus* (as *Carneophallus basodactylophallus* [Perry 1975, Overstreet 1978]) are commonly infected by this hyperparasite in Gulf waters. The metacercariae are found in the hepatopancreas and musculature of blue crabs. With the maturation of the spores of *U. crescens*, the metacercariae become black. Metacercariae containing such spores cause the condition known as "buckshot" by crab fishermen. Crabs thus affected are also known as "pepper" crabs. According to Perkins (1971), rupture of the metacercaria is necessary for the release of the spores of *U. crescens* and this occurs after the death of the crab. He found no evidence that the trematode infection caused mortalities in crabs. Blue crabs infected with *U. crescens* pose problems to processors who must either pick around the cysts or discard the crab. According to Adkins (1972a), buckshot crabs are fairly common in Louisiana. More (1969) and Perry (1975) found infected metacercariae in crabs from Texas and Mississippi, respectively.

While *Ameson michaelis* is the more widely known microsporidan parasite of the blue crab, Couch and Martin (1982) reported that *A. sapidi* and *Pleistophora cargoi* have also been identified from muscle tissue of *C. sapidus*. *Ameson michaelis*, commonly found in blue crabs from Gulf and Atlantic waters (Sprague 1977), infects the musculature and is thought to cause lysis of the muscle tissue. Overstreet (1978) noted the occurrence of this species in crabs from lakes Pontchartrain and Borgne, Louisiana, and Mississippi Sound and diagramed the life cycle. Heavily infected crabs can be distinguished from healthy individuals by the chalky opaque appearance of the muscle tissue.

Heavy infestations of ectocommensal ciliate protozoans have been implicated in mortalities of blue crabs held in confinement (Couch 1966). Peritrichous ciliates of the genera *Lagenophrys* and *Epistylis* were identified from the gill lamellae of blue crabs from Chincoteague and Chesapeake bays and Couch (1966) suggested that severe infestations of these epibionts may interfere with respiration and contribute to mortality of crabs in holding or shedding tanks. Couch and Martin (1982) reported that the prevalence and intensity of infestation of *L. callinectes* in natural populations of *C. sapidus* in Chincoteague Bay increased through the spring and summer, peaking in August. He noted that this ciliate may be a seasonal factor affecting the survival of blue crabs, particularly at times when oxygen tension in the water is borderline.

A variety of cirripede symbionts are either ectocommensal or parasitic on blue crabs. Fouling species include the barnacles *Balanus venustus niveus* and *Chelonibia patula* (Overstreet 1978). Barnacle fouling of mature female blue crabs is common (Adkins 1972a, Perry 1975). Perry (1975) noted that large numbers of spent female crabs occasionally litter barrier island beaches in the northern Gulf and that these crabs are heavily fouled and parasitized. The pedunculate barnacle *Octolasmis muelleri* (as *O. lowei* [Perry 1975]) is found on the gills and in the gill chamber of *C. sapidus*. Infestations have been observed on male and female crabs from waters of high salinity with the incidence of occurrence greater on mature females (More 1969, Perry 1975). Overstreet (1978) noted that heavy infestations may interfere with respiration by decreasing the amount of available gill surface.

The barnacle *Loxothylacus texanus* is a true parasite of blue crabs in the Gulf of Mexico. The cypris larvae infect immature crabs during the molting process. Following a period of internal development, an externa or sac protrudes from beneath the abdomen of the crab. The externa contains the male and female gonads and serves as a brood pouch for the developing larvae. Rhizocephalan infection alters the secondary sex characteristics of the crab, causing the abdomen to appear as that of a mature female. There is some controversy in the literature as to the effect that rhizocephalan infection has on molting and growth. Reinhard (1956) reported that in infected crabs gonadal development is suppressed and that once the externa emerges, molting and growth cease. Overstreet (1978) observed that crabs with externae can molt but questioned whether this process was typical. The influence of rhizocephalan infection on blue crab stocks is of particular concern in Louisiana. Harris and Ragan (1970) reported that 43% of the blue crabs collected in May and June from two estuarine areas in Louisiana were infected with *L. texanus*. Adkins (1972b) found a direct correlation between temperature and percentage of infected crabs, with peak occurrence of the barnacle from July through September. In September 1971, 17.1% of the crabs taken in his samples were infected. More (1969), Adkins (1972b) and Ragan and Matherne (1974) found peak occurrence of the barnacle in higher salinities. According to Ragan and Matherne (1974) adult rhizocephalans cannot tolerate low salinity; maturing externae do not protrude and ones already protruding take on water and rupture. Blue crabs infected with *L. texanus* are becoming more prevalent in Mississippi coastal waters. Christmas (1969) noted that the rate of infection in the Sound was negligible in 1966. Perry (1975) reported that the barnacle was found on less than 1.0% of the crabs collected in 1971 and 1972, and Perry and Herring (1976) noted that 0.1% of the crabs taken in samples from October 1973 through September 1976 carried an externa or had a modified abdomen. Since these data were collected, the incidence of parasitism has risen to over 4.0% (Perry and Stuck 1982b). Additionally, parasitized crabs now show wider areal distribution in Mississippi Sound. From 1971 through 1976 catches of parasitized crabs were highest in the western portion of Mississippi Sound. Subsequently, infected crabs have been collected throughout local waters. Overstreet (1978) noted that over half of the crabs taken aboard a shrimp trawler in Mississippi Sound in July 1977 exhibited infections. Overstreet (1978) suggested that the "dwarf" or "button" crabs that appear seasonally in the commercial catch in Mississippi may be a result of sacculinid infection. Gunter (1950) observed that only 1.5% of the crabs collected in Aransas and Copano bays, Texas, were parasitized. Daugherty (1952), however, noted that 25.8% of the crabs collected near the southwestern end of Mud Island in Aransas Bay from 1947–1950 were infected. More (1969) found 8.0% and 5.8% infection rates in crabs examined from the lower Laguna Madre and upper Laguna Madre, respectively, with the incidence of infection never exceeding 1.0% in other Texas bays.

Carcinonemertes carcinophila, a parasitic nemertean, is common on the gills and egg masses of mature female crabs (More 1969, Perry 1975). Hopkins (1947) discussed the use of this worm as an indicator of the spawning history of *Callinectes sapidus.* Overstreet (1978) noted that while the blue crab is the usual host, it has been found on other portunids.

Digenetic trematodes of the family Microphallidae form an interesting group of parasites that often use a crustacean as a second intermediate host. In those species infecting the blue crab, a snail usually serves as the first intermediate host with a fish, bird or mammal serving as the final host. The cercariae (shed from the snail) enter the branchial chamber of the crab, attach to the gill lamellae and penetrate into the gill lumen. The circulatory fluid of the crab carries the cercariae to various parts of the body where they encyst (usually in the hepatopancreas and/or musculature). The encysted or metacercarial stage may or may not be visible depending upon the species. The metacercaria of *Levinseniella capitanea* are very large and easily seen, whereas the metacercariae of *Microphallus basodactylophallus* are not visible unless they are hyperparasitized by *U. crescens.*

Because the types of habitats in which these trematodes complete their life cycle are often quite specific, they have potential use as "biological tags" (Heard, Gulf Coast Research Laboratory, personal communication). In the northern Gulf of Mexico the life cycle of *L. capitanea* is completed in the high salinity marshes and baylets of the offshore barrier islands, thus the presence of the metacercariae of this species is an indication that the crab has spent time in the marsh habitats of these islands. Another example is *Megalophallus diodontis,* the metacercariae of which are found only in the gills of crabs that have spent all or part of their juvenile and/or adult life in high salinity turtle grass beds where the life cycle of this digenean is completed.

Perry (1975) and Overstreet (1978) found the metacercariae of *M. basodactylophallus* (as *Carneophallus basodactylophallus*) in blue crabs from the northern Gulf of Mexico. More (1969) and Adkins (1972a) reported a metacercaria similar to *Spelotrema nicolli* in blue crabs from Texas and Louisiana, respectively. Heard (1976) noted that the metacercariae observed by More and Adkins were in all probability *M. basodactylophallus* because *S. nicolli* is known only from New England (Cable and Hunninen 1940). The taxonomic status of several species of microphallids is in question (Heard, Gulf Coast Research Laboratory, personal communication). Deblock (1971) placed *Spelotrema* and *Carneophallus* in synonymy with *Microphallus.* Heard and Overstreet are currently reviewing the taxonomic status of those species from the southeastern United States which have been previously assigned to the genus *Carneophallus.*

Levinseniella capitanea was described from blue crabs from lower Lake Borgne and western Mississippi Sound by Overstreet and Perry (1972). The large metacercariae of this species appear as opaque, white cysts in the hepatopancreas, gonads or musculature. There are no published data on the prevalence of this species; Overstreet (Gulf Coast Research Laboratory, personal communication) reports it to occur with more frequency in crabs from Alabama and northwestern Florida.

Leeches (*Myzobdella lugubris*) are common on crabs from low salinity waters. Hutton and Sogandares-Bernal (1959) noted that *M. lugubris* may have been responsible for mortalities of blue crabs in Bulow Creek, Florida, although Perry (1975) and Overstreet (1978) found no evidence to suggest a harmful relationship.

A branchiobdellid annelid, *Cambarincola vitreus,* also infests blue crabs from low salinity and freshwater habitats. These small worms (2 to 3 mm long) are found in the gill chambers and on the external shell surface and apparently cause no harm to the crab (Overstreet 1978).

Microbial infections of blue crabs include the nonfatal bacteria responsible for "shell disease" and pathogenic species of *Vibrio.* Cook and Lofton (1973) in their study of the chitinoclastic bacteria associated with blue crabs and penaeid shrimp isolated one strain, *Beneckea* type I, from all necrotic lesions but noted that in all cases there was no penetration of the epicuticle by the bacteria.

Several species of *Vibrio* have been identified from blue crabs. Davis and Sizemore (1982) isolated bacteria taxonomically identical to *V. cholerae, V. vulnificus* and *V. parahaemolyticus* from blue crabs collected in Galveston Bay, Texas. Species of *Vibrio* were the predominant bacterial types in the hemolymph occurring in 50% of the crabs sampled in the summer. *Vibrio cholerae* and *V. vulnificus* were isolated from 3.5 and 9.0% of the crabs, respectively, with *V. parahaemolyticus* occurring in 30% of the study organisms. *Vibrio parahaemolyticus* and *V. vulnificus* were commonly isolated from the same crab, however, *V. parahaemolyticus* and *V. cholerae* were never found together.

Vibrio parahaemolyticus has caused mortalities in blue crabs and food poisoning symptoms in humans eating contaminated crabs (Overstreet 1978). Keel and Cook (1975) found *V. parahaemolyticus* in Mississippi coastal waters and related its prevalence to temperature and distance from land.

Gulf coast blue crabs were linked to an outbreak of human cholera in Louisiana in 1978. Evidence indicated that the outbreak was due to poor sanitary practices in home-prepared crabs, with no implication of commercially processed crab meat. Moody (1982) discussed zoonotic diseases associated with blue crabs and reviewed the history of the 1978 Louisiana cholera outbreak.

2.2.7 *Migration*

Tagging studies in the Gulf include those of More (1969), Perry (1975) and Oesterling and Evink (1977). Migrational patterns observed by More (1969) and Perry (1975) were typical of the onshore/offshore movements as characterized in previous studies (Fiedler 1930, Van Engel 1958, Fischler and Walburg 1962, Tagatz 1968a, Judy and Dudley 1970). Oesterling and Evink (1977) provided evidence of an along-shore movement of females in Florida coastal waters. Migratory patterns observed in their study demonstrated movement of females to sites north of their mating estuary with the Apalachicola Bay region appearing to be a primary spawning ground for crabs along the Florida peninsular Gulf coast. A hypothesis for redistribution of larvae to southwestern Florida involved transport of zoeae in surface currents associated with Apalachicola River flow and the Gulf of Mexico Loop Current.

2.2.8 *Mortalities*

Blue crab mortalities associated with chemical and biological pollutants, sediment, temperature, salinity and dissolved oxygen were discussed by Van Engel (1982). One of the most serious incidences of chemical pollution affecting the blue crab fishery occurred in Virginia and was associated with the release of the chlorinated hydrocarbon Kepone into the James River from the late 1950's to late 1975. Closure of the river to commercial fishing had a severe negative effect on the industry throughout the Chesapeake Bay. The annual mortality of young and adult blue crabs due to exposure to Kepone remains unknown, however, both commercial landings and juvenile crab abundance have been lower in the James River than in the York or Rappahannock rivers for the past 15 years (Van Engel 1982). Lowe et al. (1971) reported Mirex (closely related to Kepone) to be toxic to blue crabs either as a contact- or stomach-poison.

Low levels of dissolved oxygen not only cause mortality of blue crabs but also impede migration. Trap death due to anoxia is a serious problem in many areas. Tatum (1982) reported oxygen deficient bottom waters covered as much as 44% of Mobile Bay, Alabama, in the summer of 1971 with some area fishermen indicating as much as 75% of their catch dead. Low levels of dissolved oxygen in the deeper waters of Chesapeake Bay and associated tributaries during the summer months have also been implicated in trap death. Periodic "kills" of blue crabs following excessive freshwater runoff and the subsequent depletion of oxygen due to rapid decomposition of organic matter were reported by Van Engel (1982).

Other mortalities of blue crabs have been related to extreme cold or to sudden drops in temperature (Gunter and Hildebrand 1951, Van Engel 1978 [from Rhodes and Bishop 1979], Van Engel 1982, Couch and Martin 1982) and to red tides (Wardle et al. 1975, Gunter and Lyles 1979).

Mass mortalities of blue crabs occurred in South Carolina, North Carolina and Georgia in June 1966, and in South Carolina and Georgia in June 1967. While the pathogenic amoeba (*Paramoeba perniciosa*) was alluded to as a possible cause of the mortalities, there was some implication that pesticides may have been involved. According to Newman and Ward (1973) blue crab mortalities of greater and lesser magnitude have occurred during May and June with *Paramoeba* involved in the majority of the kills that were investigated.

Adkins (1972) and Perry (1975) reported large numbers of dead crabs periodically littered the beaches of Louisiana and Mississippi, respectively; observing that the vast majority of these crabs were heavily fouled, spent females.

3. DESCRIPTION OF THE FISHERY

3.1 Development of the Hard Crab Fishery

Information in this section was obtained from interviews with crab fishermen and processors.

The states bordering the Gulf of Mexico were more similar than disparate in the development of the blue crab fishery. The search for the earliest activity in each state has, thus far, ended at least one generation away from inception. Names, places and dates are extant in the minds of early fishermen, who entered an existing industry or in the evidence of heirs, and are subject to the limitations of retrospect.

The gaps in information and "foggy" dating in these early histories suggest that a more concerted effort be made to authenticate this fishery. Each state has crab stories to tell, but more confusing, each bay system, each fisherman and each crab plant also has a story to tell. As time passes the stories get more vague, dating fades and names are lost. The obvious inadequacies in the following sections enforce the need to learn and record what may soon be lost.

The blue crab fishery is characterized by the uniqueness of the product which, in itself, prevented fishery development until the advent of railroads. The importance of the coming of the railroads cannot be overemphasized in the development of markets for perishable items such as crab meat. Prior to rail travel, the fastest mode of transportation was by sailing schooner, with the trip from Biloxi, Mississippi, to New Orleans, Louisiana, requiring a full day. The onset of picking operations in the late 1920's heralded a new era of expansion for the fishery.

The earliest commercial fishery for blue crabs in the Gulf that could be documented through interviews existed in Florida in the 1880's. William H. Boyington and his son Jesse fished trotlines in Doyle and Whiskey George creeks, trading their crabs for farm products and staples in West Point (now Apalachicola).

3.1.1 Mississippi

Luke Dubaz, born in 1897 and of Yugoslavian descent, sailed with his parents and brothers from Pensacola, Florida, to Biloxi, Mississippi, in 1902. There he eventually entered the oyster fishery and crabbed and fished as a sideline. By the early 1920's, there were three fish houses picking crab meat for stuffed crab products. These were owned by Bill Cruso, Steve Papich and a man known only as Valpino. The Dubaz family bought Valpino's operation in the 1920's. A live market in Mobile, Alabama, bought 150- to 200-dozen live crabs per week from the Biloxi picking houses as well as from Lewis Johnson, who only shipped live crabs. The crabs were packed in moss, 8-dozen to an orange crate and shipped twice a week. The shippers received 20 cents per dozen. Markets quickly opened in Montgomery, Alabama, Washington, D.C. and Baltimore, Maryland.

Crabbers supplying the Biloxi crab houses fished 200-fathom trotlines, baited every few feet with beef lips and tripe at a cost of 3 to 8 cents per pound. Each crabber ran two or more lines at night from a rowed skiff. They reportedly harvested 1,200 to 1,500 pounds per day and were paid 10 cents per dozen. Pickers received 4 cents per pound of picked meat. Some of the pickers hand-dipped crabs in the shallows the night before, with a good catch being about 200 pounds per person.

3.1.2 Florida

Prior to 1930, the Florida blue crab fishery supplied a local, barter-type market where all the crab meat and crab meat products were consumed locally. "Seeb" Russell changed all that when he returned to Florida from Biloxi and reported that crab meat was being picked and shipped in large-scale operations. Arthur Tucker, from the Apalachicola-East Point area, investigated the report and began his own full-scale picking operation in Florida by spring of 1930. He packed crab meat in pint jars and shipped it to New York. This is the earliest report of crab meat produced for interstate shipment from Florida. The Tucker family still operates their seafood business to this date.

Florida crabbers fishing trotlines could harvest as much as 2,500 pounds per day on good days. Crabbers were paid 5 cents per dozen, translating to about $10.00 per day. Expenditures for the Florida crabber, as well as those for other Gulf states, were mainly for bait—two trotlines required about 100 pounds of bait.

Florida's blue crab fishery began to expand significantly after World War II due to the development of large-scale processing plants. Charles Barwick, Sr., started a picking plant in Panacea in 1949, and Herman Metcalf opened another between 1953 and 1954. During this post-war period, Ralph Newton added crab processing to his importing and seafood business. From 1963 to 1971 Newton was processing more than 2,000 pounds of product per day, requiring about 30,000 pounds of live crabs. Top production in Barwick's operation was 2,269 pounds per day, requiring 111 crabmeat pickers. The families of those mentioned above still operate several crab-processing facilities which provide the bulk of Florida Gulf coast crab meat entering eastern seafood markets.

3.1.3 Alabama

In Baldwin County, crabbers have been fishing since at least 1900, selling the live crabs in Mobile. The first crab shop in Baldwin County opened in 1947; the meat was canned and trucked to Bayou La Batre for sale. Bayou La Batre developed into a distribution center which now competes with Mobile. The first crab shop in Mobile County was opened in the early 1920's at Alabama Port. Crabs were brought in and boiled on the beach in 55-gallon drums which were cut lengthwise and set on four pipes in the ground. The cooked crab was taken into the plant, backed, washed at a hand pump and picked. The meat was packed fresh for shipment. Southern Fish Company, owned by Mr. Jess Jemison, was the first company in Mobile to distribute crab meat for intra- and interstate shipment.

3.1.4 Louisiana

Any early history of the Louisiana fishery presents a formidable challenge for the researcher. The type of evidence gathered from other Gulf states is available for Louisiana, but is scattered throughout a maze of wetlands, bays and estuaries. Early on, New Orleans grew into a major market for seafood products linking Houston, Texas, Mobile and Biloxi with inland centers. One of the first crab fisheries in the Gulf developed near New Orleans to supply the French Market and local restaurants. The first crabmeat plant was constructed in 1924 in Morgan City and, by 1931, there were seven more plants in the Morgan City/Berwick area. This time frame roughly corresponds with the onset of picking operations in most other Gulf states.

Louisiana now supplies live blue crabs to Baltimore, Maryland, and surrounding eastern cities. These crabs are shipped by airfreight, a practice which began in Louisiana. Verlon Davis, manager of Bo Brooks of Texas, has stated that Charles Turan of Turan Seafood in Metairie, Louisiana, was the first to ship live crabs by air.

Louisiana's vast fertile wetlands have provided a surplus of blue crabs over local demand. Since 1968, Louisiana has produced one third to one half of the total Gulf harvest. This surplus has historically been exported to other states. Mississippi and Alabama have consistently relied upon Louisiana crabs to keep their plants operating during years of low supply. Star Crab Company in Palacios, Texas, trucked crabs regularly from Hackberry, Louisiana, in the 1960's.

3.1.5 Texas

In the early 1900's, Homer Clark fished Galveston Bay, Texas, and shipped live crabs by the barrel to Houston via High Island and the Bolivar Peninsula. This is the earliest documented Texas crab fishery. Certainly, however, there must have been other crabbing operations supplying Houston restaurants and markets with Texas blue crabs. Owen Raby, now of Port O'Connor, Texas, fished and crabbed around Port Arthur, Texas, in 1914. He used trotlines with stagings every 3 to 6 feet baited with fresh fish. He sold his crabs to a man who stopped the Orange-to-Houston train and shipped the crabs live to Houston. Where this marketing chain ended is unknown.

The earliest documented crab-picking plant in Texas was built in 1958 in Palacios by a Mr. Willis. However, there are reports of a plant of earlier construction built in Flour Bluff. The owner was said to be a man from Mississippi whose name and history remain as vague memories.

Mr. Joseph [Preston?] Lowe (originally of Crisfield, Maryland, and later of Pascagoula, Mississippi) purchased the Palacios plant from Mr. Willis sometime after 1958. The plant was called Star Crab Company and Mr. Lowe bought crabs from Flour Bluff, Texas, to Hackberry, Louisiana. Joseph Lowe's death terminated an amazing career that began in Crisfield, Maryland, and profoundly affected the Gulf coast fishery. His wife, Ruby, continued to operate Star Crab Company which was eventually absorbed by Ed Collins Seafood.

Edmond Collins operated a shrimp cannery in Palacios in 1960. In 1966, he sold out and opened a seafood business which became Ed Collins Seafood in 1967. By 1970, he had built a hard crab processing plant capable of handling 25,000 pounds of crabs per day, adopting the first steam cooking and first pasteurizing process in Texas. He also led in the development of and promoted the legislation for regulations and inspection standards of Texas crab-processing plants.

Prior to the mid-1970's, blue crab production in Texas was severely limited due to the parochial marketing channels and low local demand for crab meat.

Bill Marsh of Marsh Seafood in Anahuac, Texas, reported a man named Glen Pearson began shipping crabs from Texas in the early 1970's. The receiver paid the freight charges. As air freighting became popular and east coast markets developed, Texas began to fully exploit its blue crab resources. This business now exports an estimated 20% of the reported landings in Texas at a wholesale price of about $1.00 per pound.

East coast "crab barons" soon took interest in Texas' productivity and invested in or bought out Texas processors. Verlon Davis, a Louisiana crab buyer, shipped live crabs to Baltimore, Maryland. He sold his interest to Bo Brooks of Baltimore who constructed a picking plant in Seadrift, Texas, in 1976. Mr. Davis continues to manage this plant. Ralph Newton, of Florida, took over South Bay Seafood in Aransas Pass, Texas, and renamed it Blue Sea. Ed Collins Seafood was purchased by a group of east coast crab buyers while a man named Mr. Dinardo opened up a crab house in Matagorda.

With the influx of new markets, increasing fishing pressure is being placed on the resource. Texas now provides over 20% of the Gulf coast production.

3.1.6 Regulatory Responsibility

Louisiana is the first of the Gulf states to assume responsibility for the quality of crab meat and crab meat products. One hundred years ago, in 1882, Louisiana passed food and drug legislation, predating the federal govenment. Since 1921 the Health Department has permitted and inspected crab plants with revision in 1950. The State

Sanitary Code, Chapter Six, now regulates seafood products.

In 1937 the Mississippi State Board of Health wrote crab meat regulations. In 1954 the Gulf States Shellfish Conference first met in Mississippi; the topics being crabmeat, crab products and interstate trade. In 1980 North and South Carolina began participating in the conference which now includes states from the Gulf and South Atlantic.

The Texas blue crab industry appealed to the legislature in 1969 for regulatory control including the licensing and inspection of plants to qualify for acceptance in interstate marketing. Presently this inspection and licensing is authorized by the Texas Department of Health.

Florida Department of Natural Resources assumed regulatory authority over the crab industry, writing regulations in 1977. Prior to that date, the production of crab meat was subject to State Health Department supervision.

Alabama also permits and inspects crab-processing plants.

3.1.7 Gear

The front beaches and back bays were surely a colorful sight at night in the 1800's as lanterns and torches lighted up the shallows. There the crabbers (both men and women) waded with hand-held dip nets, scooping up crabs and dropping them into towed skiffs, tubs, half-barrels or burlap sacks. The dip nets were long-handled with little webbing to facilitate removing the crab with a quick shake. When crabbing was good it was possible to dip 200 pounds a night. The hard crabs were kept for barter or for picked meat and the peeler crabs kept until they shed.

Crabbers used drop nets in deeper water that could not be waded. These were net-covered iron bar frames 18 inches square with a bait fastened to the middle of the webbing. Lines, attached to the frame, led to a float. Periodically, the drop net was raised and the crabs were placed in the skiff, probably in a moss- or brush-lined barrel. The trotline was found to be more effective in catching crabs and quickly replaced the drop net.

Trotlines were of two basic types. The earliest type consisted of a length of rope (mainline) to which were attached short (10-inch) lines at approximately 2-foot intervals. Bait was attached to the ends of these short lines (called snoods, drops, stagings or gangions) (Figure 10). When rollers or spools came into use with the advent of motor boats, the snoods were often abandoned as they easily became tangled in the roller; bait was then secured either in a slip knot in the mainline or tucked between the strands. A trotline with baits attached to the mainline is shown in Figure 11.

The bait varied, but beef lips and tripe were the most common. They were tough and durable. Chunks of salted eels were favored by some crabbers and were reported to be particularly effective for catching male crabs. Bait was constantly a problem; the lines had to be rebaited as needed after each use and then stored in a brine barrel in the bow of the skiff to preserve the cotton twine. As the bait became rank, the brine barrel began to develop a unique aroma. Sometimes the beef lips had to be boiled to remove them from the line. The whole gear was placed into a vat and boiled until the bait loosened up. If the bait was secured to the mainline with a slip knot, the line was strung around a tree or post and pulled in a sawing motion until the bait came loose and the slip knot gave way.

Most crabbers ran at least two lines, with some of the lines longer than a mile. The lines were run from a skiff which had been rowed to the crabbing grounds. Small outboard motors were not used in the Gulf until the 1950's. After the first line was set, the second was put out and the first run. If crabs were plentiful in a particular area, lines would be run until the supply was exhausted. Crabbers would then move the lines to more productive grounds.

To harvest the crabs, the crabber pulled his skiff along the set line, reaching out and dipping the crabs (feeding on the bait) into the boat. The dip net was constructed long enough to reach over the side of the skiff and into the water. The net was made of shallow webbing or chicken wire. Some nets were little more than tennis rackets used to bat the crabs off the bait and into the skiff. Most of the trotline fishing was done at night by lantern or in the early morning because the shadow of the skiff in clear water would "spook" the crabs and they would release the bait. The location of trotlines varied seasonally. The orientation of trotlines in an estuary was dependent upon tide (Van Engel 1962), season and geographic location (Jaworski 1972).

The arrival of the crab pot moved the blue crab fishery from a crab kitchen operation to the large-scale processing plant. The most vivid change took place in Florida after 1950. According to Bill Marsh, the crab pot was introduced in Panacea, Florida, by his cousin, Rose Bradshaw, and her husband, Leroy. From the reported landings and number of gear units (Tables 10 and 13) for the 1950's and 1960's, one can see that something spectacular happened in Florida and later in Louisiana that can be traced to the adoption of the crab pot. This is what enabled the large picking plants to expand; the new technology increased the supply of hard crabs beyond the capacity of local markets to consume them and the industry was forced to seek new marketing channels.

The only authenticated date on the arrival of the crab pot to the Gulf of Mexico is for Mississippi. Joseph Lowe brought the Chesapeake pots to Pascagoula in 1951, and they were placed in the water near Gautier. Emile DeSilva, of the Mississippi Marine Conservation Commission, picked up 200 of the pots, confiscating them as outlaw devices. A Justice of the Peace tried the case and instructed the Commission to return the pots to the water. Legality of the pot was based on the conclusion that the animal was not trapped but merely enticed by the bait and could leave

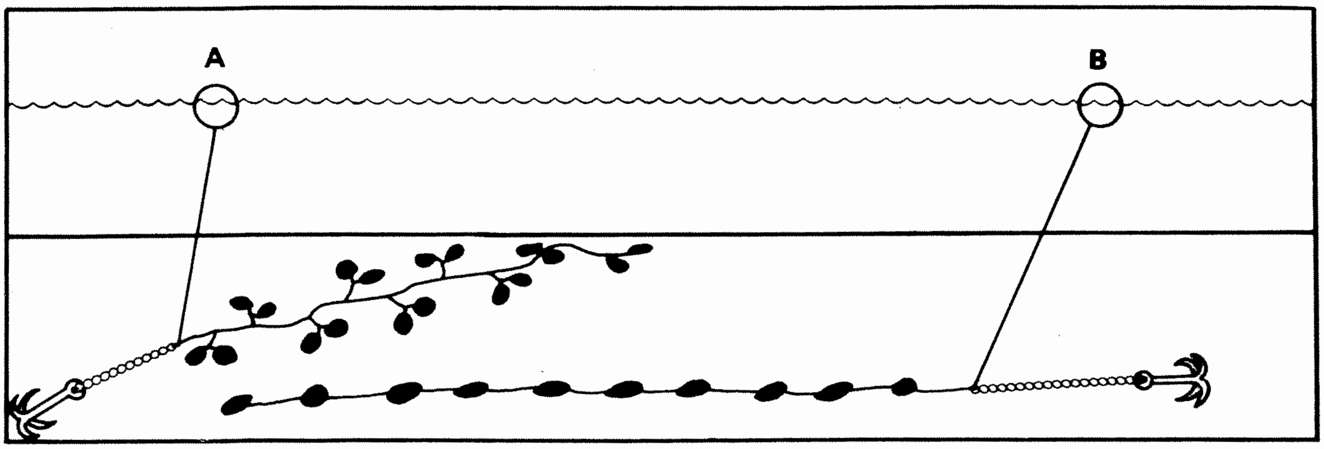


Figure 10. (A) Trotline with snoods. (B) Trotline with bait attached to mainline.

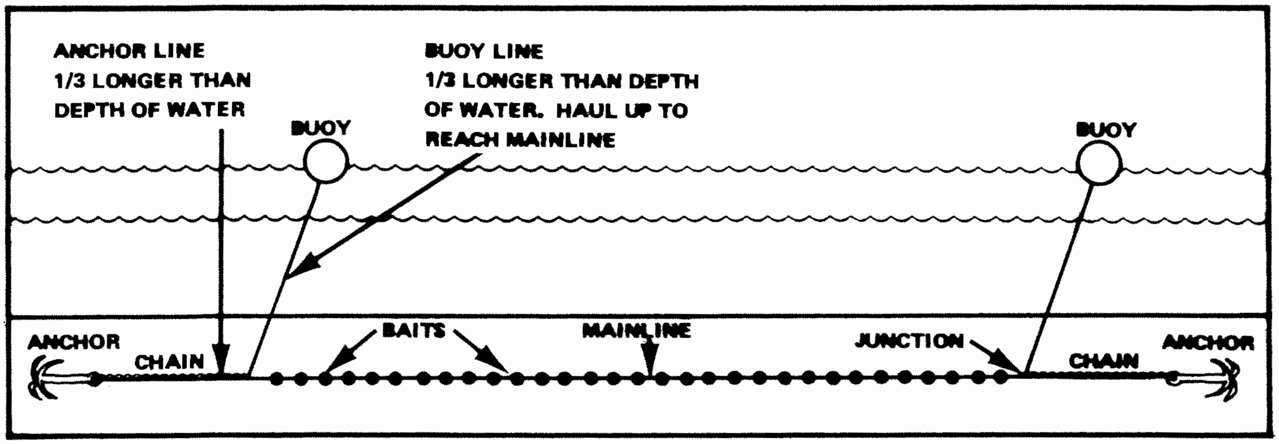


Figure 11. A trotline with baits attached to the mainline (from Floyd 1968).

as it entered. The term "pot" was coined to escape the connotation of trapping. Further details of this landmark case are reportedly a matter of public record and hopefully will be published.

It is not clear when the technology moved to Louisiana. However, both Alabama and Louisiana experienced difficulty in establishing pot fishing. Trotline fishermen felt that the more efficient pot was depleting the resource because their catch was decreasing. Another barrier to accepting the new technology was the capital investment required to purchase wire, floats, tools, and other necessary materials.

With legal precedence established in Mississippi, small skirmishes occurred between pot and trotline fishermen. Pots were stomped flat and float lines cut. Efficiency, however, won over tradition and Louisiana crabbers finally adopted the pot throughout the fishery by the 1960's.

The crab pot is a cubical shaped device constructed of 18 gauge, hexagonal mesh, galvanized wire fastened together with lacing wire, hog rings or "J" clips (Figure 12). Crabs enter through openings in the sides near the bottom. The number of openings is usually two, although some crabbers prefer four. The openings taper inward, leading the crab to a bait-well centered on the floor of the pot. The pot is divided into upper and lower chambers by means of a baffle which may arch from the floor over the bait-well and back to the floor or is tied into the sides in gull-wing fashion. Openings in the baffle permit the crabs to travel from the baited area to the upper chamber where they remain until removed.

Pot fishermen generally set their crab pots in a line. Each pot is fitted with a length of rope and a float. The crab pots are baited with any type of scrap fish (menhaden are the preferred bait) available at a reasonable price. They are usually run daily, early in the morning, but double runs during peak production months are not uncommon. Captured crabs are usually culled, sorted as to size, and placed in containers for sale. Sale generally takes place before noon to avoid heat-induced mortality.

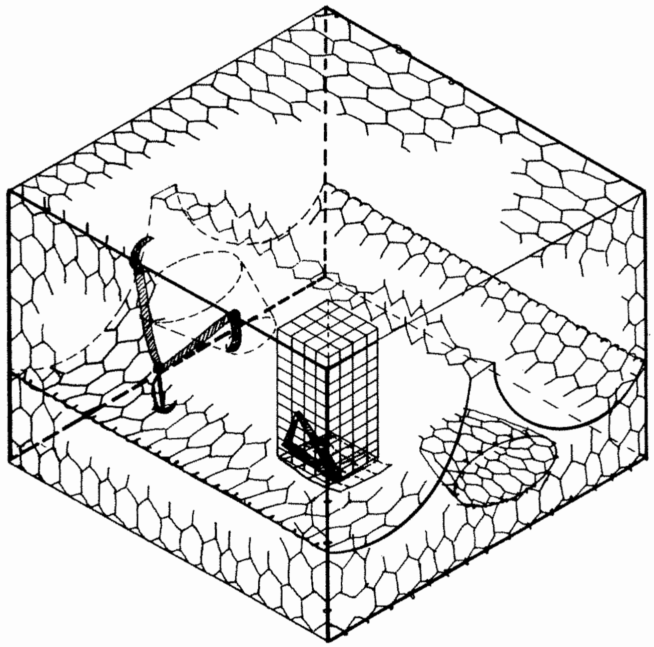


Figure 12. Commercial crab pot.

3.2 Development of the Soft Crab Fishery

Historically and presently, Louisiana has been the center for soft crab production in the Gulf of Mexico. According to Jaworski (1982) the soft and peeler crab fishery in the Gulf states developed along the northern shore of Lake Pontchartrain and in the area of the Rigolets, borrowing both terminology and shedding techniques from the Chesapeake Bay fishery. The fishery in the Barataria estuarine system, however, evolved quite differently. The discovery that peeler crabs could be harvested using the fresh willow branches (*Salix nigra*) designed to catch river shrimp and eels led to the development of a folk-oriented fishing technique (bush trotlines made of wax myrtle) still in use today (Figures 13–16).

The fishery in the other Gulf states relied on hard crab harvesting techniques.

3.3 Harvesting – Hard Crab Fishery

Knowledge of the exploitation rate of blue crabs by various user groups is essential for proper management of the resource. Total production figures for the blue crab fishery are difficult to obtain for a variety of reasons. The seasonal, supplemental nature of the fishery along with the wide distribution and easy accessibility of the resource contribute to the difficulty in identifying user density. Reported commercial landings are probably less accurate than similar data for other fisheries. Indeed, Roberts and Thompson (1982) observed that 60% of the hard crab landings from Lakes Pontchartrain and Borgne, Louisiana, moved through market channels not covered by government statistical surveys. Bootlegging, roadside vending, direct sale to fish markets and direct sales to the public also contribute to unreported landings (Moss 1982).

3.3.1 Trends in Landings by Year and State

Commercial blue crab landings from the Gulf of Mexico have been reported since 1880 (Table 10). The availability of these data prior to 1948 has not been consistent, however, the general trend indicates that total reported landings gradually increased from about 1 million pounds in the late 1800's to over 18 million pounds just prior to World War II. Louisiana contributed as much as 93% of the total Gulf landings during this period. Reported landings from almost all states rose significantly in 1945 and may be attributable to World War II veterans reentering the fishery. From 1948 to 1954, landings declined substantially in Alabama, Mississippi and Louisiana. Part of the decline in landings in these states from 1948–1949 was interpreted as a response by the fishermen to market conditions (Gulf fishermen were not willing to fish for crabs at a price that would allow competition with Chesapeake Bay crab meat [NMFS, Statistical Digest Number 25]), however, no explanation was available for the continued decline through 1954. During this period Florida was just beginning to expand its fishery and Texas was maintaining a small subsistance fishery.

Landings increased in all states in 1955, declined in 1956 and began a general increase through 1960. Florida, in 1960, was the leading producer of blue crabs on the Gulf coast, with Texas also reporting a large increase in blue crab landings. It was during these years that crab pots began to gain wide acceptance by the commercial fishermen. From 1962 through 1964, Gulf landings were substantially below the 35-million-pound levels recorded in 1960 and 1961. While the volume of catch in individual states varied, with the exception of Alabama, all states showed a general decline in harvest. Low Gulf landings in 1963 were attributed to decreases in catch in Louisiana and Texas due to unfavorable environmental conditions in those states as market conditions were good and the number of fishermen, craft and gear was nearly the same as in the previous year (NMFS Statistical Digest Number 57).

Following 1964, Alabama and Mississippi landings leveled off at about 1.6 million pounds while Florida fluctuated between 9 and 15 million pounds. Louisiana reported record landings of 23 million pounds during 1973 and leveled off at approximately 16 million pounds through 1980. Texas landings generally increased by about one-half million pounds from 1974 through 1980.

3.3.2 Seasonal Landings by State

Seasonal fluctuations in reported commercial landings are similar among all the Gulf states (Figure 17). Commercial crabbing generally begins in March or April as water temperatures rise above 15°C. Greatest commercial catches usually occur from May through August with June

Figure 13. Wax myrtle, *Myrica cerifera* (courtesy Lionel Eleuterius).

Figure 14. Bush trotline.

Figure 15. Running bushline.

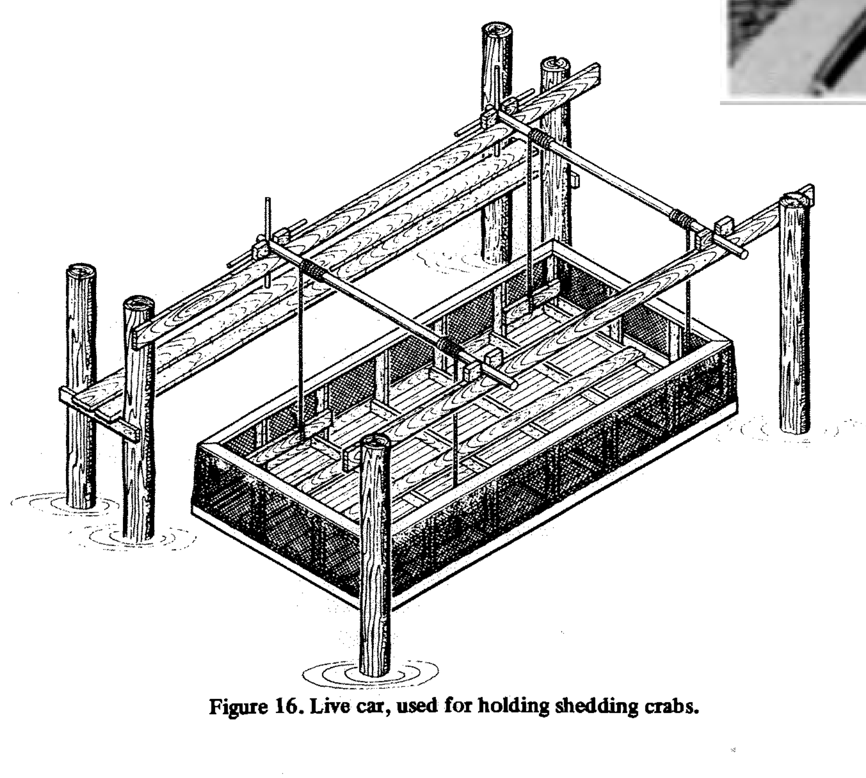


Figure 16. Live car, used for holding shedding crabs.

TABLE 10. Historical hard-shell blue crab landing statistics, 1880–1980 (thousands of pounds; thousands of dollars).

	Florida West Coast		Alabama		Mississippi		Louisiana		Texas		Total	
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1880	–	–	–	–	–	–	288	7	36	1	324	8
1887	(2)	(2)	(2)	(2)	38	1	837	13	111	4	(2)	(2)
1888	3	(1)	96	6	16	(1)	851	13	115	4	1,081	23
1889	–	–	–	–	48	1	842	14	189	5	1,079	20
1890	–	–	–	–	33	1	851	13	191	5	1,075	19
1891	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1892	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1895	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1897	6	(1)	24	1	132	3	1,459	13	138	4	759	21
1898	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1899	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1901	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1902	1	(1)	75	2	235	5	312	16	43	2	1,666	25
1904	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1905	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1908	2	(1)	246	6	380	10	244	8	199	5	1,071	29
1915	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1918	–	–	96	3	216	6	282	10	193	11	787	30
1919	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1920	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1921	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1922	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1923	–	–	84	3	435	11	312	8	109	9	940	31
1924	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1925	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1926	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1927	12	1	32	1	2,426	62	1,091	51	121	9	3,682	124
1928	7	1	102	4	1,518	40	2,320	78	300	12	4,247	135
1929	2	(1)	103	3	1,247	33	2,675	78	163	11	4,190	125
1930	4	(1)	80	1	673	11	4,186	63	29	1	4,972	76
1931	4	(1)	78	1	454	7	4,985	53	49	1	5,570	62
1932	4	(1)	70	1	320	5	5,878	57	45	1	6,317	64
1933	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1934	49	1	257	4	603	7	11,676	164	258	13	12,843	189
1935	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1936	821	12	997	14	2,011	30	12,576	168	320	8	16,725	232
1937	775	12	756	11	1,435	25	14,717	195	922	24	18,605	267
1938	1,104	16	511	8	1,016	17	10,533	106	971	24	14,135	171
1939	722	11	558	8	1,469	25	11,228	129	406	8	14,383	181
1940	1,170	16	1,381	28	1,488	26	14,062	172	252	6	18,353	248
1941	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1942	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1943	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1944	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1945	1,092	54	2,207	110	5,639	282	31,280	1,418	339	39	40,557	1,903
1946	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1947	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1948	(2)	(2)	2,373	119	5,503	275	21,110	608	526	34	29,512	(2)
1949	2,056	91	2,128	106	4,163	208	17,874	555	374	22	26,595	982
1950	684	27	599	26	4,040	202	13,106	599	387	30	18,816	884
1951	2,076	83	1,109	46	1,623	82	8,710	461	280	24	13,798	696
1952	1,984	89	655	39	1,726	86	7,334	314	338	24	12,037	552
1953	3,153	126	1,087	54	1,412	71	8,131	333	432	39	14,215	623
1954	2,903	145	972	49	1,256	68	7,085	294	379	26	12,595	582
1955	4,954	248	1,613	81	1,763	88	10,811	449	356	29	19,497	895
1956	3,728	180	725	36	1,979	99	9,402	433	195	20	16,029	768

TABLE 10 (Continued). **Historical hard-shell blue crab landing statistics, 1880–1980 (thousands of pounds; thousands of dollars).**

	Florida West Coast		Alabama		Mississippi		Louisiana		Texas		Total	
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1957	5,302	318	1,462	73	2,400	144	8,559	419	201	11	17,924	965
1958	8,693	461	1,182	56	2,124	123	9,336	402	570	51	21,905	1,083
1959	13,895	681	1,093	57	3,003	165	9,570	461	1,192	75	28,753	1,439
1960	18,648	895	499	26	2,812	169	10,050	497	2,867	177	34,876	1,764
1961	17,130	736	838	46	2,505	143	11,910	514	2,875	178	35,258	1,617
1962	10,356	487	634	35	907	55	9,523	463	4,473	289	25,893	1,329
1963	13,148	644	1,297	75	1,112	64	7,982	447	2,980	199	26,519	1,429
1964	14,068	843	1,762	110	1,286	82	5,692	379	2,484	175	25,292	1,589
1965	20,598	1,185	1,812	153	1,692	131	9,284	635	3,622	286	37,008	2,390
1966	16,547	912	2,183	182	1,457	105	7,986	537	2,778	228	30,951	1,964
1967	13,976	817	2,353	188	1,015	79	7,559	520	2,625	222	27,528	1,826
1968	9,008	674	1,980	159	1,136	108	9,551	807	4,084	329	25,759	2,077
1969	11,584	1,074	1,920	223	1,740	177	11,602	1,072	6,343	599	33,189	3,145
1970	14,786	1,076	1,407	144	2,027	193	10,254	928	5,525	509	33,999	2,850
1971	12,279	952	1,997	212	1,259	126	12,186	1,256	5,810	567	33,531	3,113
1972	10,673	959	1,613	195	1,362	169	15,083	1,777	6,464	653	35,195	3,753
1973	9,599	1,147	2,098	294	1,815	231	23,080	2,811	6,881	830	43,473	5,313
1974	10,134	1,280	1,826	284	1,667	227	20,640	2,701	6,088	832	40,355	5,324
1975	12,807	1,585	1,640	283	1,137	177	17,144	2,510	5,992	948	38,720	5,503
1976	12,048	1,966	1,299	281	1,335	268	15,211	3,061	6,668	1,179	36,561	6,755
1977	15,832	3,119	2,174	548	1,919	473	16,379	3,765	8,249	1,947	44,553	9,852
1978	11,679	2,235	2,009	458	1,940	423	15,207	3,189	7,470	2,004	38,305	8,309
1979	11,198	2,235	1,314	383	1,311	316	17,370	3,885	8,312	2,146	39,505	8,965
1980	11,263	2,392	1,557	464	2,748	690	16,342	3,874	8,953	2,456	40,863	9,876

(1) – less than 500 pounds or $500.00.
(2) – data not available.

or July as peak months. Reported landings then begin to decline along with water temperature. These general trends may shift slightly from month to month depending upon prevailing environmental and/or market conditions.

3.3.3 Percent Contributions – States to Gulf Landings ana Gulf to United States Landings

The percent contribution of each state to the total Gulf of Mexico blue crab landings from 1960–1980 is shown in Table 11. Prior to 1960, Louisiana led the Gulf coast in total reported landings. In 1959, Florida surpassed Louisiana and remained in the lead through 1967. Landings were roughly equal between these states from 1968 through 1971, however, Louisiana regained the lead in blue crab production in 1972 and remained there through 1980.

Prior to 1968, Texas contributed about 10% of the total Gulf landings. From 1968 through 1977, Texas landings contributed 15 to 18% of the total Gulf landings, increasing to 22% in 1980. Alabama and Mississippi each have contributed about 5% of the total Gulf landings consistently throughout the two decades.

The percent contribution of the total Gulf landings to the total U.S. landings for 1960–1980 are shown in Table 12. From 1962 through 1967, the Gulf states generally contributed less than 20% of the total U.S. landings. However, this contribution increased gradually to almost 35% in 1977. From 1978 through 1980, the Gulf contribution declined to about 25%.

3.3.4 Trends in Landings by Gear

Dominant commercial gear types used to harvest hard blue crabs in the Gulf are trawls, trotlines and crab pots. Annual reported blue crab landings by gear and state are shown in Table 13.

Reported landings of blue crabs taken in trawls have fluctuated widely. Although directed trawl fisheries for blue crabs exist, much of the fishing is seasonal and is, in many instances, related to economic conditions in other fisheries. Louisiana and Texas produced most of the trawl-caught crabs from 1948 through 1960, with Louisiana leading in later years. In Texas, landings of trawl-caught crabs have always been incidental to the shrimp fishery. Florida's trawl crab catch increased substantially in 1963 when a directed otter trawl fishery for crabs began. Gulf-wide landings from trawls were low and steady between 1948 and 1956, increasing to record levels in 1965. All states, except Alabama, experienced an increase from 1964–1965. Louisiana's landings alone increased by almost

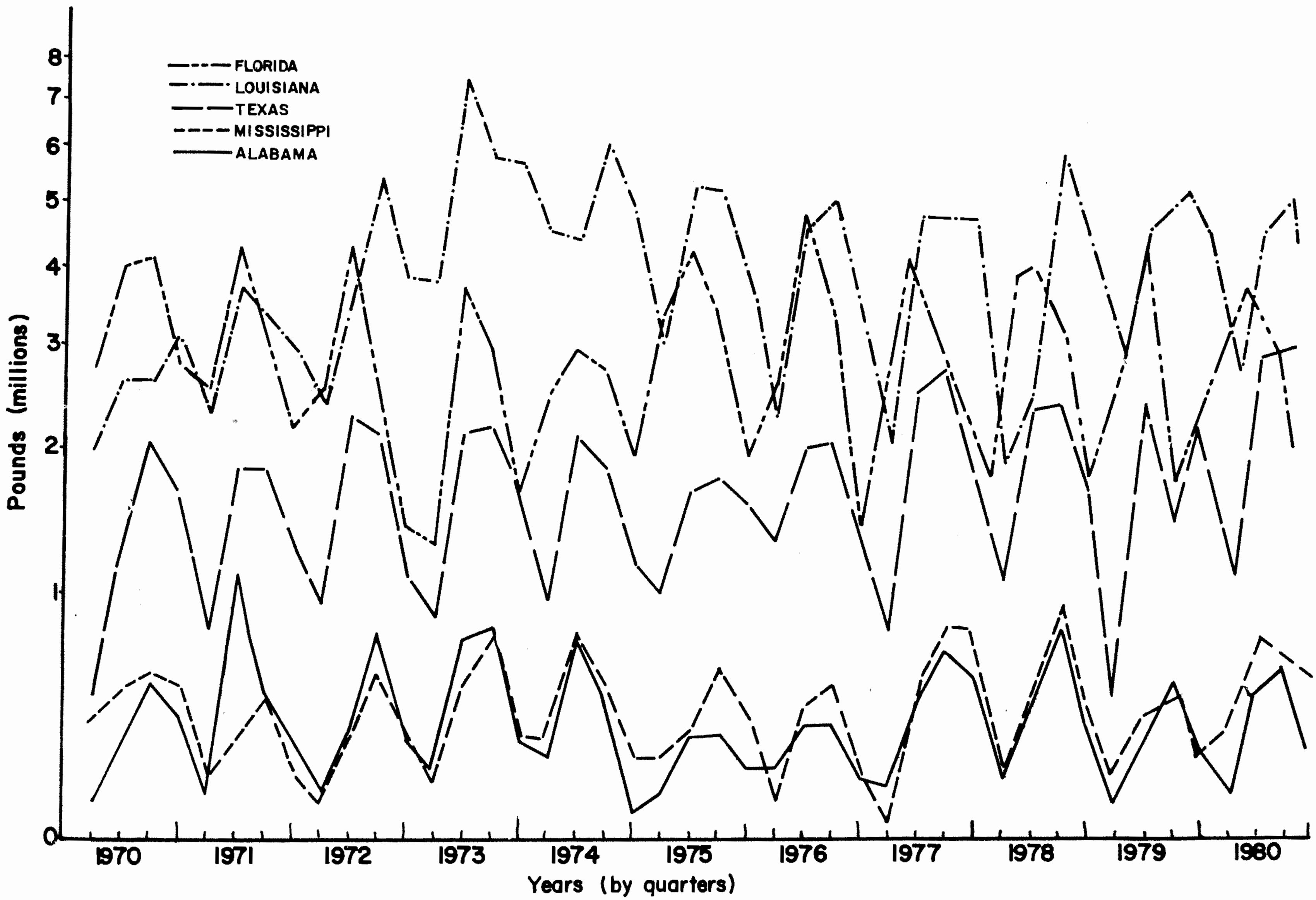


Figure 17. Seasonal blue crab landings by state, 1970–1980.

1026 (2)

TABLE 11. **Percent contribution by state to total Gulf landings.**

Year	Florida–Gulf	Alabama	Mississippi	Louisiana	Texas
1960	53.5	1.4	8.1	28.8	8.2
1961	48.6	2.4	7.1	33.8	8.2
1962	40.0	2.4	3.5	36.8	17.3
1963	49.6	4.9	4.2	30.1	11.2
1964	55.6	7.0	5.1	22.5	9.8
1965	55.7	4.9	4.6	25.1	9.8
1966	53.5	7.1	4.7	25.8	9.0
1967	50.8	8.5	3.7	27.5	9.5
1968	35.0	7.7	4.4	37.1	15.9
1969	34.9	5.8	5.2	35.0	19.1
1970	43.5	4.1	6.0	30.2	16.3
1971	36.6	6.0	3.8	36.3	17.3
1972	30.3	4.6	3.9	42.9	18.4
1973	22.1	4.8	4.2	53.1	15.8
1974	25.1	4.5	4.1	51.1	15.1
1975	33.1	4.2	2.9	44.3	15.5
1976	33.0	3.6	3.7	41.6	18.2
1977	35.5	4.9	4.3	36.8	18.5
1978	30.5	5.2	5.1	39.7	19.5
1979	28.3	3.3	3.3	44.0	21.0
1980	27.6	3.8	6.7	40.0	21.9

TABLE 12. **Percent contribution of Gulf landings to total United States landings.**

Year	Percent
1960	23.3
1961	23.9
1962	17.3
1963	18.7
1964	16.6
1965	22.2
1966	18.6
1967	19.0
1968	22.7
1969	25.1
1970	23.4
1971	22.5
1972	23.9
1973	31.8
1974	27.1
1975	30.0
1976	32.3
1977	34.6
1978	27.7
1979	25.8
1980	25.0

67%. This increase was followed by a 71% decline which lasted through 1967. Despite a drop in 1972, landings generally increased Gulfwide from 1967 through 1973, declining again through 1976. Record trawl landings in 1965 amounted to only 6% of the total reported Gulf landings for that same year.

Reported landings of blue crabs caught on trotlines declined sharply from 1948 to 1952, leveled off from 1952 to 1961, and then steadily declined to less than 1% of the total 1976 Gulfwide landings. Louisiana has consistently produced more trotline-caught crabs than the other Gulf states, with all reported trotline landings coming from Louisiana during the period 1972 through 1976. The decline in landings of blue crabs caught on trotlines is attributable to the increased use of crab pots Gulfwide.

Reported landings of blue crabs caught in pots have shown a steady increase from 1948 to 1973. Fluctuations occurred between 1960 and 1962, 1965 and 1968, as well as 1973 and 1976. Pot-caught crabs began to influence total state landings in Florida by 1954 and in Texas as early as 1952. By 1960, every state except Alabama and Louisiana reported more crabs caught in crab pots than any other gear.

Drop nets were used only in Louisiana to catch blue crabs. Landings from this gear are shown in Table 14. Blue crab landings from drop nets generally increased from 1948 through 1961. By 1964, the use of drop nets began to decline and reported landings ended in 1972.

3.4 Harvesting – Soft Crab Fishery

3.4.1 Harvesting Techniques, Landings, Value and Number of Fishermen by Gear

Recent improvements in the methods of holding and shedding crabs have emphasized the need for the selective harvest of premolt crabs. Directed fisheries for peelers exist only in Louisiana. Bush trotlines are fished in the Barataria Bay estuary and are effective in the selective capture of premolt crabs. Peeler pots and dip nets are used along the northern shore of Lake Pontchartrain to capture shedding crabs. In all states, a variety of gear types have been and continue to be employed although the catch of peelers is, in most instances, an incidental catch. Landings, value and number of fishermen (casual and regular) by gear type are shown in Tables 15 through 17. Harvesting methods for peelers are illustrated and explained in Figures 18 through 22.

3.4.2 Shedding Techniques

Traditionally, crabs were shed in floating boxes (Figure 23). Although this is the least-expensive method of holding shedding crabs, it has several limitations. Successful float operations require good quality water in an area of tidal flow or wave action. Siltation, pollution, rapid

TABLE 13. Blue crab catch (thousands of pounds) by gear by state.

Year	Florida			Alabama			Mississippi			Louisiana			Texas		
	Trawls[4]	Pots	Trotlines[1]	Trawls[4]	Pots	Trotlines[1]	Trawls[4]	Pots	Trotlines[1]	Trawls[4]	Pots	Trotlines[1]	Trawls[4]	Pots	Trotlines[1]
1948	NS[2]	NS	NS	--	--	2,373	--	--	5,503	32	110	20,545	20	341	165
1949	--	89	1,964	--	--	2,128	--	--	4,163	37	85	17,274	8	228	138
1950	--	4	680	32	31	535	--	94	3,946	26	60	12,739	40	195	152
1951	(1)[3]	(1)	2,071	61	22	1,027	--	307	1,316	1	706	7,654	10	185	85
1952	2	135	1,844	42	190	423	--	751	975	37	550	6,402	12	249	77
1953	3	9	3,141	47	394	647	--	674	738	34	517	7,243	22	284	126
1954	3	1,045	1,853	--	120	852	--	233	1,023	120	--	6,387	20	335	19
1955	1	2,735	2,218	--	420	1,193	--	456	1,307	55	--	9,827	21	335	--
1956	2	2,490	1,237	--	386	339	--	812	1,167	41	--	7,331	(1)	195	--
1957	2	4,861	431	--	360	1,102	--	1,018	1,382	73	17	6,795	35	142	25
1958	6	7,799	889	--	255	927	--	1,279	844	98	13	7,390	114	387	69
1959	11	12,844	1,041	--	241	852	--	2,797	206	137	19	7,414	256	928	8
1960	17	17,343	1,289	--	140	359	--	2,607	204	140	38	7,557	82	2,784	--
1961	64	16,065	1,001	--	420	418	--	2,335	170	904	38	8,613	131	2,744	--
1962	33	10,073	251	1	631	2	--	841	67	709	57	6,812	328	4,138	7
1963	81	12,828	240	(1)	1,293	4	--	1,029	83	568	82	5,902	180	2,801	--
1964	98	13,626	345	118	1,585	59	--	1,108	178	649	297	3,368	174	2,228	--
1965	118	20,021	457	36	1,760	16	5	1,634	54	1,953	1,119	4,640	245	2,944	--
1966	87	16,311	148	9	2,165	8	--	1,295	163	669	3,126	3,476	238	2,455	--
1967	164	13,688	120	10	2,343	--	--	996	19	464	4,279	2,263	54	2,571	--
1968	138	8,865	--	46	1,933	--	--	1,116	20	449	5,414	2,869	232	3,852	--
1969	243	11,331	--	103	1,817	--	--	1,713	27	945	6,686	3,199	172	6,171	--
1970	101	14,670	--	2	1,405	--	8	2,006	14	1,181	5,728	2,568	267	5,200	59
1971	78	12,201	--	441	1,556	--	--	1,259	--	1,065	9,386	1,734	295	5,496	18
1972	127	10,454	--	87	1,525	--	8	1,355	--	692	11,307	2,916	219	6,246	--
1973	246	9,439	--	120	1,979	--	20	1,795	--	1,301	19,157	2,622	308	6,573	--
1974	69	10,065	--	93	1,732	--	76	1,591	--	206	19,601	833	497	5,591	--
1975	118	12,688	--	49	1,591	--	16	1,121	--	266	15,788	1,089	305	5,687	--
1976	120	11,928	--	18	1,260	--	199	1,135	--	354	14,713	130	125	6,543	--

[1]Trotlines with baits or snoods. [2]No survey taken. [3]Less than 500 pounds [4]Trawls–miscellaneous.

TABLE 14. Catch from drop nets and number of fishermen in Louisiana by year.

Year	Catch (1,000 pounds)	Number of Regular Fishermen	Number of Casual Fishermen
1948	415	54	48
1949	466	90	32
1950	282	40	43
1951	330	39	55
1952	345	50	96
1953	338	74	152
1954	578	102	118
1955	930	58	76
1956	2,031	109	69
1957	1,675	119	65
1958	1,835	141	58
1959	2,000	143	60
1960	2,315	143	61
1961	2,354	230	51
1962	1,946	300	44
1963	1,431	285	59
1964	1,378	388	32
1965	1,573	357	46
1966	716	106	21
1967	553	94	34
1968	819	94	38
1969	772	78	55
1970	778	58	84
1971	2	30	50
1972	167	14	27

changes in environmental conditions (changes in salinity with rainfall), and predation all affect shedding success. Because of this, many operators have turned to shore facilities where water is pumped from the bay or bayou through a series of tanks and returned overboard (Figure 24). Again, many of the environmental problems that affect the float operator also plague this type of shore facility. Recently, the use of closed, recirculating seawater systems has increased shedding success and has allowed facilities to develop in areas otherwise unsuited to shedding crabs (Figure 25).

3.4.3 Landings

The first record of soft crab production in the Gulf dates to 1887 when 133,000 pounds valued at $7,000 were harvested in Louisiana and 15,000 pounds worth $1,000 were recorded from Mississippi (Lyles 1969). Recorded production in Texas, Florida and Alabama began much later with landings rarely exceeding 10,000 pounds. The catch and value of the soft crab fishery by state and total Gulf production are shown in Table 18.

Louisiana remains the largest supplier of soft crabs to the southern states. Landings in the state have fluctuated widely. Jaworski (1982) noted that the substantial increase in landings beginning in 1934 was the result of the development of the bush line fishery. The decline in production in recent years has been attributed to several factors, including a decline in coastal water quality, loss of natural habitat and disease (Jaworski 1971, Perry et al. 1982). Despite the decline in production the value for soft crabs has continued to increase. Growth and expansion of the industry is dependent on the adoption of closed, recirculating seawater systems to hold and shed peelers and the development of directed fisheries to harvest premolt crabs. Development of closed, recirculating seawater systems to hold intermolt-stage crabs until they show molting signs and the commercial feasibility of using stimulating hormones derived from plants to initiate the molt cycle may be alternative solutions to the problem of source of supply.

3.5 Recreational Fishery

Accurate data on the recreational catch of crabs in the Gulf are lacking. The sport fishery is thought to contribute significantly to total fishing pressure, though estimates of the impact of recreational fishing on the resource vary widely.

3.5.1 Gear

Gear in the recreational fishery is varied, including dip nets, "strings with baits," drop nets, fold up traps and the standard hard crab pot. With the exceptions of Louisiana and Texas, recreational fishermen are not required to purchase a license. Although Louisiana has a $2.00 license fee for sports fishermen using from five to ten crab pots, no licenses were sold in 1979–80 because the fee would not cover the cost of processing the application. In Texas, all recreational crab fishermen are required to purchase a general sportfishing license unless they are under 17 years of age, over 65 or are crabbing in the county of their residence.

3.5.2 Landings

In Louisiana the sport fishery landings are estimated to exceed the commercial fishery landings by almost four times. A sport crab survey conducted by the Bureau of Sports Fisheries and Wildlife in 1968 estimated the recreational catch of blue crabs in Louisiana to be 29 million pounds (Lindall and Hall 1970) compared to hard and soft crab reported landings of 9.5 million pounds and 284,000 pounds, respectively. Total Gulf hard crab landings for the survey period were 25.7 million pounds; thus the estimated recreational catch in Louisiana alone exceeded the reported hard crab landings from all Gulf states in 1968.

Tatum (1982) conservatively estimated that the recreational catch in Alabama equaled approximately 20% of the annual commercial catch.

Based on interviews with 810 sports fishermen in the Mississippi Coastal Zone, Herring and Christmas (1974) reported a recreational catch of 50,000 pounds of hard crabs in 1971. Compared to commercial landings of 1,259,230 pounds for that year, the sports catch represented less than 4% of the total. Data from a recreational survey of

TABLE 15. Number of regular and casual fishermen, operating units, catch, and value by gear type for the Florida soft and peeler crab fishery.

	Dip Nets					Trotlines with Baits					Pots					Otter Trawls				
	Fishermen					Fishermen					Fishermen					Fishermen				
Year	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*
1950	15	1	16	(1)	(1)															
1951	5	10	15	2	(1)	86		86	1	(1)										
1952	7	5	12	(1)	(1)	99		114	14	2										
1953						107		105	3	(1)	69		10,575	(1)	(1)					
1954											134	15	16,665	(1)	(1)					
1955											128	21	16,000	1	(1)	120	1	933	(1)	(1)
1956											152	20	17,875	1	1					
1957											227	23	27,265	10	5					
1958											188	20	25,516	1	(1)					
1959		10	100	(1)	(1)						305	15	39,720	3	2					
1960											266	16	34,300	4	2					
1961											221	12	30,358	5	3					
1962	Pound Nets										228	15	32,059	(1)	(1)					
1963											194	24	31,530	4	2					
1964	2		40	11	6						287	19	48,885	2	1					
1965	2		40	4	3						316	43	59,020	8	6					
1966											294	56	52,670	1	(1)					
1967	334	5	105	4	3											110	35	1,787	3	2
1968																88	30	1,850	(1)	(1)
1969											196	48	28,921	(1)	(1)					
1970											215	55	30,940	(1)	(1)					
1971																				
1972											153	37	28,405	(1)	(1)					
1973																				
1974											169	24	27,745	(1)	(1)					
1975											168	24	34,290	2	1					
1976																				

***Thousands of pounds and thousands of dollars.**

(1)–less than 500 pounds or $500.00.

(2)–data not available.

TABLE 16. Number of regular and casual fishermen, operating units, catch, and value by gear type for the Mississippi, Alabama, and Texas soft and peeler crab fishery.

	Mississippi										Alabama					Texas				
	Trotlines with Baits					Pots					Dip Nets (Drop)					Pots				
	Fishermen					Fishermen					Fishermen					Fishermen				
Year	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*
1950											5		5	(1)	(1)					
1951	197	32	229	(1)	(1)	21		1,220	6	2	2	3		(1)	(1)					
1952	191	36	227	3	1	27		2,000	13	4										
1953	53	18	71	(1)	(1)															
1954																				
1955	40	4	44	2	1	22		2,660	4	2										
1956	37	4	41	1	(1)	21		2,510	5	1										
1957	34	4	38	7	1	23	3	2,520	10	2										
1958	27	4	31	9	1	23	8	2,820	12	1										
1959	15	4	20	1	(1)	49	16	4,535	10	1										
1960	11	4	15	2	(1)	57	11	5,150	3	(1)						71		7,099	2	(1)
1961	13	2	15	2	(1)	55	4	6,460	5	1						76		7,200	2	1
1962	11	2	13	(1)	(1)	46	3	5,065	2	(1)						84	3	9,220	6	1
1963						19	3	1,870	3	(1)						80	2	9,668	2	(1)
1964	8	3	11	1	(1)	26	3	2,930	1	(1)						72	4	8,680	(1)	(1)
1965	13	2	15	(1)	(1)	27	7	3,000	1	(1)										
1966						28	6	3,100	1	(1)										
1967						29	5	3,400	1	(1)										
1968						33	8	3,870	1	(1)										
1969						35	36	4,250	(1)	(1)										
1970																				
1971																				
1972																				
1973																				
1974																				
1975																				
1976						20	23	2,950	(1)	(1)										

***Thousands of pounds and thousands of dollars.**
(1)–less than 500 pounds or $500.00.
(2)–data not available.

TABLE 17. Number of regular and casual fishermen, operating units, catch, and value by gear type for the Louisiana soft and peeler crab fishery.

	Pots					Trotlines with Baits					Otter Trawls				
	Fishermen					Fishermen					Fishermen				
Year	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*
1946	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1947	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1948															
1949															
1950															
1951	50	20	3,500	44	26										
1952	49	28	4,070	75	36										
1953	40	25	3,575	108	43										
1954						506	89	631	138	57					
1955						495	108	603	180	90					
1956						429	109	538	93	37					
1957						409	98	507	67	24					
1958						451	93	544	59	30					
1959	3	8	275			443	87	528							
1960						492	95	598	59	29					
1961						498	132	634	68	34					
1962						496	147	643	46	23					
1963						587	122	743	64	32					
1964	25	9	3,250	23	14	590	104	750	49	26					
1965	101	21	11,465	14	10	578	122	786	35	24					
1966	321	76	40,240	20	13	524	125	649	33	22					
1967	470	89	58,785	53	44	388	120	569	20	16					
1968	474	103	65,550	88	71	416	146	562	39	32					
1969	489	105	67,920	61	50	412	159	471	19	16					
1970	490	67	75,760	35	32	308	34	1,197	5	4	2,914	1,305	6,122	(1)	(1)
1971	530	136	84,070	30	32	292	49	629	(1)	(1)	2,791	1,260	6,233	(1)	(1)
1972	571	123	87,632	23	24	289	44	724	(1)	(1)	2,808	1,448	6,291	6	3
1973	609	148	93,595	50	59	151	50	415	8	9	3,188	1,599	7,756	3	2
1974	630	179	108,100	31	43						3,152	1,611	7,052	9	4
1975	687	212	122,840	28	40						3,130	1,595	6,201	2	1
1976	789	226	144,014	26	42						3,168	1,578	7,307	2	1

	Brush Traps					Haul Seines					Dip Nets (Drop)				
1945	526		143,220	877	632	189	6	64	460	331	39	20	2,410	1,033	744
1946	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1947	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1948	130		93,500	295	148	129	3	41	184	92	54	48	4,060	402	201
1949	125		88,500	213	90	108	7	44	82	35	90	32	6,800	160	67
1950	129		88,950	188	86	93	11	44	74	32	40	43	5,110	102	46
1951	130		96,500	243	124	99	3	36	22	13	39	55	4,945	41	25
1952	130		96,500	299	143	85	3	33	23	11	50	96	6,880	51	24
1953	133		101,600	296	123	76	2	29	31	12	74	152	8,270	52	25
1954	100		12,500	247	124	59		24	32	16	102	118	8,235	39	19
1955	152	37	26,825	327	164						58	76	6,990	73	36
1956	131	37	26,400	343	139						109	69	12,175	164	73
1957	105	30	21,000	317	111						119	65	13,750	167	57
1958	88	24	16,800	338	169						141	58	14,575	180	99
1959	88	20	16,200	340	170						143	60	14,750	209	105
1960	85	18	18,200	200	100						143	61	15,114	255	126
1961	141	18	52,300	274	137						230	51	20,559	278	139
1962	74	8	39,950	107	53						300	44	23,436	192	96
1963	88	16	43,160	52	26						285	59	22,792	213	107
1964	65		28,275	24	16						388	32	29,032	112	71
1965	48		17,000	40	27						357	46	28,957	115	80
1966	45		16,500	37	25						106	21	11,067	37	25
1967	48		16,600	52	43						94	34	9,952	553	38
1968	88		35,200	106	63	Dip Nets (Common)					94	38	10,532	51	41
1969	86		38,300	78	64						78	55	8,840	38	31
1970	117	35	41,730	37	33	6	9	15	5	5	58	84	10,520	6	6
1971	110	38	43,150	57	61	6	2	8	32	27	30	50	6,816	2	3
1972	105	28	42,750	44	47	6	6	12	17	18	14	27	3,222	17	19
1973	79	8	41,700	37	44	6	2	8	15	16					
1974	83	10	42,740	57	76	6	2	8	6	8					
1975	81	10	42,680	77	111	6	2	8	3	4					
1976	75	10	42,500	57	93	6	2	8	6	10					

*Thousands of pounds and thousands of dollars.
NS – no survey taken.
(1)–less than 500 pounds or $500.00.
(2)–data not available.

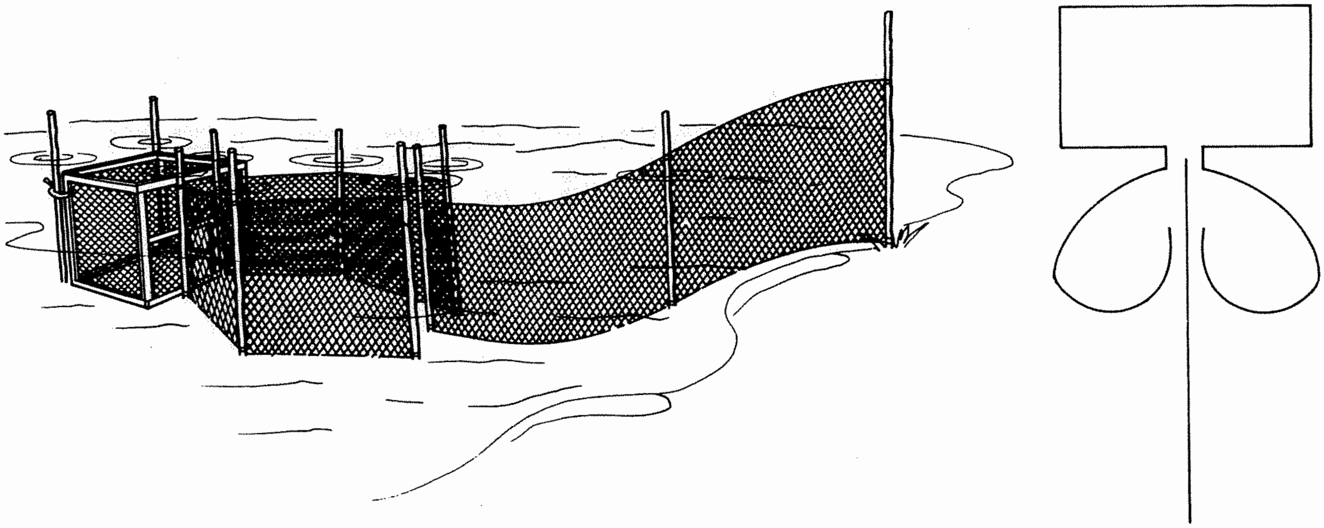


Figure 18. Peeler pound or crab fyke–pound net made of chicken wire. The pot or trap is attached to a wooden frame that rises above the high tide mark so that crabs can be scooped from the top or it is fitted with a lid so that the trap can be lifted out of the water to remove the crabs. Chicken wire leads run from the shore to the trap with "hearts" that direct the crabs toward the funnel. Pounds are common in Virginia in quiet waters in areas where there are known concentrations of peelers (from Dumont and Sundstrom 1961).

Figure 19. Bush trotline (below)–branches of wax myrtle (*Myrica cerifera*) fashioned into bundles and tied to a stout line at approximately 15-foot intervals. Bushlines are successful in shallow, turbid waters with little tidal flow. The bushes are held off the bottom by floats tied to the line at varying intervals. The lines are checked daily. As shown above, each bush is raised by hand and a dip net is placed under the bush to catch any crabs that may fall out when the bush is shaken (from Perry et al. 1982).

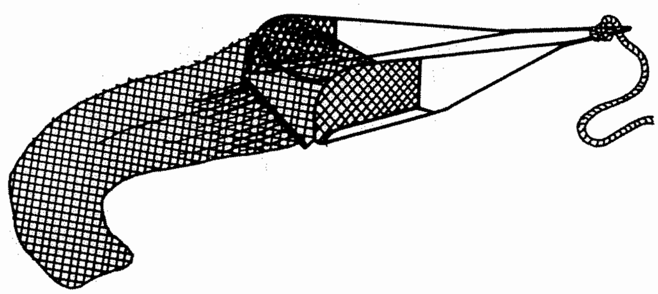
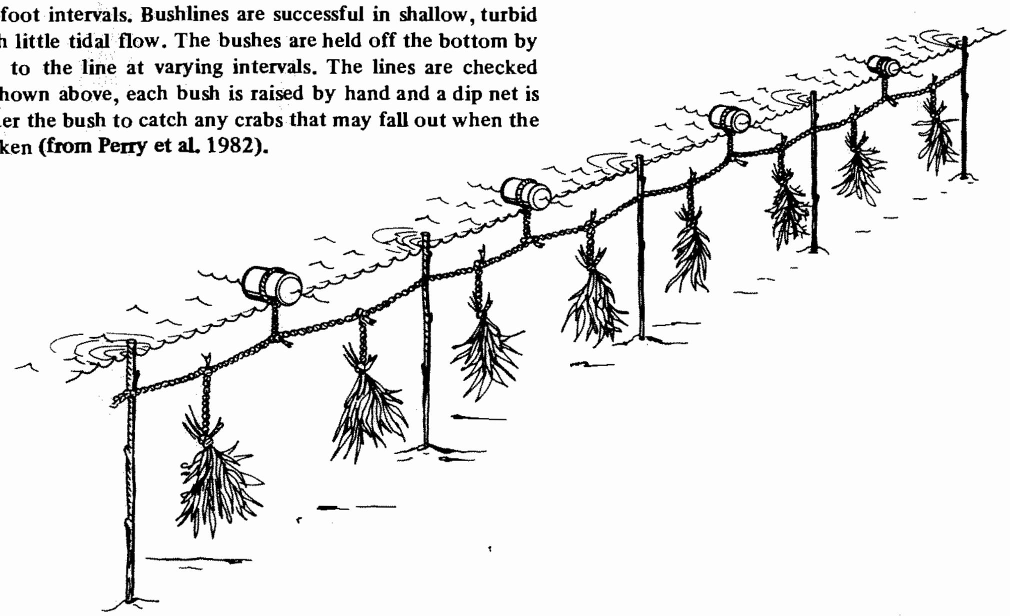


Figure 20. Crab scrape–retangular metal frame with an attached bag of webbing and a bridle for towing. There are no teeth on the scrape bar. In Chesapeake Bay, scrapes are pulled over submerged grasses where peelers congregate seeking protection (from Dumont and Sundstrom 1961).



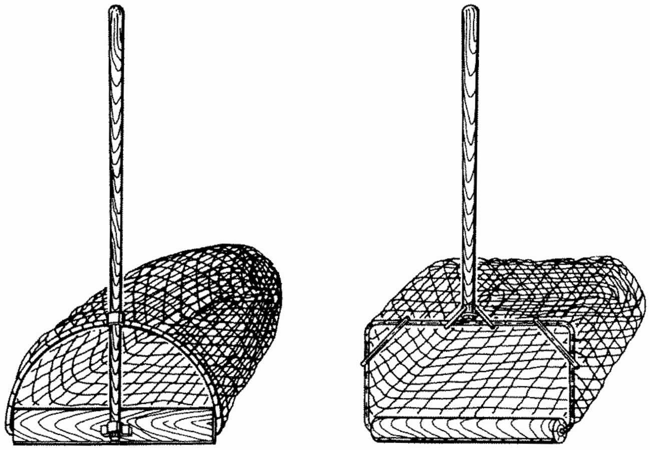


Figure 21. Push net—large-mouth net with a flat wooden blade or a metal roller attached to a 2-inch mesh bag. These nets are pushed over grass beds to "scare" peelers up into the bag. An adaptation of this gear is used on the north shore of Lake Pontchartrain (Louisiana) in the Lacombe area. A fiberglass blade attached to handles is pushed through the grass and "spooked" peelers are scooped up with a dip net (illustrations courtesy of Steve Otwell).

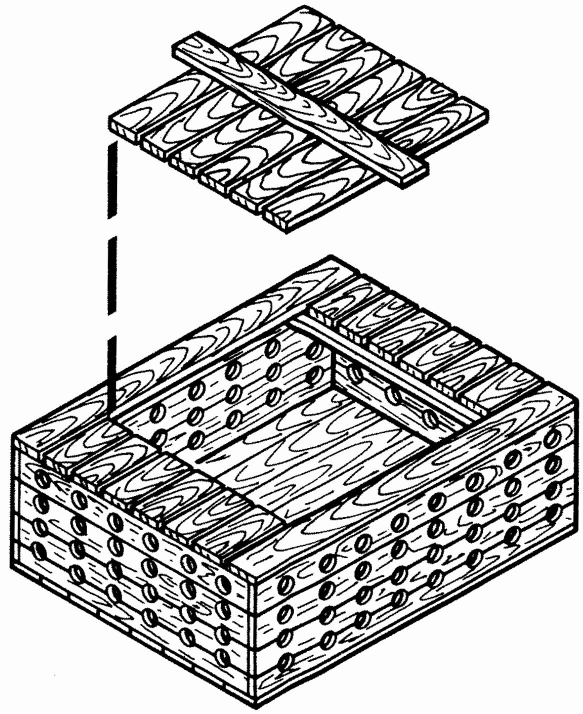


Figure 23. A traditional southern crab float constructed of cypress. The box is wider at one end, producing a taper that allows the box to face into the waves when anchored (from Perry et al. 1982).

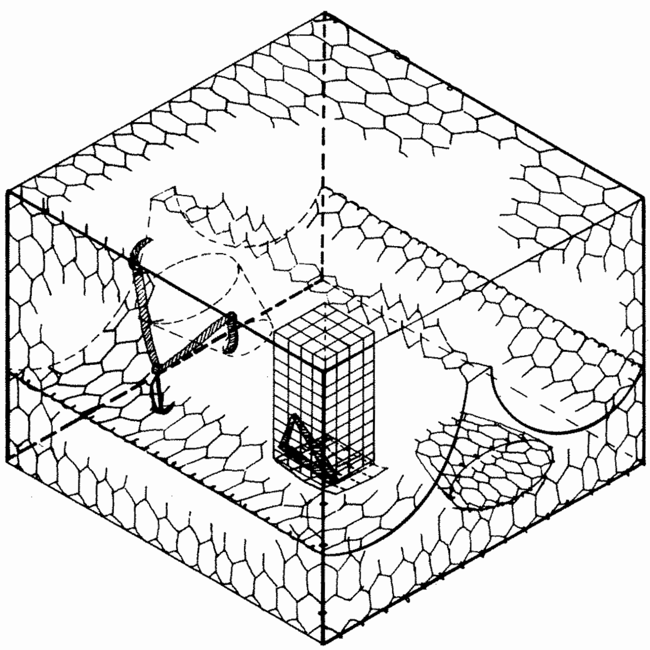


Figure 22. Peeler or "jimmy" pot—traditional crab pot using males as bait to attract females. The success of jimmy pots is dependent upon behavioral patterns exhibited by pubertal-molt females and upon the ability of fishermen to "fish out" or remove a sizable portion of the male crabs from a natural population. The removal of large numbers of male crabs from the natural environment makes the captive "jimmy" crab more attractive to pubertal-molt females seeking a mate. In areas where this gear is employed, it is seasonally effective with highest catches in the spring and early summer. A 1-inch wire mesh may be used in the construction of this pot, and the upper compartment of the pot may be modified to keep jimmies separated from the females. In some areas, shrubbery or frayed rope is put into traditional crab pots to attract peelers of both sexes seeking protection (from Perry et al. 1982).

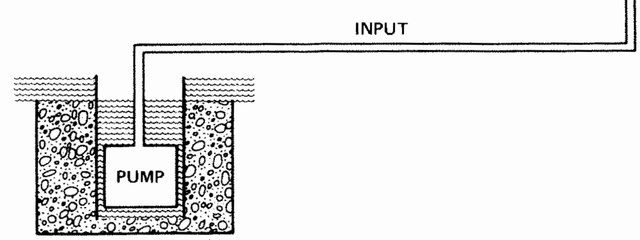


Figure 24. A land-based shedding system consisting of a pump in a mechanical filter box, plumbing, venturi aerators, crab tanks and drains (from Perry et al. 1982).

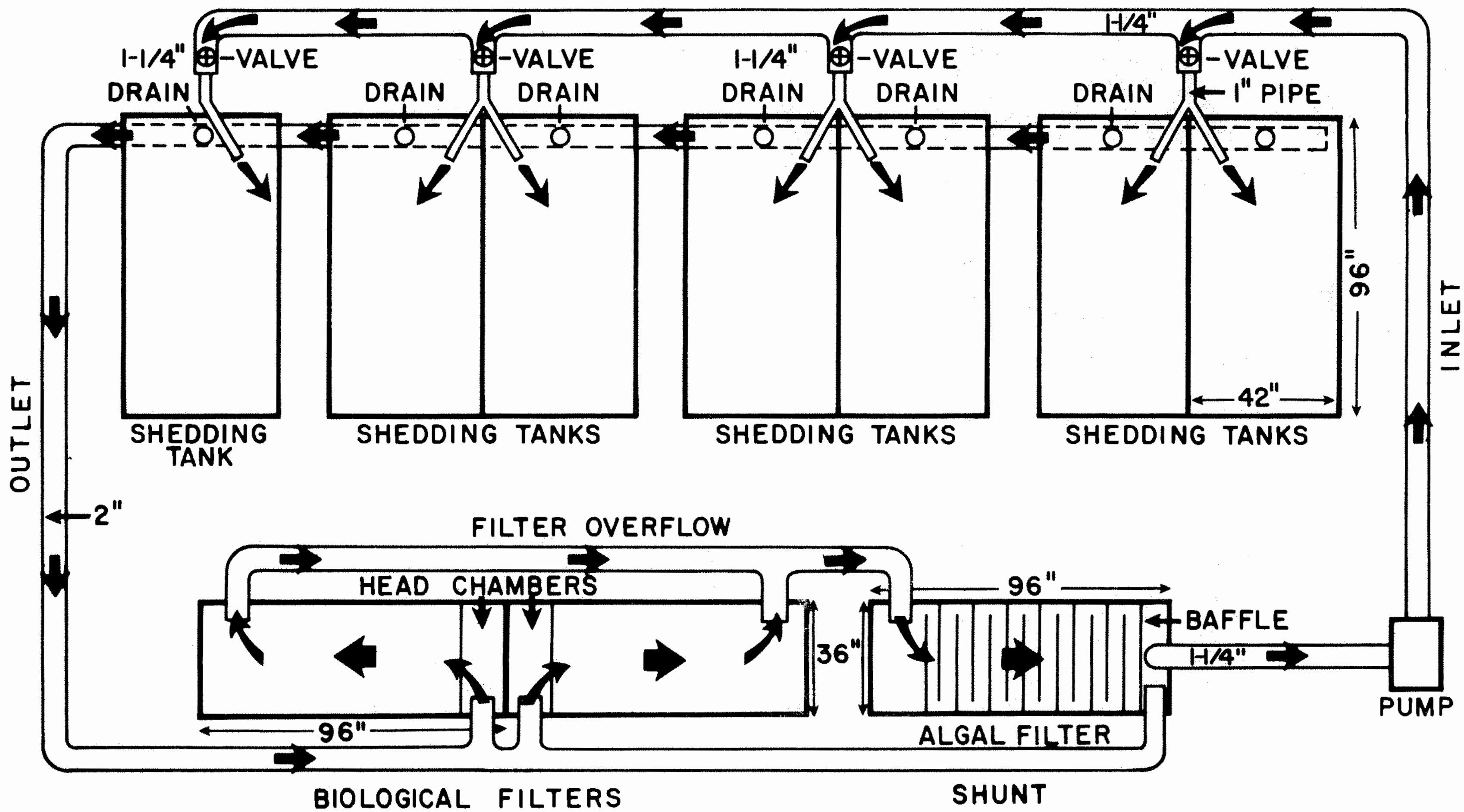


Figure 25. Diagram of an operational commercial shedding system using recirculating seawater (from Perry et al. 1982).

TABLE 18. **Historical soft-shell blue crab landing statistics, 1880–1980 (thousands of pounds; thousands of dollars).**

	Florida West Coast		Alabama		Mississippi		Louisiana		Texas		Total	
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1880	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1887	(2)	(2)	(2)	(2)	15	1	133	7	–	–	(2)	(2)
1888	–	–	–	–	40	1	143	7	–	–	183	8
1889	–	–	–	–	19	1	147	8	–	–	166	9
1890	–	–	–	–	15	1	130	7	–	–	145	8
1891	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1892	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1895	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1897	–	–	–	–	21	2	–	–	–	–	21	2
1898	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1899	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1901	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1902	(1)	(1)	–	–	30	3	–	–	–	–	30	3
1904	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1905	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1908	–	–	–	–	47	6	78	21	1	(1)	126	27
1915	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1918	–	–	–	–	9	2	–	–	1	(1)	10	2
1919	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1920	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1921	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1922	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1923	–	–	–	–	9	2	3	1	–	–	12	3
1924	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1925	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1926	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1927	–	–	–	–	8	2	137	48	–	–	145	50
1928	–	–	3	1	67	12	183	52	–	–	253	65
1929	–	–	4	1	12	4	81	25	–	–	97	30
1930	–	–	1	(1)	6	2	146	58	–	–	153	60
1931	–	–	1	(1)	5	1	121	45	–	–	127	46
1932	–	–	1	(1)	4	1	99	25	–	–	104	26
1933	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1934	–	–	2	(1)	4	1	651	86	–	–	657	87
1935	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1936	–	–	1	(1)	3	1	365	53	–	–	369	54
1937	2	(1)	–	–	2	(1)	329	51	–	–	333	51
1938	–	–	–	–	–	–	248	37	–	–	248	37
1939	–	–	–	–	–	–	215	33	–	–	215	33
1940	–	–	–	–	(1)	(1)	252	40	–	–	252	40
1941	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1942	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1943	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1944	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1945	–	–	–	–	–	–	2,370	1,706	–	–	2,370	1,706
1946	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1947	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1948	(2)	(2)	–	–	–	–	881	440	–	–	(2)	(2)
1949	–	–	–	–	–	–	455	192	–	–	455	192
1950	(1)	(1)	(1)	(1)	–	–	364	165	–	–	364	165
1951	4	1	(1)	(1)	6	2	350	188	–	–	360	191
1952	15	2	–	–	15	4	448	215	–	–	478	221
1953	3	(1)	–	–	(1)	(1)	488	203	–	–	491	203
1954	(1)	(1)	–	–	–	–	455	215	–	–	455	215
1955	1	(1)	–	–	7	3	581	290	–	–	589	293
1956	1	1	–	–	6	1	600	250	–	–	607	252

TABLE 18 (Continued). Historical soft-shell blue crab landing statistics, 1880–1980 (thousands of pounds; thousands of dollars).

	Florida West Coast		Alabama		Mississippi		Louisiana		Texas		Total	
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1957	10	5	–	–	17	3	551	192	–	–	578	200
1958	1	(1)	–	–	20	2	577	298	–	–	598	300
1959	3	2	–	–	11	1	605	302	–	–	619	305
1960	4	2	–	–	5	1	514	256	2	(1)	525	259
1961	5	3	–	–	7	1	620	310	2	1	634	315
1962	(1)	(1)	–	–	2	(1)	344	172	6	1	352	173
1963	4	2	–	–	3	1	329	164	2	(1)	338	167
1964	13	7	–	–	2	(1)	200	127	(1)	(1)	215	134
1965	12	9	–	–	1	(1)	204	141	–	–	217	150
1966	1	(1)	–	–	1	(1)	128	85	–	–	130	85
1967	7	4	–	–	1	(1)	146	121	–	–	154	125
1968	–	–	–	–	1	(1)	284	207	–	–	285	207
1969	(1)	(1)	–	–	(1)	(1)	197	161	–	–	197	161
1970	(1)	(1)	–	–	–	–	90	79	–	–	90	79
1971	–	–	–	–	–	–	127	126	–	–	127	126
1972	(1)	(1)	–	–	–	–	102	109	–	–	102	109
1973	–	–	–	–	–	–	119	132	–	–	119	132
1974	(1)	(1)	–	–	–	–	96	127	–	–	96	127
1975	2	1	–	–	–	–	110	155	–	–	112	156
1976	–	–	–	–	(1)	(1)	88	145	–	–	88	145
1977	–	–	–	–	–	–	224	570	–	–	224	570
1978	22	27	–	–	2	1	133	276	–	–	157	304
1979	9	5	–	–	–	–	119	272	–	–	128	277
1980	16	12	–	–	–	–	79	182	–	–	95	194

(1) – less than 500 pounds or $500.00.
(2) – data not available.

Galveston Bay, Texas, produced similar results. Benefield (1968) estimated the recreational catch of blue crabs from Galveston Bay to be 33,125 pounds or 5.9% of the commercial harvest from that area.

The data of Lindall and Hall (1970) emphasize the need for accurate recreational catch statistics to estimate total production.

3.6 Incidental Catch

In addition to the commercial and recreational hard and soft crab fisheries, large numbers of crabs are harvested as "by-catch" in other fisheries. Adkins (1972a) noted that commercial shrimp fishermen in Louisiana "eat, give away, swap for supplies or sell many of the crabs they catch while trawling for shrimp." Results of field interviews of sport and commercial shrimp fishermen from a single docking facility in Terrebonne Parish, Louisiana, follow.

Results of field interviews of sport trawlers and commercial trawlers showing bushels, pounds, and percent of blue crabs utilized but not reported as landings (modified from Adkins 1972a).

	Sports	Commercial
No. of interviews	26	40
Time interviewed	Daily	Weekly
No. bushels/pounds* caught	42/ 1,890	5,538/249,210
No. bushels/pounds (not reported)	42/ 1,890	203/ 9,135
Percent (not reported)	100	3.7
Total number bushels/pounds (yearly not reported)	2,100/94,500	4,060/182,700

*1 bushel = 45 pounds

Adkins (1972a) also reported that during the late fall and winter crabs are frequently taken in shrimp trawls following strong cold fronts. He noted that one shrimper, trawling in the mouth of a deep bayou, caught 8,000 to 9,000 pounds of crabs in a single day. These crabs were sold but no record of the transaction was made. Commercial and recreational butterfly or wing net (paupier) fishermen also harvest large numbers of crabs. According to Adkins (1972a) these "paupier" crabs are "eaten, given to friends, or sold, thus not entering into commercial landings."

Data on incidental catch from other Gulf states are lacking.

4. SOCIO-ECONOMICS

4.1 Regional Landings, Ex-vessel Value and Price per Pound

Total United States reported landings for hard shell blue crabs in 1980 amounted to 163.2 million pounds valued at 35.2 million dollars, accounting for 30% of the total U.S. crab catch (combined species) and 12% of the value. Following significant declines in king and snow crab landings, the blue crab became the dominant crab species landed, capturing 43% of the total U.S. landings and 16% of the value in 1981 (Dressel and Whitaker 1982).

Nearly 41 million pounds of hard blue crabs were landed in the Gulf states in 1980, accounting for about 25% of the total U.S. blue crab landings. Production in the Gulf lags behind both the Chesapeake and South Atlantic regions. Landings, value and price per pound for major crab-producing regions are shown in Tables 19 through 22. Landings by region are presented graphically in Figure 26. Total reported landings and catch percentages between regions have not changed significantly over the past 20 years (Dressel and Whitaker 1982).

TABLE 20. **Hard blue crab landings, value and price per pound, Chesapeake Bay, 1960–1980.**

Year	Landings*	Value*	Price/Pound ¢
1960	66,338	3,535	5.4
1961	70,634	3,411	4.8
1962	81,332	4,293	5.3
1963	63,072	3,697	5.9
1964	74,112	4,994	6.7
1965	82,561	6,239	7.6
1966	94,104	5,852	6.2
1967	79,412	4,675	5.9
1968	54,186	6,010	11.1
1969	56,654	5,374	9.5
1970	67,351	4,475	6.6
1971	73,882	5,171	8.4
1972	72,036	6,288	8.7
1973	56,285	6,849	12.2
1974	65,510	8,308	12.7
1975	59,083	9,294	15.7
1976	45,191	9,683	21.4
1977	56,421	11,358	20.1
1978	52,645	10,806	20.5
1979	64,652	12,395	19.2
1980	62,995	12,825	20.4

*Thousands of pounds and thousands of dollars

TABLE 19. **Hard blue crab landings, value and price per pound, United States, 1960–1980.**

Year	Landings*	Value*	Price/Pound ¢
1960	149,646	7,810	5.2
1961	147,652	6,737	4.6
1962	149,374	7,539	5.0
1963	141,743	7,719	5.4
1964	152,292	9,267	6.1
1965	166,996	11,237	6.7
1966	166,827	9,963	6.0
1967	145,027	8,603	6.0
1968	113,619	11,143	10.0
1969	132,255	12,459	9.4
1970	145,410	10,317	7.1
1971	149,081	12,921	8.7
1972	147,468	14,671	10.0
1973	136,516	17,661	13.0
1974	149,176	19,259	13.0
1975	130,816	18,793	14.4
1976	113,152	22,966	20.3
1977	128,860	27,454	21.3
1978	138,230	28,180	20.4
1979	152,830	31,424	21.0
1980	163,206	35,167	21.5

*Thousands of pounds and thousands of dollars

TABLE 21. **Hard blue crab landings, value and price per pound, South Atlantic, 1960–1980.**

Year	Landings*	Value*	Price/Pound ¢
1960	44,786	2,115	4.7
1961	40,350	1,589	3.9
1962	38,731	1,657	4.3
1963	50,769	2,454	4.8
1964	52,011	2,570	4.9
1965	45,976	2,468	5.4
1966	40,517	2,006	5.0
1967	37,335	2,008	5.4
1968	33,316	2,994	9.0
1969	41,280	3,795	9.2
1970	42,701	2,772	6.5
1971	39,551	3,262	8.2
1972	36,248	3,631	10.0
1973	31,813	4,182	13.1
1974	38,315	4,553	11.9
1975	30,502	4,089	13.4
1976	27,369	5,199	19.0
1977	31,131	6,337	20.4
1978	47,425	8,841	18.6
1979	48,877	9,315	19.1
1980	55,147	10,772	19.5

*Thousands of pounds and thousands of dollars

TABLE 22. **Hard blue crab landings, value and price per pound, Gulf of Mexico, 1960–1980.**

Year	Landings*	Value*	Price/Pound ¢
1960	34,876	1,764	5.1
1961	35,258	1,617	4.6
1962	25,893	1,329	5.1
1963	26,519	1,429	5.4
1964	25,292	1,589	6.3
1965	37,008	2,390	6.5
1966	30,951	1,964	6.4
1967	27,528	1,826	6.6
1968	25,759	2,077	8.1
1969	33,189	3,145	9.5
1970	33,999	2,850	8.4
1971	33,531	3,113	9.3
1972	35,195	3,753	10.7
1973	43,473	5,313	12.2
1974	40,355	5,324	13.2
1975	38,720	5,503	14.2
1976	36,561	6,755	18.5
1977	44,553	9,852	22.1
1978	38,305	8,309	21.7
1979	39,505	8,965	22.7
1980	40,863	9,876	24.2

*Thousands of pounds and thousands of dollars.

4.2 Ex-vessel Value Trends

Although ex-vessel prices have continued to rise, inflation accounted for much of the increased price per pound paid to the fishermen. According to Dressel and Whitaker (1982), discounting inflation, real prices paid to U.S. blue crab fishermen have increased at a compound rate of 2.1% per year or 50% during the past 20 years.

Since 1960 the annual reported commercial landings of blue crabs in the Gulf states have varied from a low of 25 million pounds in 1964 to a high of over 44 million pounds in 1977. There was a steady increase in the rate of growth in landings over that 21-year period. Landings have remained relatively stable at about 40 million pounds per year since 1977. The nearly threefold increase in reported commercial landings may reflect increased processing capabilities, greater fishing effort, market expansion and improved statistical collecting procedures, rather than an increase in biological stocks.

Total dollar value of reported Gulf landings varied from a low of 1.3 million dollars in 1962 to a high of 9.9 million dollars in 1980. The price per pound for the same years was $0.051 and $0.242, respectively. Much of the increase in price can be attributed to price inflation

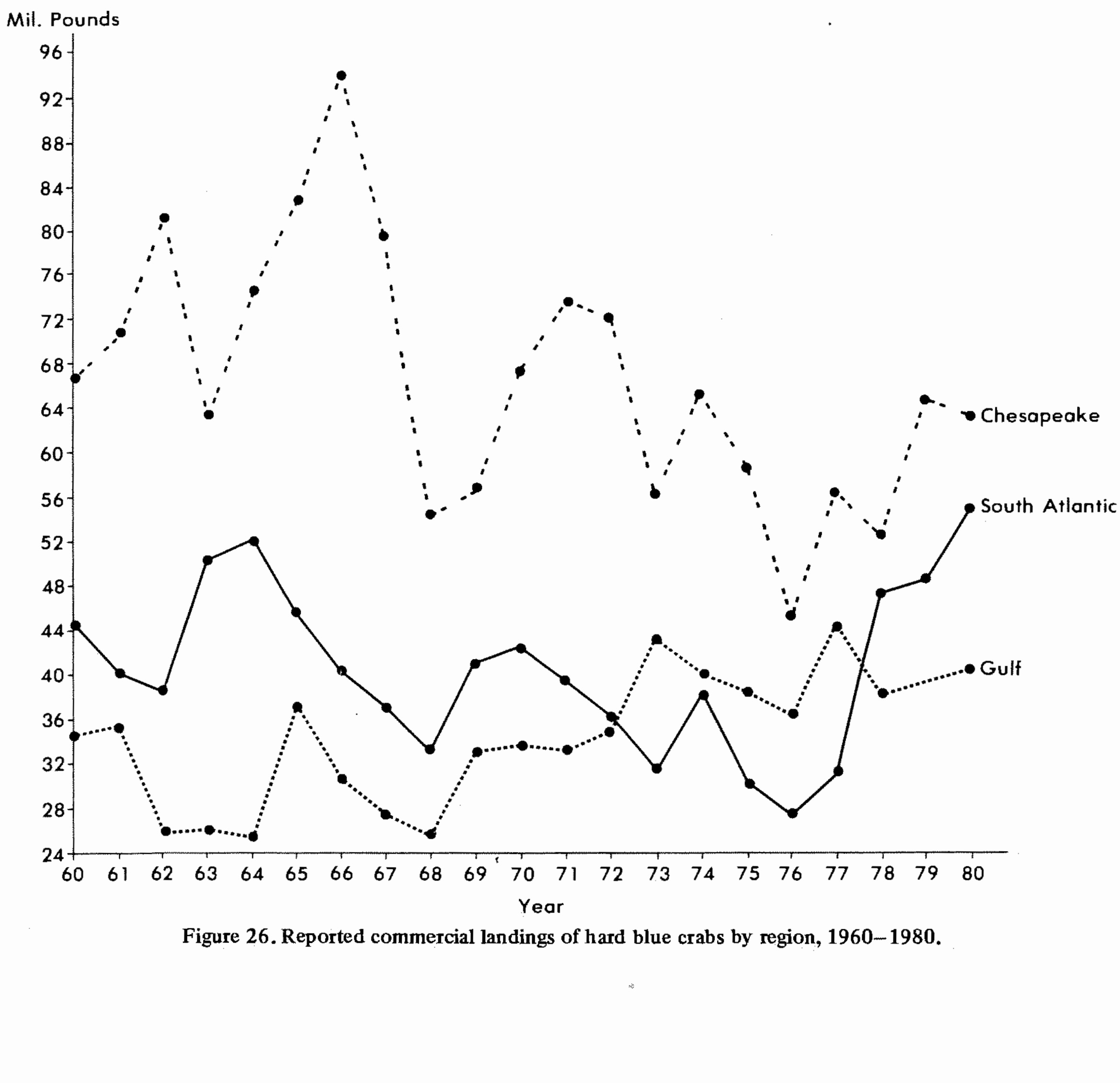


Figure 26. Reported commercial landings of hard blue crabs by region, 1960–1980.

during that period. The price of a pound of live crabs in 1980 of \$0.242 shrinks to \$0.135 in constant 1972 dollars (Figure 27). Therefore, it is evident that the real price of raw materials sold by crabbers has not increased as much as current prices might indicate.

Price relationships between major crab-producing regions and the total U.S. landings are shown in Figure 28. Annual average prices for the U.S. and each region generally exhibited the same trends over the 21-year period. Since 1976, however, wide divergences in price per pound have occurred. Gulf prices have been consistently higher than Chesapeake and South Atlantic prices since the mid 1970's. This may represent a structural change in the blue crab fishery along the Gulf coast. There has been a significant increase in the involvement of east coast processors in the Gulf crab fishery. This has taken the form of partnerships or ownership of Gulf processing facilities, especially in Texas. An unknown, but supposedly large, quantity of live and processed crabs are being diverted from these plants to east coast markets. The increased sales of higher priced large male crabs may account for some of the observed price differential, however, the supply/demand characteristics of the Chesapeake fishery and the high percentage of trawl-caught crabs entering the South Atlantic fishery may depress prices in those regions. Trawl-caught crabs tend to decrease the annual average price for two reasons: (1) trawl-caught crabs are usually females which yield less meat than males, and (2) the incidence of mud and sand lowers the quality of the crab and hence its value (Rhodes 1982).

Hard blue crab landings, value and price per pound are shown for individual Gulf states in Tables 23 through 27. Landings have declined in the Florida west coast fishery following a peak production of 20.5 million pounds in 1965. The fishery in Mississippi and Alabama has remained relatively stable with production at 1.5 to 2 million pounds. Louisiana remains the major supplier of crabs in the Gulf providing raw crabs for Texas, Alabama and Mississippi processing plants. Landings in Louisiana from 1960 to 1980 declined through the early 1960's, peaked in 1973 at 23 million pounds, and have approximated 16 million pounds since 1975. Reported landings from Texas continued to increase, approaching 9 million pounds in 1980. Reported landings in 1968 were nearly double the landings of the preceding year with gradual yearly increases through 1980.

Prices paid to Florida fishermen have consistently been below the Gulf average. Highest prices traditionally have been paid to Alabama fishermen with the price per pound falling below the Gulf average only twice in the period from 1960 to 1980. Prices in Texas, while generally high, were below average in 4 of the 21 years. Price per pound in Mississippi has always exceeded the Gulf average but is usually below Alabama and Texas prices. Louisiana prices have been below Mississippi, Alabama and Texas but are considerably above the price per pound in Florida.

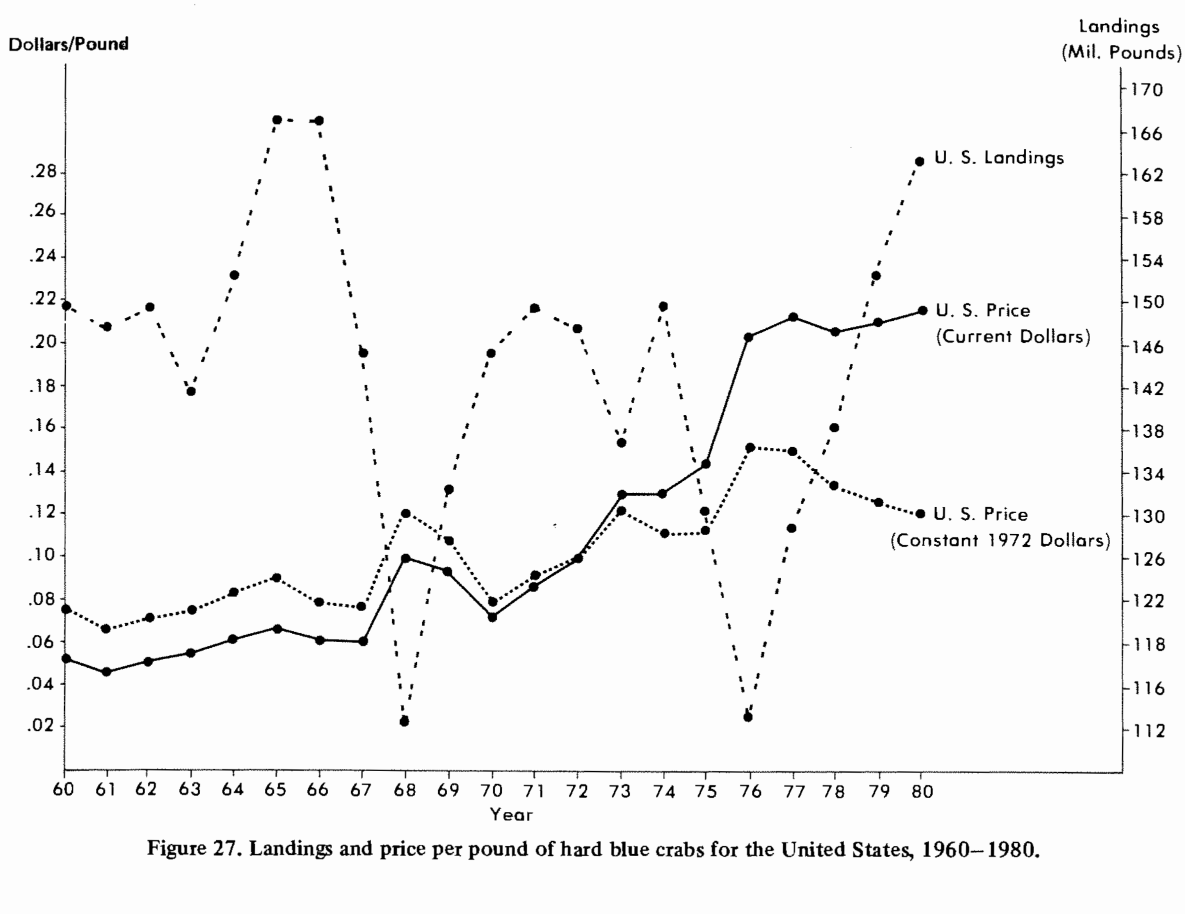


Figure 27. Landings and price per pound of hard blue crabs for the United States, 1960–1980.

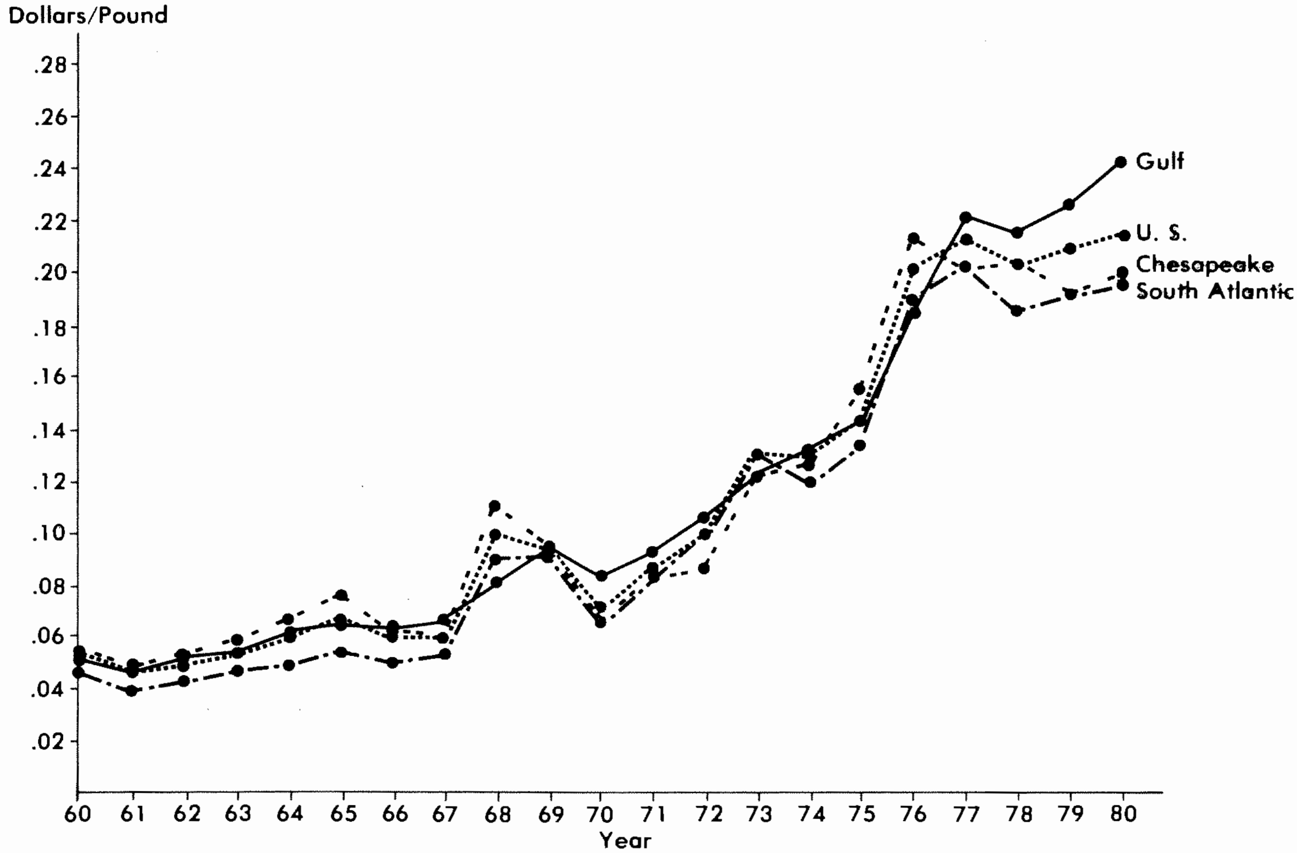


Figure 28. Price per pound of hard blue crabs for the United States and regions, 1960–1980.

TABLE 23. Hard blue crab landings, value and price per pound, Florida Gulf coast, 1960–1980.

Year	Landings*	Value*	Price/Pound ¢
1960	18,648	895	4.8
1961	17,130	736	4.3
1962	10,356	487	4.7
1963	13,148	644	4.9
1964	14,068	843	6.0
1965	20,598	1,185	5.7
1966	16,547	912	5.5
1967	13,976	817	5.8
1968	9,008	674	7.5
1969	11,584	1,074	9.3
1970	14,786	1,076	7.3
1971	12,279	952	7.8
1972	10,673	959	9.0
1973	9,599	1,147	11.9
1974	10,134	1,280	12.6
1975	12,807	1,585	12.4
1976	12,048	1,966	16.3
1977	15,832	3,119	19.7
1978	11,679	2,235	19.1
1979	11,198	2,235	20.0
1980	11,263	2,392	21.2

*Thousands of pounds and thousands of dollars

TABLE 24. Hard blue crab landings, value and price per pound, Alabama, 1960–1980.

Year	Landings*	Value*	Price/Pound ¢
1960	499	26	5.2
1961	838	46	5.5
1962	634	35	5.5
1963	1,297	75	5.8
1964	1,762	220	6.2
1965	1,812	153	8.4
1966	2,183	182	8.3
1967	2,353	188	8.0
1968	1,980	159	8.0
1969	1,920	223	11.6
1970	1,407	144	10.2
1971	1,997	212	10.6
1972	1,613	195	12.1
1973	2,098	294	14.0
1974	1,826	284	15.6
1975	1,640	283	17.3
1976	1,299	281	21.6
1977	2,174	548	25.2
1978	2,009	458	22.8
1979	1,314	383	29.1
1980	1,557	464	29.8

*Thousands of pounds and thousands of dollars

TABLE 25. **Hard blue crab landings, value and price per pound, Mississippi, 1960–1980.**

Year	Landings*	Value*	Price/Pound ¢
1960	2,812	169	6.0
1961	2,505	143	5.7
1962	907	55	6.1
1963	1,112	64	5.8
1964	1,286	82	6.4
1965	1,692	131	7.7
1966	1,457	105	7.2
1967	1,015	79	7.8
1968	1,136	108	9.5
1969	1,740	177	10.2
1970	2,027	193	9.5
1971	1,259	126	10.0
1972	1,362	169	12.4
1973	1,815	231	12.7
1974	1,667	227	13.6
1975	1,137	177	15.6
1976	1,335	268	20.1
1977	1,919	473	24.6
1978	1,940	423	21.8
1979	1,311	316	24.1
1980	2,748	690	25.1

*Thousands of pounds and thousands of dollars

TABLE 26. **Hard blue crab landings, value and price per pound, Louisiana, 1960–1980.**

Year	Landings*	Value*	Price/Pound ¢
1960	10,050	497	4.9
1961	11,910	514	4.3
1962	9,523	463	4.9
1963	7,982	447	5.6
1964	5,692	379	6.7
1965	9,284	635	6.8
1966	7,986	537	6.7
1967	7,559	520	6.9
1968	9,551	807	8.4
1969	11,602	1,072	9.2
1970	10,254	928	9.1
1971	12,186	1,256	10.3
1972	15,083	1,777	11.8
1973	23,080	2,811	12.2
1974	20,640	2,701	13.1
1975	17,144	2,510	14.6
1976	15,211	3,061	20.1
1977	16,379	3,765	23.0
1978	15,207	3,189	21.0
1979	17,370	3,885	22.4
1980	16,342	3,874	23.7

*Thousands of pounds and thousands of dollars

TABLE 27. **Hard blue crab landings, value and price per pound, Texas, 1960–1980.**

Year	Landings*	Value*	Price/Pound ¢
1960	2,867	177	6.2
1961	2,875	178	6.2
1962	4,473	289	6.5
1963	2,980	199	6.7
1964	2,484	175	7.0
1965	3,622	286	7.9
1966	2,778	228	8.2
1967	2,625	222	8.5
1968	4,084	329	8.1
1969	6,343	599	9.4
1970	5,525	509	9.2
1971	5,810	567	9.8
1972	6,464	653	10.1
1973	6,881	830	12.1
1974	6,088	832	13.7
1975	5,992	948	15.8
1976	6,668	1,179	17.7
1977	8,249	1,947	23.6
1978	7,470	2,004	26.8
1979	8,312	2,146	25.8
1980	8,953	2,456	27.4

*Thousands of pounds and thousands of dollars.

4.2.1 Statistical Analyses of Crab Prices

A number of statistical analyses have been conducted to determine the effects of landings of blue crabs on ex-vessel prices and to examine the impacts of landings in various geographical areas on prices in other areas. Two of these studies are discussed followed by a statistical analysis of the impact on Gulf coast crab prices of a number of independent variables.

Prochaska, Cato and Keithly (1982) analyzed dockside prices in the blue crab fishery in Florida from 1952 to 1976 (hereafter referred to as the Florida model). They found that Florida landings had a statistically significant negative effect on Florida prices, while a positive relation existed between per capita income levels and price: a one-million-pound increase in Florida blue crab landings will decrease dockside prices by 0.08 of one cent.

Expressed differently, this means that a 10% change in landings will change Florida dockside prices by 1.9% in the opposite direction (price flexibility at the mean of –0.19196).

Per capita income was the most significant variable in determining the level of Florida blue crab prices: an increase in per capita income of $1,000 results in an increase in Florida dockside blue crab prices of 2.3 cents per pound.

Florida dockside prices per pound have increased since 1961 and appear to be higher on the east coast than on the west coast. Florida's east coast landings were more significant in determining prices than west coast landings. Florida dockside prices have normally been lower than for other Gulf of Mexico states and the Chesapeake region.

There were relatively small dockside price changes for given changes in quantities supplied implying a highly elastic consumer demand exists for Florida blue crabs.

The Florida model used four demand- or price-response models to explain the variation in Florida blue crab prices and to determine what variables were important in causing crab price variations. Prochaska, Cato and Keithly (1982) concluded that the Chesapeake region blue crab supply had a significant negative effect on Florida prices; specifically, a one-million-pound increase in Chesapeake landings would cause a 0.02 of one cent decrease in Florida prices.

Table 28 shows two statistical models developed to explain the impact of selected variables on the ex-vessel price of hard blue crabs. The Florida model used ex-vessel prices in Florida as the dependent variable while the Rhodes model (Rhodes 1982) used ex-vessel prices from the entire Gulf region. Three common independent variables were included in both equations; landings in the Gulf and Chesapeake regions and disposable income. The time periods covered by the two equations are not identical but have considerable overlap. The Florida model included data from 1952 to 1976 and the Rhodes model from 1955 to 1977.

Some similarities and differences can be noted. Both models showed disposable income to be highly significant in price determination and both models were found to explain a large percentage of the total price variation, 99% for the Florida model and 96% for the Rhodes model. Quantity of crabs landed in the Gulf states was not statistically significant in the Florida model. Quantity landed in the Chesapeake region was significant in the Florida model but not in the Rhodes model.

A possible explanation for the differences may lie in the fact that the Florida price was for crabs landed on both the east and west coasts of Florida. Prices for crabs landed on the west coast of Florida tended to be lower than prices in other Gulf states during the period of the analysis. Price and quantity relationships were evidently heavily weighted toward the east coast of Florida and they more nearly paralleled those in the Chesapeake and South Atlantic regions rather than the Gulf region.

Step-wise Regression Analysis

A step-wise multiple regression analysis was conducted using annual landings and price data in an attempt to verify the results of the Florida and Rhodes models. The equation was formulated using reported commercial landings, prices and U.S. total disposable income. Years included were 1960 through 1980. Figure 27 shows the U.S. price for hard blue crabs expressed in both current and constant price for those years.

Ex-vessel prices in the Gulf of Mexico were the dependent variable.

The equation was hypothesized as follows:

$$P_G = a - b_1 Q_C - b_2 Q_{SA} - b_3 Q_G + b_4 I_{TD}$$

where P_G = ex-vessel prices in the Gulf , 1960–1980; a = constant; b = coefficients; Q_C = reported commercial landings in the Chesapeake region; Q_{SA} = reported commercial landings in the South Atlantic region; Q_G = reported commercial landings in the Gulf of Mexico region; and I_{TD} = total U.S. disposable income (billions of dollars).

Even though each of the independent variables was given an equal opportunity to enter the equation, only two were statistically significant.

The final step of the step-wise equation was:

$$P_G = 3.2148 - \underset{(1.98)}{0.00049\, Q_C} + \underset{(21.34)}{0.13915\, I_{TD}} \qquad R^2 = .97$$

Values in parentheses under the coefficients are "t" values.

As with the Florida model, it was found that reported commercial landings in the Chesapeake region were statistically significant in explaining Gulf of Mexico ex-vessel price

TABLE 28. Comparison of price determination models for hard blue crabs landed in the Gulf of Mexico (values in parentheses are "t" values).

Equation	Dependent Variable	Constant	Q_{GM}	Q_C	Q_{SA}	Q_{MA}	I	R^2	Durbin-Watson Statistic
Florida model	P_F	−0.00113	−0.00005 (0.17)	−0.000177* (2.01)	0.000541* (2.31)	0.000776 (1.08)	0.023145* (17.80)	0.99	1.85
Rhodes model	P_G	0.02812	−0.00133* (2.94)	−0.00022 (0.101)			0.00018* (17.31)	0.96	1.26

P_F = Ex-vessel price of hard blue crabs landed in Florida (1952–1976).
P_G = Ex-vessel price of hard blue crabs harvested by pots and trotlines (1955–1977).
Q_{GM} = Quantity of hard blue crabs landed in the Gulf of Mexico (time periods as specified).
Q_C = Quantity of hard blue crabs landed in the Chesapeake region (time periods as specified).
Q_{SA} = Quantity of hard blue crabs landed in the South Atlantic region (time periods as specified).
Q_{MA} = Quantity of hard blue crabs landed in the Middle Atlantic region (time periods as specified).
I = Total disposable income (time periods as specified).
* = Statistically significant at the 0.95 confidence level.

variation. Reported commercial landings in the other regions did not enter the equation. This equation confirmed both the Florida and Rhodes conclusions that disposable income is the independent variable most highly significant in explaining Gulf price variations.

This analysis indicated that a 1% increase in the total U.S. disposable income at the mean ($8.3 billion) would cause a $0.014 increase in ex-vessel price of hard blue crabs in the Gulf, or a $1 billion increase in total U.S. disposable income would increase Gulf prices by $0.002 per pound.

An increase in Chesapeake landings of 1% (666,000 pounds) would decrease Gulf prices by $0.000049 or about 0.005 of one cent. A one-million-pound increase in Chesapeake landings would reduce Gulf prices by $0.000074 or about 0.007 of one cent. While the statistical tests showed the variables to be significant, the magnitude of the coefficients of those variables was so small as to be considered inconsequential in predicting price changes.

Inflation has reduced the apparent increases in both blue crab prices and personal disposable income since 1960 (Table 29). While per capita disposable income in current dollars has increased from $1,936 in 1960 to $8,002 in 1980 (413%), real per capita income in constant 1972 dollars has increased from $2,695 to $4,473 (166%) over the same time period. The ex-vessel price of hard blue crabs increased from $0.052 in 1960 to $0.215 in 1980 (413%) while the price in 1972 dollars has increased from $0.072 to $0.12 (167%) during the same period. There has been a decline in the real price of hard blue crabs from the high of $0.154 in 1977.

The current ex-vessel price of $0.215 per pound in 1980 is 179% of the constant price of $0.12 per pound.

4.3 Harvesting Sector

4.3.1 Economic Interdependencies

The interdependency of the blue crab fishery with other fisheries has been established by a number of studies (Strand and Matteucci 1977, Meeter et al. 1979, Dressel and Whitaker 1982, Roberts and Thompson 1982). Strand and Matteucci (1977) provided empirical evidence for the existence of short-term economic interrelationships between the Virginia crab and oyster fisheries and suggested that the economic impact of this interdependency may argue for joint management considerations. While interrelationships between the crab fishery and oyster fishery (Meeter et al. 1979) and the crab fishery and shrimp fishery (Roberts and Thompson 1982) have been identified in the Gulf, the year-round availability of blue crabs in the Gulf should serve to lower participation in joint fisheries. Data indicate that the percent participation in more than one fishery varies from state to state. A 1982 survey of crab fishermen in Texas revealed that 73% of those surveyed derived their total income from crab harvesting (Texas A&M University,

TABLE 29. Population, current and constant disposable income, and hard blue crab prices for the United States, 1960–1980.

			Per Capita Disposable Income		Price per Pound of Hard Blue Crabs	
Year	Population[1] (Millions)	Total Disposable Income[1] (Billions of Dollars)	Current[1] (Dollars)	Constant 1972[2] (Dollars)	Current[3] (Cents)	Constant 1972[4] (Cents)
1960	179,979	352	1,936	2,695	5.2	7.2
1961	182,992	365	1,985	2,715	4.6	6.3
1962	185,771	385	2,060	2,796	5.0	6.8
1963	188,483	403	2,125	2,849	5.4	7.2
1964	191,141	432	2,248	3,009	6.1	8.2
1965	193,526	476	2,235	3,152	6.7	9.4
1966	195,576	512	2,331	3,274	6.0	8.4
1967	197,457	546	2,399	3,371	6.0	8.4
1968	199,399	590	2,474	3,464	10.0	14.0
1969	201,385	630	2,507	3,515	9.4	13.2
1970	203,810	695	3,390	3,619	7.1	7.6
1971	206,219	746	3,617	3,714	8.7	8.9
1972	208,234	797	3,837	3,837	10.0	10.0
1973	209,860	914	4,315	4,062	13.0	12.2
1974	211,389	998	4,667	3,968	13.0	11.1
1975	212,965	1,096	5,075	4,007	14.4	11.4
1976	214,965	1,196	5,477	4,137	20.3	15.3
1977	216,436	1,312	5,954	4,293	21.3	15.4
1978	218,258	1,463	6,571	4,409	20.4	13.6
1979	220,009	1,642	7,293	4,493	21.0	12.9
1980	227,700	1,822	8,002	4,473	21.5	12.0

Sources:

[1]The Statistical Abstract of the U.S. Department of Commerce, 1974, 1977, and 1981.

[2]Handbook of Cyclical Indicators, A Supplement to the Business Conditions Digest, U.S. Department of Commerce, May 1977.

[3]National Marine Fisheries Service, Annual Landing Statistics.

[4]Calculated from data from the above publications.

unpublished data). In contrast, Roberts and Thompson (1982) noted that 61% of the crab fishermen in Lakes Pontchartrain and Borgne, Louisiana, fished other species in 1980. In addition to full-time fishermen who engage in multi-species harvesting, part-time crabbers who derive a portion of their income from nonfishing activities move in and out of the fishery. Part-time crabbers, whether full-time fishermen or not, are becoming an increasingly important part of the blue crab fishery. According to Dressel and Whitaker (1982) there has been a six-fold increase in the number of part-time harvesters in the U.S. blue crab fishery since 1960. Data from the Gulf tend to substantiate this trend. Landrum and Prochaska (1980) reported an increase in the number of part-time to full-time (more than 50% of income derived from fishing) fishermen in the Florida west coast fishery and suggested that it may reflect an increase in the actual number of part-time fishermen or that fishermen once classified as full-time now receive the larger portion of their income from nonfishing activities.

TABLE 30. **Cost and return budget for a commercial blue crab enterprise in Lake Pontchartrain and Lake Borgne, Louisiana, 1980 (from Roberts and Thompson 1982).**

Description		
Average experience of crabber	20 years	
Average boat length	26 feet	
Average horsepower	240	
Average number of traps fished	218	
Average number of lifts per year	32,112	
Average annual catch	1,781 bushels	
Average annual catch (pounds)	71,240	
Gross Returns		$28,496.00
Variable Costs		
Bait	$6,562.00	
Boat fuel	3,632.00	
Truck operation	2,985.00	
Traps	1,939.00	
Boat and engine repair	1,142.00	
Oil	63.00	
Subtotal		16,323.00
Overhead Costs		
Depreciation: boat and engine	984.00	
Licenses	95.00	
Truck insurance	180.00	
Loan interests	864.00	
Subtotal		2,123.00
Self-employment tax (8.1% of $10,050)		814.00
Total costs		19,260.00
Net returns		9,236.00*

*All commercial crabbers surveyed were free of debt on their boat and engine. Funds set aside for the eventual replacement of this equipment would reduce the amount of net income below $9,236.

The movement of part-time fishermen in and out of the fishery may be the result of economic factors external to the fishing industry or may reflect a seasonal "switch" to a more profitable fishery. During recession years many individuals are inclined to supplement their incomes by crabbing.

4.3.2 *Harvesting Costs*

Cost and return budgets have been prepared for commercial blue crab fishermen in Lakes Pontchartrain and Borgne, Louisiana (Roberts and Thompson 1982), and in Florida (Prochaska and Morris 1978) (Tables 30 and 31, respectively). In both budgets, variable costs far exceeded

TABLE 31. **Costs and returns for 26-foot Cedar Key (Florida) crab vessels, 1971 and 1975 (from Prochaska and Morris 1978).**

Item	1971	1975
Returns:		
Pounds	100,000	100,000
Price per pound[1] (dollars)	0.08	0.12[2]
Dollars	8,000.00	12,385.00
Costs:		
Variable costs:		
Bait	$ 3,560.00	$ 5,466.58
Trap replacement	1,500.00	2,719.06
Fuel	800.00	1,928.84
Vessel repair[3]	420.00	602.03
Transportation	200.00	229.62
Supplies	100.00	153.56
Total variable costs	6,580.00	11,099.69
Fixed costs:		
Interest on investment (10%)[4]	100.00	100.00
Depreciation	50.00	50.00
License	10.00	10.00
Accounting	10.00	12.98
Total fixed costs	170.00	172.98
Total costs	$ 6,750.00	$ 11,272.67
Returns above total variable costs	1,420.00	1,285.31
Returns to operator labor and management (returns less total costs)	1,250.00	1,112.33
Returns to investment (gross returns less all costs except interest on investment and less management charge[5])	– 4,650.00	– 6,761.29

[1] Average 1975 Florida west coast dockside price of blue crab was used because the 1971 budget price differed from 1971 west coast average price by less than $0.01. Consequently, the average 1975 west coast price was the best available approximation for the 1975 budget price.

[2] Actual number used in calculation was $0.12385.

[3] Includes operator's labor at $30.00 per day.

[4] Interest is uniformly charged against all investment, whether or not borrowed.

[5] Management charge is the value of operator's management in alternative employment. It was estimated by cooperating fishermen to be $6,000.00 in 1971 and adjusted by the consumer price index for "all items" to be $7,973.62 in 1975.

fixed costs with bait the major expense. Major expenditures in the Florida fishery were for bait, trap replacement and fuel, with these costs representing 89.7% of the total expenditures. Major expenses in the Louisiana study were for bait, fuel and truck operation (fuel, depreciation, repairs). Based on the cost/return budget, Roberts and Thompson (1982) estimated that each commercial crabber was responsible for generating $23,700.00 income to the local economy (using a multiplier of 2.37 and average net returns to the crabber of $10,000.00). Prochaska and Morris (1978), using the expenditures derived from their cost/return budget, estimated a primary economic impact of $186.18 for each $100.00 in sales in the Florida blue crab fishery, the highest for any fishery in the state (Table 32). The Florida model utilized internal data to compute the primary economic impact, while the Louisiana model used an external economic multiplier. Using a multiplier for the Florida data, comparable to the Louisiana multiplier, would have resulted in a similar impact on the local economy.

TABLE 32. Expenditures, sales, income, and primary economic impact associated with the Florida blue crab fishery, 1975 (from Prochaska and Morris 1978).

Item	Dollars per 100 pounds blue crab landed[1]	Dollars per $100 blue crab landed[2]	State Total[3] (Dollars)
Expenditures:			
Bait	5.467	41.790	929,065.10
Trap replacement	2.719	20.784	462,068.41
Fuel	1.929	14.745	327,815.36
Vessel repair	0.602	4.602	102,304.22
Transportation	0.230	1.758	39,086.33
Supplies	0.154	1.177	26,170.85
Interest on investment	0.100	0.764	16,994.06
Depreciation	0.050	0.382	8,497.03
License	0.010	0.076	1,699.41
Accounting	0.013	0.099	2,209.23
Total	11.274	86.177	1,915,910.00
Sales:			
Blue crab	13.082	100.000	2,223,180.00
Income:[4]	1.808	13.823	307,270.00
Primary economic impact:[5]	24.356	186.177	4,139,090.00

[1] Based on total landings in budget of 100,000 pounds of blue crab (Table 31).

[2] $E = (\$100/P_f)\ DQ_f$ where E = expenditures, income, and primary economic impact per $100 of crabs landed; P_f = average price of crabs per 100 pounds of crabs; and DQ_f = expenditures, income, and primary economic impact per 100 pounds of crabs landed (items in column 1).

[3] Based on state landings and sales of blue crabs.

[4] Income is sales of blue crabs less expenditures, and includes wages, crew shares, salaries and profits.

[5] Primary economic impact is computed as expenditures plus sales of crabs.

4.4 Processing Sector

The blue crab processing sector has seen few changes since its beginnings. In a survey of processing plants in 1961, Lee et al. (1963) found that a variable supply of raw product, inadequate labor force and marketing of the processed product were problems in all states harvesting the resource. Recently George H. Harrison, past president of the National Blue Crab Industry Association, noted in an address that, "The past 75 years have given us rather little progress in essence. The crab meat industry is where the bulk of the U.S. food industry was 50 years ago" (Rhodes and Van Engel 1978). Methods of cooking and packing crab meat and the history of the development of mechanical processing were reviewed by Moody et. al. (1982).

4.4.1 Processing Schemes

A typical processing scheme for blue crabs is illustrated in Figure 29. The following review of crab meat processing was taken from Moody et al. (1982) unless otherwise indicated.

Blue crab meat production is still predominantly a hand operation. In the Gulf states, workers pick the white meat and crack open the claws so that the meat can be removed still attached to the cartilage and one of the dactyls. This product is called a "claw finger" or "cocktail claw." On the east coast, the white meat is similarly picked by hand, but the claws are usually mechanically picked to remove the meat from the cartilage. The physical structure of the internal crab body with its segments and partitions has impeded the development of mechanical means of picking the meat while still retaining some of the cohesiveness of the muscle fibers. Because of the decline in the labor force and in the increasing costs associated with picking blue crabs, considerable effort has been expended toward mechanization of the industry. Moody et al. (1982) also reviewed the development of mechanical processing. Research to date has been directed toward mechanical debacking and picking, reformation of machine-picked meat into "lump-like" pieces using an alginate binder and development of consumer-acceptable crab products using machine-picked meat.

Miller et al. (1982) investigated techniques for recovering meat particles left in the core after hand and machine picking. Using a meat/bone separator, they were able to recover an additional 30.0 pounds of product from 100 pounds of crab cores (Figure 30). Included in their study was a review of the sanitation, production, and marketing problems associated with mechanically separated meat.

4.4.2 Methods of Cooking

Unrefrigerated live crabs are normally delivered to the processor by boat or by vehicle shortly after being harvested. The interstate trucking of live crabs over long distances has necessitated development of procedures to minimize mortality. A university study of the survival rates

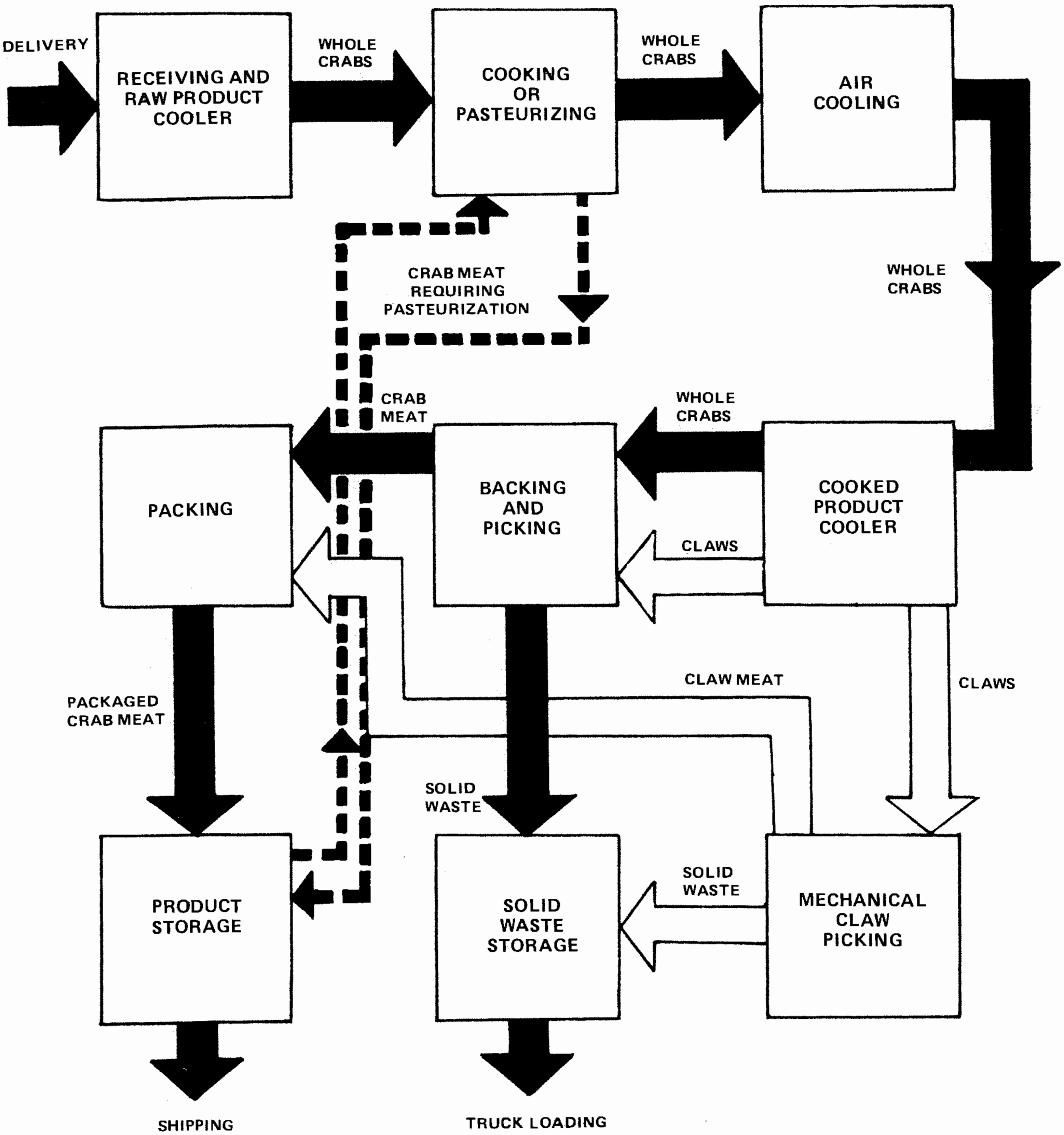


Figure 29. Processing scheme (from Miller et al. 1974).

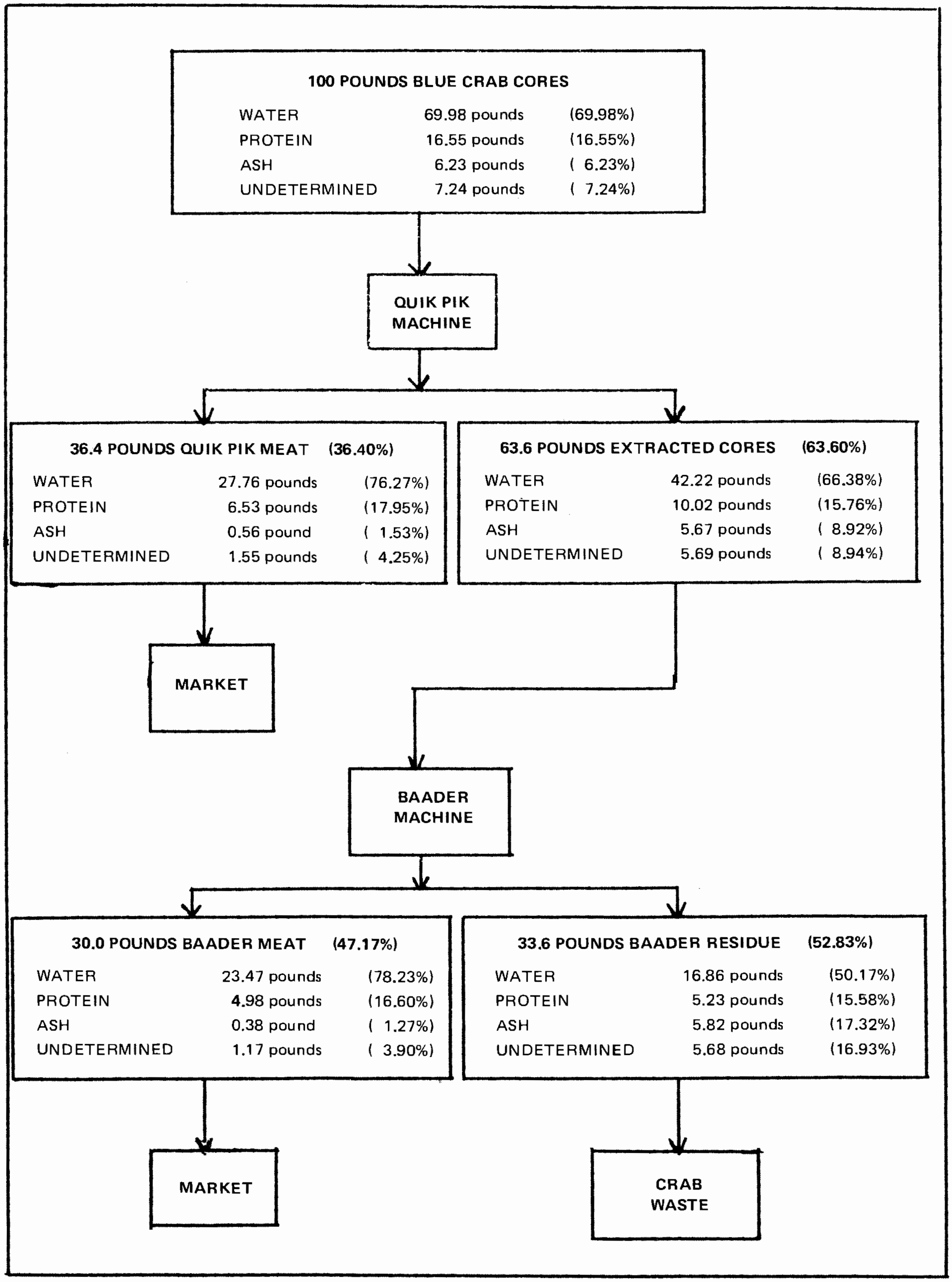


Figure 30. Flow chart of material balance through Quik Pik (mechanical picker) and Baader 694 (mean/bone separator). (Illustration taken from Miller et al. 1982.)

of crabs shipped from North Carolina to Baltimore, Maryland, showed that adequate ventilation, a cool temperature, and an upright position (dorsal side up) in the shipping container were the three factors which in combination guaranteed the highest number of live crabs reaching their final destination. Once in the plant, those crabs not immediately cooked should be stored in a cooler between 40 and 50°F.

Each state that produces crab meat has its own regulations governing the methods of cooking live crabs. In some states only pressure cooking or open steam is allowed. Traditionally, the Gulf states have cooked crabs by boiling. After the water is brought to a boil, the crabs are placed in the vat and cooked for 15 minutes after the water has started to boil again. They are hoisted or dipped from the vat and spread on tables to air cool.

The steam cooking of crabs involves placing them in a metal basket or expanded metal car, enclosing it in a retort and introducing steam at 15 pounds per square inch (psi) (250°F) for approximately 10 minutes. Vertical and horizontal retorts are illustrated in Figures 31 and 32, respectively.

A boiling operation has a cheaper initial equipment cost; all that is needed is an open vat with gas or steam jets to heat the water. A steaming operation, however, requires a boiler to generate steam and a cooking retort. Both items are expensive. Some advantages and disadvantages of each cooking method are summarized below:

Steaming Under Pressure

Slightly lower meat yield

Less water to get on pickers' hands and arms

Cooking time begins shortly after packing retort with crabs; no need to preheat water

Initial equipment cost high.

Boiling

Slightly higher meat yield

Crabs messier to pick

Water must be brought to boiling before adding crabs; after adding crabs, it needs to be brought to a boil again for cooking time.

Comparatively low initial equipment cost.

Processing yield not only varies with the method of cooking, but also with the sex and size of the crab, season, and skill of the picker. The average yield is approximately 14% but can range from 8 to 22% depending upon the above variables.

4.4.3 Methods of Preservation

Most blue crab meat is presently marketed in the Gulf states as a fresh, refrigerated product with a shelf life of 6 to 20 days. Several techniques for preserving blue crab meat have been developed to extend the shelf life. Heating and freezing are in use today by the industry with varying degrees of success. Product acceptability is usually lower for preserved meat than for the fresh product.

Pasteurization

Pasteurization is the process of heating picked crab meat in a hermetically sealed can in a water bath until an internal temperature of 185°F is reached. The meat is held at that temperature for one minute. Heat penetration capabilities for each retort may vary and must be determined for each water bath. After reaching and holding the crab meat at the proper temperature, the crab meat should be cooled to 100°F within 50 minutes after removal from the water bath. Although pasteurized crab meat has an extended shelf life, it must be kept under refrigeration at temperatures above freezing but not exceeding 36°F. A pasteurization tank hook-up is illustrated in Figure 33.

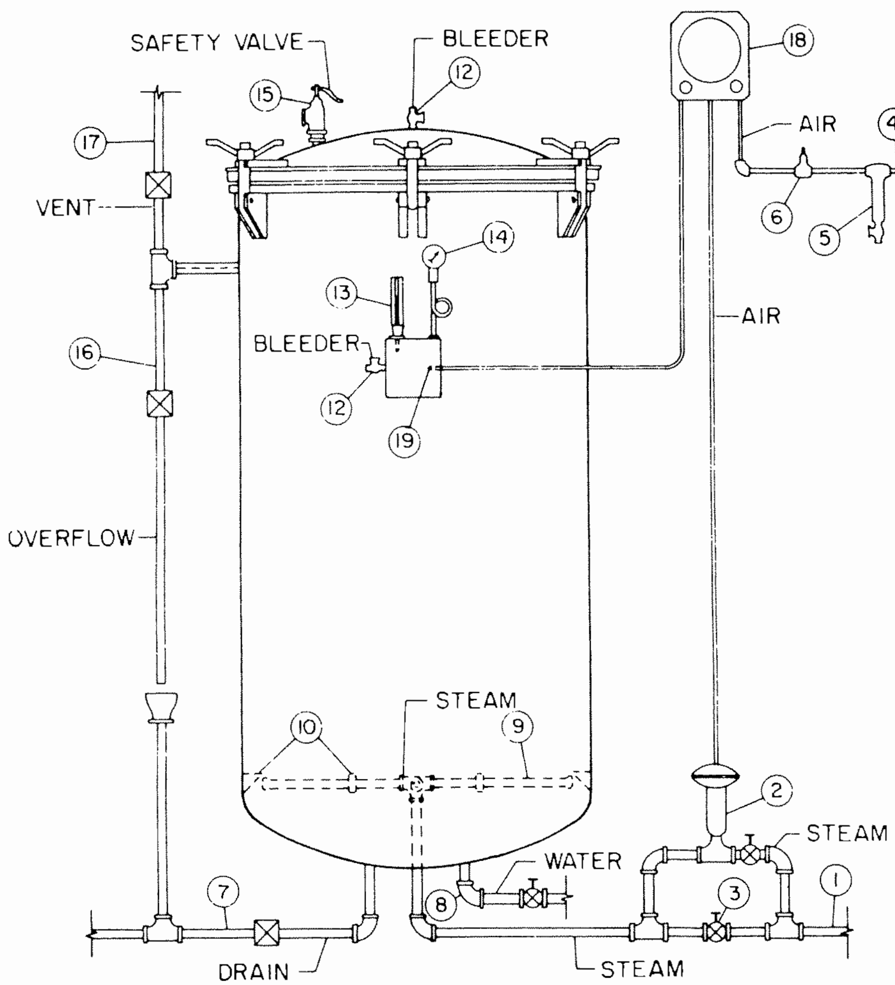
Dressel and Whitaker (1982) reviewed the advantages and costs of pasteurization. The extended shelf life of pasteurized crab meat was found to improve the economics of production by increasing the geographical distribution of sales, increasing the length of the processing season and allowing marketing of the product when demand and price are high. They noted that although difficult to quantify, the economic gains made from lower production costs during times of "glut" and higher product prices during times of "famine" are significant. They estimated the 1981 costs for adding pasteurizing capabilities to an existing plant were:

Heating and cooling tanks	$1,000
Regulator with recording thermometers	3,000
Electric beam and hoist	1,000
Air compressor	400
Plumbing	400
Miscellaneous	1,700
	$7,500

Not included in the above estimates were the cost of the cans (approximately $0.70 each) or the rental of the can sealing machine. Additionally, the cost of trained personnel required to operate the machines and maintain quality control must be considered. The decision as to whether or not to pasteurize ultimately depends upon the product volume of the individual plant or the potential cost savings and marketing advantages.

Sterilization

Production of heat-sterilized crab meat is limited. The sterilization procedure involves cooking the crab meat in a hermetically sealed can in a retort until commercial sterility is reached. Problems arising from sterilization include heat-induced coloration changes in the meat, textural changes, and an "off flavor."



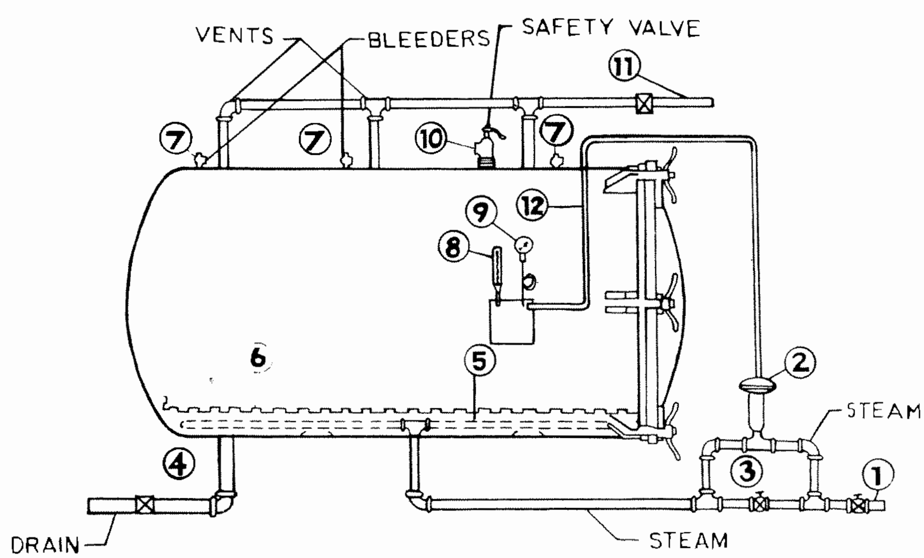
1. Steam Inlet
2. Steam Control Valve
3. By-pass
4. Air, Instrument
5. Filter
6. Pressure Regulator
7. Drain
8. Water Inlet
9. Steam Spreader
10. Basket Supports
11. Vent
12. Bleeder
13. Thermometer
14. Pressure Gauge
15. Safety Valve
16. Overflow
17. Vent
18. Control, Steam
19. Control Element

MANUAL VALVES

GLOBE

GATE

1. Steam Inlet
2. Steam Control Valve
3. By-Pass
4. Drain
5. Steam Spreader
6. Basket Supports
7. Bleeder
8. Thermometer
9. Pressure Gauge
10. Safety Valve
11. Vent
12. Control Element



MANUAL VALVES GLOBE GATE

Figures 31 (upper left) and 32 (lower right). Vertical and horizontal retorts, respectively (from Flick et al. 1976).

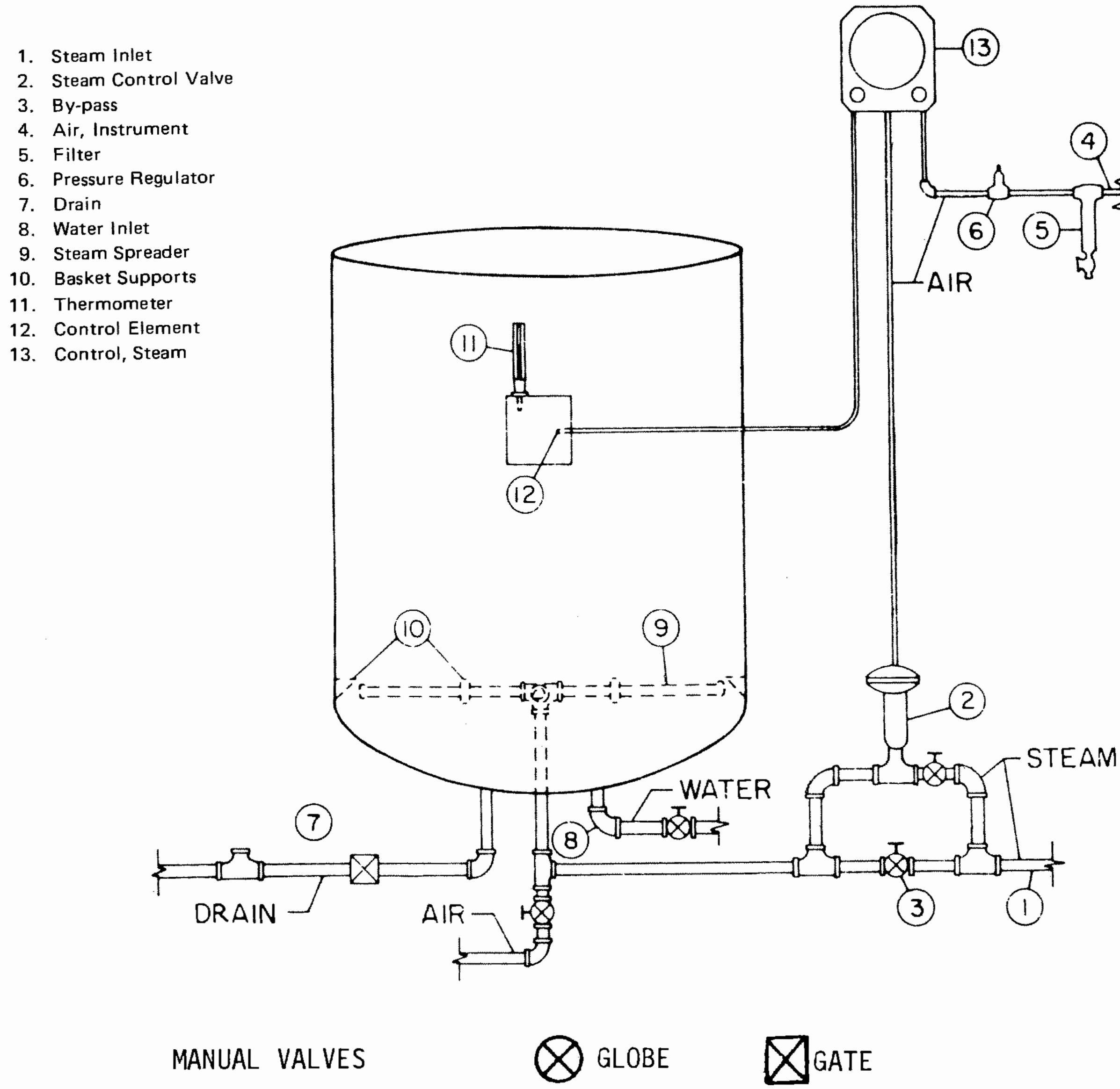


Figure 33. Pasteurization tank hook-up (from Flick et al. 1976).

Freezing – Picked Meat

The quality of frozen crab meat, under conventional processing techniques, does not measure up to the fresh or pasteurized product. Changes in the texture of the meat and a loss of flavor are characteristic of blue crab meat held at 0°F. Strasser et al. (1971) found that rapid freezing using Freon 12 (dichlorodifluoromethane) or low temperature nitrogen, storage below 0°F, and vacuum packaging extended the shelf life of blue crab meat and provided a product that was highly acceptable when compared with fresh, refrigerated meat. Strasser et al. (1971) noted that the quality of frozen-stored crab meat was directly related to the rapidity at which it was frozen.

Freezing – Raw, Cleaned Cores

The seasonal nature of the crab fishery and the limited shelf life of the product are responsible for the "glut" and "famine" conditions characteristic of the blue crab industry. The assurance of a steady supply of raw product throughout the year would help to stabilize the industry.

In the past some crab processors on the east coast have attempted to freeze whole crabs for the purpose of controlling the supply cycle during the year. In most cases meat from these frozen crabs was of poor quality. The freezing of cleaned crab cores has proven to produce a more acceptable product. Meats picked from frozen cores are far superior to regular commercial meats that have been frozen. A series of experiments were designed to determine the best procedure for freezing raw crab cores and cores from crabs given a minimum and a maximum cook. They were either shelf frozen at 0°F or quick frozen in Freon (Tinker and Learson 1970). The cores were placed in plastic bags and stored at 0°F for 2 months. The results of these experiments were as follows:

1. The quality is best retained in the meats picked from crab cores that were given a lesser cook and quick frozen in Freon;
2. Meats picked from cores which had been given the maximum cook showed quality slightly lower than the cores given the lesser cook; and
3. Meats picked from quick frozen cores were always superior to the shelf frozen cores in all the quality attributes (appearance, odor, flavor, and texture).

All the results obtained in studies for the cooking of crabs have shown that meats from crabs given a lesser cook were better in quality after freezing, pasteurizing, and sterilizing than commercially picked meats. It was felt that the minimal cooking process caused less damage to the meats and, therefore, they could be frozen, pasteurized and/or sterilized without too much further reduction in quality. The shorter cook and accelerated freezing cause less damage to protein. Also, by leaving the meat intact in the cores there is less physical damage to the meat than would occur during the normal picking operation.

The quick freezing of crab cores from crabs exposed to a shortened or minimum cook could provide the industry with a ready source of crabs during the periods of low supply.

4.4.4 Production Costs

A production cost profile (Table 33) based on data from Maryland blue crab processors indicates that raw product and labor comprise the largest cost components (Dressel and Whitaker 1982). Similar data were obtained from a profile prepared for Texas plants with raw product and labor accounting for over half of the production costs, however, raw product costs were higher and labor costs lower in the Texas study (Table 34). Variations in yield will alter raw material cost by as much as $1.18 per pound (Table 35).

The continued viability of seafood processing plants was projected by Dressel and Whitaker (1982) by examining trends in production cost increases in relation to changes in prices received as indicated by FOB prices. The average percent increase in production costs for picked crab meat from 1975 to 1980 are shown in Table 36. The total cost of producing one pound of crab meat rose 35% or approximately 7% per year. Increases in production costs were offset by plant price increases of 33% (Table 37) thus processors have been able to pass on price increases to consumers, indicating strong consumer demand.

TABLE 33. Percentage share of cost components of picked blue crab meat, 1980 (from Dressel and Whitaker 1982).

Cost Item*	Percent
Operating Costs	
Live crabs	34.4
Labor	28.6
Containers	7.1
Overhead	14.0
Fixed Costs	
Depreciation	1.9
Interest	0.2
Other	13.8
Total	100.0

*Cost profile based on estimated average yields from hand-picked crabs and an average weighted sales price based on variations in amounts and prices for each grade of crab meat. Distribution costs may be significantly different in highly mechanized plants.

TABLE 34. Costs per pound of processed crab meat in Texas (Texas A&M University, unpublished data).

Crab costs ($0.26 X 8 pounds at 12.5% yield)		$2.08
Processing Costs		
Direct:		
Cooking, backing, cleaning	$0.50	
Picking	0.90	
Container	0.15	
Total Direct	$1.55	
Indirect:		
Overhead	$0.80	
Taxes	0.20	
Transportation	0.20	
Processing Margin	0.67	
Total Indirect	$1.87	
Total Processing Costs		3.42
Total Production Costs		$5.50
Wholesale Margin (7% on cost)		0.38
Retail Markup (24% on cost)		1.42
Price to Consumer		$7.30

TABLE 35. Raw materials costs* based on different yields (from Dressel and Whitaker 1982).

Yield	Dollars per Pound
8%	2.75
10%	2.20
12%	1.67
14%	1.57

*Based on 1980 U.S. average price of $0.22 paid to blue crab fishermen.

TABLE 36. **Average percent increase in production costs for picked blue crab meat, 1975–1980 (from Dressel and Whitaker 1982).**

Cost Item	Percent
Live Crab	23
Labor	21
Containers	65
Overhead	86
Depreciation	200
Interest	––
Total Costs	35
Wholesale Price Increase[1]	33
Retail Price Increase[2]	57

[1] At New York [2] At Baltimore

TABLE 37. **Increases in production costs and price increases, 1975–1980 (from Dressel and Whitaker 1982).**

Production Costs	+ 35%	7.0% annual
Overall Inflation	+ 53%	10.6% annual
FOB Prices	+ 33%	6.6% annual
Retail Prices	+ 57%	11.4% annual

4.4.5 Disposal of Shell Waste

The blue crab fishery produces the second highest weight volume of solid waste in the seafood industry, surpassed only by the bivalve molluscan fisheries. According to Brown (1982), of the 50-million-pound annual crab catch from the Chesapeake Bay, 10% is deducted for "cook loss," approximately 12% for picked meat with the remaining 78% designated as "crab scrap" or waste.

Traditionally, crab scrap has been landfilled, dumped into nearby bodies of water, used as fertilizer or feed, or converted into crab meal. The use of crab scrap as landfill, however, has come under stricter environmental control and has been disallowed in some areas.

The economic uncertainties associated with crab meal production were discussed by Brown (1982). Existing plants have had to meet increasingly strict and costly air pollution control regulations. Additional problems include an inconsistent supply of raw product, an anticipated decline in the protein content of crab scrap associated with increased use of mechanization and fluctuations in the commodities grain market which determines the price of meal. The feasibility of entering into crab meal production was evaluated by Murray (1981) and Murray and DuPaul (1981). The large initial investment required to begin operation coupled with marketing the resulting low-profit product do not make it an attractive alternative to waste disposal at the present time.

In certain areas swine farmers have used crab waste as a feed supplement. Husby et al. (1981) found that king or Tanner crab meal could replace 50% of the soybean meal in a corn-soybean diet for swine with no reduction in weight gain. Additional studies with lactating dairy cows indicated that there was no significant difference in milk production or weight gain between prepared soybean rations and king crab rations. Beef cattle fed crab meal were found to maintain their body weight equal to control animals after a six-week period for adjustment in the rumen microbial populations.

Blue crab scrap has value as fertilizer although no work has been conducted with the waste to establish equivalent application rates with commercially prepared fertilizers. The use of dungeness crab scrap as fertilizer was evaluated by Costa (1978). Various application methods were incorporated with oven-dried, broken shell and tested with two types of pasture crops. No significant difference was found in nitrogen and phosphorous uptake by the plants fed either crab waste or inorganic fertilizers when applied at equivalent rates.

The use of crab scrap to produce chitin/chitosan is still under study. Brown (1982) stated that the industrial production of chitin/chitosan is entirely feasible and economically viable, however, potential commercial users have not afforded it much attention.

4.5 Marketing

4.5.1 Live Product

Live crabs are marketed through sales to processing houses or first level crab buyers or through direct sales to the general public, restaurants or retail outlets. Although the vast majority of crabs are sold for processing, an undetermined percentage of crabs are marketed live locally or shipped to the east coast through the "basket trade." Dressel and Whitaker (1982) estimated that 30% of the total U.S. landings were marketed live in the basket trade. Among the Gulf states, Louisiana, Florida and Texas report significant activity in the basket trade with as much as 20% of the Texas landings sold as live product in eastern markets.

Roberts and Thompson (1982) found that the marketing channels for live crabs varied with geographic proximity to major population centers. They noted that isolation from consumers enhanced the role of the crab buyer, whereas in heavily populated areas the fishermen may market their products directly to the retailer, restaurant or the general public. The participation of part-time crabbers in the fishery was also found to affect distribution of live product; their relatively small volume allowing them to market their catch through channels other than a first level buyer.

The variety of live markets and the large percentage of part-time fishermen in the fishery led to under-reporting of landings and thus economic impact. In their survey, Roberts and Thompson (1982) found that 70% of the crab fishermen used unsurveyed market channels in 1980, accounting for 60% of the total harvest from the lakes. This marketing pattern, if indicative of other areas, indicates that both catch and economic impacts from commercial crab fishing are grossly underestimated.

4.5.2 Processed Product

Approximately 75% of hard crabs are sold as processed product. Product forms include fresh picked and pasteurized meat, breaded specialties and sterilized canned meat which accounted for 64.6%, 26.6% and 8.8% of the 1980 processed crab in the U.S., respectively (Dressel and Whitaker 1982).

Although varying with individual processors, general grades of fresh picked and pasteurized crab meat are as follows:

lump or backfin – large muscles associated with the fifth pereiopod. These are varying grades of lump including jumbo lump (largest pieces), lump (smaller pieces) and deluxe or backfin (a mixture of lump and flake).

flake or special – muscles associated with pereiopods 2 through 4.

cocktail claw or claw finger – muscle of the propodite of the cheliped with dactyl attached.

brown claw or claw meat – muscle of the meropodite.

machine processed – small pieces of meat, used in institutional pack.

The quantity and value of processed blue crab meat and specialty products for the Gulf states are shown in Table 38. Most processed crab meat is sold in the retail market.

The marketing system for blue crabs is similar to that for other seafood. Like other shellfish, crabs require considerable processing to make them consumer-ready.

As is common with highly processed products, the margin is high between ex-vessel prices for the whole animal and the portion appearing on the restaurant diner's plate. This is because of the low yield of edible meat from the live crab and the amount of expensive labor required to pick and prepare crab meat for consumers.

The following depicts the processing and marketing channel for blue crabs (unpublished data from the Texas A&M Sea Grant Program):

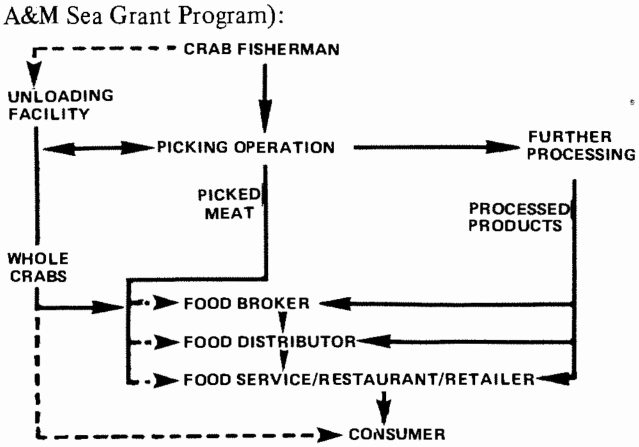


Figure 34 shows the distribution of the consumer's dollar spent for crabs and crab products. The largest share accrues to the processor ($0.48) while the second largest share goes to the fishermen ($0.28).

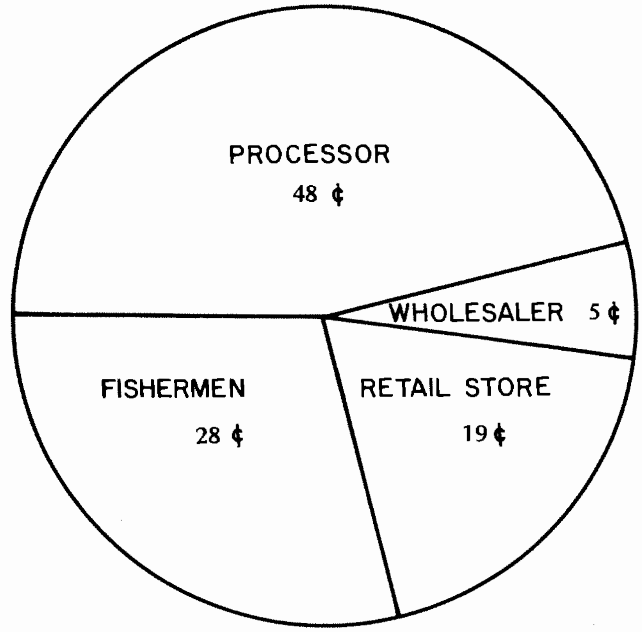


Figure 34. Distribution of consumer's dollar (based on figures in Table 34).

4.6 Demand

According to Dressel and Whitaker (1982) the consumption of blue crab products in the U.S. has been stable during the past 20 years, averaging 20.2 million pounds. They reported per capita consumption in 1980 as 0.10 pound.

4.7 Export–Import

Blue crab landings in the United States are believed to be utilized entirely within the domestic market. According to Smith (1982), there is a potential market for frozen, whole blue crabs in Japan; however, United States producers must be willing to conform to Japanese specifications for packing crabs.

Dressel and Whitaker (1982) reported that some blue crab meat is imported from Mexico and Venezuela but annual quantities are below one million pounds. Total combined crab species imported in 1980 amounted to 11,269,000 pounds with an average price of $2.58 per pound; less than one half the retail price of most blue crab meat.

4.8 Estimated Economic Impact, Gulf

The estimated economic impact of the hard blue crab fishery in the Gulf of Mexico has increased significantly since 1970 (Table 39). That impact was estimated to be more than $85 million in 1980, the highest in history. Table 39 shows the manner in which the impact was

TABLE 38. Quantity and value of processed blue crab meat and specialty products in thousands of pounds and dollars, respectively, by state and year.

	Florida, West Coast				Alabama				Mississippi				Louisiana				Texas			
	Meat[1]		Speciality[2]		Meat[1]		Speciality[2]		Meat[1]		Speciality[2]		Meat[1]		Speciality[2]		Meat[1]		Speciality[2]	
Year	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
1960	1,828	1,677	--	--	67	57	*	*	365	365	*	*	505	525	441	295	390	399	--	--
1961	2,069	1,941	--	--	79	79	*	*	337	320	14	10	480	474	221	167	*	*	*	*
1962	1,337	1,486	*	*	44	44	*	*	121	121	*	*	605	589	188	118	434	444	*	*
1963	1,894	2,246	17	12	202	222	*	*	150	150	*	*	571	673	154	108	330	341	*	*
1964	1,840	2,444	43	39	306	383	*	*	185	204	*	*	321	406	270	185	309	350	*	*
1965	2,598	3,243	26	32	335	416	*	*	250	275	*	*	577	732	276	173	528	598	*	*
1966	1,884	2,461	*	*	428	540	*	*	199	230	*	*	459	582	185	132	338	406	*	*
1967	1,593	2,298	*	*	449	632	*	*	136	164	53	42	395	548	294	175	237	332	†	†
1968	1,275	2,604	343	212	344	547	*	*	193	242	*	*	423	728	329	227	582	878	*	*
1969	1,717	3,091	254	153	324	597	*	*	252	374	--	--	704	1,257	384	297	551	839	*	*
1970	1,514	2,841	517	381	278	569	*	*	338	536	--	--	539	996	318	243	947	1,436	*	*
1971	1,402	3,033	520	411	322	645	*	*	498	828	--	--	618	1,085	437	332	687	1,107	*	*
1972	1,169	2,674	322	247	364	720	*	*	493	1,020	--	--	708	1,541	700	404	1,080	2,366	*	*
1973	1,516	4,158	1,000	614	522	1,344	*	*	678	1,659	--	--	1,276	3,052	80	110	991	2,519	*	*
1974	1,521	4,110	945	728	481	1,335	*	*	721	1,586	--	--	1,207	2,867	82	114	997	2,665	*	*
1975	1,472	4,608	68	69	582	1,888	3,085	3,330	568	1,925	--	--	1,081	3,350	605	416	540	1,913	*	*
1976	1,516	5,999	935	1,048	486	1,893	3,852	4,636	360	1,219	--	--	1,279	4,969	88	155	578	2,601	29	47

[1]Meat includes both fresh and frozen. [2]Specialty products include: deviled crab, stuffed crab, breaded crab, crab rolls, etc. *Less than 500 pounds or $500. †Data not available.

TABLE 39. Estimated economic contribution of the Gulf of Mexico hard blue crab fishery, 1970–1980.

Year	Price per Pound (dollars)	Estimated Meat Price (dollars)	Estimated[1] Retail Price (dollars)	Value Added per Pound (dollars)	Landings (thousands of pounds)	Salable Meat (thousands of pounds)	Total Retail Value (thousands of $)	Total Value Added (thousands of $)	Estimated[2] Economic Impact (thousands of $)
1970	0.084	0.700	2.414	1.714	33,999	4,080	9,849	6,933	24,623
1971	0.093	0.775	2.672	1.897	33,531	4,223	12,990	9,223	26,475
1972	0.107	0.892	3.076	2.184	35,195	4,223	12,990	9,223	32,475
1973	0.122	1.017	3.507	2.490	43,473	5,217	18,296	12,990	45,740
1974	0.132	1.100	3.793	2.693	40,843	4,843	18,369	13,092	45,922
1975	0.142	1.183	4.079	2.896	38,720	4,646	18,951	13,445	47,378
1976	0.185	1.542	5.317	3.775	36,561	4,387	23,326	16,561	58,315
1977	0.221	1.842	6.352	4.510	44,553	5,346	33,958	24,110	84,895
1978	0.217	1.808	6.234	4.426	38,305	4,597	29,555	20,346	73,888
1979	0.227	1.892	6.524	4.632	39,505	4,741	30,930	21,960	77,325
1980	0.242	2.017	6.955	4.938	40,863	4,904	34,107	24,216	85,268

[1]Fisherman's share estimated at 29% of retail prices. [2]Multiplier estimated at 2.5 times retail price of processed crabs.

calculated. Data were not available on retail prices for blue crabs landed in the Gulf so the total spread between ex-vessel and retail prices had to be estimated.

4.9 Socio-cultural Characteristics of Blue Crab Fishermen

Relatively little has been published on socio-cultural aspects of the blue crab fishery. Pesson (1974) in a survey of the coastal fishermen of Louisiana provided data on their attitudes, characteristics, practices and responsiveness to change which may be representative of fishermen in other areas. Included in the survey were responses from 24 crab fishermen.

The coastal fishermen of Louisiana tended to be middle age, were poorly educated and lived in rural communities. Age characteristics showed 52% to be from 40 to 59 years of age with 35% under age 40. One half were full-time fishermen and had been fishing for over 20 years. Part-timers had typically been engaged in fishing for a shorter period of time.

The ownership structure was that 88% owned their own business, 9% were part-owners and 3% were managers. Many of the fishermen preferred to be self-insured with only 45% reported as having insurance. Twenty-two percent had loans to finance their operations.

Louisiana coastal fishermen, as those in other areas, appeared to prefer to operate as independent businessmen. Twenty-six percent said forming cooperatives would be helpful, while 43% expressed negative feelings about cooperatives.

New ideas faced considerable resistance by fishermen with only 19% replying in the affirmative and 81% in the negative.

With respect to new ideas Pesson (1974) stated: "At the time of the study, no substantial change had been made in their fishing operations in recent history. The few ideas which had been adopted were very diverse and indicated that no concerted efforts had been made to introduce new ideas among the fishermen."

Some information in the study dealt specifically with crabbers. Part-time crabbers made up 89% of the total crab fishermen interviewed. Traps were used by 90%, with fish as the typical bait. Sixty-four percent marketed their crabs through dealers, with the remaining proportion marketing the crabs themselves. One third of the fishermen cultured soft-shell crabs. Hired labor was utilized by 17% of the crabbers.

4.10 Socio-cultural Conflicts

Historically, new entrants into commercial fisheries have caused immediate but temporary socio-cultural problems. The most serious recent socio-cultural conflict in the fishery developed as a result of the influx of Southeast Asian refugees to coastal areas. Socio-cultural characteristics of the Southeast Asians contributed to existing problems in fishing communities and created new problems as well. Their tendency to settle in small, rural communities with limited economies, inability to speak English, ignorance of fishing regulations and local fishing customs, life style and their entrance into fisheries already experiencing overcrowding were identified as the major sources of conflict (report from Texas A&M University, 1979).

5. CONDITION OF THE FISHERY

5.1 Current Status of the Stocks

Use of traditional statistical models to assess maximum sustainable yield (MSY) is complicated by the following factors.

- lack of estimates of recreational and incidental harvest
- large unreported commercial harvest
- identification of year classes complicated by year-round spawning
- no demonstrable parent-progeny relationship has been established
- role of offshore recruitment in determining levels of young on nursery grounds is poorly understood
- environmental conditions on nursery grounds are thought to influence levels of harvestable stocks
- lack of an analytical method which would allow consideration of catch by the various harvesting techniques in use in all segments of the fishery
- lack of efficiency estimates and/or changes in efficiency within various gear types
- lack of data on number of and harvest by untended traps
- inability to divide historic data into year-class, size and sex categories
- processing capacity may limit catch and effort
- market conditions may dictate processing volume

Because of the aforementioned limitations, estimates of MSY calculated from surplus production models were not considered reliable. The catch-effort curves generated from these data, while they may not reflect total resource availability, did provide some information on the fishery. These data were used in evaluating the condition of the fishery in the individual Gulf states.

5.2 Condition of the Fishery by State

5.2.1 Florida West Coast

Reported landings in the Florida west coast fishery have fluctuated widely around a 21-year-mean of 13.2 million pounds (Figure 35). Following landings of 20.5 million pounds in 1965, there was a decrease in reported harvest with landings above the mean in only four subsequent years. Although processing capacity is large, it is highly localized. Competition for the resource has become an increasingly important issue. Hard crab fishermen are concerned about the expanding soft crab fishery and the catch of untended traps (ghost traps). The volume of crabs landed per fisherman has increased since 1970; however, the catch per trap has shown an overall decrease (Landrum and Prochaska 1980). Although additional effort has helped to offset the declining catch per trap, crab fishermen now feel that increased effort will not result in a higher catch.

5.2.2 Alabama and Mississippi

The fisheries in Alabama and Mississippi have stabilized with production fluctuating around a 21-year-mean of 1.6 million pounds in each state (Figures 35 and 36). Processing capacity of Mississippi plants may limit catch and effort in times of "glut" with raw product being trucked into the state during times of low supply. Fishing is seasonal with multi-species fishermen operating in both states. Processing capacity of Alabama plants is adequate with raw product brought into the state throughout the year to supplement local harvest and maintain production. Labor may affect production in both states. In those plants that process several species, labor is often diverted to the more profitable fishery. The introduction of Southeast Asian refugees into the labor force has helped to ease labor problems, particularly in Mississippi. The level of local harvest, limited processing capacity, and low technological level of the industry do not encourage expansion of the fishery in either state.

5.2.3 Louisiana

Reported landings in Louisiana peaked at 23.1 million pounds in 1973 and have approximated 16 million pounds since 1975. Landings have been above the 21-year-mean of 12.8 million pounds since 1972 (Figure 36). Although most processing plants are small, capacity is adequate. Much of Louisiana's harvest is marketed as live product. A large portion of the harvested resource is consumed locally. Crabs not utilized locally are shipped to other Gulf states or to east coast markets. There appears to be room for some increase in effort in both the hard and soft crab fisheries. While the influx of Southeast Asian refugees has created some stability in the labor market, there remain problems in maintaining an adequate, dependable work force. Higher paying jobs in the petroleum industry and in other fisheries divert laborers from the crab fishery.

5.2.4 Texas

Reported landings in 1968 were nearly double the landings of the preceding year with harvest above the 21-year average of 5.3 million pounds from 1968 through 1980 (Figure 35). The freezing of whole crabs for shipment to the east coast, expanding basket trade and increased processing capacity have enabled maximum utilization of the harvested resource. Future fishery expansion appears to be more dependent on increased harvesting efficiency rather than on increased effort as effort may be limited by available fishing area. As in Louisiana, Southeast Asian refugees entering the industry have created some stability in the labor force.

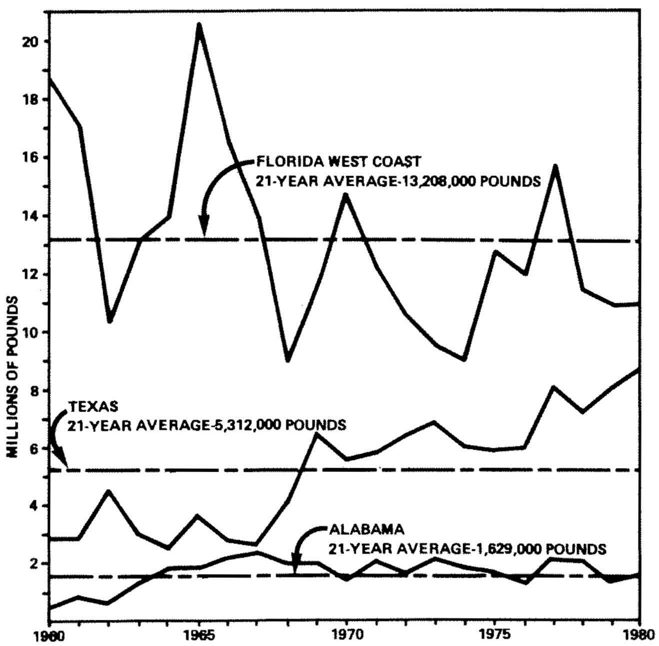


Figure 35. Yearly reported hard crab landings and 21-year average catch for Florida west coast, Texas and Alabama, 1960–1980.

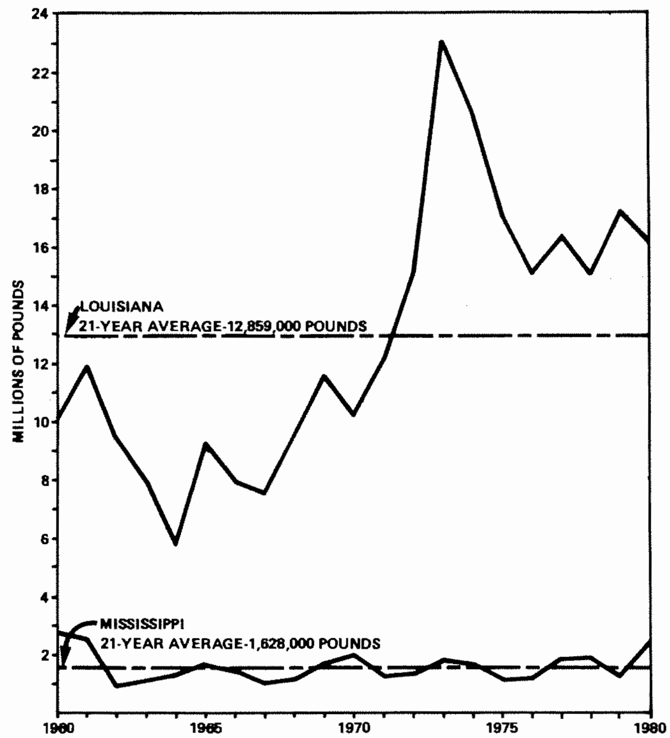


Figure 36. Yearly reported hard crab landings and 21-year average catch for Louisiana and Mississippi, 1960–1980.

5.3 Economic Considerations

Physical growth and expansion of the industry will be limited by resource availability and harvesting and processing capabilities. Landings in most Gulf states have not risen significantly in recent years, thus the ability to produce additional product from the same amount of raw material may provide the only opportunity for industry expansion in the future. While the ex-vessel value of blue crabs has remained relatively stable over the last few years, bait and fuel costs have risen steadily, creating economic hardships in the fishing community. Although per capita crab consumption has been stable during recent years, rising prices for crab products threaten to reach a level resulting in consumer resistance.

5.4 Factors Affecting Abundance

5.4.1 Larvae and Juveniles

Both density-independent and density-dependent variables operate to influence larval and juvenile population levels. The vulnerability of blue crabs to changing environmental conditions is perhaps greatest during the larval and juvenile stages. While current and past crab research has emphasized the role of the nursery area as a limiting factor in determining the success of a year-class or modal group, conditions that affect the initial movement of larvae and postlarvae toward the estuary must also be considered. This differential distribution of early- and late-stage zoeae, though it helps assure wide dissemination of the species, subjects recruitment to the vagaries of offshore transport. The role that offshore recruitment plays in determining levels of young on estuarine nursery grounds is currently under investigation.

Laboratory studies on *Callinectes* larvae indicate that there is a behavioral basis for the vertical distribution of blue crab zoeae. According to Sulkin (1981), "experiments indicate that during the course of blue crab zoeal development changes occur in critical behavioral responses which, through ontogeny, produce a characteristic pattern of differential vertical distribution." From these observations he developed a dispersal-based recruitment model for the Middle Atlantic Bight which included mechanisms for both the estuarine retention of larvae and the recruitment of larvae from offshore. He noted that significant retention of larvae is most likely to occur in stratified estuaries which are wide with respect to depth near the mouth. In such an estuary, larvae released at depth below the pycnocline would be retained. The majority of field data indicate, however, that *C. sapidus* larvae are released to surface waters with the result that they are transported offshore. As these zoeae progress in their development they move to deeper waters which have a pronounced landward drift. This would concentrate late-stage zoeae and megalopae near the mouths of estuaries. That recruitment to the estuary occurs in the megalopal stage has been substantiated in the literature (Tagatz 1968a, More 1969, King 1971, Perry 1975). The Sulkin (1981) model predicts that for large, stratified estuaries, there is a low, but stable, base level of recruitment via retention that is augmented by a highly variable degree of recruitment from offshore and it is the level of this offshore recruitment that is responsible for the annual variations in recruitment success. In smaller estuaries that are stratified aperiodically, or in which stratification is less stable, blue crab recruitment would be more sensitive to the uncertainties of the offshore larval pool and recruitment would be more variable. Understanding mechanisms of larval transport and the effect of changing environmental conditions on survival of larvae are aspects of the life history of the blue crab that have received little attention in the Gulf of Mexico.

Once the megalopae have reached the estuary, the major concerns for survival are related to maintenance of adequate habitat and favorable environmental conditions on the nursery grounds.

The importance of establishing an extended data base to gain an understanding of the relationship between density-dependent and density-independent factors and species-specific estuarine population levels has long been recognized. Estuarine species respond to a multiplicity of physical, chemical, biological and anthropogenic variables. While juvenile sampling programs document observed changes in population levels, the parameters that affect species abundance are complex interactions, not easily defined.

Variations in salinity, temperature, pollutants, predation, disease, habitat loss and food availability all affect survival. The diversity of these parameters and their possible synergistic effects make precise identification of the influence of specific variables difficult. Additionally, the effect of variables such as salinity may be intrinsic (physiological) and/or extrinsic (affecting the composition of the biotic environment). Van Engel (1982) suggested that temperature, salinity and substratum are the primary factors affecting growth, survival and distribution of blue crabs in Chesapeake Bay. Salinity has been identified as a determinant affecting blue crab abundance in Texas bays (Hoese 1960, More 1969). More (1969) found an inverse relationship between salinity and the abundance of juvenile crabs and noted that low crab stocks on the lower Texas coast from 1963 to 1965 were associated with drought conditions. In contrast, Livingston et al. (1976) noted that temperature and salinity might not be as critical in the determination of estuarine population levels as are biological parameters. They observed that biological parameters related to trophic phenomena may play an important role in estuarine population shifts.

5.5 Factors Affecting Commercial Landings

According to Van Engel (1982) fluctuations in Chesapeake Bay landings result primarily from variations in year-class strength and distribution of the stock, both of which he considered largely influenced by density-independent environmental variables. Using simple and multiple correlation analyses to determine the relationship between environmental variables and subsequent harvest, Van Engel and Harris (1979) found that three parameters accounted for 86% of the variation in the total 12-month biological year (September through August) commercial landings from September 1965 through August 1975. These variables were identified as the cooling degree days at Norfolk, Virginia, in May of the year of the hatch, meridional wind stress of Delaware Bay in January following the year of the hatch, and an index of juvenile crab abundance from the York River in fall of the year of the hatch and in the following spring and summer.

More (1969) listed changes in recruitment to the fished population and migrations to and from fishing grounds as factors influencing landings in Galveston Bay, Texas. In Florida, Tagatz (1965) reported that market conditions as well as crab migrations and year-class strength were influential in determining the level of commercial catch. While variations in year-class strength undoubtly influence commercial harvest, the use of landings data as an index of adult stock abundance may be misleading.

The relationship between commercial fisheries landings (blue crabs, oysters, penaeid shrimp) and long-term environmental factors was investigated by Meeter et al. (1979) for the Apalachicola Bay estuarine system in Florida. They found that while there were initial indications that long-term river flow from the Apalachicola influenced annual commercial landings of blue crabs from Franklin County, when catch data from other species were partialled out, river flow explained very little of the annual variation in blue crab harvest. The authors suggested that unidentifed socio-economic variables and individual species strategies relative to short- and long-term climatic changes may in part be responsible for the lower "r" values observed with partial correlation analysis. According to Lyles (1976) fluctuations in the commercial catch of blue crabs appear to be governed more by economic conditions than by a scarcity of crabs. Moss (1981) noted that landings do not necessarily reflect populations, they may only reflect economic fluctuation.

5.6 Habitat Concerns

Blue crabs occupy a variety of habitats depending upon the physiological requirements of each particular stage in their life history. The upper, middle and lower estuary and adjacent marine area together constitute the blue crab habitat (Figure 37). Early larval stages are found in the lower estuary and adjacent marine waters; salinities in excess of 20.0 ppt being required for successful development. Later stage zoeae exist mainly in the open Gulf where their areal and vertical distribution determine their eventual transport shoreward. Blue crabs enter the estuary as megalopae, adopting a more benthic existence. Molt to the first crab takes place within the estuary. Factors affecting distribution and survival include substratum, food availability, available shelter, temperature and salinity. Juvenile blue crabs are euryhaline and their distributional patterns in Gulf estuaries suggest that perhaps temperature and salinity play a lesser role in spatial distribution than do substratum and food availability. Adults exhibit a differential distribution by sex and salinity with females found in high salinity waters and males in waters of low salinity. Because blue crabs occupy a variety of habitats and are an integral part of the estuarine ecosystem, maintenance of the entire estuarine system in a condition suitable for continued production is of prime importance.

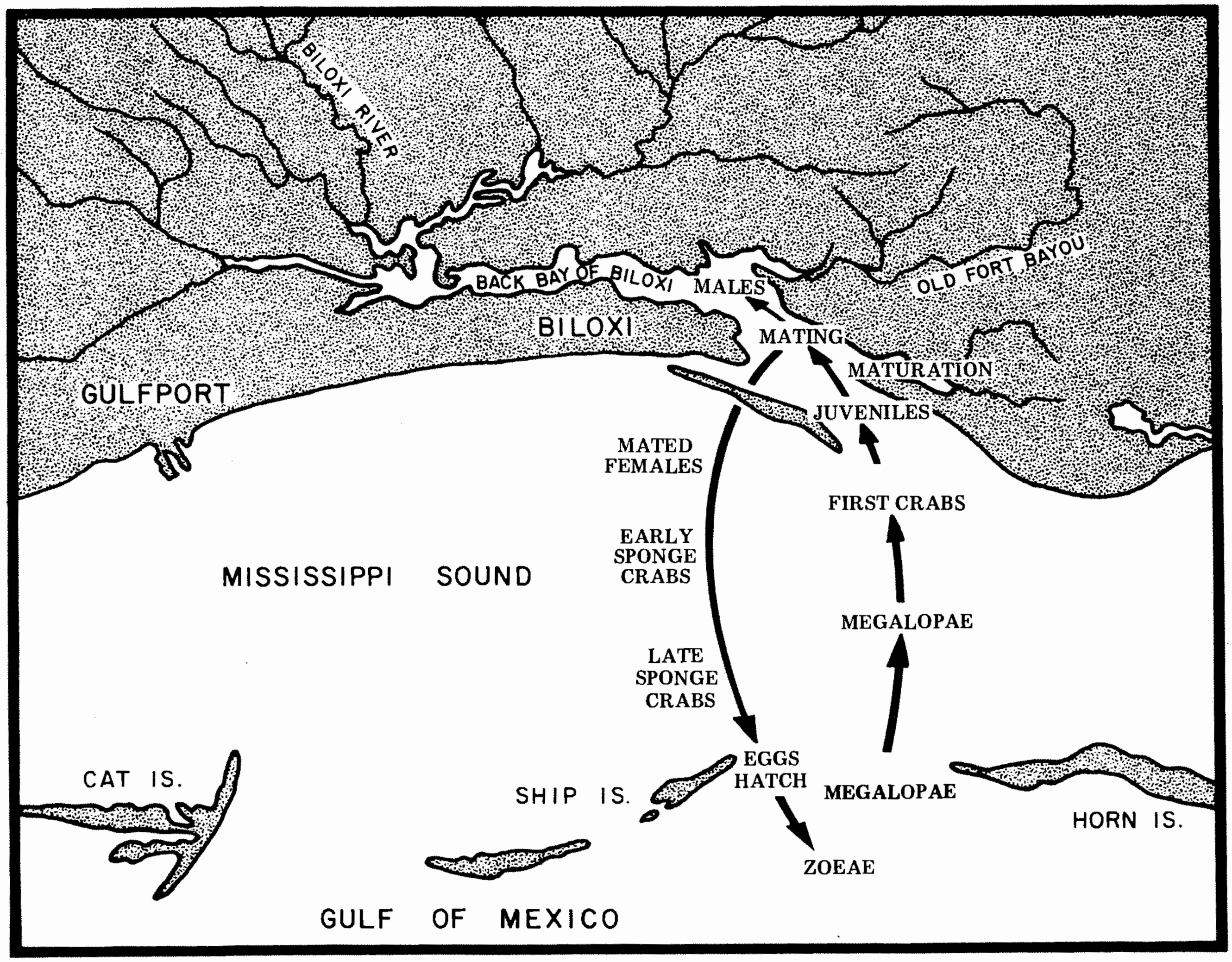


Figure 37. Overview of the general life history pattern of the blue crab (from Perry 1980).

6. RULES AND REGULATIONS

6.1 Alabama

A. Administrative Organization:

Alabama Department of Conservation and Natural Resources
Marine Resources Division
P.O. Box 189
Dauphin Island, AL 36528
Telephone: (205) 861–2882

The Conservation Advisory Board is endowed with the responsibility to advise on policies of the Alabama Department of Conservation and Natural Resources (ADCNR). The Board consists of the governor, the Commissioner of ADCNR and ten regular board members. The Marine Resources Division manages the marine fisheries with regulatory authority vested in the Commissioner.

B. Legislative Authorization:

Chapters 2 and 12 of Title 9, Code of Alabama, contain statutes that concern marine fisheries.

C. Reciprocal Agreement and Limited Entry Provisions:

1. Reciprocal Agreement Provisions:
   a. Licenses

Statutory authority provides an arrangement that may permit nonresidents to fish in the coastal waters of Alabama on a reciprocal basis. The reciprocal arrangements are extended to include crabbing activities.

   b. Management

Alabama has no statutory authority to enter into reciprocal management agreements.

2. Limited Entry:

Alabama has no statutory provisions for limited entry.

D. Commercial Landings Data Reporting Requirements:

While Alabama law requires that wholesale seafood dealers file monthly reports at quarterly intervals to the Department, these records have not been collected prior to 1982. Records are now compiled by National Marine Fisheries Service and ADCNR port agents on sales of fishery products under a cooperative agreement.

E. Penalties for Violations:

Violation of provisions of any statute or regulation is considered a misdemeanor and punishable by fines of $25 to $500.

F. License Fees:

Seafood packer, canner or processor – $50.00

Nonresident fees are doubled.

G. Laws and Regulations:

1. Minimum Size:

Blue crabs sold for commercial purposes shall not measure less than four inches from widest points of the uppershell. The size limit does not apply to softshell crabs nor crabs sold for use as bait.

2. Protection of Female Crabs:
   None.
3. Fishing Methods and Gear Restrictions:
   None.

6.2 Florida

A. Administrative Organization:

Florida Department of Natural Resources
Division of Marine Resources
3900 Commonwealth Blvd.
Tallahassee, FL 32303
Telephone: (904) 488–6058

The Department is the agency responsible for research and management of marine fisheries resources. The governor and six cabinet members have final approval on regulations promulgated by the Department.

B. Legislative Authorization:

Chapter 370 of the Florida Statutes Annotated contains law regulating the coastal fisheries. The legislature passes statutes for the management of fisheries resources, as well as specific laws which are applicable within individual counties.

C. Reciprocal Agreement and Limited Entry Provisions:

1. Reciprocal Agreement Provisions:
   a. Licenses

Florida statutory authority provides for reciprocal agreements related to fishery access and licenses.

   b. Management

Florida has no statutory authority to enter into reciprocal management agreements.

2. Limited Entry:

Florida has no statutory provisions for limited entry.

D. Commercial Landings Data Reporting Requirements:

Processors are required to report monthly on volume and price of saltwater products. Data are collected and published by the National Marine Fisheries Service.

E. Penalties for Violations:

It is a felony of the third degree, punishable as provided in s. 775.082, s. 775.083, or s. 775.084, for any person willfully to molest any traps, lines, or buoys, as defined herein, belonging to another without permission of the permitholder.

F. License Fees:

Resident wholesale seafood dealer	$100.00
Nonresident wholesale seafood dealer	150.00
Alien wholesale seafood dealer	500.00
Resident retail seafood dealer	10.00
Nonresident retail seafood dealer	25.00
Alien retail seafood dealer	50.00
Alien and nonresident commercial fishing license	25.00

G. Laws and Regulations:

1. Minimum Size:

Except when authorized by special permit issued by the Department for the soft-shelled crab or bait trade, it is unlawful for any person to possess for sale blue crabs measuring less than five inches from point to point across the carapace in an amount greater than 10% of the total number of blue crabs in such person's possession.

2. Protection of Female Crabs:

It is unlawful to sell or offer for sale any egg-bearing blue crabs.

3. Fishing Methods and Gear Restrictions:

a. No person, firm, or corporation shall transport on the water, fish with, or caused to be fished with, set, or place, any trap designed for taking blue crabs unless such trap has a current state permit number permanently attached to the buoy. The permit number shall be affixed in legible figures at least one inch high on each buoy used. The blue crab permit shall be on board the boat, and both the permit and the crabs shall be subject to inspection at all times. Only one permit shall be issued for each boat by the Department upon receipt of an application on forms prescribed by it. Individuals may fish with no more than five traps without such a permit.

b. A buoy or a time release buoy shall be attached to each trap or at each end of a weighted trotline and shall be of sufficient strength and buoyancy to float and of such color, hue and brilliancy to be easily distinguished, seen and located. Such color and permit number shall also be permanently and conspicuously displayed on the boat used for setting and collecting said traps and buoys in the manner prescribed by the Division of Marine Resources, so as to be readily identifiable from the air and water. Any vessel engaged in blue crab fishing pursuant to the provisions of Chapter 370.135, Florida Statutes, shall at all times while engaged in blue crab activities have the buoy design of its permitted buoy painted on a flat piece of permanent material permanently affixed to the uppermost structural portion of the vessel and displayed horizontally with the painted design up. If the vessel is of open design (example: skiff boat), one seat shall be painted with buoy assigned color with permit numbers painted thereon in contrasting color. Numbers are to be 10 inches in height.

The buoy design placard will be reproduced on a 20-inch diameter circle outlined in a contrasting color on the above mentioned flat piece of permanent material, together with the permit numbers permanently affixed under the 20-inch circle in number of not less than 10 inches in height. Nothing shall be placed on or above said placard as it is displayed on the vessel.

The preceding requirements do not apply to individuals fishing five or fewer traps.

c. It is unlawful for any person willfully to molest any traps, lines or buoys belonging to another without permission of the permit holder.

d. Traps may be worked during daylight hours only, and the pulling of traps from one hour after official sunset until one hour before official sunrise is prohibited.

6.3 Louisiana

A. Administrative Organization:

Louisiana Department of Wildlife and Fisheries
P.O. Box 15570
Baton Rouge, LA 70895
Telephone: (504) 925–3617

The secretary of the Department of Wildlife and Fisheries is the chief administrative officer of the department and as such has "sole responsibility for the policies of the department and for the administration, control, and operation of the functions, programs and affairs of the department." The secretary is appointed by the governor with Senate consent and serves at the governor's pleausre.

The seven-member Louisiana Wildlife and Fisheries Commission Board may advise the secretary and is responsible for control and supervision of the marine life of the state.

B. Legislative Authorization:

Article VI, Section I (1921) of the Louisiana Constitution contains the statutes which govern marine fisheries in the state. Specific statutes for crabs are included in subparts 311, 326, 332 and 337.

C. Reciprocal Agreement and Limited Entry Provisions:

1. Reciprocal Agreement Provisions:

a. Licenses

The Louisiana Department of Wildlife and Fisheries is authorized to enter into reciprocal fishing license agreements with the proper authorities of any other state.

b. Management

The Louisiana Revised Statute authorizes the Department to enter into reciprocal management agreements with the states of Arkansas, Mississippi and Texas on matters pertaining to aquatic life in bodies of water which form a common boundary. Because the Gulf of Mexico does not form a common boundary between Louisiana and the aforementioned states the application of this statute to coastal fisheries management agreements is questionable.

2. Limited Entry:

Louisiana law provides that limited entry may be utilized as a management procedure if it is in the best interest of the people of the state. Interpretation of the limited entry statute is, however, vague.

D. Commercial Landings Data Reporting Requirements:

Processors or any other first purchasers must report the previous month's purchases by the tenth of each month. The quantity, vessels, owners and other dealers from whom crabs are purchased must be included in the reports. Wholesalers, processors and first purchasers are also required to report sales of crabs and to whom crabs are sold.

E. Penalties for Violations:

Violation of any regulation, where no penalty has been specifically provided, shall be mandatorily fined not less than $25 nor more than $75 or imprisoned for not more than thirty days, or both, for the first offense; fined not less than $100 nor more than $200 or imprisoned not more than sixty days, or both, second offense; fined not less than $200 nor more than $300 or imprisoned no less than sixty days and no more than ninety days, and loss of license for minimum of one year with confiscation of all tackle and equipment for the third offense.

F. License Fees:

Recreational	$ 2.00
Commercial crab pots: resident	25.00
Commercial crab pots: nonresident	500.00
Resident wholesale dealer	50.00
Nonresident wholesale dealer	150.00
Wholesale agent	10.00
Resident retail dealer	5.00
Nonresident retail dealer	50.00
Nonresident commercial fisherman vessel	1,000.00

Licenses must be purchased from January 1 through January 31 of each year. Owners of newly acquired vessels may obtain licenses within 45 days of purchase of vessel.

G. Laws and Regulations:

1. Minimum Size:

a. Hard crabs less than five inches from point to point of upper shell are illegal to keep.

b. Softshell crabs less than four and one-half inches are illegal to keep.

c. Crabs used to produce softshell crabs less than four and one-half inches carapace width are legal to possess.

2. Protection of Female Crabs:

It is illegal for any person to keep or sell adult female crabs with sponge, and such crabs must be returned immediately to the water.

3. Fishing Methods and Gear Restrictions:

a. Crab trawls are illegal; however, properly licensed shrimp fishermen may keep or sell crabs taken incidental to their fishing operations.

b. A recreational crab fisherman may use up to five traps without obtaining a license. He may use a maximum of ten traps provided that he first obtains a recreational license at a cost of $2.00.

c. Each trap shall be attached to a visible float of at least six inches minimum diameter, or one-half gallon volume size and, in Lake Pontchartrain, the crab fisherman's license number shall be printed on the float in indelible ink. Floats shall be attached to the traps by a nonfloating line.

d. Crab traps which are no longer serviceable or in use shall be removed from the water by the owner. No person shall intentionally damage or destroy crab traps or the floats or lines attached thereto, or remove the contents thereof, other than the licensee or his agent.

e. No crab traps shall be set in navigable channels or entrances to streams.

6.4 Mississippi

A. Administrative Organization:

Mississippi Department of Wildlife Conservation
Bureau of Marine Resources
P.O. Box 959
Long Beach, MS 39560
Telephone: (601) 864–4602

The five-member Commission on Wildlife Conservation has the responsibility to manage, control, supervise and direct any matters pertaining to marine resources not otherwise delegated to another agency.

B. Legislative Authorization:

Chapter 49–15 of the Mississippi Code of 1972 (Annotated) contains provisions for the Management of marine fisheries resources.

C. Reciprocal Agreement and Limited Entry Provisions:

1. Reciprocal Agreement Provisions:

a. Licenses

Mississippi statutory authority allows

reciprocal license agreements with other states.

b. Management

The Commission on Wildlife Conservation is authorized to enter into advantageous interstate or intrastate agreements with proper officials which directly or indirectly result in the protection, propagation and conservation of Mississippi's seafood. The Commission may also continue any existing agreements.

2. Limited Entry:

Mississippi has no statutory provisions for limited entry.

D. Commercial Landings Data Reporting Requirements:

The quantity landed by each crabber is obtained from each firm weekly. Statistical agents may copy firm records and interview crabbers for areas in which traps are set and the number of traps set. The quantity of crabs caught incidentally by any other means and sold, will also be reported by each landing or processing firm. Daily records on sales of bait (crabs) are kept and reported on forms furnished by the Bureau of Marine Resources. All data collected are considered confidential information.

E. Penalties for Violations:

Any person, firm, or corporation violating any of the provisions of Chapter 49–15 or any ordinance duly adopted by the Commission, shall on conviction, be fined not less than $100 nor more than $500 for the first offense, and not less than $500, nor more than $1,000 for the second offense when such offense is committed within a period of three years from the first offense; and not less than $2,000 nor more than $4,000, or imprisonment in the county jail for a period not exceeding thirty days for any third or subsequent offense when such offense is committed within a period of three years from the first offense and also upon conviction of such third or subsequent offense, it shall be the duty of the court to revoke the license of the convicted party and of the boat or vessel used in such offense, and no further license shall be issued to such person or for said boat to engage in catching or taking of any seafoods from the waters of the state of Mississippi for a period of one year following such conviction. Further, upon conviction of such third or subsequent offense committed within a period of three years from the first offense, it shall also be the duty of the court to order the forfeiture of any equipment or nets used in such offense. Provided, however, that equipment shall not mean boats or vessels. Any person convicted and sentenced under this section shall not be considered for suspension or other reduction of sentence. Except as provided under subsection (5) of section 49–15–45, any fines collected under this section shall be paid into the seafood fund.

In addition, the Chief Inspector, or any other inspector shall seize, confiscate and dispose of any crabs caught in violation, as well as any boat (specific penalty), vehicle, net or other paraphernalia used or employed in connection with a violation of crab Ordinance 106.

F. License Fees:

Crab vessel license (resident or nonresident)	$ 2.00
Wholesale dealers license (resident or nonresident)	100.00

G. Laws and Regulations:

1. Minimum Size:
None.

2. Protection of Female Crabs:

The fishing for sponge crabs is prohibited in the area south of the Intracoastal Waterway, commencing at the Alabama-Mississippi boundary, and running west to the Gulfport Ship Island Channel. Any person taking sponge crabs in the sanctuary area by net, trap or any other means shall immediately return them to the water.

3. Fishing Methods and Gear Restrictions:

a. All crabs caught in trawls regardless of the location shall be immediately returned to the water unless the vessel operating the trawl has a valid crab license.

b. Any person fishing for crabs by means of crab traps or pots shall mark each trap or pot with the corresponding license number in such a manner to be clearly visible to an inspecting officer.

6.5 Texas

A. Administrative Organization:

Texas Parks and Wildlife Department
Coastal Fisheries Division
4200 Smith School Road
Austin, TX 78744
Telephone: (512) 475–4835

A six-member Texas Parks and Wildlife Commission, each of whom is appointed by the governor for terms up to six years, is responsible for the management of coastal fisheries resources.

B. Legislative Authorization:

Chapter 61, Texas Parks and Wildlife Code (Uniform Wildlife Regulatory Act) provides the Texas Parks and Wildlife Commission with responsibility of saltwater resources management. Fifteen of the eighteen coastal counties are under the Commission's regulatory authority; the remaining three counties are regulated by general statute (Chapter 78, TPWD Code).

C. Reciprocal Agreement and Limited Entry Provisions:

1. Reciprocal Agreement Provisions:

a. Texas statutory authority allows

reciprocal license agreements such as the one which provided that recreational fishing (for crabs) licenses from either state are accepted on waters which are a common boundary between Texas and Louisiana.

b. Management

Texas has no statutory authority to enter into reciprocal management agreements.

2. Limited Entry:

Texas has no statutory provisions for limited entry.

D. Commercial Landings Data Reporting Requirements

All seafood dealers who purchase directly from fishermen are required to file a monthly marine products report with the Department. The reports must include species, poundage, price, gear utilized and location of fishing activity.

E. Penalties for Violations:

A violation of any regulation of the Commission is a misdemeanor and punishable by a fine of not less than $25 nor more than $200, and each individual fish (crab) constitutes a separate offense. Penalties vary with violations of sections of the Parks and Wildlife Code.

F. License Fees:

Resident sport license	$ 5.00
General commercial fisherman license	10.00
Commercial fishing boat license	6.00
Wholesale dealer (business) license	250.00
Wholesale dealer (truck) license	125.00

G. Laws and Regulations:

1. Minimum Size:

a. Except in Galveston County, no hard-shell blue crabs less than five inches, soft-shell blue crabs less than four and one-half inches or peeler crabs less than four inches in carapace width, measured from tip of spine to tip of spine, may be taken, except for bait. Crabs shall be separated by the catcher at the time taken, and all crabs less than the minimum size shall be returned to the waters from which taken or placed in a separate container for the possession of bait only. A tolerance of not more than 5% by number of undersized crabs may be possessed for purposes other than bait.

b. In Chambers, Galveston, Harris and Victoria counties no crabs smaller than five inches across the shell from tip to tip may be caught and retained except during the period from March 1 to April 30, when blue crabs of any size may be taken and retained for use as bait if bait blue crabs are kept alive in a container separate from nonbait crabs.

2. Protection of Female Crabs:

a. No person may take sponge crabs from the coastal water of the state by any means.

b. No person may buy or sell a female crab that:

(1) has its abdominal apron detached; and

(2) was taken from coastal water.

3. Fishing Methods and Gear Restrictions:

a. In Aransas, Brazoria, Calhoun, Cameron, Galveston, Jackson, Jefferson, Kennedy, Kleberg, Matagorda, Nueces, Orange, Refugio, San Patricio and Willacy counties, crabs may be taken in any number and at any time by dip net, set line, hand line, gig, trotline, crab trap and 20-foot seine.

b. Crabs taken during legal shrimping operations may be retained.

c. No more than 300 crab traps may be used by any person.

d. Crab traps must be marked with the owner's name, address and license number imprinted on material as durable as the trap.

e. Crab traps must be marked with floating, visible buoys not less than 10 inches in diameter or width, and such buoys must be 10 inches above the waterline, or with plastic bottles of not less than one-gallon size.

f. Crab trawls of not less than five inches stretch mesh are permitted.

g. In Aransas County no crab trap may be placed in any area designated as a net-free zone or within 200 feet of a marked navigable channel.

h. In Burnett Bay, Crystal Bay, Scott Bay and Black Duck Bay in Harris County, crabs may be taken by crab lines, hooks or lines, trotlines and no more than three traps only.

7. CURRENT AND PROJECTED RESEARCH ACTIVITIES

Past research efforts were directed toward understanding various aspects of the life history of and the fishery for blue crabs in the Gulf of Mexico. Currently, emphasis has been placed on the monitoring and assessment of juvenile populations on estuarine nursery grounds to develop predictive models based on indices of juvenile abundance and/or to identify environmental variables that determine levels of harvestable crab stocks. Current and past crab research has stressed the role of the nursery area as a limiting factor in determining the number of juvenile crabs that survive and mature. Conditions that affect the survival and movement of larvae and postlarvae toward the estuary may also be limiting in determining the success of a year class or modal group. Recent research activities in this area include taxonomic studies to reliably separate the zoeae and megalopae of *Callinectes sapidus* from *C. similis* and studies on factors affecting the distribution and abundance of *C. sapidus* megalopae in nearshore waters.

A summary of current and projected research activities and a list of selected references are provided for each state.

7.1 Alabama

7.1.1 Research

Research and Management of Alabama Coastal Fisheries. Alabama Coastal Fishery Resources, Assessment and Monitoring. Conducted by the Alabama Department of Conservation and Natural Resources, Marine Resources Division, under PL 88–309, Project 2–000–R. Project leader, Steve Heath.

Seasonal and areal distribution and abundance of megalopae and juveniles on estuarine nursery grounds.

Crab Pot Anti-Fouling Paint Study. Conducted by the Alabama and Mississippi Marine Advisory Services and the Gulf Coast Research Laboratory. Project leader for Alabama, William Hoskins.

7.1.2 Selected References

Swingle, H. A. 1971. Biology of Alabama estuarine areas – cooperative Gulf of Mexico estuarine inventory. *Alabama Mar. Res. Bull.* 5:1–123.

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Tatum, W. A. 1982. The blue crab fishery of Alabama. *Proc. Blue Crab Colloquium*, October 18–19, 1979, Biloxi, Mississippi. Gulf States Marine Fisheries Commission 7:23–28.

7.2 Florida

7.2.1 Research

Population Dynamics of the Blue Crab, *Callinectes sapidus*, in Tampa Bay, Florida, 1980–1982. Conducted by Florida Department of Natural Resources under PL 88–309, Project 2–341–4. Project leader, Phil Steele.

Spawning, molting, migration, habitat, parasites and disease, seasonal and areal distribution and abundance, CPUE.

Population Dynamics of the Blue Crab, *Callinectes sapidus*, in Indian River, Florida, 1981–1983. Conducted by Florida Department of Natural Resources under PL 88–309, Project 2–341–R. Project leader, Phil Steele.

Spawning, molting, migration, habitat, parasites and disease, seasonal and areal distribution and abundance, CPUE.

A New Method for Dipping Crab Traps Utilizing an Ortho-tin Based Anti-fouling Paint. Cooperative project, Marine Advisory Service, Palmetto, Florida, and Florida Department of Natural Resources. Project leaders, John Stevely and Phil Steele.

Blue Crab Tagging Project, Tampa Bay 1982–83. Conducted by Florida Department of Natural Resources under PL 88–309, Project 2–341–R. Project leader, Phil Steele.

Ten thousand adult blue crabs will be tagged at stations throughout Tampa Bay.

7.2.2 Selected References

Cato, J. C. and F. J. Prochaska. 1980. Economic impact estimates for Florida's commercial fisheries: 1978. Food and Res. Econ. Depart., Staff Paper Series, Staff Paper 155:1–41.

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Livingston, R. J. 1976. Diurnal and seasonal fluctuations of organisms in a north Florida estuary. *Estuarine Coastal Mar. Sci.* 4:373–400.

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Colloquium, October 18–19, 1979, Biloxi, Mississippi. Gulf States Marine Fisheries Commission 7:173–185.

Menzel, R. W. 1964. Report on preliminary studies on the blue crab in Alligator Harbor and adjacent Gulf of Mexico with some observations on stone crab larvae. Oceanographic Institute, Florida State University: 1–12.

Nishimoto, R. T. and W. F. Herrnkind. 1978. Directional orientation in blue crabs, *Callinectes sapidus* Rathbun: escape responses and influence of wave action. *J. Exp. Mar. Biol. Ecol.* 33:93–112.

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7.3 Louisiana

7.3.1 Research

Monitoring and Assessment Activities in Louisiana's Territorial Waters. Conducted by the Louisiana Wildlife and Fisheries Commission under PL 88–309, Project 2–381–R. Project leader, Phil Bowman.

Monitoring of larval, juvenile and adult blue crabs, parasites and disease.

Louisiana Offshore Oil Port Monitoring Program. Conducted by the Louisiana Wildlife and Fisheries Commission. Funded by LOOP Inc., Project Number 13. Principal investigators, Tim Morrison and Barney Barrett.

Environmental monitoring–larvae, juveniles and adults.

A Study of the Seasonal Presence, Relative Abundance, Movements and Use of Habitat Types by Estuarine-Dependent Fishes and Economically Important Decapod Crustaceans, on the Sabine National Wildlife Refuge. Conducted by the Louisiana Cooperative Fishery Research Unit, School of Forestry and Wildlife Management (in the Louisiana Agricultural Experiment Station, LSU). Funded by the U.S. Fish and Wildlife Service, Project Number LA 2076. Principal investigator, William Herke; Project leader, B. D. Rogers.

Faunal survey, environmental monitoring, life history, ecology, larvae, juveniles, adults.

Seasonal Abundance of Estuarine-Dependent Organisms versus Water Site Quality and Meteorological Conditions. Conducted by the Louisiana Cooperative Fishery Research Unit, School of Forestry and Wildlife Management (in the Louisiana Agricultural Experiment Station, LSU). Funded by the U.S. Soil Conservation Service, Project Number LA 2205. Principal investigator, William Herke; Project leader, E. E. Knudsen.

Faunal survey, environmental monitoring, life history, ecology, larvae, juveniles, adults.

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7.4 Mississippi

7.4.1 Research

Coastal Fisheries Monitoring and Assessment – Mississippi. Conducted by the Gulf Coast Research Laboratory under PL 88–309, Project 2–393–R. Project leader, blue crab studies, Harriet M. Perry.

Seasonal and areal distribution and abundance of megalopae and juveniles on estuarine nursery grounds; parasites and disease.

Morphological Characteristics of Blue Crab Larvae, *Callinectes sapidus,* from the Northern Gulf of Mexico. Conducted by the Gulf Coast Research Laboratory under a grant from the Gulf States Marine Fisheries Commission, Project 000–011. Principal investigators, Kenneth C. Stuck and Harriet M. Perry.

Evaluation of a Closed Recirculating Seawater System for Production of Soft-shelled Crabs – Component to LSU Sea Grant Proposal R/A–14. Conducted by the Gulf Coast Research Laboratory under a grant from Mississippi-Alabama Sea Grant Consortium. Project R/RD–2. Principal investigator for Mississippi, Harriet M. Perry.

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7.5 Texas

7.5.1 Research

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7.5.2 Selected References

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8. IDENTIFICATION OF PROBLEMS

8.1 Biological

Lack of reliable data on catch and catch-per-unit-effort in the commercial fishery. Reported landings for hard and soft crabs are at best poor estimates of annual catch because of the seasonal, supplemental nature of the fishery and the wide distribution and easy accessibility of the resource.

Lack of data on recreational catch of blue crabs. The sport fishery is thought to contribute significantly to total fishing pressure, although estimates of the impact of recreational fishing on the resource vary widely in individual states.

Lack of incidental catch data. Large numbers of commercial size blue crabs are landed each year by non-directed fisheries. Estimates of these landings are poor.

Lack of data on mortality associated with trawl by-catch, ghost fishing, trap death and culling practices.

Lack of data on blue crab population dynamics. Use of traditional statistical models to assess maximum sustainable yield (MSY) are complicated by biological characteristics of the animal and lack of pertinent data on total resource utilization.

Gaps in life history data. Data are lacking on: (1) the distribution of *Callinectes sapidus* zoeae and megalopae in offshore waters; (2) mechanims of larval transport; (3) role of offshore recruitment of larvae in determining estuarine population levels of juveniles; (4) influence of environmental variables on growth, distribution and survival; (5) migration patterns; (6) influence of parasites on subsequent levels of harvestable adults; and (7) distribution and abundance of premolt crabs (peelers).

8.2 Environmental

Need for identification of sources of environmental degradation and the impact of habitat alteration on all phases of blue crab life history. Because blue crabs occupy a variety of habitats during their life cycle, maintenance of the entire estuarine/marine system in a condition suitable for continued production is of prime importance.

8.3 Technological

Low technological level of industry. Shortage of skilled labor and its rising cost necessitate the increased use of mechanization. New techniques are needed to increase processing efficiency and lower production costs, and to produce additional product from the same quantity of raw materials.

Lack of integrated data on the effects of different processing techniques on relative yield, quality, and bacterial content. Few studies have dealt with the comparison of various methods of cooking and preserving crab meat.

Disposal of shell waste. Approximately 78% of live weight is waste or scrap. The inconsistent supply of raw product and changes in protein content associated with mechanization have decreased industrial interest in crab meal production. Continuation of research is needed in areas of utilization of crab waste (human food, fertilizer, industrial [e.g., chitin/chitosan production]).

8.4 Quality Control

Live product. Generally no jurisdiction exists over handling techniques employed on harvesting vessel and transport vehicles. Acceptable procedures should be developed to avoid mortalities and crab deterioration during harvest and transport.

Processing. Excessive handling of raw and cooked product necessitates high sanitary standards. Lack of standardized equipment and processing methods impedes development of established procedures for quality control. The majority of crab processing plants are unable to monitor microbiological quality of their product.

Marketing. Problems exist at the marketing level with a lack of standardized marketing forms, and with proper handling and storage of crabmeat products prior to sale.

8.5 Economic

Inadequate statistics on harvest, processing and marketing have precluded accurate assessment of the economic impact of the fishery.

Information is lacking on the economic impact of existing and proposed fishery management regulations.

Economic interdependence of the crab fishery with other fisheries is poorly understood.

Information on and analysis of the interdependencies of interregional landings and prices are needed.

Increasing cost for bait suggests research is needed to develop low cost, artificial bait.

8.6 Sociological

A lack of understanding exists among resources managers, users, and the public. Cooperation may be increased with greater communication of management rationale and recognition of individual needs among these groups.

8.7 Administrative

Lack of coordination and standardization of assessment and monitoring programs. Assessment and monitoring programs vary from state to state making comparison of data among states difficult or impossible.

Lack of standardization of state management regulations. Efforts by states to form compatible regulations for blue crab management, as far as biological, economical and socio-political considerations permit, would allow more efficient management of the fishery.

Need to improve communication between fisheries data gatherers, user groups and implementing agencies. Increased communication among individuals of all groups involved with the fishery could reduce misunderstanding and conflict over many issues.

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