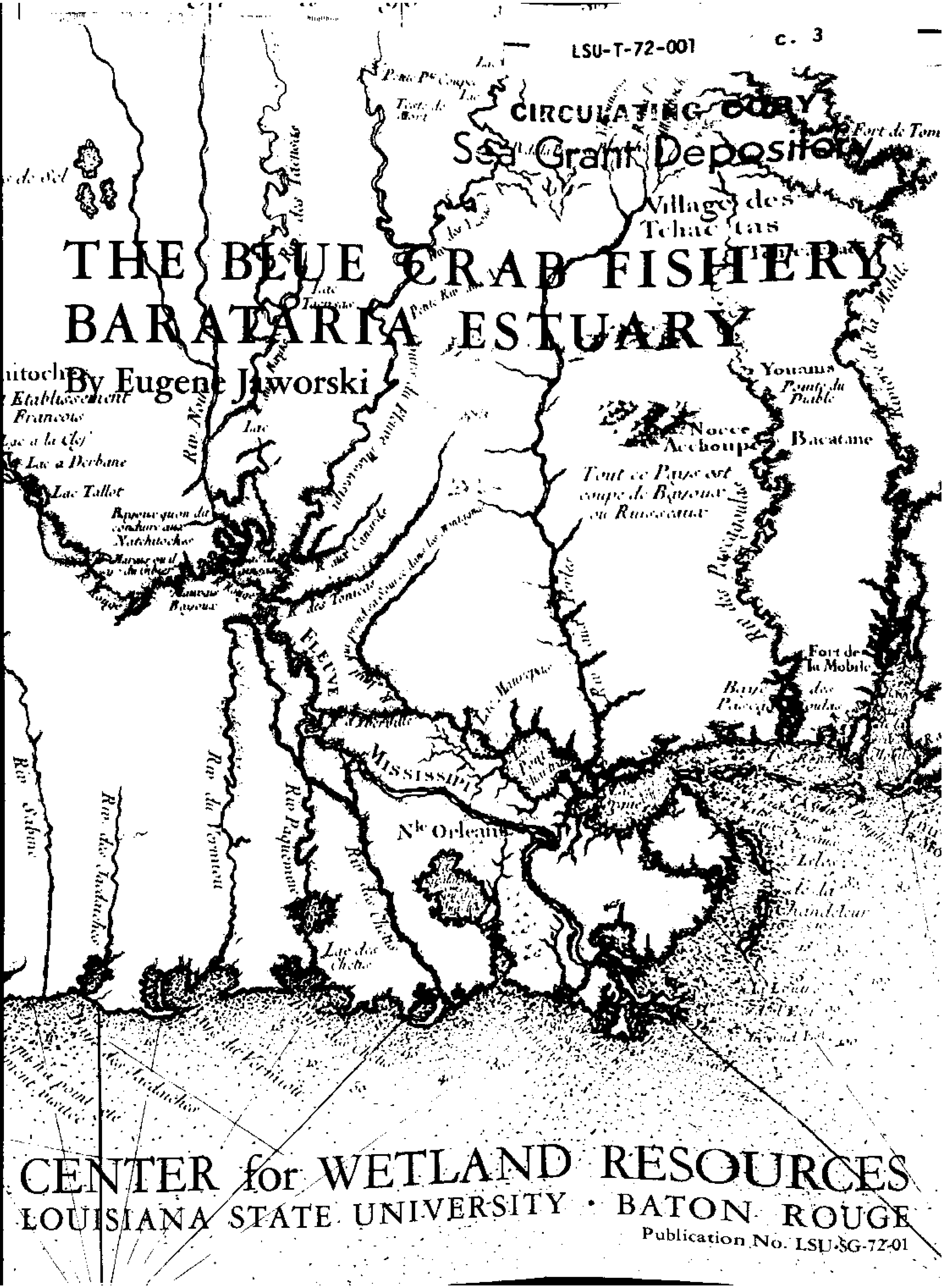

THE BLUE CRAB FISHERY BARATARIA ESTUARY

By Eugene Jaworski

CENTER for WETLAND RESOURCES
LOUISIANA STATE UNIVERSITY · BATON ROUGE
Publication No. LSU-SG-72-01

GLOSSARY

Terms Used by Louisiana Crab Fishermen

Apron - The abdomen on the ventral side of the crab; sometimes called the tail.

Brackish-water crabs - Crabs that migrate up-estuary to low-salinity waters during the warm months.

Buck and Rider - A large male crab carrying a sexually mature female; part of the mating behavior of the blue crab.

Buster - Crab in an advanced stage of molting wherein the old exoskeleton has cracked under the lateral spines. Term also applies to molting crabs that died during the actual shedding process but were salvaged by the crabber for home consumption.

Carriers (Doubles) - Term that is synonymous with buck and rider but is more commonly utilized by fishermen.

Car-worm crab - A crab that has remained in the shedding cars, or floats, for two or more weeks without shedding. Worn spots on the sternum are common. Many of these crabs appear to be infested with chitonoclastic bacteria which produce pits in the exoskeleton and which may inhibit molting.

Clear (light) crab - Crab that is clear, shiny, brightly colored, and light in weight, indicating very recent molting.

Counter - A large, soft-shell crab, i.e., larger than 5.5 inches wide.

Dwarf female - A small but sexually mature female crab.

Fat crab - Crab that has not recently shed and which is heavier than a "skinny" crab. Fat crabs have yellow-brown coloration on the ventral side instead of bright blue and white coloration.

Green crab - Crab that exhibits visible external signs of shedding but has not yet reached the buster stage.

Hard crab - Crab that is not undergoing molting, hence has a firm exoskeleton.

Marsh (swamp) crab - A crab with dark brown coloration; usually caught in organic-rich, shallow tidal channels and ponds of the marsh and swamps bordering an estuary.

Paper-shell crab - A crab that is in the late stages of molting wherein the new exoskeleton of the soft-shell crab begins to harden and becomes leathery.

Peeler crab - Along Chesapeake Bay this term is applied to all shedding crabs caught by soft-shell fishermen. Term is rarely used by Louisiana crabbers.

Pink (sign) line - A shedding sign consisting of a pink line near the edge of the paddle of the swimming legs. In Louisiana the white, pink, and red line terminology is common only to the Lake Pontchartrain-Lake Borgne area.

THE BLUE CRAB FISHERY, BARATARIA ESTUARY, LOUISIANA

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Publication No. LSU-SG-72-01

Center for Wetland Resources
Louisiana State University
Baton Rouge, Louisiana

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ABSTRACT

Although it is one of the state's major commercial fisheries, the blue crab fishery of Louisiana has been given low research priority. This study was designed to generate field data on the crab fishing patterns and ecology of the crab population of a single estuarine system.

By analyzing the crab-fishing patterns of the Barataria Estuary, Louisiana, a model of the ontogenetic distribution of the crab population was generated. An estuary and the adjacent marine area constitute a complete crab habitat. As the blue crab passes through various stages of its life cycle, specific environments of the estuarine system are occupied as subhabitats. The spawning, wintering, and maturation subhabitats were identified by associating crabs in a particular life stage, as reflected in the crab fishermen's landings, with a specific portion of the estuary. The resulting subhabitat model predicts the location of several segments of the crab population and partially explains the five crab migration patterns that were observed in the estuary.

Crabbing is a seasonal activity and secondary occupation for most soft-shell and many hard-crab fishermen. With the introduction of crab pots in 1964, the hard-crab fishermen are now harvesting two segments of the crab population previously not fully exploited. Soft-shell crab production in the estuary is decreasing. Pollution of shoreline

environments in the upper estuary is probably reducing the recruitment of juvenile crabs in the maturation subhabitat. The actual crab harvest, including the recreational crab fishery, may be twice as high as that indicated in the landing records.

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ACKNOWLEDGMENTS

This investigation was sponsored in part by Louisiana State University's Office of Sea Grant Development. LSU's Sea Grant Program is a part of the National Sea Grant Program, which is maintained by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. Special thanks go to Wilmer Dufrene and the crab fishermen of the Barataria Basin for their cooperation while the field work was being conducted. Field assistance was provided by Arthur L. Stowe. Data on crab landings were obtained through Orville Allen of the National Marine Fisheries Service. R. M. Darnell, Marlin E. Tagatz, and Ted Ford provided criticisms of the manuscript. Crab diseases were identified by Robin M. Overstreet. Cartographic services were furnished by the Cartography Section, Coastal Studies Institute.

EDITOR'S NOTE

A major responsibility of the Louisiana State University Sea Grant Program is dissemination of research findings and practical results of scholarship to a broad spectrum of technical and interested lay audiences. To facilitate effective communication of potentially useful information about an important estuarine food resource to these audiences, editing of Dr. Jaworski's dissertation manuscript substituted common terms for much of the more precise nomenclature, and deleted certain biological material in the blue crab's life history which, although well known to the marine biologist, would be of peripheral interest to one whose interest lies in catching crabs or managing the fishery.

Sponsorship of this publication by LSU Sea Grant was undertaken in the belief that Dr. Jaworski's study of the Barataria crab fishery has produced down-to-earth, useful information about a segment of the estuarine socio-economic complex which deserves consideration in any serious effort to implement a multiple-use management strategy in Louisiana's coastal and estuarine wetlands. The LSU Sea Grant Program is a part of the National Sea Grant Program, which is maintained by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce.

INTRODUCTION

The blue crab, _Callinectes sapidus_ Rathbun, is the only commercial crab species in Louisiana. Louisiana crab landings in 1970 amounted to 10,203,300 pounds valued at $994,785. In terms of pounds landed, the crab fishery in Louisiana ranks third, after menhaden and shrimp. In terms of dollar value, the crab catch ranks fourth, behind shrimp, menhaden, and oysters (National Marine Fisheries Service, 1970, Landing Records).

Research in the United States on the blue crab includes the work of Hay (1905), Churchill (1919), Truitt (1939), Cronin (1954), Van Engel (1958), Tagatz (1968b), and More (1969). Much of the research has centered on various aspects of its life history. Because of the blue crab industry's importance in Virginia and Maryland, many investigations have been carried out in Chesapeake Bay. Recent emphasis has been given to variations in annual harvests (Fischler, 1965; Tagatz, 1965; Cronin and Cargo, 1968).

Few blue crab investigations have been carried out in Louisiana. These include research on the food habits (Darnell, 1958) and life history of the crab in Lake Pontchartrain (Darnell, 1959); a description of the Louisiana crab fishery (Padgett, 1960); and a study of trawl sampling of Vermilion Bay (Perret, 1967). In Louisiana, research on shrimp and oysters has always taken priority over that on blue crabs.

Little is known about the ecology of the blue crab (Cronin and Cargo, 1968), partly because of difficulties in estimating size and growth of crab populations. Moreover, emphasis on estuarine research and management of renewable estuarine resources is relatively recent.

Advances in instrument technology and data manipulation are constantly being made, but more data on the organism and its habitat are needed.

This investigation focuses on crab fishing patterns and their relationship to ecology of the blue crab population within a single estuarine system, or habitat. As the crab population passes through larval, juvenile, and adult stages it successively utilizes distinctive environments within the habitat. These functional environments were designated as subhabitats. The identification of subhabitats places the life history of the blue crab in spatial context with the habitat and should guide future sampling of crab populations. Where data were available, hydrologic factors, including salinity, water temperature, and circulation, were related to the crabs' distribution and migration patterns.

Attention was given to seasonal distribution of crabs, their migrations, and size and sex of the crabs landed. Field observations provided insights into the growth and recruitment of the crab population, although no estimate was made of its size.

The Barataria Estuary and adjacent marine area, located in southeastern Louisiana, were selected as the study region. The entire life cycle of the blue crab occurs within this natural hydrological unit. Moreover, the Barataria Estuary has long been a major center of Louisiana's blue crab industry. Thus, a goal of this study is to assess the Barataria Estuary as a blue crab habitat, as well as to provide field data on the blue crab and its environment.

The field procedure consisted of accompanying crab fishermen and observing their seasonal activities, crabbing gear in use, and crab fishing areas. Seafood dealers, crab buyers, and other individuals associated with the crab fishery were informally interviewed. Fishermen in each of eleven fishing settlements were contacted. Field trips were taken during the period June 1969 to May 1970 so that fishing patterns of an entire year could be studied. Additionally, the soft-shell crab fishery of Louisiana was further investigated during May 1971, and in July 1970 a trip was made to Chesapeake Bay so that the soft-shell crab industry of that area could be observed. Data on numbers of fishermen, gear types, and catch statistics were obtained from the National Marine Fisheries Service office in New Orleans, Louisiana. The knowledge and lore of the fishermen were noted, and a glossary of terms used by the fishermen was compiled.

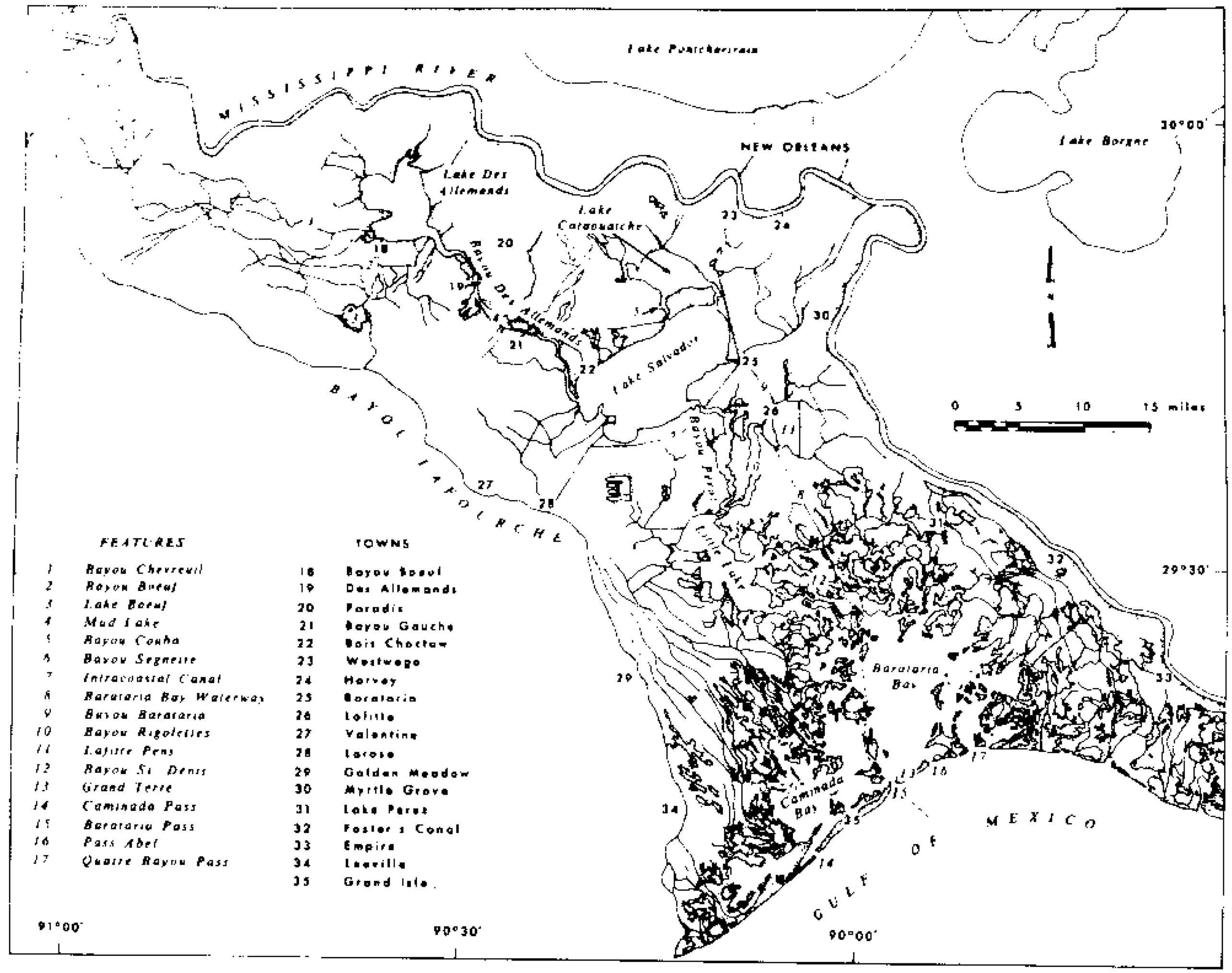


Fig. 1. The study region, Barataria Estuary, Louisiana.

DESCRIPTION OF THE PHYSICAL ENVIRONMENT

The Blue Crab Habitat

Barataria Estuary occupies a region west of the Mississippi River and south of the city of New Orleans (Fig. 1). The estuary is an inter-deltaic feature between the main distributary levee system of the present Mississippi River delta and the abandoned distributary complex of the older Lafourche-Mississippi delta (Morgan, 1967). Low-lying swamps and marsh flank the estuary and, together with water bodies, form what is referred to as the Barataria Basin.

An estuary is a "semi-enclosed body of water having a free connection with the open sea and within which the sea is measurably diluted with fresh water runoff" (Pritchard, 1967). The Barataria Estuary conforms to that definition, although no river discharges into its head, as is the case in many estuaries. The estuary includes all the inter-connected water bodies extending inland from the tidal inlets, or passes. Caminada and Barataria bays comprise the lower estuary. The nearshore area in the Gulf of Mexico, south of the tidal inlets, is the adjacent marine area.

All the various life stages of the blue crab occur within the estuary and adjacent marine area. The upper estuary, lower estuary, and adjacent marine area together constitute a blue crab habitat (Fig. 2). Because the open gulf is a boundary of the ecosystem, some exchange of crabs, especially larvae and small juveniles, probably occurs between adjacent estuaries, including the lower delta of the Mississippi River to the southeast and the Terrebonne Bay system on the west. Crabs of commercial size do not usually migrate between estuaries (Fischler and Walburg, 1962), but migrate within a single estuary and the adjacent

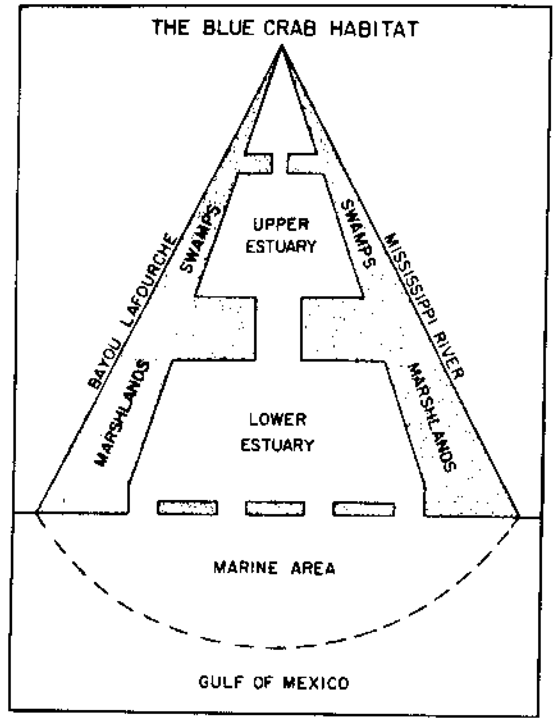


Fig. 2. Diagram of the blue crab habitat.

marine area.

All the various life stages of the blue crab occur within the estuary and adjacent marine area. The upper estuary, lower estuary, and adjacent marine area together constitute a blue crab habitat (Fig. 2). Because the open gulf is a boundary of the ecosystem, some exchange of crabs, especially larvae and small juveniles, probably occurs between adjacent estuaries, including the lower delta of the Mississippi River to the southeast and the Terrebonne Bay system on the west. Crabs of commercial size do not usually migrate between estuaries (Fischler and Walburg, 1962), but migrate within a single estuary and the adjacent marine area.

The Barataria Estuary is a shallow, interconnected hydrologic network which extends inland for 65 miles. The adjacent marine subhabitat extends offshore about 15 miles, where water depths reach about 90 feet. Offshore slope beyond the surf zone is approximately 6 feet per mile. The lakes and bays of the estuary vary in shape but usually possess relatively flat bottoms. Depths in Lake Salvador range from 6 to 12 feet, while those in Little Lake and Barataria Bay average 6 to 8 feet. The tidal inlets and tidal channels, as well as artificial waterways, are the deepest passages in the estuary.

Hydrologic Conditions in the Habitat

The principal factors which control the abundance of blue crabs in a given ecosystem are environmental (Hargis, 1968). Those of major importance are salinity, water temperature, circulation, and tides. Because the estuary is shallow, climatological elements such as precipitation, air temperature, wind, and evaporation can change hydrological conditions relatively quickly. The dynamic hydrological conditions characterize the habitat and affect its blue crab population.

Variation in salinity affects the osmoregulation of the crab and is thus an important hydrologic characteristic of the Barataria Estuary ecosystem. A salinity classification which can be used to describe an estuary is presented in Table 1. Except near tidal inlets and during the spring floods of the Mississippi River (Mackin and Hopkins, 1962), salinity in the marine area is more stable than in the estuary. Average monthly salinities 7 miles south of Grand Isle, measured at depths of 15 feet, range from 16 to 36 ppt. Lowest values occur from April to June (Louisiana Wild Life and Fisheries Commission, 1969).

Table 1

Classification of Water Based on Salinity

Salinity Range	Salinity Zone
0.0 to 0.5 ppt	Limnetic
0.5 to 5.0 ppt	Oligohaline
5.0 to 18 ppt	Mesohaline
18 to 30 ppt	Polyhaline
30 to 40 ppt	Euhaline

Source: Symposium on the Classification of Brackish Waters, 1959, held in Venice 8-14 April 1958, Summary of classification *in* (G. H. Lauff, *ed*.) Estuaries, Am. Assoc. Advancement Science.

The horizontal salinity gradient in the estuary is distinct (Fig. 3). Although salinity wedges exist in the tidal inlets (Gagliano et al., 1970), the waters of the estuary are well mixed (Barlow, 1955). Lake Des Allemands is classified as limnetic. Bayou Des Allemands, Lake Cataouatche, Lake Salvador, and Bayou Perot are oligohaline most of the time. The mesohaline zone occasionally extends into southern Lake Salvador, but generally it is confined to Little Lake and northern Barataria Bay. Although the marine area is classified as euhaline, the polyhaline zone extends considerably gulfward during the winter and spring.

Freshwater input to the estuary results primarily through local precipitation and runoff. Short-term salinity changes in the upper estuary can be attributed to the wind, but periods of higher salinity

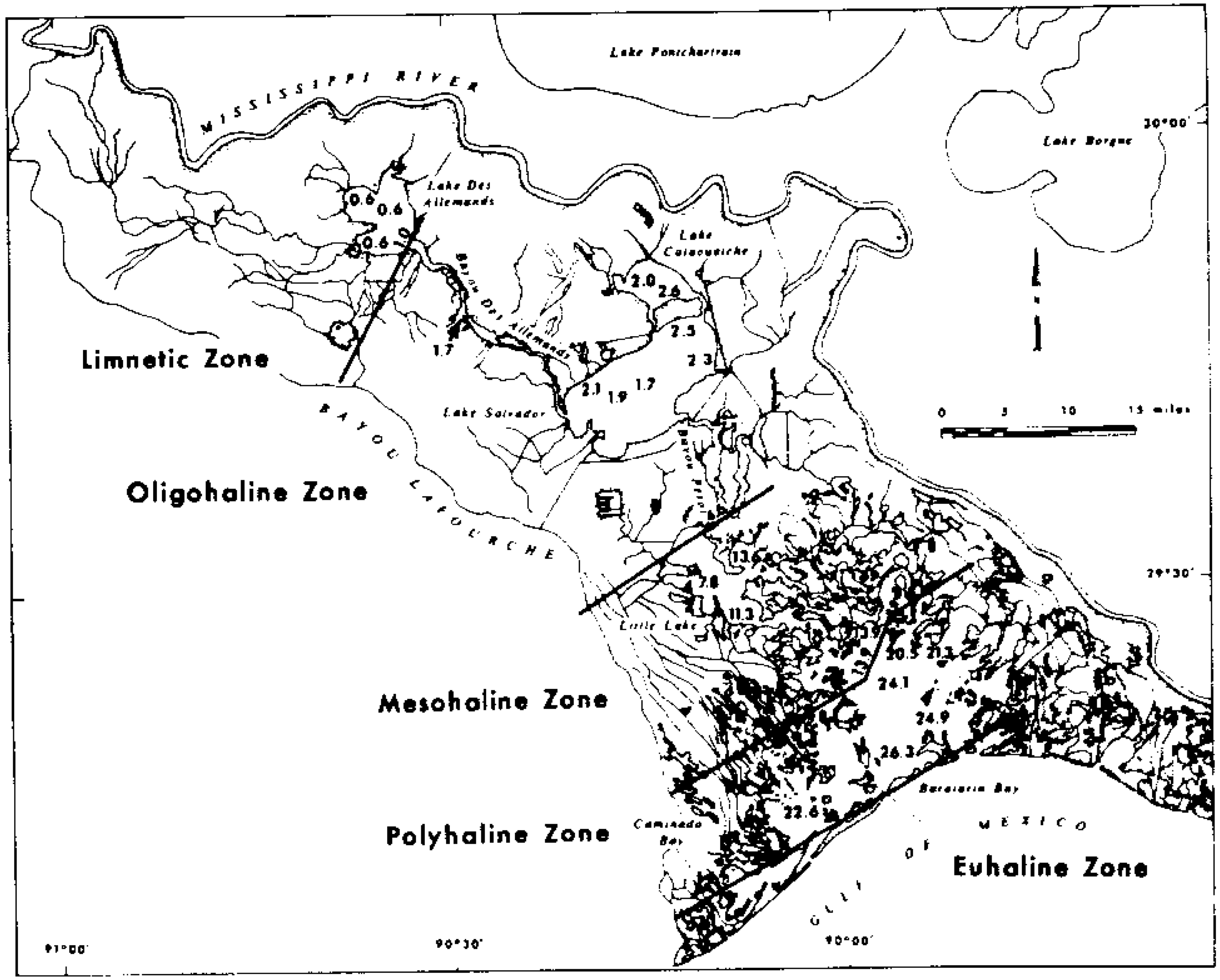


Fig. 3. Horizontal salinity gradient and salinity zones in the Barataria Estuary. Salinity values shown on the map are in parts per thousand and were measured in mid-October 1969. Data for the delineation of salinity zones were taken from U.S. Army Corps of Engineers, 1963.

result from extended periods of low rainfall (Barlow, 1955). April, May, October, and November are dry months (Fig. 4). A water budget analysis (after Thornthwaite and Mather, 1957) indicates that freshwater input occurs primarily from November to March (Table 2). Crab fishermen associate good summer crab fishing with mixing zones between fresh and brackish water. Plant detritus carried into the estuary by local drainage from flanking swamps and marshes has been recognized as a major factor in the food chain of Louisiana's estuaries (Darnell, 1961).

Because of the low hydraulic gradient and low tidal amplitude, circulation in the estuary is poorly developed. Except in the tidal inlets and channels, current velocities seldom exceed 1 knot (Table 3). Estuarine currents are important for the transport of organic and inorganic substances, dissolved minerals, oxygen, and heat. Currents also flush the estuary, carry chemical clues to predators, and transport eggs, larvae, and drifting organisms (Carriker, 1967). Stagnant portions of the estuary are less productive and are subject to rapid changes in water quality.

Diurnal tides are the main cause of current in the estuary. Equatorial tides in the lower estuary range from 0.2 to 0.4 foot, whereas tropic tides range from 1.4 to 1.8 feet. Lowest tides occur from December through February, and highest tides from June to October (Mackin and Hopkins, 1962). Tidal amplitude on the Barataria Bay side of Grand Isle averages 0.7 foot (Marmer, 1954). In the upper estuary, where tidal currents are weak, the direction and rate of flow are greatly influenced by wind and thunderstorms, according to Barlow (1955).

Table 2

Monthly Water Balance in Inches, Paradis, Louisiana, 1945-1968

Year	J	F	M	A	M	J	J	A	S	O	N	D	Totals
1945	4	5	5	0	-1	-3	3	3	4	2	0	6	27
1946	8	4	14	1	5	12	0	-1	2	-3	2	2	46
1947	6	2	5	3	0	3	-3	0	-1	-2	12	7	33
1948	4	0	14	-1	-2	-3	-3	2	10	-2	11	4	34
1949	1	1	11	4	-5	2	1	-2	1	0	-1	5	17
1950	0	2	3	6	-2	-1	1	-1	-5	-3	0	7	7
1951	3	1	5	5	-1	-4	-2	-4	2	-2	2	3	9
1952	1	7	1	6	-1	-4	-2	-1	-1	-2	2	7	12
1953	1	6	2	2	-5	2	5	1	-3	-3	8	8	25
1954	5	0	0	-2	2	-1	1	-6	5	0	1	3	8
1955	5	4	-2	2	-2	-1	3	0	-2	-2	5	2	11
1956	1	4	2	1	-1	2	1	-4	4	-2	-1	4	10
1957	0	1	6	5	-4	0	-1	-1	11	0	3	1	21
1958	7	4	9	0	2	-4	-1	1	2	-2	-1	1	20
1959	2	9	4	-1	13	4	4	-1	-4	7	9	1	38
1960	4	5	3	1	-1	-4	-2	0	-4	0	-2	4	6
1961	6	12	12	1	-1	2	2	3	3	-1	4	4	47
1962	3	0	0	0	-5	-1	-4	1	-3	0	0	2	-8
1963	4	5	-1	-3	-3	2	-1	-3	1	-4	11	4	13
1964	9	6	5	4	-4	-4	5	-2	-1	2	1	1	21
1965	6	2	1	-3	-2	-3	-2	3	2	-2	-1	7	9
1966	13	9	0	4	9	-3	6	-4	0	1	-1	4	39
1967	3	7	0	-1	-1	-5	1	4	2	1	-1	8	19
1968	1	4	1	0	1	-6	-2	1	0	-1	3	7	9
Mean	4	4	4	1	0	-1	0	0	1	-1	2	4	20

Table 3

Current Velocities, Depths and Flow Volumes,

Lower Barataria Estuary, Louisiana

Location	Water Depth, Feet	Mean Current Velocity, Knots	Maximum Current Velocity, Knots	Minimum Flow Volume, Million Cubic Feet/Day		Maximum Flow Volume, Million Cubic Feet/Day
Bayou Lafourche near Leeville bridge	10.5	0.4	1.0	58.5		80
Upper Barataria Bay in Bayou St. Denis	18.0	0.5	1.3	-		-
Barataria Bay, 2 miles SE of Manila Village	5.0	0.3	0.8	-		-
				Flood	Ebb	Excess Ebb Flow
Barataria Pass	165	1.3	2.9	3229	3438	209
Quatre Bayou Pass	29	1.1	2.2	874	1005	131
Caminada Pass	16	1.5	2.4	627	653	29
Pass Abel	11	1.2	2.5	129	212	83

Sources: Mackin, J. G., 1962, Canal dredging and silting in Louisiana bays, Publ. Inst. Marine Science, Univ. Texas, 7:262-314; Mackin, J. G., and S. H. Hopkins, Studies on oysters in relation to the oil industry, idem, pp. 1-131.

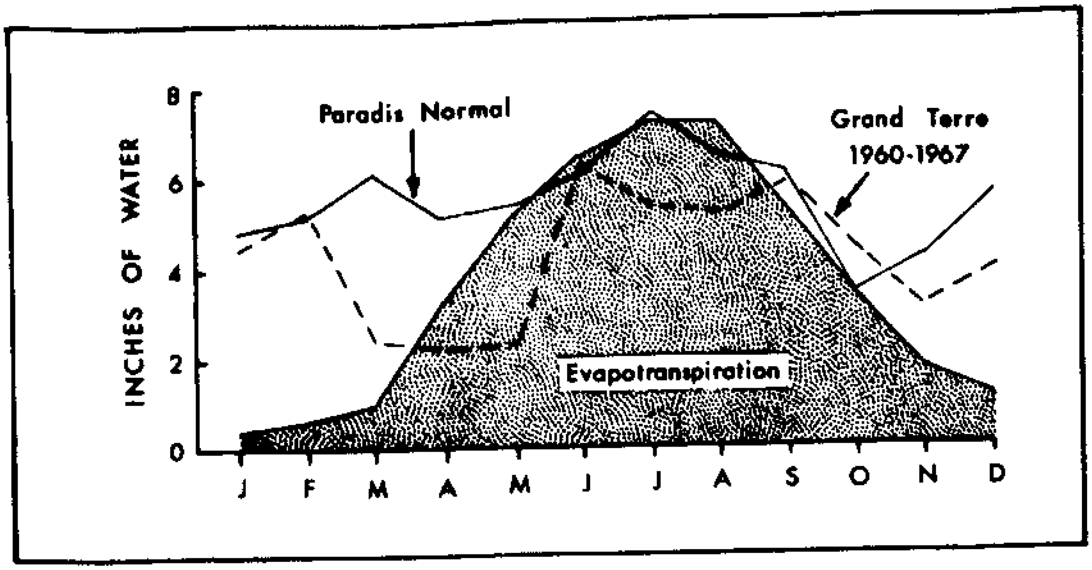


Fig. 4. Monthly precipitation and evapotranspiration in the Barataria Estuary. Data were taken from Louisiana Wild Life and Fisheries Commission, 1969, Table 1, and from U.S. Department of Commerce, 1964, p. 15.

In the marine area, surface water currents trend northwesterly, except for westerly currents in January and northerly currents during July and August (Scruton, 1956).

Water temperatures in the estuary are influenced by air temperatures (Fig. 5). Water in the upper estuary is slightly cooler in winter and warmer in summer than that in the lower estuary (Louisiana Wild Life and Fisheries Commission, 1962-63). Temperatures in the lower estuary are moderated through tidal exchange with gulf waters of the marine area. Summer temperatures in Caminada and Barataria bays average 27° to 32°C but reach 40°C in marsh lakes and ponds, and winter water temperatures in the estuary fluctuate over the range from 8° to 22°C (Mackin and Hopkins, 1962).

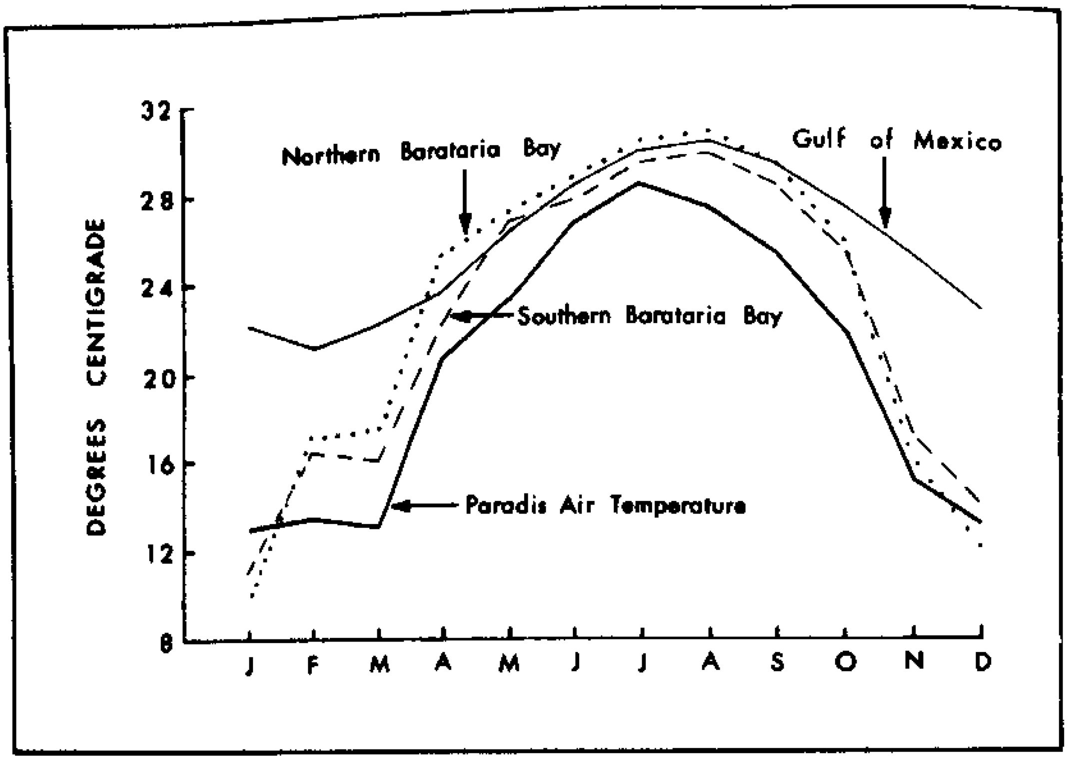


Fig. 5. Relationship of air temperature to water temperatures, Barataria Estuary. Data were taken from Louisiana Wild Life and Fisheries Commission, 1962-63, p. 152; Walsh, 1969, p. 44; and U.S. Department of Commerce, 1964, Table 1.

Because blue crabs are poikilothermic, or cold blooded, the water temperature of the ecosystem affects their activity. Adult female and juvenile crabs can survive temperatures ranging from 0° to 39°C but are slightly less tolerant of temperature extremes in low-salinity waters (Tagatz, 1969). During the winter months, absence of crabs in the upper estuary is associated with low water temperatures. Optimum temperatures for hatching of crab eggs and survival of the larvae are 19° to 29°C (Sandoz and Rogers, 1944) and 20° to 35°C (Costlow, 1967), respectively.

The climate of Louisiana is influenced by maritime tropical and continental air masses. From April to mid-September maritime tropical air dominates. Prevailing southeasterly to southwesterly winds transport warm maritime air inland, resulting in frequent summer thunderstorms. From mid-November to mid-March the area is subjected alternately to tropical and continental air masses (U.S. Department of Commerce, 1968). During this period recurrent cold fronts with stronger-than-average wind velocities are experienced.

A relationship exists between wind direction and air mass source (Fig. 6). From September through March, strong northerly winds are relatively frequent, whereas from April through August mild southerly winds prevail. Southerly winds tend to move saline waters from the gulf through the tidal inlets into the estuary. On the other hand, northerly and northwesterly winds tend to reduce water levels and push fresher, upper-estuary waters toward the lower estuary. Hurricanes and tropical storms are not uncommon in the region, but their effect on the blue crab has not been determined (U.S. Army Corps of Engineers, 1970).

In summary, the Barataria Estuary is a shallow and dynamic blue crab habitat characterized by marked fluctuations in salinity, water temperature, circulation, and other hydrologic variables. The blue crab population must be able to adjust to such a dynamic ecosystem. The following section on the life history of the blue crab describes relationships between salinity, food supply, and life stage and patterns of distribution and migration. The section on crab fishing patterns contains field data on the relationships between the crab and its subhabitats.

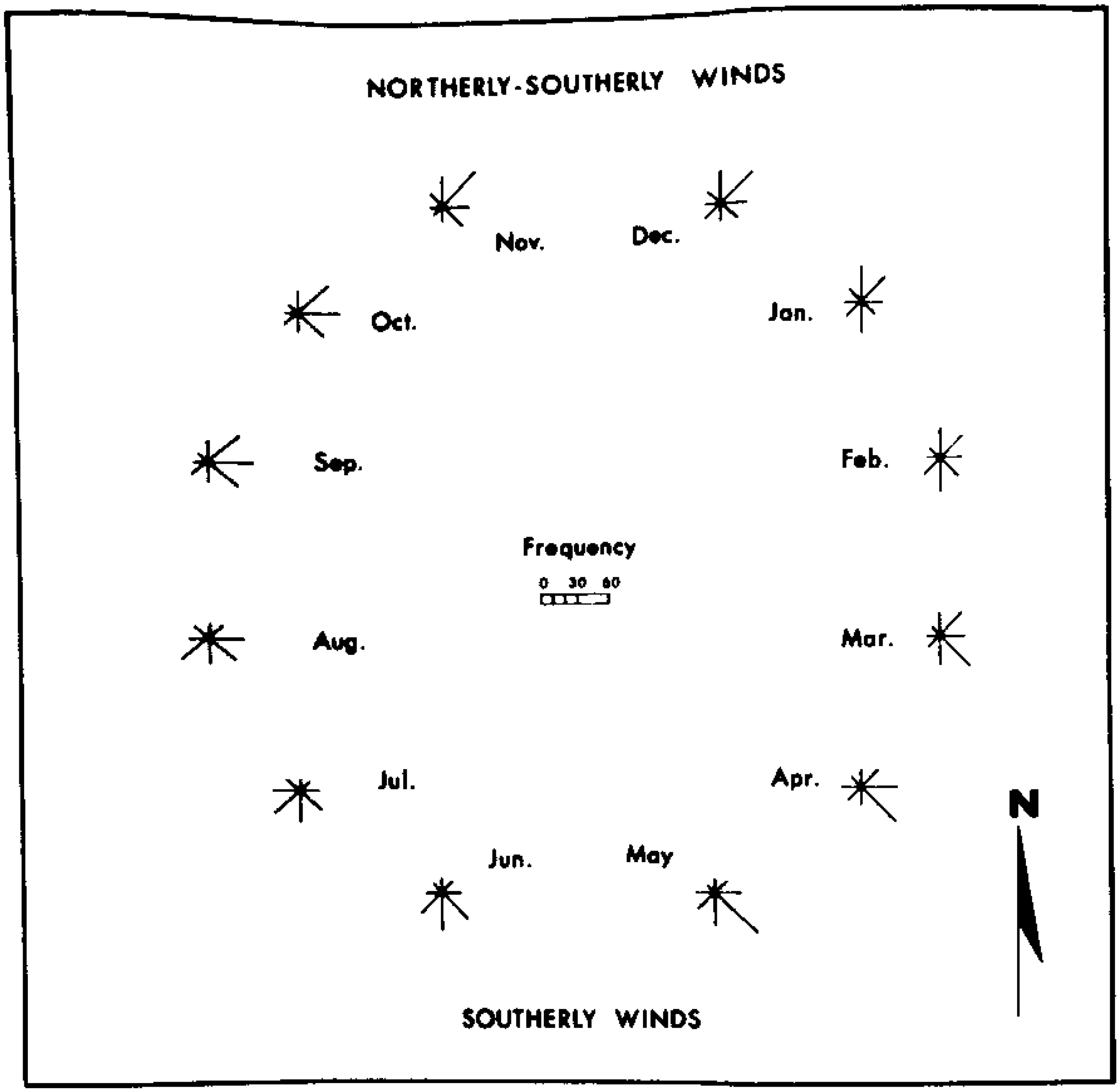


Fig. 6. Monthly surface wind directions, Burrwood, Louisiana. Data were taken from Walsh, 1969: p. 85. Observations of winds were made from 1942 to 1945.

LIFE HISTORY OF THE BLUE CRAB

Commercial blue crab fishery practices, both hard- and soft-shell, are peculiarly associated with the crab's life history and physiology. Salient features of this ontogeny, as they relate to seasonal occupancy of subhabitats, migration patterns, fishery practices. and production of soft-shell crabs for market, are described in this section.

Description of the Blue Crab

The blue crab, *Callinectes sapidus* Rathbun, belongs to the decapod family of Portunidae, the swimming crabs. Swimming crabs are characterized by the last pair of walking legs, which have evolved to form swimming paddles (Leary, 1967). *C. sapidus* is identified by four ridges between the eyes on the carapace (Photo 1).

The blue crab is a common inhabitant of the east and gulf coasts of North America, but it ranges from Nova Scotia to Uruguay (Williams, 1965). Within a given habitat the distribution of various segments of the crab population may result from physiological requirements of the various life stages.

The carapace of the blue crab is moderately convex and smooth. Its width (including the lateral spines) is two and a half times its length. The abdomen of the male has an inverted T shape. On the immature female the abdomen is triangular, whereas on the mature female it is broad and rounded. Mature males attain a carapace width of 125 to 200 mm. Adult females are slightly smaller, averaging 125 to 175 mm in width. Overall color of the crab varies from grayish brown to yellowish brown to bluish green (Williams, 1965). Immature males and females have bluish-red colorations on the chelipeds (pinching claws). Mature males have blue chelipeds, and those of mature females are reddish orange.

THE BLUE CRAB

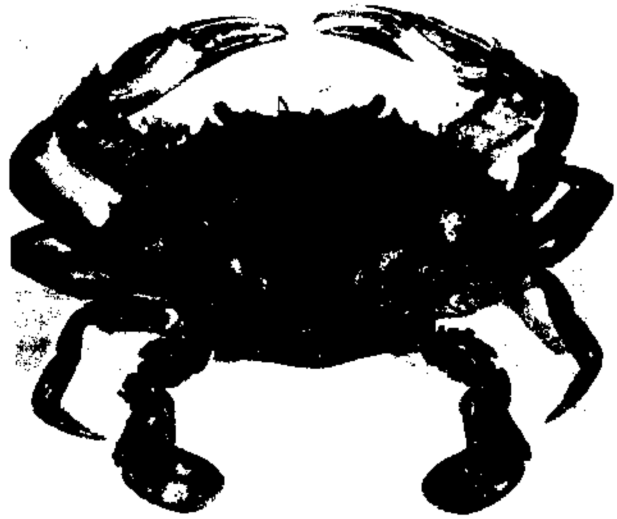


Photo 1. The blue crab, Callinectes sapidus Rathbun. The photograph of a large female blue crab was adapted from Leary, 1967, p. 6.

The only other common crab species of the genus Callinectes in the shallow coastal waters of Louisiana is C. similis, a small crab that closely resembles the juvenile blue crab. This species can be distinguished from C. sapidus by six ridges (instead of four) on the carapace between the eyes. In addition, C. similis attains a carapace width of only about 80 mm (Daugherty, 1952; Gunter, 1950; and Williams, 1966, Table 1). Because the larvae of these two crab species are almost identical in appearance, recruitment of C. sapidus into the lower estuary through tidal inlets is difficult to assess by plankton sampling.

Life Cycle in an Estuary

Blue crabs have a life span of two to four years, but they are fished as soon as commercial sized is attained, 12 to 18 months after hatching (Rees, 1963). The life history is generally as outlined in Table 4.

According to Loesch (1971, personal communication), female blue crabs tend to occupy more saline waters than the males, even in the brackish upper estuary. Mating takes place when the sex ratio is highly unbalanced, (e.g., 90 percent females, 10 percent males). Although female blue crabs mate only once, while they are in the soft-shell stage of their final molt, males may mate during each of their last three or four stages between molts. Mating marks the female's transition to maturity. Viable spermatozoa can be carried in the female's seminal receptacles for at least a year, so that she may spawn several times during her ensuing lifetime. Most females spawn only twice in their lifetime; these events may occur during the summer and fall after mating, the following spring and summer season, or during two consecutive seasons (Togatz, 1968b).

After mating, the females migrate to more saline waters in the lower estuary and nearshore gulf, where spawning occurs. As many as 700,000 to 2,000,000 eggs may be produced during a single spawn. These are fertilized as they pass through the seminal receptacles, and are subsequently attached by an adhesive secretion to the female's abdominal swimmerets, where they are carried until hatching occurs. Female crabs bearing egg masses under the abdomen are called sponge crabs and are said to be "in berry." Crabs that have mated and are about to spawn are said to be gravid.

Many of the eggs do not hatch, and of those that do only about 1 in 1,000,000 survives to adulthood (Van Engel, 1958). Causes of egg

Table 4

Life History of the Blue Crab in a Habitat

Stage - Life Cycle	Duration	Location	Remarks
Eggs	9 - 15 days	Lower estuary & marine area	Females spawn in saline waters during warm months.
Larval			
Zoea	31 - 49 days	Marine area	Larval stages are found in the water column in the neritic zone. Zoea undergo 4 - 8 molts.
Megalops	6 - 20 days	Marine area & tidal inlets	Molt once; pass into first true crab stage of 2 - 2 1/2 mm size.
	46 - 84 days		
Crab			
1st Year Juvenile	1 - 9 months	Lower to upper estuary	Molt 4 - 17 times and attain size of 6 - 100 mm in first year. Forced out of upper estuary with onset of cold season.
2nd Year Juvenile	2 - 9 months	Upper estuary	Molt an additional 3 - 16 times and mature at 125 - 200 mm.
	Total maturation time 12 - 18 months		5 - 9 larval molts 18 - 23 post-larval molts 23 - 32 total molts

Sources: Costlow, Rees, and Bookhout, 1959; Churchill, 1919; Cronin, 1947; Darnell, 1959; More, 1969; Tagatz, 1968b; Van Engel, 1958; as well as field observations.

mortality include fungus decay, consumption by small nemertean worms, suffocation in stagnant water, and thermal shock (Costlow et al., 1959).

Surviving eggs hatch into larval zoea about 1 mm long. Normal zoea pass through several distinctive stages, although authorities differ on the exact number, since some of those observed may be pathological. The zoea persist in a free-swimming form for some 30-39 days, during which molts mark emergence of successive stages.

Megalops larvae emerge from the zoeal stage. The megalops is characterized by a more crablike appearance, although a bulbous carapace one-fourth inch in width is its dominant feature. Duration of the megalops stage is about one to three weeks, depending on salinity and temperature (Costlow et al., 1959). Ratios of zoea to megalops of 164 to 1 have been found (Tagatz, 1968b). Highest survival of megalops larvae is in waters of 20° to 35°C and salinities greater than 15 ppt. The megalops can swim or move across the bottom in typical crablike fashion.

Molting climaxes the metamorphosis from megalops to juvenile crab. The tiny postlarval crabs begin active predation early in their juvenile stage. They migrate through the tidal inlets and from the lower estuary inland toward shallow, low-salinity environments in search of food, and perhaps to escape predators (Carriker, 1967). Growth to maturity requires 12 to 18 months (Van Engel, 1958). With the onset of cold weather, the juveniles migrate back to the lower estuary but return to the upper estuary in the spring.

As the immature blue crab grows, it repeatedly sheds its exoskeleton, a process known as ecdysis or molting. Hormones produced by glands located on the eyestalks and second maxillae regulate molting. Crabs that have just molted are called "soft-shell crabs." A crab 100 to 125 mm in width will shed in 2 to 3 hours; 2 hours later the soft-shell crab will have taken up water and become firm; and 9 to 12 hours after shedding the new exoskeleton will have a leathery or paper shell (Van Engel, 1958). The term "peeler" is applied to crabs in the various stages of molting (a glossary of crab terminology used by Louisiana crab fishermen is appended on the inside covers of this report).

Salinity and Osmoregulation

The blue crab is classed as a euryhaline species (Table 5). Optimum salinities for survival and growth of the crab's pelagic larvae are in the range from 15 to 45 ppt (Sandoz and Rogers, 1944; Costlow, 1967). Adults can tolerate salinities ranging from 0.7 to 88 ppt. Salinities in the marine area of the study region (Fig. 3) are well within this range.

Ecologically, blue crabs are wide-ranging, motile, epibenthic

Table 5

Classification of Estuarine Organisms

According to Salinity Tolerance

Type of Organism	Tolerated Salinity Range
Limnetic	0.0 to 0.5 ppt (fresh water)
Oligohaline	0.5 to 5.0 ppt
True estuarine	Between fresh and sea water
Euryhaline	From seawater to oligohaline
Stenohaline	Along open seashore or near estuaries
Migrant	Capable of passing through entire salinity continuum

Source: Carriker, M. R.. 1967, Ecology of estuarine benthic invertebrates: a perspective. In (G. H. Lauff, ed.) Estuaries, Am. Assoc. Advancement Science.

organisms. Salinities in shallow estuaries, such as Barataria, change relatively quickly; the crab must be able to adjust to these salinity changes or die.

Crabs adapt to salinity changes through a variety of physiological and behavioral responses, including ionic regulation, volume regulation, and osmotic regulation (Ballard, 1967; Kinne, 1967). Ion regulation refers to the tendency of organisms to maintain differences in ionic composition between blood, cell fluids, and the surrounding medium. Cells of marine organisms have generally higher concentrations of potassium and hydrogen ions, lower levels of sodium and chloride ions, and negligible magnesium and sulphate ions. These differences in ion concentration are manifested as differences in pH levels between body fluids and the surrounding medium.

Volume regulation is an ability possessed by many euryhaline species to respond to sudden changes in ambient salinity through rapid loss or gain of water and salts. In this manner changes in the organism's body volume are effected, and new levels in the steady-state balance of continuous in- and outflow of water and salt are established. Osmoregulation is an ability possessed by certain marine animals to resist loss or gain of water in body fluids in response to osmotic pressure differences associated with changing salt concentration of the host waters. There are apparent sexual differences in osmoregulatory responses which may in part account for differential salinity preferences of the sexes. Differences in the salinity gradient between the external medium and blood at low salinities demand more osmotic work by females than by males. At high salinities the salinity gradient between ambient waters and blood is slightly greater for males. This corresponds to the sexual distribution; males predominate in low salinities, females in high. However, Ballard and Abbott (1969) state that sex-associated differences in blood-medium gradients do not appear sufficient to account for the observed differences in sexual ratios and that the differential distribution of the sexes may be behavioral rather than physiological. High temperatures apparently increase the hypo- and hyper-regulatory ability of both sexes, and cool winter temperatures cause crab migrations out of both low-salinity and hypersaline areas of the estuary (Ballard and Abbott, 1969).

Food Items and Trophic Level

The blue crab is a detritivore, bottom predator, and general scavenger (Darnell, 1958). Food items are listed in Table 6. As detritivores, crabs consume decaying plant debris and inorganic material. Clams (especially *Rangia cuneata*), small crabs (including *Callinectes sapidus*), mussels, and snails are important prey to this bottom predator. As a scavenger, the blue crab feeds on fresh and decomposing flesh of all kinds (Darnell, 1958). Predation on fish may be much more important than Darnell suggests (Van Engel, 1958; Tagatz, 1968b).

With their stalked, compound eyes blue crabs perceive movements and are capable of responding with quick thrusts of their chelipeds. Chelipeds are large, powerful claws used to seize and crush the prey, tear it apart, and guide it to the mandibles. Water currents are sensed by tactile and chemoreceptors located on the antennules and antennae. The antennules move jerkily in the direction of the approaching current. Associated with the activity of the antennules is the rapid beating of the maxillipeds, which force a current of water across the head. In

Table 6

Food Items of Blue Crabs, Lake Pontchartrain, Louisiana

Food Item	Crabs 30 to 74 mm		Crabs 125 to 147 mm		Crabs 148 to 198 mm	
Crabs (undetermined)	13.8[a]	2.7	16.7	5.7	12.5	4.3
Rithropanopeus harrisii	-	-	4.2	0.2	5.0	0.1
Callinectes sapidus	10.3	1.4	8.3	13.0	7.5	5.0
Cirripedia	-	-	-	-	-	-
Crustacea (undetermined)	31.0	31.7	20.1	3.5	10.0	1.0
Odonata	-	-	4.2	0.2	-	-
Annelida	-	-	4.2	T	-	-
Mollusca						
Rangia cuneata	41.4	32.4	70.8	30.0	57.5	46.5
Mytilopsis leucopheata	-	-	25.0	19.4	20.0	11.9
Gastropoda	13.8	1.9	29.2	5.5	25.0	5.0
Hydroids	3.4	0.3	8.3	0.5	2.5	T
Vertebrata						
Fish remains	3.4	0.5	16.7	1.6	17.5	5.4
Bottom diatoms	-	-	-	-	-	-
Algae, filamentous	-	-	4.2	T	2.5	0.3
Vascular plants	6.9	0.4	20.8	0.8	10.0	2.0
Organic matter (undetermined)	17.2	7.7	25.0	5.9	17.5	8.8
Detritus, inorganic	37.9	12.1	33.3	12.7	15.0	9.7
Sand	37.9	9.1	29.2	1.7	2.5	T
SUMMARY						
Crabs and crustacea		35.8		22.4		10.4
Mollusks		34.3		54.9		63.4
Rangia cuneata		32.4		30.0		46.5
Fish remains		0.5		1.6		5.4
Miscellaneous vegetation		0.7		1.5		2.3
Inorganic material		28.9		20.3		18.5

[a]The first number in each size category is percentage of stomach tracts containing the food item and the second number is percentage of total stomach volume.

Source: Darnell, R. M., 1958, Food habits and larger invertebrates of Lake Pontchartrain, Louisiana, an estuarine community. Publ. Inst. Marine Science, Univ. Texas, 5:353-416.

this manner the blue crab is able to sense its surroundings so that it can respond when an appropriate stimulus is detected (Lochhead, 1949).

In the trophic spectrum of the estuarine community the blue crab is a major component, both as a predator and as a food item (Darnell, 1961). A large number of organisms prey heavily on the blue crab (Table 7).

Table 7

Predators of Blue Crabs,

Lake Pontchartrain, Louisiana

Common Name	Scientific Name
Alligator gar	*Lepisosteus spatula*
Spotted gar	*Lepisosteus oculatus*
Sea catfish	*Galeichthys felis*
Blue catfish	*Ictalurus furcatus*
Yellow bass	*Roccus mississippiensis*
Freshwater drum	*Aplodinotus grunniens*
Atlantic croaker	*Micropogon undulatus*
Black drum	*Pogonias cromis*
Red drum	*Sciaenops ocellata*
Freshwater eel	*Anguilla rostrata*

Source: Darnell, R. M., 1958, Food habits of fishes and larger invertebrates of Lake Pontchartrain, Louisiana, an estuarine community. Publ. Inst. Marine Science, Univ. Texas, 5:353-416. According to local fishermen, raccoon, snakes, turtles, freshwater eels, and blue catfish prey on soft-shell crabs.

Evidence that juvenile crabs feed at night or in the very early morning hours suggests that they come under severe predation (Lambou, 1952). Small juveniles feed at the water surface or amid vegetation, whereas large crabs tend to feedon water bottoms in areas of strong current.

Although some data are available on seasonal abundance of various fish in Caminada and Barataria bays (Thomas, Wagner, and Loesch, 1971; Fox and Mock, 1968), the effect of predation on the blue crab population has not been studied in Louisiana. Except for adult females spawning offshore, large blue crabs probably have fewer predators than small juveniles.

In summary, the blue crab is a motile, euryhaline organism. It occupies particular subhabitats according to the physiological requirements of each life stage, including salinity, water temperature, and food supply.

DEVELOPMENT OF CRABBING IN THE BARATARIA ESTUARY

History of Crabbing in Louisiana

One of the earliest blue-crab fisheries in the United States developed near the city of New Orleans, Louisiana. Initially the fishery was characterized by folk harvesting and local consumption; therefore only near large cities was there a market for live hard- and soft-shell crabs (Rathbun, 1884). Most of the crabs that were fished in the vicinity of New Orleans were sold in the New Orleans French Market, live and by the dozen. They were sold principally to proprietors of hotels and restaurants and to steamboat operators or were shipped to nearby cities (Stearns, 1887).

Louisiana's hard- and soft-shell blue crab production for the period 1880 to 1970 is presented in Table 8. By 1915 the fishery was valued at $45,000 and the main sources of the crabs were Lake Pontchartrain, Barataria Bay, and Bay Adams (Louisiana Conservation Bulletin, 1914-1916). According to elderly fishermen from Bucktown, Louisiana, soft-shell crabs were being produced as early as 1900 along the southern shore of Lake Pontchartrain. The first crabmeat plant in Louisiana was constructed in Morgan City in 1924 (Morgan City Review, 31 August 1951). By 1931 there were eight crabmeat plants in the Morgan City-Berwick area (Fisher, 1931).

Increased hard crab landings in the 1920's were due to the development of commercial processing of crabmeat. Soft-shell crab production increased when fishermen from the upper Barataria Estuary discovered a technique for catching peeler crabs (Frost, 1938). Both hard- and soft-shell crab production reached a peak immediately following World War II (Table 8). In the past 20 years the hard-crab harvest has ranged from 7 million to 11 million pounds annually, and soft-shell crab

Table 8

Louisiana Blue Crab Landings, Hard- and Soft-shell, 1880 – 1970

Year	Hard Crabs Pounds	Hard Crabs Value	Soft-shell Crabs Pounds	Soft-shell Crabs Value
1880	288,000	$ 7,000	–	$ –
1887	837,000	13,000	133,000	7,000
1888	851,000	13,000	143,000	7,000
1889	842,000	14,000	147,000	8,000
1890	851,000	13,000	130,000	7,000
1908	244,000	8,000	78,000	21,000
1923	312,000	8,000	3,000	1,000
1927	1,091,000	51,000	137,000	48,000
1928	2,320,000	78,000	183,000	52,000
1929	2,675,000	78,000	81,000	25,000
1930	4,186,000	63,000	146,000	58,000
1931	4,985,000	53,000	121,000	45,000
1932	5,878,000	57,000	99,000	25,000
1934	11,676,000	164,000	651,000	86,000
1936	12,576,000	168,000	365,000	53,000
1937	14,717,000	195,000	329,000	51,000
1938	10,533,000	106,000	248,000	37,000
1939	11,228,000	129,000	215,000	33,000
1940	14,062,000	172,000	252,000	40,000
1945	31,280,000	1,418,000	2,370,000	1,706,000
1948	21,110,000	608,000	881,000	440,000

Year	Hard Crabs Pounds	Hard Crabs Value	Soft-shell Crabs Pounds	Soft-shell Crabs Value
1949	17,874,000	555,000	455,000	192,000
1950	13,106,000	599,000	364,000	165,000
1951	8,710,000	461,000	350,000	188,000
1952	7,334,000	314,000	448,000	215,000
1953	8,131,000	333,000	488,000	203,000
1954	7,085,000	294,000	455,000	215,000
1955	10,811,000	449,000	581,000	290,000
1956	9,402,000	433,000	600,000	250,000
1957	8,559,000	419,000	551,000	192,000
1958	9,336,000	402,000	577,000	298,000
1959	9,570,000	461,000	605,000	302,000
1960	10,050,000	497,000	514,000	256,000
1961	11,910,000	514,000	620,000	310,000
1962	9,523,000	463,000	344,000	172,000
1963	7,982,000	447,000	329,000	164,000
1964	5,692,000	379,000	200,000	127,000
1965	9,284,000	635,000	204,000	141,000
1966	7,986,000	537,000	128,000	85,000
1967	7,559,000	520,000	146,000	121,000
1968	9,550,800	807,294	284,000	206,398
1969	11,718,560	1,229,868	196,600	161,236
1970	10,113,700	915,253	89,600	79,532

Source, 1880-1967: Lyles, C. H., 1969, Historical catch statistics – shellfish, Fish & Wildlife Service, U.S. Dept. Interior, C.F.S. No. 5007; 1968-1970: National Marine Fisheries Service, 1955-1970, Landing records – Louisiana coastal parishes, Fish & Wildlife Service, U.S. Dept. Commerce, New Orleans, Form 2-164 SA&G.

production has slowly declined. Nearly all these crabs are caught in estuaries, but an increasing quantity are being caught in the marine areas along the coast.

Crabbing in the Barataria Estuary

Development of the commercial blue-crab industry in Barataria Estuary followed settlement of the Barataria Basin and lower portions of Bayou Lafourche and the Mississippi River. White settlement of the Mississippi River flood plain first occurred on the broad natural levees of the main waterways (Smith, 1937). French-speaking Acadian farmers from Nova Scotia were the early settlers of upper Bayou Lafourche and the nearby Mississippi River (Bowie, 1935). Spaniards, Germans, Slavonians, Chinese, Filipinos, and Italians (Kammer, 1941) were also among the early settlers. Pressure for agricultural land and displacement of earlier inhabitats began to increase in the mid-1800's as Anglo-American planters sought land for their plantations (Comeaux, 1969). In the late 1800's and early 1900's small groups of earlier inhabitants moved into the interlevee basins and to the coastal portions of the rivers and bayous (Lyell, 1849; Smith, 1937).

From 1890 to about 1930 a number of extended-family settlements of marshdwellers or swampdwellers existed in the Barataria Basin. The settlements were located on the banks and shell mounds bordering Bayou Des Allemands, Lake Salvador, Bayou Barataria, Bayou Dupont, and Bayou St. Denis. Other settlements were established along lower Bayou Lafourche (Rome, 1966) and the Mississippi River. Bois Choctaw, which was located on the northwestern shore of Lake Salvador, consisted of four or five families with eight to ten children per family (Photo 2). Small vegetable gardens were cultivated in the spring, and alligators were hunted in the

Photo 2. Bois Choctaw, a former swampdweller village along Lake Salvador, Louisiana. Photograph was taken about 1910. A family from Des Allemands retained the photograph and granted permission for its use.

summer. During the cool winter months the swampdwellers turned to crabbing, fishing, and waterfowl hunting (Wilkinson, 1892).

Introduction of boat motors and construction of highways in the 1930's resulted in abandonment of many swampdweller settlements. Only those settlements with highway connections tended to grow. During this period the shrimp and fur-trapping industries grew tremendously. Commercial soft-shell crab production in the estuary began about 1927. Although a crabmeat plant was constructed in Westwego in 1934, hard crab fishing in the Barataria Estuary for commercial processing did not become significant until World War II.

The development of crabmeat processing plants stimulated commercial demand for hard crabs. Today, both hard and peeler crabs are fished, but in recent years soft-shell crab production has declined considerably. In 1970, 20 percent by weight of the hard crabs and 46 percent of the peeler crabs taken from Louisiana waters were derived from the Barataria Estuary (National Marine Fisheries Service, 1970, Landing Records).

CRAB FISHERMEN AND THEIR GEAR

The Crab Fishermen

Most of those fishermen who crab commercially in the Barataria Estuary are native descendants of former swampdwellers. There were approximately 255 hard-crab fishermen and 76 soft-shell crab fishermen in Barataria Basin in 1970 (Table 9). Many of the hard-crab fishermen and nearly all the soft-shell crab fishermen live in the settlements of Lafitte and Barataria.

Commercial crab fishermen can be classified as full-time, seasonal, or casual (Table 10). Because the full-time crabber derives most of his income from this activity, he must be an "ace," or unusually

Table 9

Number of Crabbers by Settlement in Barataria Basin, Louisiana, 1970

Settlement	Hard Crabbers	Soft-shell Crabbers
Des Allemands	7	0
Bayou Boeuf	5	0
Bayou Gauche	15	1
Westwego	40	0
Lafitte-Barataria	125	74
Larose	15	0
Golden Meadow	10	0
Leeville	5	0
Grand Isle	28	0
Lake Perez (Lake Hermitage)	5	1
	255	76

Table 10

Categories of Crab Fishermen by Parish, 1970

Type of Fishing Gear Used	Full-time	Seasonal	Casual
Jefferson Parish (exclusive of Grand Isle)			
Crab Pot	80	53	25
Trotline with Baits	4	59	0
Bush Lines (Brush Traps)	2	72	5
Otter Trawl for Shrimp	322	200	85
Total Fishermen in Parish	463	-	100
Grand Isle			
Crab Pot	0	28	0
Trotline with Baits	0	0	0
Bush Lines (Brush Traps)	0	0	0
Otter Trawl for Shrimp	190	50	130
Total Fishermen in Grand Isle	206	-	130
St. Charles Parish			
Crab Pot	0	5	3
Trotline with Baits	0	2	10
Bush Lines (Brush Traps)	0	0	0
Fish[a]	57	30	15
Total Fishermen in Parish	63	-	27
Lafourche Parish[b]			
Crab Pot	0	18	0
Trotline with Baits	0	11	0
Bush Lines (Brush Traps)	0	0	0
Otter Trawl for Shrimp	306	135	105
Total Fishermen in Parish	316	-	105

[a]Catfish fishing in St. Charles Parish is as important as shrimping is in the other parishes bordering the Barataria Estuary.

[b]Crabbers from Lafourche Parish fish in the Barataria Estuary and in adjacent Terrebonne Parish.

Source: National Marine Fisheries Service, 1957-1970, Operating Unit Data - Boats and Shore. Fish & Wildlife Service, U.D. Dept. Commerce, New Orleans, Form 2-168 SA&G.

skillful fisherman who can catch crabs year-round. Soft-shell crab fishermen and those hard-crab fishermen whose annual rounds include other activities comprise the seasonal category. Casual crab fishermen are usually persons who previously were more fully engaged in the fishery but, because of the unreliable nature of crabbing, have taken jobs in industry. On days off, weekends, and vacations, these men crab.

Most of the fishermen who crab in Barataria Estuary, especially the soft-shell crabbers, are seasonal crab fishermen. Their main activity, in terms of income, is trawling for shrimp in inland waters. Inland shrimpers comprise the "mosquito fleet," a separate group from the shrimpers with large, offshore-type vessels. In addition to inland shrimping and crabbing, the seasonal crabber may engage in catfishing, fur trapping, and temporary winter employment (Fig. 7). His activities are structured around the May-July and August-December inland shrimp seasons.

The annual hard- and soft-shell crab catch from the Barataria Estuary (Fig. 8) reflects the seasonal nature of crab fishing. Because the market price of shrimp is relatively high, crab fishing effort declines during inland shrimp seasons. The hard-crab catch is highest during the summer, and often there is a secondary peak in winter. Production of soft-shell crabs is seasonal. The output of soft-shell crabs is greatest in April and late summer.

Relationship with Seafood Dealers and Crab Buyers

Crabbers may market their catch in three ways: direct sale to the consumer, sale to seafood dealers, and sale to crab buyers. Many crabbers from Bayou Boeuf, Des Allemands, Bayou Gauche, Westwego, and Larose sell live hard crabs directly to the public. Some fishermen have

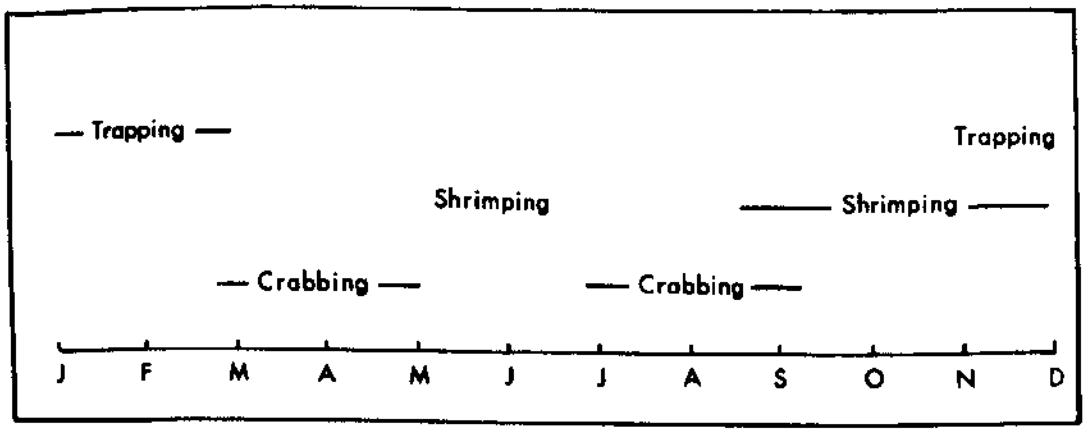


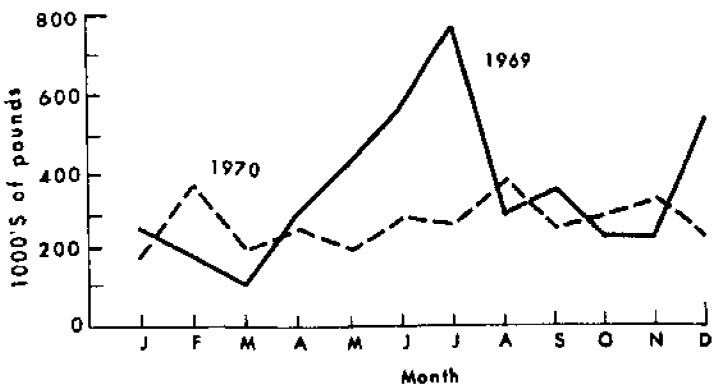
Fig. 7. Annual activities of the seasonal crab fisherman.

regular customers, including operators of restaurants and bars. In 1970 crabbers received $1.00 a dozen, or $5.00 a bushel, for large hard crabs. Operators of numerous small stuffed-crab factories in the area purchase crabs directly from these fishermen. Soft-shell crab fishermen usually sell their soft crabs to seafood dealers. Relatively few restaurants deal directly with the soft-shell crab fishermen.

Most hard-crab fishermen from Lafitte and Barataria sell their catch to seafood dealers, who in turn may sell to processing plants or to the public. The seafood dealer maintains a boat landing, scales, ice or refrigeration facilities, and a refrigerated truck (Photo 3). Generally he buys shrimp and fish, and sometimes furs and nutria carcasses, in addition to crabs. Each dealer trades with 15 to 20 fishermen who regularly bring their catch to him. Some dealers do not buy hard crabs in the hot summer months because the crabs die easily and require ice or refrigeration.

The fishermen are customarily paid in cash as soon as the catch is weighed or counted. Fishermen and seafood dealers are reluctant to show receipts of their transactions.

HARD-CRAB CATCH



SOFT-SHELL CRAB PRODUCTION

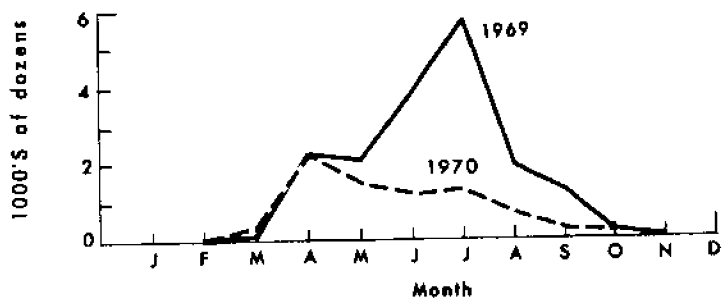


Fig. 8. Hard- and soft-shell crab landings by month, 1969 and 1970, New Orleans and lower Mississippi River area. Data source: National Marine Fisheries Service, 1969 and 1970, Market News Service--Gulf Fisheries (Selected Areas), New Orleans, Louisiana; Fish and Wildlife Service, U.S. Department of Commerce.

Crab buyers operate in the lower estuary where there are fewer seafood dealers. A few industrious crabbers also act as buyers. A buyer needs only a refrigerated truck, a portable scale, some boxes or baskets, and, in summer, ice to chill the crabs. Crab buyers act mainly as middlemen who purchase hard crabs for the large crabmeat plants. A buyer normally deals with 4 to 10 crab fishermen regularly. Each day he makes a round of the crabbers' boat landings.

Photo 3. A seafood dealer's establishment in Lafitte, Louisiana.

Crab buying is highly competitive among agents from the larger crabmeat plants in Houma, Pierre Part, and the New Orleans area. Like seafood dealers, the crab buyers' profit margin is only 2 cents a pound, delivered to the processor.

Prices paid to hard-crab fishermen depend on the season, regional demand, and size and quality of the crabs (National Marine Fisheries Service, 1968, Market News Service). These prices increased during the 1955-1970 interim (Table 11). During peak supply periods, usually from May to September and in February, the price drops as low as 6 to 8 cents per pound live weight. Most crabbers believe that 8 cents per pound is marginally profitable. Male crabs are worth slightly more than females because they yield a larger chunk of lump meat (Dunker et al., 1960). The operator of a large crabmeat plant

Table 11

Prices Paid to Fishermen in Louisiana

for Hard Crabs, 1955 and 1962 - 1970

Year	Price/Pound - Live Weight
1955	3 - 5 cents
1962	2.5 - 7 cents
1963	4 - 8 cents
1964	4.5 - 10 cents
1965	4 - 11 cents
1966	4 - 10 cents
1967	4 - 10 cents
1968	5 - 10 cents
1969	6 - 15 cents
1970	6 - 15 cents

Source: National Marine Fisheries Service, 1955-1970, Market news service - Gulf fisheries (selected areas). Fish & Wildlife Service, U.S. Dept. Commerce, New Orleans, La.

reported that 65 percent of the hard crabs processed by his plant are females.

Crabmeat processors report a seasonal crabmeat market and raw hard-crab supply (National Marine Fisheries Service, 1967, Louisiana Landings). During peak periods the supply occasionally exceeds the plant's processing capacity. At these times the crabbers are asked to stop crabbing, or the catch is shipped out of state. In the early spring, during the past few years, some live hard crabs have been shipped out of state, especially to Alabama and Maryland.

Crabs trucked to a plant on a given day will usually be processed the next morning; excesses can be held only a day or two. The operator of one of the larger crabmeat plants also buys furs and shrimp.

Seafood dealers also buy soft-shell crabs and resell directly to the public or to freezer plant operators, who in turn market them to restaurant owners, hotel proprietors, and other establishments. Seafood dealers will buy all the soft-shell crabs the fishermen can produce. In 1969 the seafood dealers of Lafitte-Barataria received $2.00 to $6.00 a dozen for live soft-shell crabs.

Crabbers reported returns of 25 to 40 cents each ($3.00 to $5.00 a dozen) for "counters." "Counters" are crabs more than 5.5 inches in width; smaller crabs are sold as two- or three-for-one. Large male crabs are the preferred market items.

Hard- and Soft-shell Crab Gear

Crab fishing equipment can be classified as hard-crab gear and soft-shell crab gear. Hard-crab fishermen in the Barataria Estuary use either a trotline with baits or crab pots. Soft-shell crab fishing gear includes bush lines and shedding cars.

Gear types and practices peculiar to the blue-crab fishery developed in Chesapeake Bay and subsequently spread to the Atlantic and Gulf coasts. The first blue-crab fishery developed during the 1800's near Crisfield, Maryland, on the eastern shore of Chesapeake Bay. In Chesapeake Bay trotlines with snoods were used from 1870 to the 1920's, when they were replaced by trotlines with baits (Van Engel, 1962). The trotline with snoods consists of a heavy cord line with drop lines spaced about 3 feet apart. Bait, classically consisting of cattle ears and lips or strips of salted cowhide purchased from slaughter houses, was tied to the free end of the drop line.

The first gear used to catch hard crabs in Louisiana was the trotline with snood lines (Rathbun, 1884; Stearns, 1887; and Wilkinson, 1892). Trotlines with baits became common in the Barataria Estuary during the World War II period (Thompson, 1946). A trotline with baits is a baited hookless line that is placed on the bottoms of lakes and channels of the estuary. Baits, as described above, are tied directly onto the line by means of a slip knot. The crabber usually sets up two or more trotlines, each a half mile or more in length. Each trotline is stretched between two poles which hold the lines in place. Feeding crabs, as described in the next chapter, are attracted to the baits. As the line is raised from the bottom, the crabs tenaciously grasp the baits with their chelipeds. An outrigger, or arm, extending over the water from one side of the fishing craft supports the line at one point. As the boat is propelled along the line, the outrigger raises the trotline from the bottom, knocks the crabs off the baits (Photo 4), and returns the baited line to the water behind the boat.

In the past, a crab fisherman sat at the side of his boat near the outrigger and caught the crabs with a hand dip net as they fell off the baits. During the 1950's the mechanized crab cage (Photo 5) came into vogue, replacing the hand dip net. With a crab cage the crabber is able to use longer trotlines or more of them and thereby increase his catch. With either method a motor is used to advance the boat at a low, steady speed as the trotline continually passes over the outrigger.

About 1965 the crab pot (Photo 6) began to achieve popularity among Barataria Estuary crab fishermen. Like the trotline, a crab pot

Photo 4. The trotline with baits gear type in operation. The blue crab (center) clinging to a bait will be knocked off and will drop into the crab cage below.

Photo 5. Use of the crab cage with the trotline with baits. A crabber is in the process of emptying the crab cage.

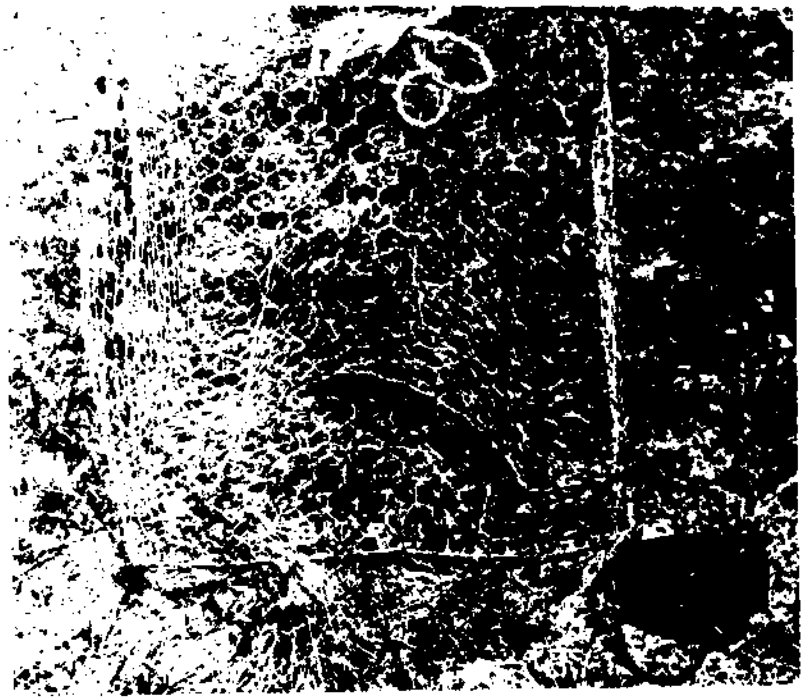


Photo 6. Chickenwire crab pot, or crab trap. Feeding hard crabs are attracted to the baits inside the pots.

is used to catch hard crabs that are actively feeding. Though designs vary, most crab pots are constructed of chickenwire. Each has a bait container in the bottom center. Generally, the pot has two funnel-shaped entrances on the sides, through which crabs enter. Some have an upper and a lower chamber. Fishermen attach painted plastic jugs, or cork floats, to locate and identify the pots in the water.

The operator of a large crabmeat processing plant in Westwego, Louisiana, reported that approximately 90 percent of the Barataria Estuary hard crabs purchased by processors are taken with crab pots. A fisherman using crab pots can take more crabs, on the average, than the trotline crabber. In 1970, only about 60 commercial crabbers retained use of the trotline with baits in Barataria Estuary.

A small percentage of the hard crabs caught in the estuary are taken with shrimp trawls, drop nets, and butterfly nets. The intentional use of shrimp trawls for catching crabs is illegal in Louisiana. However, taking of crabs incidentally while shrimp trawling appears to be increasing, especially in marine areas. Trawled crabs are usually taken in winter and are sold to a processing factory in Alabama. Taking of hard crabs smaller than 5 inches across the carapace is also illegal in Louisiana, as is taking of peeler crabs smaller than 4 inches.

In about 1927 a swampdweller living along Lake Cataouatche discovered that peeler crabs were attracted to fresh willow branches being placed in the lake to catch river shrimp and eels. When the branches were raised from the water, blue crabs undergoing molting were found inside the mass of branches. In this stage, blue crabs often bury themselves in the mud of the shorelines and may occasionally be observed among the roots and stumps of shoreline vegetation. In Lake Pontchartrain, molting crabs seek protection in beds of submerged aquatic plants, e.g., *Ruppia maritima* and *Vallisneria spiralis.*

The fishermen soon found that wax myrtle (*Myrica cerifera*) branches were more effective in attracting peeler crabs than willow branches (Frost, 1938) and that clumps of branches tied to trotlines would serve this purpose. Wax myrtle, locally known as the seria bush, is an evergreen shrub that is widely distributed in south Louisiana (Brown, 1965). To prepare a "bush," the crabber takes 6 or 7 fresh branches about 3 feet in length and binds them together at the base (Photo 7). The bushes are tied to a line, about 15 feet apart, to form

Photo 7. Seria bushes on a bush line. The soft-shell crab fisherman places the bushes in water bottoms where crabs are molting.

a bush line. In earlier years, a soft-shell crab fisherman used about 200 bushes, but in 1970 the fishermen were using from 500 to 1,000 bushes.

Attracted to the bushes are "green" crabs (those that will molt in about a week) and "busters" (crabs with cracked exoskeletons, indicating that ecdysis is in an advanced stage). Only a small number of soft-shell crabs and hard crabs are shaken, or picked, from the bushes.

For keeping crabs alive while they complete the shedding process, the fishermen utilize crab shedding cars (Photo 8). These are actually fish cars--large, open boxes suspended in the water and used to keep fish alive before marketing. Shedding cars, hand made from cypress slats or perforated boards, usually measure 8 feet wide, 12 feet long,

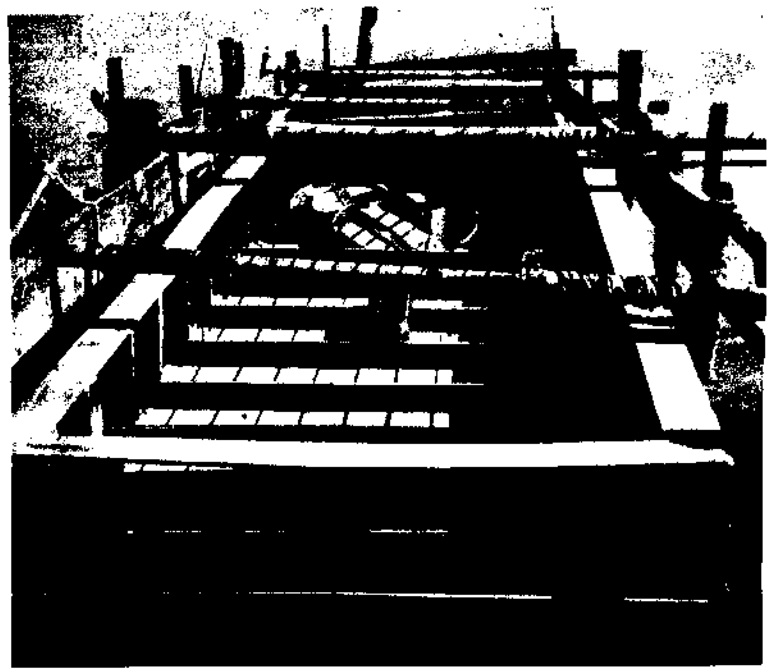


Photo 8. Two empty crab shedding cars. Peeler crabs are kept in the cars until they undergo ecdysis.

and 3 to 4 feet deep. Windlasses are used to raise and lower the boxes in order to examine the crabs. A soft-shell crab producer generally utilizes two to four shedding cars. From 250 to 500 live peelers are kept in a single car. When the busters emerge from their old exoskeletons, they are soft crabs. At this stage they are removed from the cars and placed under refrigeration until marketed.

Soft-shell crab producers develop the ability to judge at a glance how soon a peeler crab will shed. Accordingly, crabs are hand sorted by stage, and each group is held in a different car until molting occurs. Hard crabs are highly cannibalistic and will prey on the immobilized soft crabs if allowed to remain in the same car.

CRABBING GEAR

Field observations of crab fishermen and various types of fishing gear in use provide insights regarding the ecology of the blue crab. The use of hard-crab fishing gear, trotlines and crab pots, reflects the feeding habits and distribution of the larger juveniles and adult crabs. Practices associated with soft-shell crab fishing gear, including bush lines and shedding cars, are related to the process by which the larger juveniles undergo ecdysis.

Use of the Trotline with Baits

Trotlines are used in the upper Barataria Estuary mostly during warm months. Elderly fishermen and those who sell hard crabs to the public may use trotlines in preference to crab pots. Crabbing is carried on 7 days a week. Each trotline crabber maintains 2 to 6 baited trotlines, which must be laid out and picked up every day. Fishermen begin crabbing in the early morning and work until midafternoon. From December through March crabbing with trotlines is less productive; then crabbing is begun later in the day, after the shallow estuarine waters have warmed. When estuary waters are cold, crabs are less active; consequently they feed less and therefore are less attracted to the baits.

Those crabs caught with a trotline are actively feeding; therefore, the crabber must continually tend his trotlines. According to these men, crabbing in the upper estuary is best from 5 till 9 in the morning. Crabs feed during the early hours along the edges of lakes and channels. In summer crabs apparently move deeper as the sun heats the nearsurface water. Trotline crabbing during the summer is not effective in deep water because, when a trotline is picked up from cool bottom water, the crabs release the baits as they sense the warmer surface water.

Because waters of the estuary are turbid, the crabs cannot be seen responding to the baits. Fishing success is measured by the size and number of crabs clinging to baits as the lines are raised. A crab every fourth or fifth bait is considered good, and seldom are two crabs found clinging to one bait. Only where a high concentration of actively feeding crabs exists can the trotline crabber's catch compare with that of a pot fisherman. A daily trotline catch of 25 to 35 baskets (35 to 40 pounds per basket) is common.

Fresh beef lips and ears are the usual trotline baits. Catfish heads and skins and other meat scraps can also be used with success, but such baits are not very durable. Fresh baits attract crabs better than old baits. Baits are changed every 2 to 3 days in summer and every 2 weeks in cooler months. When crabs are "biting" actively trotlines are placed close together and run frequently to prevent the crabs from eating baits off the lines.

The trotlines are usually stretched across areas of current, perpendicular to the shorelines (Fig. 9). The crabbers know that crabs tend to move in areas of current during the spring migration toward the upper estuary. When crabs migrate seaward from the upper estuary in late fall they tend to stay closer to the shoreline. In summer the trotline crabbers fish locations along the shore where there are tidal currents. Centers of upper-estuary lakes are seldom crabbed.

Large numers of crabs which have recently shed are taken by trotline in the upper estuary. Recently shed crabs are light-weight and

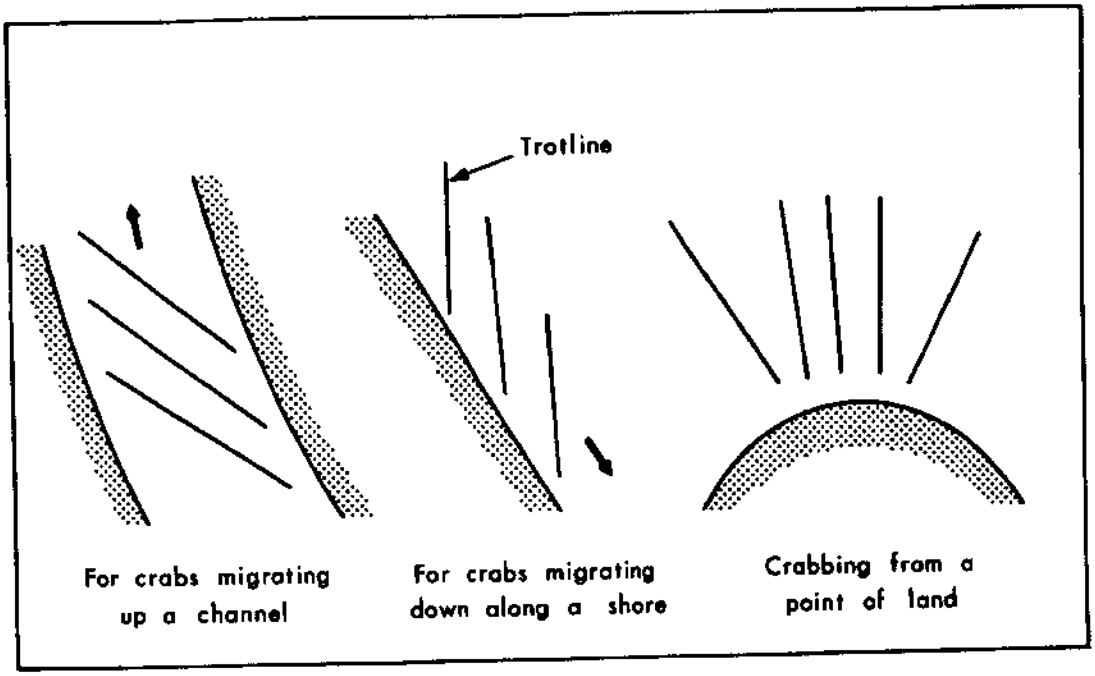


Fig. 9. Orientation of the trotlines in the estuary.

brightly colored. The light and hungry crabs respond better than do "fat" crabs. Spawned females returning to the estuaries from the marine area are also active feeders. Crabs smaller than 3 to 4 inches across the carapace are seldom taken with trotlines.

During the hot months of June, July, and August the mechanized crab cage is not satisfactory in the lower estuary. Lower estuary crabs caught in summer are called saltwater crabs, whereas those caught in the upper estuary are referred to as brackish water crabs. When saltwater crabs are taken, they must be shaded and iced immediately to prevent mortality. These crabs die rapidly if restrained by crab cages; evidently the blue crab's ability to hyporegulate efficiently is impaired by captive suspension in a warm, saline current. Also, female crabs which have recently spawned die easily.

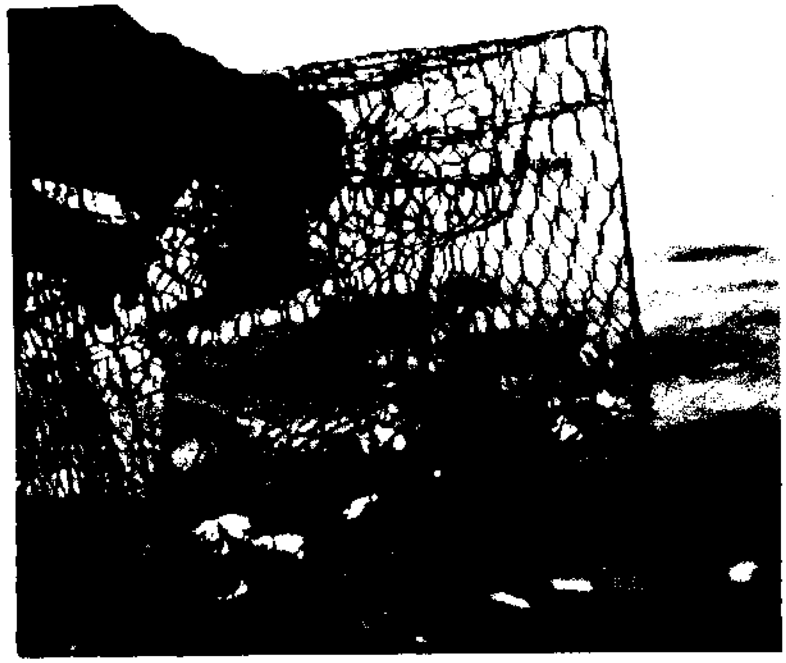


Photo 9. Use of the crab pot in the Barataria Estuary, Louisiana. The fisherman is about to empty the crabs from the pot into his boat.

Crab Pots

A crab pot is illustrated in Photo 9. Most of the Barataria Estuary hard-crab catch is taken with these traps. Crab pot fishing is usually more productive than trotlining. Crab pot fishermen use as many as 200 pots at a time and may take a daily catch of 1,200 pounds. The pots remain on the bottom for long periods, even when the crabbers are not working. They are usually checked daily before noon. The condition of crabs caught with pots is good, and mortality in pots is low.

Like the trotline, the pot is baited to attract feeding crabs. Fresh, frozen croakers are popular bait, but mullet has been used with equal success. The low cost and year-round availability of frozen croakers favors their widespread use. About 1.5 pounds of bait are placed in each bait chamber.

Trapped crabs tend to stay in the pots as long as the bait lasts, although pots need not be emptied when crabs are feeding actively. Once the bait has deteriorated, the crabs may leave; after a day or two only stone crabs and a few very large blue crabs may remain in the pots. Baits are changed daily because croakers deteriorate rapidly. From September through December in the lower estuary stone crabs, oyster drill snails, and hermit crabs may also be attracted by the bait.

Small juvenile crabs are seldom taken. Either they do not enter the pots or else the size of the mesh entrances allows them to escape. Recently caught crabs tend to be in the lower chamber, whereas those restrained for some time are usually in the upper chamber. Two-chamber pots seem to be losing popularity because they are more difficult to empty.

Pots must be placed in areas of moving water because large crabs do not feed in shallow environments with poor circulation. Tidal channels, connecting waterways, and shorelines where tidal exchange occurs are excellent crabbing areas. To facilitate recovery of the pots, they are spaced linearly about 100 feet apart in winter and somewhat closer in summer.

In the upper estuary pots are placed in locations similar to those of trotlines. In the lower estuary, areas with oyster beds and direct tidal exchange are preferred. The fishermen recognize that large concentrations of gravid females congregate in the lower estuary near tidal inlets during the period from November through March. In winter these crabs, which do not respond well to trotlines, are taken in very large numbers by the crab pot and trawl fishermen. Male crabs are also taken, but they tend to be more widely distributed.

The successful hard-crab fisherman must move his gear frequently because the crabs migrate and the stock in a given area can be depleted. Well-maintained gear, fresh bait, and a willingness to work 7 days a week are important factors in success. Young, inexperienced men often follow the movements and practices of an experienced crabber.

Use of the Bush Lines

The bush line technique for catching peeler crabs is peculiar to Louisiana. Soft-shell crab fishermen from Lafitte-Barataria use bush lines from March through October. In early March, when fur trapping and other winter activities end, the crabbers begin cutting seria branches and preparing bush lines. In mid-March these are staked out in Lake Cataouatche, Lafitte Pens, and other water bottoms.

Freshly prepared bushes are quite effective in attracting peeler crabs. However, after about 2 weeks in the water the resinous seria leaves turn black. Crabs appear to avoid the bushes at this time. After the black leaves have fallen off and slimy, algal growths cover the branches, the bushes become effective again. Most crabbers replace the bushes after a month and use 2 or 3 sets of bushes each year. Crabbers asserted that 1969 was a good year because much "slime" formed on the bushes.

Using a small boat and a hand dip net, the crabber runs his bush lines once a day. As he pulls himself along the line, each bush is carefully raised by hand and the dip net is quickly placed to catch any crabs that may fall out (Photo 10). Often a peeler crab is found in every third or fourth bush; one in every bush is unusually good.

Photo 10. Use of the bush lines to catch shedding crabs.

If the crabs are "giving" well the crabber may check his lines twice a day. A fisherman with 500 bushes expects to catch about 150 peelers a day.

After the crabs have been shaken, or picked, from the bushes, they are placed in shaded baskets in the boat. Busters and soft-shell crabs are kept in one basket, green crabs in another, and hard crabs, if any, in a third. Soft-shell crabs are seldom found in the bushes. Crabbers believe that eels devour large numbers of soft-shell crabs.

Largest catches of peelers are made in quiet, shallow waters of high turbidity. Crabs that are molting apparently move to calm, shallow, muddy environments. In less turbid water many peelers escape when the bush line is raised. The number of shedding crabs taken is reduced during cool weather, but immediately after warming occurs the catch becomes somewhat higher than usual. Branches of the bush apparently serve as obstacles which the crabs may pry against as they extricate themselves from their old exoskeletons and use as protection from predators.

Shedding Cars

A minimum of two shedding cars is required because green crabs must be kept separate from the busters. Green crabs are still able to feed and can attack another crab, but busters and soft-shell crabs are defenseless and do not feed.

The crabber must be able to recognize shedding signs in order to sort peeler crabs (Table 12). A molting crab takes from 10 minutes to 2 hours to emerge from its old exoskeleton. Small females shed faster than large males. Most of the busters shed at night, when water temperatures are cooler. A newly shed crab is soft, defenseless, and wrinkled. After copious absorption of water the crab increases in size from 8 to 50 percent (Tagatz, 1968a, p. 284). The increase in size is illustrated in Photo 11. In 4 to 12 hours the new exoskeleton is firm and leathery.

Each morning and evening the crabber raises the buster car and removes all the soft-shell crabs. If the weather is hot and the sun is bright this must be done quickly, or some of the crabs may die. Every other day the crabber raises the green crab car and grades the crabs. If a crack under the carapace is found, the crab is gently tossed into the nearby buster car. Crabs remain in the green car 2 to 7 days and in the buster car from 12 to 36 hours.

Production of 100 "counters" per day is considered very good. A "counter" is a soft-shell crab measuring more than 5.5 inches across the carapace. Soft-shell crabs are worth much more than hard crabs. In 1970, fishermen received 35 cents apiece for "counter" soft-shell crabs compared with 2 to 5 cents each for hard crabs. In order to keep the

Table 12

Shedding Signs Utilized for Soft-shell Crab Sorting

Characteristic	Duration
White line*	5 to 9 days
Purple line	5 to 10 days
Pink line*	3 days
Red line*	24 hours
Buster stage	12 hours
Emergence	2 hours
Soft-shell stage	3 to 6 hours
Paper-shell stage	12 to 24 hours

*Signs recognized by soft-shell crabbers in the Lake Pontchartrain - Lake Borgne area but not by fishermen in the Barataria Basin.

soft-shell crabs alive and in the soft-shell state, the crabs must be kept under refrigeration.

Each shedding car holds 250 to 500 peelers, depending upon the size of the crabs and water temperature. Overcrowding in June, July, and August can cause high mortality among molting crabs. Windlasses are used to vary water depth in the cars from 4 to about 24 inches. Since warm water hastens the molting process, shallow depths are maintained in the cars during early spring. When the water is very warm or stagnant, or when heavy rains occur, water depth is increased.

The fishermen believe that water salinity, provided it is not completely fresh or very saline, has little effect on molting. Tagatz (1968a) successfully shed blue crabs in water of less than 1 ppt salinity. A few crabbers observed that crabs may die in the shedding cars after exceptionally heavy rains. Galvanized metal in the shedding cars will

Photo 11. Illustration of the size increase of the blue crab after molting. The soft-shell crab (left background) has just emerged from the old exoskeleton (left foreground). On the right is an empty exoskeleton from another crab.

also cause mortality.

During recent years producers of soft-shell crabs have encountered problems. In very warm water the peelers molt faster, but mortality rates are also higher. Losses as high as 50 percent may occur, especially among the fattest crabs. Some crabbers report that male crabs die more easily than females. High water temperature in midsummer may be a limiting factor in the Barataria Estuary. Wave wash and mud in the bottoms of the shedding cars are also undesirable.

During periods of lower water levels in the upper estuary, the crabbers complain of "bad water." In these circumstances stagnant water drains into the lakes from surrounding swamps and marshes. Drainage from agricultural fields, sugar cane mills, oil and pipeline canals, and reclamation pumping stations is also detrimental to shedding crabs.

Crabs swimming at the water surface and crab kills in the shedding cars are associated with an influx of polluted water. Polluted water retards shedding, especially during the buster stage. After several days' exposure a molting crab weakens and dies. Soft-shell crabbers on Lake Pontchartrain and Lake Borgne are combating pollution by constructing shedding houses equipped with pumps. These men have found that surface water is more detrimental than water pumped from the bottom of the bayous or lakes.

Mortality in the shedding cars from crab diseases does not appear to be a significant problem. Many molting crabs in the upper estuary are covered with freshwater branchiobdellid annelids, small leech-like worms that also live on the gills and bodies of crayfish, but these small worms are probably not detrimental to the crabs (Blackford, 1966). A very small number of crabs in the shedding cars become "car worn," i.e., develop small pits on the exoskeleton, especially on the sternum. This condition, which may inhibit molting, may be caused by chitonoclastic bacteria (Rosen, 1967).

Occasionally both hard- and soft-shell crabbers will catch sick crabs. Many of these are infested with Microsporidia, _Nosema_ sp. (Weidner, 1970). Minor crab mortalities along the South Atlantic Coast have been attributed to this organism (Mahood et al., 1970). Bridgman (1968) reported that 9.2 percent of the crabs sampled in the upper Barataria Estuary were infected with encysted flukes, or metacercaria, of the genus _Carneophallus_ (Trematoda: Microphallidae). When these are infected with *Urosporidium* sp., black haplosporidia are produced, commonly known as "pepper-in-the-meat" disease. However, the *Carneophallus* parasite itself is probably not harmful to the crab (Overstreet, personal communication).

A few Louisiana crabbers have attempted unsuccessfully to accelerate molting of peeler crabs by removing the eyestalks, which produce molt-inhibiting hormones. Perhaps lack of success resulted because the eyestalks were not completely removed. A molt-stimulating hormone, ecdysterone (Krishnakumaran and Schneiderman, 1969),is available from chemical supply outlets, but at present it is much too expensive for this commercial application.

To summarize, in the Barataria Estuary hard crabs are fished with gear that use baits to attract feeding crabs. Trotlines are used primarily in the upper estuary during the summer months. Crab pots are the most popular hard-crab gear. These are used throughout the estuary, and are particularly effective in the lower estuary during the winter months. Fishing for peeler crabs is done with bush lines in the upper estuary during the warm months. The shedding process is completed in crab shedding cars. Pollution of the upper estuary is a growing problem for the soft-shell crab fishermen. If water quality is good, soft-shell crab fishermen claim that they can successfully shed 95 percent of the peeler crabs gathered.

CRAB FISHING AREAS AND SEASONS

Over the years crab fishing patterns have evolved which reflect the seasonal distribution and migration of blue crabs. Because many fishermen also trawl the estuaries for shrimp, they are aware of crab movements. Four hard-crab fishing seasons and two soft-shell crab fishing seasons were recognized in the Barataria Estuary. Most of the field data pertain only to commercial-size crabs.

Winter Hard-crab Fishing

During the months of December, January, and February productive hard-crab fishing areas are limited to the lower estuary in Caminada and Barataria bays (Fig. 10). Caminada Bay, though only 2 to 5 feet deep, is one of the most productive parts of the lower estuary. Other high-catch areas are along the eastern side of the Barataria Bay Waterway and from Quatre Bayou Pass to upper Barataria Bay. Crabbing is not done in the tidal inlets because currents there tip the crab pots and fill them with sand. Boat and barge traffic restricts crabbing activity near Grand Isle and Barataria Pass. Very little crabbing is done in the nearby Gulf of Mexico, even though shrimp fishermen occasionally catch crabs in their trawls.

Crabs caught during the winter are in good condition, and meat yield is high. Spawning does not occur in winter, and rarely do crabs molt at this time. A few crabs observed during this survey had black haplosporidia (pepper-in-the-meat) in the muscles and among the egg masses.

From December until mid-March many crab pot fishermen work the lower estuary. Preferred areas are those with oyster beds and direct tidal exchange. Viosca (1953) and Menzel and Hopkins (1956) reported

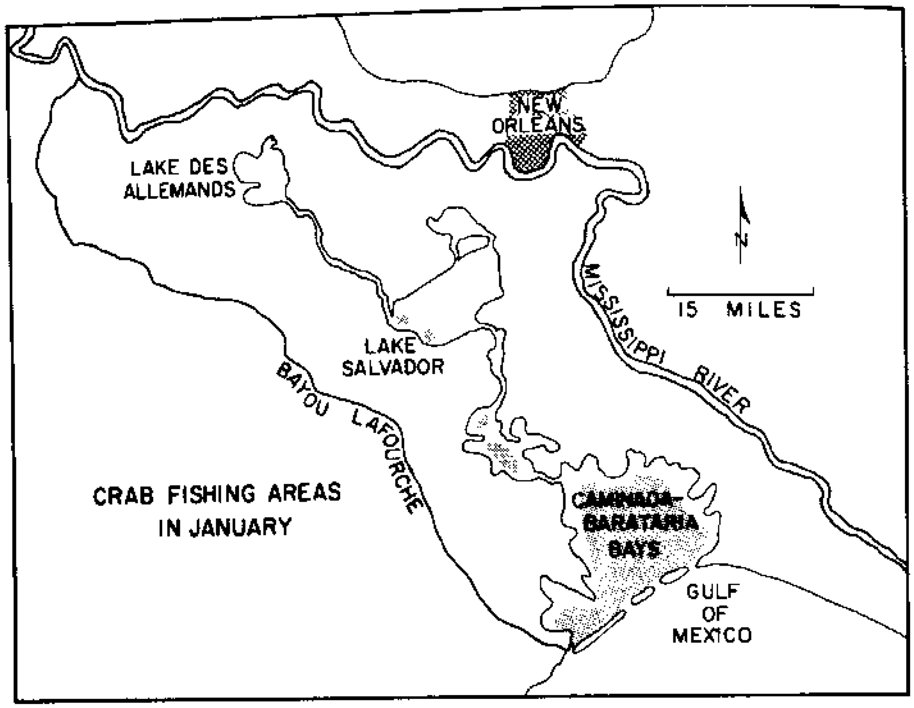


Fig. 10. Hard-crab fishing areas in the Barataria Estuary in January.

that blue crabs feed on oyster spat, small and weak oysters, and oyster predators. Cultivated oyster beds extend from lower Caminada and Barataria bays to the middle of Little Lake. Oyster fishermen occasionally dredge up crabs along with the oysters.

Blue crabs migrate from the upper estuary to the lower estuary when the water temperature falls to about 15°C (Table 13). Mean water temperatures during December, January, and February drop below 15°C in the lower estuary and below 13°C in the upper estuary. In Little Lake and Lake Salvador small numbers of adult male and large juvenile crabs burrow in the bottom muds and feed only during intermittent warm spells. Because these crabs winter in the upper estuary, the fishermen call them settler crabs. The adult male and large juvenile crabs are more tolerant

Table 13

Surface Water Temperatures (Degrees Centigrade)

in Upper and Lower Barataria Bay, Louisiana

	1959	1960	1961	1962	1963	1964	1965	1966	1967	Mean
				Grand Terre, Lower Barataria Bay						
Jan	12	14	13	13	11	12	16	12	14	13
Feb	16	13	17	17	12	13	15	13	14	14
Mar	17	17	21	16	19	18	16	17	18	18
Apr	22	23	21	22	23	22	24	21	25	23
May	27	25	26	27	25	26	25	26	26	26
Jun	28	30	29	28	26	29	28	28	30	28
Jul	31	32	31	29	28	29	29	29	29	30
Aug	31	30	30	29	29	28	28	29	29	29
Sep	30	-	28	28	27	28	26	28	27	28
Oct	26	24	23	24	23	21	22	23	22	23
Nov	18	21	18	16	19	20	21	20	18	19
Dec	15	14	16	13	9	16	15	15	16	14
Mean	22	-	23	22	21	22	22	22	22	22
				St. Marys Point, Upper Barataria Bay						
Jan				9	7	12	13	-	12	11
Feb				17	8	11	12	-	14	12
Mar				17	19	16	17	-	17	17
Apr				25	25	24	23	-	26	25
May				27	27	28	27	-	24	27
Jun				29	27	28	29	-	29	28
Jul				30	29	29	29	30	29	29
Aug				30	30	30	29	-	29	30
Sep				29	24	28	29	26	26	27
Oct				26	26	19	-	19	21	22
Nov				16	17	20	-	14	17	17
Dec				12	6	14	-	10	18	12
Mean				22	20	21	-	-	22	21

Source: Louisiana Wild Life and Fisheries Commission, 1969, Hydrology of Barataria Bay, unpublished mimeographed report, New Orleans, La.

of low temperatures than adult female crabs.

Nearly all crabs caught near the tidal inlets are gravid females. After mating, females from the upper estuary begin migrating toward the tidal inlets during October and November. When a small number of adult females were opened in December, it was found that some were developing egg masses. According to the crab fishermen, such crabs do not leave the areas of direct tidal exchange near the tidal inlets. Very large catches of these crabs are taken during the winter in the bay near Caminada Pass. When a concentration of crabs is located, each crab pot may yield a half bushel or more per run.

Inland from the tidal inlets, adult males and immature crabs are caught. In shallower, less saline portions of the lower estuary about 80 percent of the adult crabs caught are males. Crabbers who wish to take male crabs move farther away from the inlets. In Little Lake and Lake Salvador nearly all the winter catch consists of adult males and immature males and females.

Approximately one-third of the adult females in the winter catches were not the shiny, clean, bright-colored crabs usually observed, but were dull yellow-brown. Tagatz (1968b) concluded that the latter are probably repeat spawners from the previous season and that the more colorful crabs are recent migrants from the upper estuary. Crabs that mature in organic-rich environments, e.g., marsh ponds, are dark brown. The fishermen call them marsh crabs.

The winter crab catch is unreliable. Very low catches are associated with cold front passage, and crab pots cannot be run when waters are rough. During intermittent warm spells the crab catch increases, suggesting that the crabs actively feed at these times. During warm weather the crabs apparently move farther inland from the tidal inlets, and large catches are made in areas of tidal exchange. If a warm spell persists for a week or more, moderate catches of settler crabs are made in Little Lake and Lake Salvador. The fishermen continuously evaluate weather trends and the catch of previous days in order to take advantage of these factors.

Spring Hard-crab Fishing

The spring season extends from mid-February to about the first of May. The season is characterized by up-estuary migration of juveniles and adult males and by spawning of females in the lower estuary and marine areas. As the season progresses crabbing activity shifts away from tidal inlets and expands inland (Fig. 11). In April the northern portion of Barataria Bay, Little Lake, and Bayou Perot are important crabbing areas.

Gravid females begin to spawn in early March. By April, large numbers of egg-bearing females, called sponge crabs, occur in lower Caminada and Barataria bays. Spawning in the lower estuary and adjacent marine area continues until September. The crabbers must abandon this area because taking of sponge crabs is illegal.

The spring up-estuary migration begins in late February or early March but may start earlier if the weather becomes unusually warm in February. There appear to be 2 episodes of spring migration (Table 14). The first consists mostly of juvenile males ranging in size from 75 to 125 mm. The crabbers say that male crabs are "drawn to the sweet (fresh) water." Very large spring catches of male crabs taken around the Mississippi River delta, where river water mixes with gulf water, seem

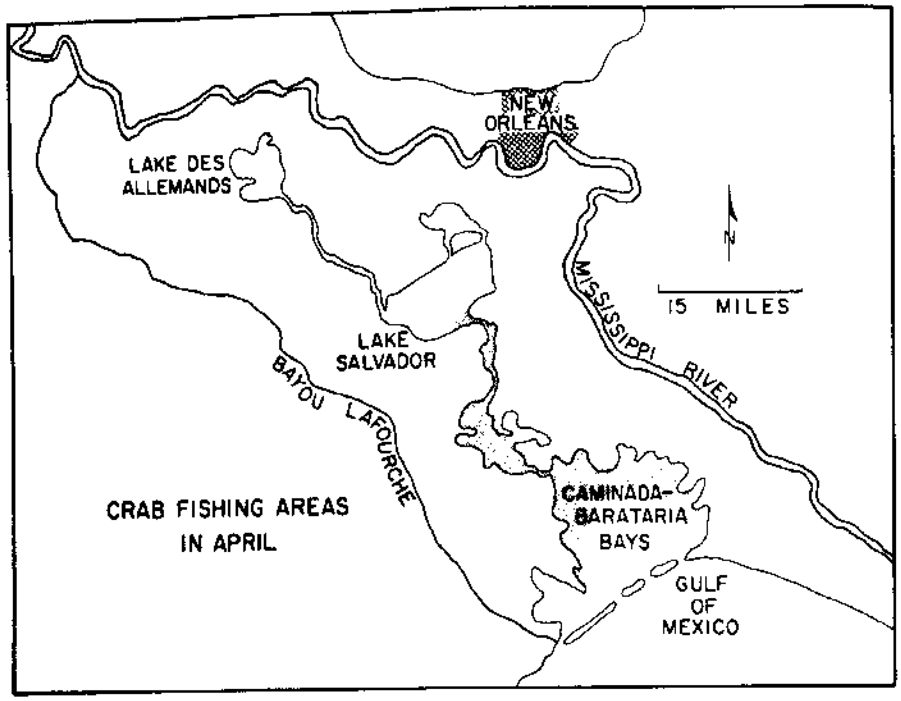


Fig. 11. Hard-crab fishing areas in the Barataria Estuary in April.

to corroborate this. Smaller juveniles of both sexes are also among the early migrants. Great numbers of these were observed in northern Barataria Bay.

Many early migrants are "clear" or have "paper shells." A "clear" crab is light-weight and bright colored, indicating recent shedding. As the waters of the estuary warm in spring, the small early migrants molt frequently as they move toward the upper estuary.

Crab fishermen assert that south winds which prevail for several weeks during March and April "push" the crabs up-estuary. The crabs often move at the water surface, especially at night. Tidal currents aid the migrations. Migrating crabs pass through Bayou St. Denis, travel up Little Lake and Bayou Perot, and then move along the shores of Lake Salvador

Table 14

Dates of Up-estuary Migration of Blue Crabs

(Based on initiation of crab fishing in the various water bodies)

Water Body	Migration Times: Early Episode	Main Episode
Bayou St. Denis	Mid-February	March
Lower Little Lake	Early March	March
Upper Little Lake - Bayou Perot	Early March	April
Lake Salvador	March	May
Bayou Des Allemands	April	June
Lake Des Allemands	April-May	June-July

and up Bayou Des Allemands. In spring, 1970, early migrants reached lower Lake Des Allemands by mid-April.

The second (main) episode of migration seems to occur more slowly. Most spring hard-crab fishing centers on this larger group. Its composition is mixed, and there is a greater proportion of adult males and immature females. Also, molting is much less evident than among earlier migrants. Many of the larger crabs are dull colored and may have broken chelipeds and missing legs.

Up-estuary migration is not a continuous movement. Cold fronts accompanied by lower temperatures, northerly winds, and lower water levels may delay or reverse the migration. During the passage of a cold front crabs often burrow into soft mud near the shoreline. When the weather warms again migration resumes, but many crabs caught a day or two afterward are covered with mud.

Although concentrations of spawning females move about in spring, they do not migrate up-estuary. An elderly crabber stated that he had caught only 2 sponge crabs during his lifetime in Lake Salvador. In the spring of 1970 very few sponge crabs were caught in lower Little Lake. A line drawn through lower Little Lake evidently marks a boundary beyond which sponge crabs do not migrate.

Until several years ago, crabbers catching sponge crabs would remove the sponges before marketing. Today, except for trawled crabs sold in Alabama, very small numbers of sponge crabs are sold to crabmeat processors. During recent years, spring crab catches in the Barataria Estuary have been low, suggesting depletion of the crab stock. The northern portion of the lower estuary is crabbed for males and nonspawning females until the May inland shrimp season opens.

Summer Hard-crab Fishing

The summer crabbing season includes May, June, July, August, and September. The locus of July hard-crab fishing is shown in Figure 12. Crabs are fished from Lake Des Allemands to Bayou St. Denis during this period. Highest catches are made in Lake Salvador and Bayou Perot. The crab fishermen report that June, July, and August are the most productive months in Lake Salvador.

Many crabs that molt in the upper estuary in summer are light. The fattest crabs are taken from Bayou Perot. Crabbers believe that brackish water from Bayou Perot brings food for the crabs. Items mentioned were flounders, spot, small catfish, silverfish, or simply "many fish." If the water in Lake Salvador is unusually fresh, the crabbers may seek fatter crabs in Little Lake.

Salinity of the upper estuary is highly variable (Fig. 13). The crab fishermen associate good summer crab fishing in the upper

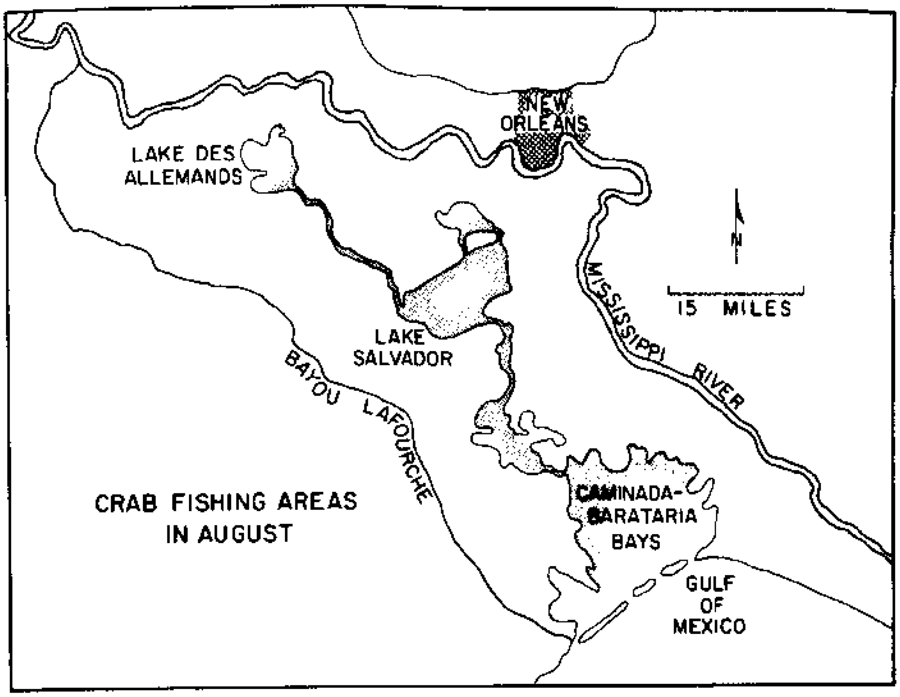


Fig. 12. Hard-crab fishing areas in the Barataria Estuary in August.

estuary with the mixing of "clear water" (brackish water) and "sweet water" (fresh water). Food items of the crab may be more abundant in the zone of mixing. In summer, crabs are often seen moving about with the tidal currents, probably in search of food.

Crabbers also associate high summer catches with sandy or shell bottoms and tidal currents. Large crabs are seldom found in areas with little water movement. Sandy bottoms correspond to locations of strong tidal currents. Many fishermen crab near clam (*Rangia cuneata*) reefs. Blue crabs devour large numbers of small *Rangia* clams (Viosca, 1953). In the Barataria Estuary, *Rangia* clams are distributed from lower Lake Des Allemands to about the middle of Little Lake.

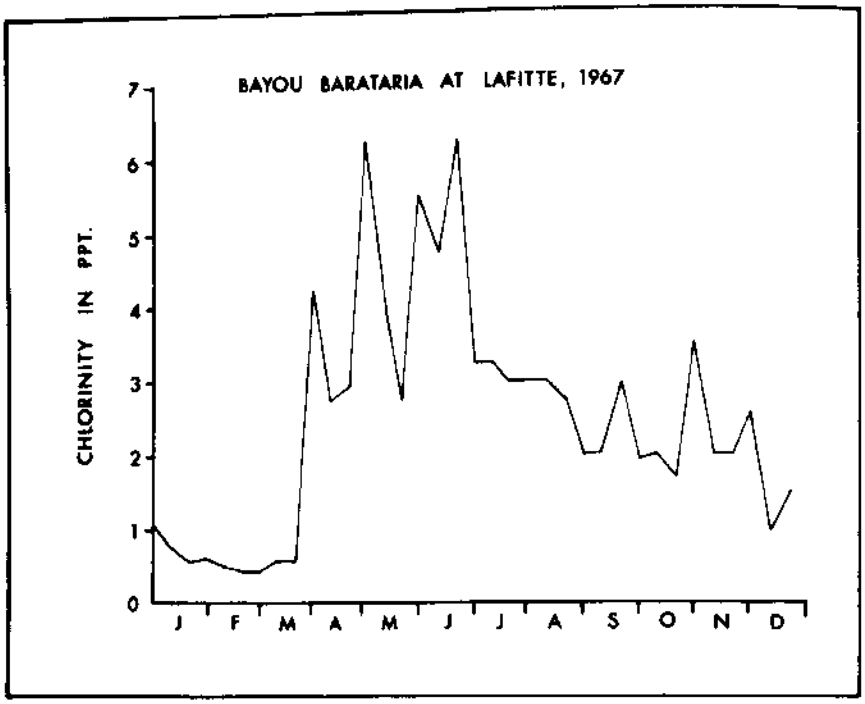


Fig. 13. Salinity variations in waters of the upper estuary. Data were taken from U.S. Army Corps of Engineers, Current Files, Tides and Gauging Section, New Orleans District, Louisiana.

The western side of Lake Salvador and the mouth of Bayou Perot are considered the best summer hard-crab fishing areas in the estuary. There, very low salinity water from the upper estuary mixes with brackish water from Bayou Perot (Photo 12). Sandy bottoms and clam reefs are also more prevalent in western Lake Salvador than on the eastern side. Points of land, e.g., Grosse Point and Point Chico, extend into western Lake Salvador, and tidal currents and sandy bottoms are prevalent in vicinities of these points.

The crab catch in Lake Des Allemands is small, and varies from year to year. In 1969, when the salinity was extremely low, the catch was also low. Medium-sized juveniles are common in the upper part

Photo 12. The mixing of fresh and brackish water in western Lake Salvador, Louisiana. Organic-rich drainage water from Bayou des Allemands (upper left) is flowing into the lighter colored water of western Lake Salvador.

of the lake, whereas larger crabs occur mainly in the lower portion. Highest catches are made from June to September. In late summer, when water temperatures and salinities rise, the crabs move farther up the lake. Crabs caught in Lake Des Allemands are smaller and less abundant than those caught in Lake Salvador. Crabs are very seldom taken in the fresh waters of Bayou Chevreuil and Bayou Boeuf.

The difficulty of keeping saltwater crabs alive in summer, as well as the high incidence of female crabs in berry, discourages crabbing effort in the polyhaline lower estuary. When crab pot fishermen do catch saltwater crabs, they must be shaded and iced as soon as possible. During the inland shrimp seasons a single vessel may take 3 to 4 bushels of crabs per day in trawls. Also, large numbers of very small juveniles are inadvertently destroyed by the trawls.

Because of their large size, male crabs appear dominant in the upper estuary hard-crab catch during the summer. However, large numbers of juveniles mature in summer, and adult females are also common during June, July, and August. Spawned females (those that have completed at least one spawning cycle) are caught mainly in the lower estuary from April to October, although occasionally they will enter Lake Salvador in late fall. Large numbers of dead "spent females" (those that have completed their spawning activity) may be observed on the beaches of Grand Isle and Grand Terre in August.

Hard-crab Fishing Areas in the Fall

The fall hard-crab season extends from September to mid-December. It appears from fishing activity that crabs achieve their widest distribution in September, ranging from upper Lake Des Allemands to Barataria Bay. Fall crabs tend to be fatter and slightly larger than those caught in the summer. Also, crabs appear to be more numerous in eastern Lake Salvador. Large males continue to dominate the catch, but females are also taken.

In September or October, following the season's first cold front passage, adult females begin to concentrate in southern Lake Salvador, Bayou Perot, and Little Lake. These gravid crabs constitute the "fall run of the females," which slowly migrates toward the lower estuary. The fishermen have observed that the "fall run of the females" has diminished in recent years.

Relatively high catches of large males are taken in Bayou Des Allemands during October and November. By November crabbing has ended in Lake Des Allemands (Fig. 14). With the onset of cold weather, centers of fishing activity shift to the lower portions of lakes and connective channels. In late November and early December crabbers concentrate on lower Mud Lake, the mouths of Bayou Des Allemands and Bayou Gouba, southern Lake Salvador, and Bayou Perot.

The late fall catch is highly variable, indicating that migration toward the lower estuary is probably occurring. Gravid females and the small juveniles leave first. In early December shrimp fishermen catch juveniles ranging in size from 40 to 75 mm in Barataria Bay and the nearby Gulf of Mexico. Three or more weeks of cold weather are required to force the large male crabs out of the upper estuary. In December only large juveniles and adult males are caught in Lake Salvador.

The fishermen try to locate crabs during the out migration by continually moving their gear. Trotline crabbers usually quit crabbing at this time. Many crabs are observed moving along the shorelines, often within 500 feet of the shore. By November the fishermen begin catching adult females near the tidal inlets. Male crabs become numerous around the oyster beds in December. As the winter season approaches, catches in the upper estuary play out, indicating that most of the crabs have gone.

Soft-shell Crab Fishing - Spring Season

The spring season extends from mid-March to the first of May. In an unusually warm winter it may start in February. Generally, peak

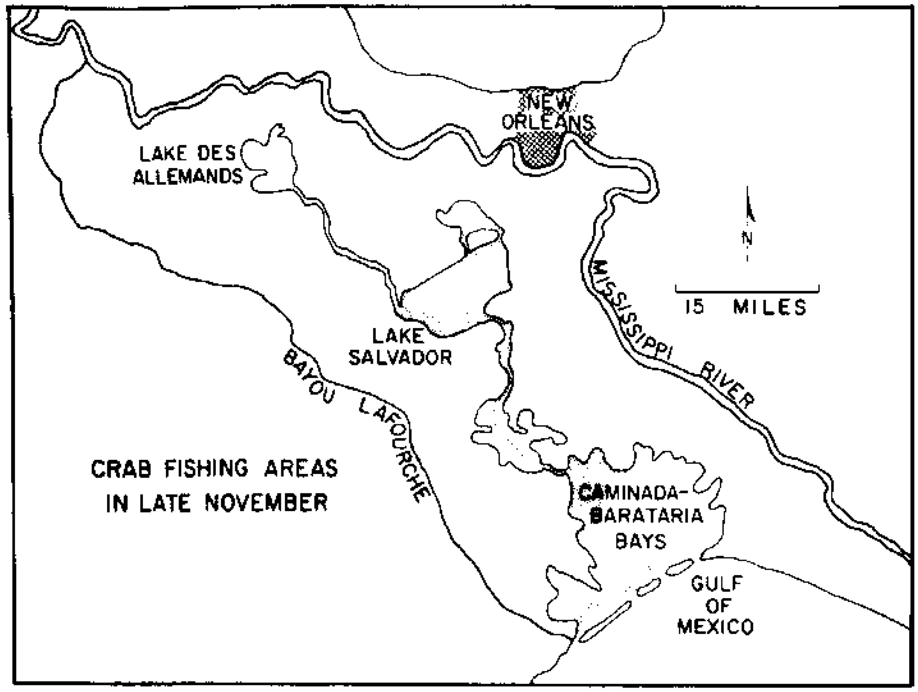


Fig. 14. Hard-crab fishing areas in the Barataria Estuary in November.

soft-shell crab production occurs in late March and April. Much of this takes place in Lake Cataouatche (Fig. 15). Other important areas are the Lafitte Pens, southwestern Lake Salvador, Bayou Perot, Bayou Rigolettes, and Little Lake.

Molting crabs occur throughout the estuary, and winter shrimpers occasionally catch them offshore. A few peeler crabs are caught in summer near Grand Isle by recreational fishermen. Mostly, however, molting by larger juveniles occurs during the warm months in the oligohaline waters of the estuary.

The spring soft-shell crab season is associated with the movement of early migrants to the upper estuary. These crabs reach Lake Cataouatche by mid-March. Large numbers of juveniles measuring 75 to

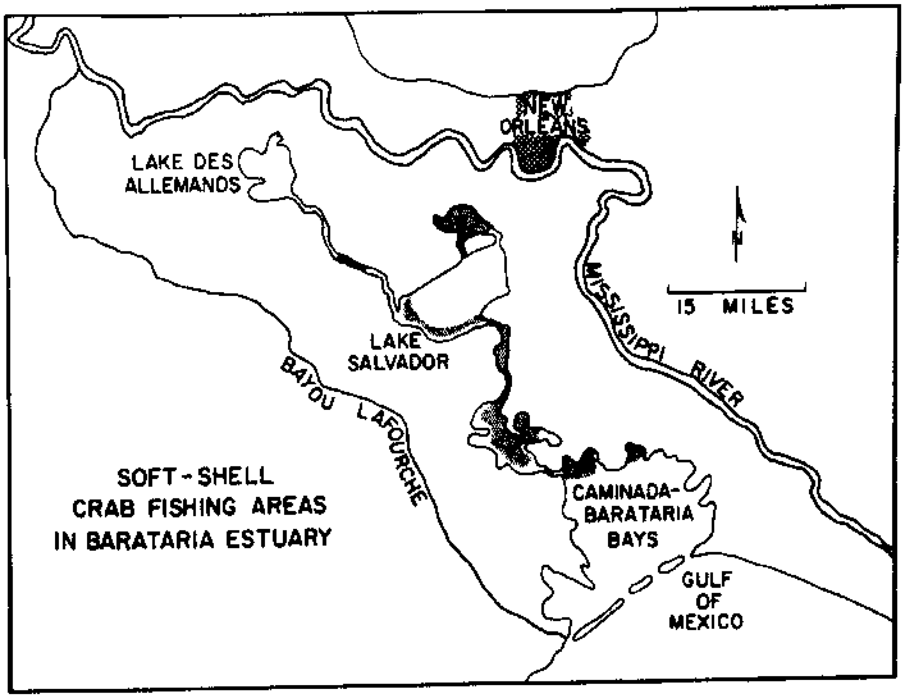


Fig. 15. Peeler-crab fishing areas, Barataria Estuary.

120 mm in width were seen in the fishermen's shedding cars in March 1970. Many of the soft-shell crabs being produced then were close to the 4-inch maximum size limit.

As previously noted, warm waters stimulate the molting process. Hence, bush line fishermen concentrate on shallow waters; Lake Cataouatche is only 3 to 4 feet deep. Should the weather suddently turn cold, the crabs apparently would return to deeper waters and the catch would diminish. When the water is very warm, the bush lines are placed closer to the shorelines.

In spring, 1970, some fishermen quit running bush lines in April because they could not catch enough peeler crabs. During recent years the spring run has declined, and many crabbers attribute this to crab pot fishermen who catch gravid females. Either the molting population is lower, or bush lines are not as effective as in previous years.

Soft-shell Crab Fishing - Second Season

Generally, during late May and June very few peelers are caught with bush lines. However, in late July and August molting crabs are again attracted to the bushes and peeler crab fishing resumes. Soft-shell crab fishing continues during October and ends with the arrival of cold weather. Crabbing areas during the autumn season are much the same as in the spring season. Some crabbing activity extends into lower Bayou Des Allemands and Mud Lake. Also, crabbing in Little Lake becomes somewhat more active, but the Lafitte Pens decline.

The second season is usually longer than the spring run. Toward the end of the spring run, doubles (pairs of mating crabs) appear in the bushes and remain abundant from June to September. The distribution of mating crabs indicates that female blue crabs reach maturity and mate in the oligohaline waters of the upper estuary. The slack period between the spring run and the second season is marked by appearance of unusually small females being carried by large males. These "dwarf females" are quite common in Little Lake, which is somewhat more saline than the other soft-shell crabbing areas.

In recent years the center of soft-shell crab fishing has shifted up-estuary. Whereas Bayou Perot and Lake Salvador were formerly the main soft-shell crab fishing areas (Lenski, 1943), Lake Cataouatche is now the most important. The northern part of Lake Cataouatche near Bayou Verret produces the largest number of peelers. The maturing juveniles may be attracted to sewage and seafood wastes being discharged into Lake Cataouatche. Many crabbers associate the decline of fishing in Lake

Salvador with pollution of the southwestern part of the lake. Others feel that construction of the Barataria Bay Waterway in 1965 has caused the estuary to become more saline and this, in turn, has somehow reduced the catch of peelers in Little Lake and Bayou Perot.

To summarize, hard crabs are caught during every month of the year, but crabbing areas change with the seasons. In contrast, peeler crabs are taken only during the warm months, and primarily in the oligohaline waters of the upper estuary. The winter habitat of crabs is in the lower estuary and adjacent marine area. In the spring, with warming of the estuary, juveniles and adult males begin migrating to the upper estuary. Summer hard- and soft-shell crab fishing in the upper estuary depends on recruitment of commercial-sized crabs. Out migration of crabs from the upper estuary to the lower estuary in November and December is evidenced by the shift of crabbing activity from Lake Salvador to Caminada and Barataria bays.

Analysis of Crab Fishing Patterns

The composition of crab catch by water body (Fig. 16) reflects the seasonal distribution of crabs and associates those in a given life stage with specific environments. In Lake Des Allemands crabs are caught from April to mid-October. The annual catch is relatively small and consists mostly of medium-to-large males. Highest catches are made in July, August, and September. The lower portion of the lake, where stronger tidal currents occur, is the best crabbing area. Very few doubles, or

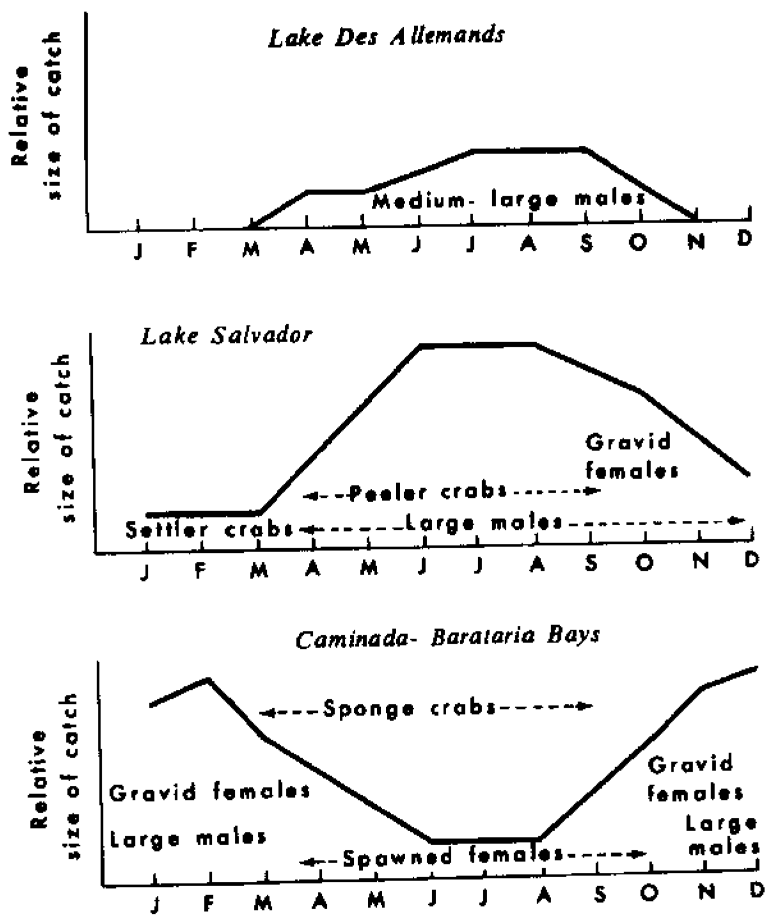


Fig. 16. Sex and size of crabs caught by water body, by month, Barataria Estuary.

mating crabs, are caught in the lake. According to the fishermen, crabs measuring less than 3 inches across the carapace are not common in Lake Des Allemands.

Crabs are caught in Lake Salvador throughout the year, including very small numbers of settler crabs taken in January, February, and March. Large numbers of juveniles and adult males migrate into this lake during March, April, and May. Masses of small juveniles migrate up-estuary all summer. From April to December male crabs ranging in size from 140 to 200 mm dominate the landings. Highest catches in the lake are taken from June to September. Spawned females appear in the landings from June to October. In October gravid females collect in groups and migrate toward the passes. Crab landings in December decrease sharply as out migration takes place.

Most of the crabs caught in Caminada and Barataria bays are in their winter habitat or are gravid females undergoing maturation of the ovaries. Large males are caught near oyster beds and in areas of tidal exchange from November to May. Gravid females comprise an important part of the catch from November to April. Although spawned females occur in the lower estuary all summer, they are taken mainly in September, when waters have begun to cool. The restriction on sponge crabs, the difficulty of keeping saltwater crabs alive, and preoccupation with inland shrimp trawling mitigate against summer crabbing effort in the lower estuary.

The generalized graph of the peeler-crab catch (Fig. 17) reflects the molting and maturaltion periods. Most peeler crabs are caught in the oligohaline waters of the upper estuary from March through September.

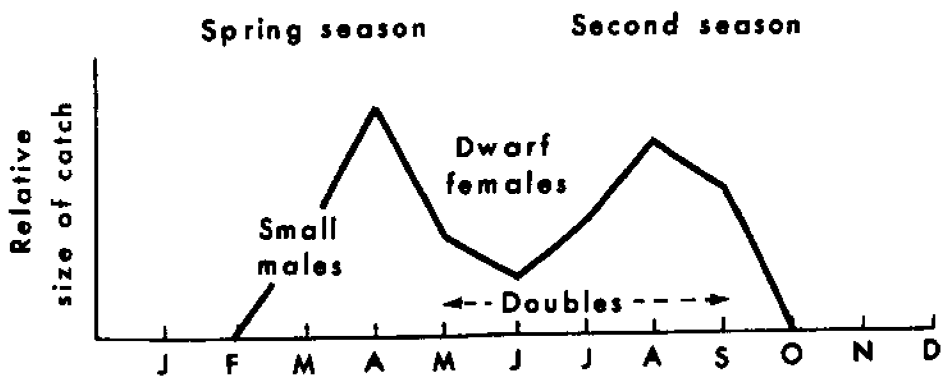


Fig. 17. Schematic diagram: Peeler-crab catch using bush lines (brush traps) by months, Lake Salvador, Louisiana.

Lake Cataouatche, southern Lake Salvador, the Lafitte Pens, Bayou Perot, and Little Lake are crabbed for peelers. The spring season is short and appears to be associated with the arrival of early migrants. Smaller molting crabs are common in the spring season, and doubles are prevalent from late May to September.

Soft-shell crab fishing east of the Mississippi River follows a similar pattern. Large numbers of smaller molting crabs are observed in March-April. June is often a slack month. In Lake Pontchartrain, highest catches of peelers are made in July, August, and early September. Mating occurs whenever there are large females molting, and crabs appear to be largest in the fall. Benedict (1940) observed that in Louisiana blue crabs mate in May and September.

The size and seasonal distribution of the peeler-crab catch should be proportional to the number of juvenile crabs reaching commercial size in a given habitat. For example, in the Barataria Estuary, an unusually high soft-shell crab population in August, 1969, corresponded with a large hard-crab catch (Fig. 8). However, gear type efficiency (catch-ability) and crabbing effort must also be considered. Field observations suggest that bush lines are not effective in June and July and that many crabbers engage in shrimping during that time. In one of the few investigations of a blue crab population, Fischler (1965) estimated recruitment in the Neuse River, North Carolina, by calculating the rate at which precommercial crabs molted and thereby became part of the commercial-sized population.

Seasonal crab fishing patterns and composition of the crab catch by water body indicate crab migration patterns. Five migration patterns have been recognized in the Barataria Estuary:

1. Spring up-estuary migration of large juveniles and adult males.
2. Recruitment of small juveniles to the upper estuary.
3. Return of the spawned females from offshore to the lower estuary in summer.
4. Upper-to-lower estuary and offshore migration of gravid females in autumn (the fall run of the females).
5. Down-estuary migration of large juveniles and adult males from the upper estuary in November and December.

Similar migration patterns have been reported in Chesapeake Bay (Van Engel, 1958), North Carolina (Fischler, 1965), Florida (Tagatz, 1968b), Lake Pontchartrain Basin, Louisiana (Darnell, 1959), and Texas (More, 1969). The spring up-estuary migration of juveniles and adult males is evidenced by the renewal of crab fishing in the upper estuary. Recruitment of small juveniles occurs continuously during the warm months. In the upper estuary crabs are frequently observed drifting with the tidal currents, but this movement appears to be related to their feeding activity. Herrnkind (1970) found that Bermuda lobsters will initiate migratory behavior when certain food items are absent from their diet.

Spawned females return to the lower Barataria Estuary from April through September. Migration of gravid females, probably in response to osmoregulation stresses, occurs in October and November. Although More (1969) suggested that a similar migration of gravid females takes place in spring and summer, such movements are not recognized by Louisiana crabbers. The large juveniles and adult males leave the upper estuary in November and December as water temperatures fall below 15°C.

In relating the blue crab's life history to specific environments of the ecosystem, the subhabitat concept is employed. As used herein, the subhabitat refers to a specific environment utilized during a given stage, or phase, of the crab's life cycle. These were delineated by associating populations in a particular life stage with specific environments. Similar subhabitats can be identified in other estuaries where blue crabs are abundant.

Three subhabitats, corresponding to spawning, wintering, and maturation, were recognized in the Barataria Estuary (Fig. 18). In late autumn gravid females concentrate about the tidal inlets in the lower estuary. According to the crabbers, these crabs do not leave the areas of direct tidal exchange. More (1969) found that the females spawned in lower estuaries of Texas if salinities remained about 20 ppt. Sponge crabs are common in lower Caminada and Barataria bays and in the nearby gulf from March through August.

In winter large crabs, including males, occupy areas of tidal exchange in the lower estuary. Only small numbers of settler crabs

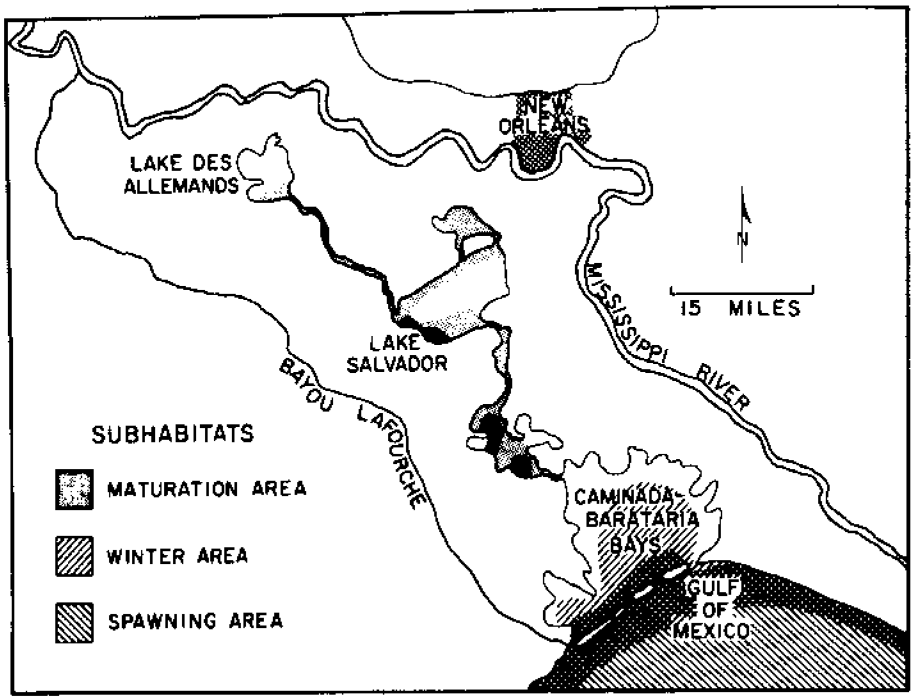


Fig. 18. Model of the blue crab subhabitats in the Barataria Estuary.

remain in the upper estuary. Tidal exchange with gulf waters probably provides sufficient warmth to maintain feeding activity. Crab catches become very low when water temperatures drop below 15°C. The fact that very few soft-shell crabs are caught indicates that little molting takes place during the winter. Gravid females remain near tidal inlets, whereas larger juveniles and adult males appear to be dispersed throughout areas of tidal exchange.

The maturation subhabitat corresponds to the summer hard- and soft-shell crab fishing areas of the upper estuary. Both the hard- and soft-shell crab fisheries are dependent on the maturation of large numbers of juveniles. Hard crabs in the upper estuary are associated with sandy and shell bottoms, tidal currents, and zones of fresh and brackish water mixing. Waters bordering eroding lake shorelines (Darnell, 1961) and points of land extending into the lakes are especially favorable environments for larger crabs. Food supply is probably the most significant factor controlling the distribution (Tagatz, 1968b) and abundance of maturing crabs.

The Barataria Estuary as a Blue Crab Habitat

A large portion of the Louisiana blue crab catch is taken from the Barataria Estuary. In order to assess this estuary and the adjacent marine area as a blue crab habitat, annual crab landings from the period 1959 to 1970 were analyzed.

Since 1959 annual landings of both hard- and soft-shell crabs from the Barataria Estuary have declined (Fig. 19). Lowest catches occurred in 1962, 1964, and 1965. During the last 10 years the annual catch from Lake Salvador has dropped from 3 million pounds to about 0.7 million pounds. Since 1964 Caminada and Barataria bays in the lower estuary have been more productive than the upper estuary, including Lake Salvador.

Annual crab landings of Lake Pontchartrain and Lake Borgne, 1959 to 1970, offer a useful comparison (Table 15). These water bodies are related subhabitats like Lake Salvador and Caminada-Barataria bays, respectively. As in Lake Salvador, the hard- and soft-shell crab catches in Lake Pontchartrain have both declined. Since 1962 the catch from Lake Borgne has exceeded that of Lake Pontchartrain. Thus crab landings have declined in the upper reaches of estuaries on both sides of the Mississippi River.

Crab landings from the Barataria Estuary in 1955 and 1970 were also compared with landings from other water bodies of coastal Louisiana (Table 16). In 1955 blue crabs were fished in a relatively few water bodies. A large hard-crab fishery centered on Grand Lake in the Atchafalaya Basin.

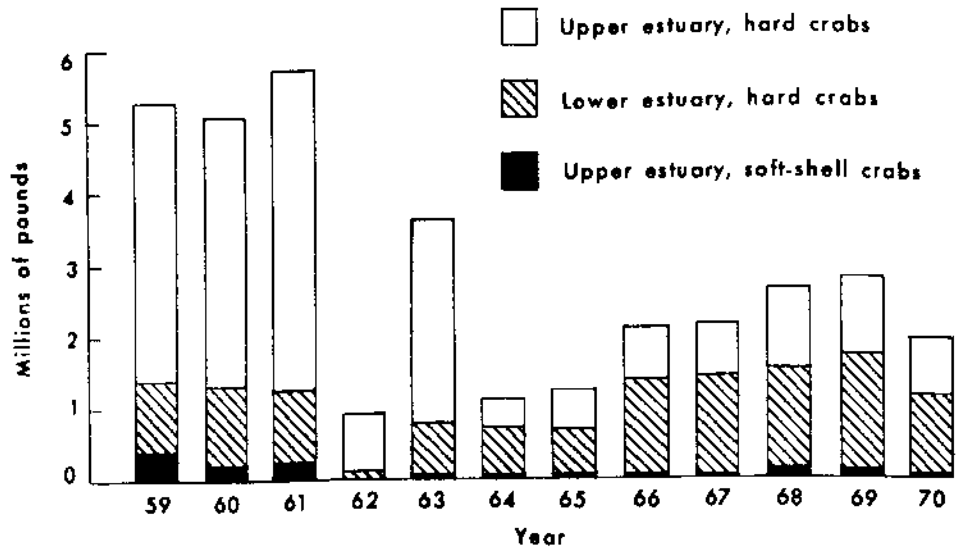


Fig. 19. Crab landings from the Barataria Estuary, 1959 to 1970. Lake Salvador and Little Lake are included in the upper estuary, and Caminada and Barataria bays comprise the lower estuary. Sources: National Marine Fisheries Service, 1959-1970, Landing Records - Louisiana Coastal Parishes, Form 2-164 SA&G; New Orleans Louisiana, Fish and Wildlife Service, U.S. Department of Commerce.

Large catches of hard crabs were also taken from Lake Salvador, Barataria Bay (including Caminada Bay), Lake Borgne, Lake Pontchartrain, and Breton Sound. Soft-shell crab production was relatively high; Lake Borgne, Lake Salvador, and Little Lake were the main sources of peeler crabs.

Although total 1970 hard-crab landings remained about the same as 1955, significant changes in fishing areas occurred. Hard-crab fishing increased significantly east of the Mississippi River. The catch in Grand Lake, formerly very high, declined markedly as a result of detrimental increases in fresh water and sediment from the Atchafalaya River (Shlemon, 1971). Lake Borgne, Breton Sound, Caminada-Barataria bays, and Chandeleur Sound--all lower estuary areas--are now the main sources of hard crabs. Though peeler-crab fishing areas have remained much the same, production of soft-shell crabs has declined considerably since 1955.

Table 15

Crab Landings from Lake Pontchartrain and Lake Borgne, Louisiana, 1959 - 1970

Year	Lake Pontchartrain	Lake Borgne	Total Pounds from Both Lakes	
			Hard Crabs	Soft Crabs
1959	1,875,300	1,182,000	2,848,000	209,300
1960	1,682,600	1,233,900	2,661,300	255,200
1961	1,806,400	1,433,500	2,961,800	278,100
1962	1,450,900	1,217,500	2,551,300	117,100
1963	1,045,300	1,150,600	2,069,480	126,420
1964	555,600	1,101,400	1,598,400	58,600
1965	325,800	1,618,400	1,887,200	57,000
1966	357,200	1,312,100	1,624,000	45,300
1967	688,300	1,299,900	1,933,700	54,500
1968	516,100	1,722,900	2,144,500	94,500
1969	577,800	1,875,100	2,377,100	75,800
1970	451,600	1,693,300	2,119,200	25,700

Source: National Marine Fisheries Service, 1955-1970, Landing records - Louisiana coastal parishes. Fish & Wildlife Service, U.S. Dept. Commerce, New Orleans, La., Form 2-164 SA&G.

Changes in numbers of crab fishermen and crabbing gear may explain the declining crab catch of the Barataria Estuary. Since 1957 there has been an increase in hard-crab fishermen and widespread adoption of crab pots in place of trotlines (Table 17). The number of soft-shell crab fishermen, i.e., bush line crabbers, has dropped. The decline in soft-shell crab production may be explained by a decrease in crabbing effort, but the same cannot be said for declining hard-crab landings.

Many crabbers, including soft-shell crab producers and trotline fishermen, blame the decline in crab catch on the increasing use of the

Table 16

Louisiana Blue Crab Landings by Water Body, 1955 and 1970

Water Body	1955 Hard Crabs	1955 Soft Crabs	1970 Hard Crabs	1970 Soft Crabs
Lake Borgne	1,010,500	102,700	1,678,600	14,700
Lake Pontchartrain	968,200	76,000	440,600	11,000
Breton Sound	914,000	77,600	1,510,200	15,200
Chandeleur Sound	705,300		1,025,600	10,200
Gulf (below Grand Isle)			12,400	
Barataria and Caminada bays	1,406,700		1,103,800	
Lake Salvador	1,478,200	225,300	663,900	24,100
Little Lake	727,900	99,000	120,000	13,000
Bay Adams			454,200	
Gulf (below Terrebonne Parish)			227,900	100
Timbalier Bay			66,700	100
Terrebonne Bay	125,600		115,800	
Caillou Bay	155,200		463,700	100
Lake Barre			105,400	
Lake Pelto			335,200	
Lake Decode			78,400	
Lake Merchant			193,700	
Lake Felicity	49,500		25,000	
Gulf (below Atchafalaya Basin)	54,700		60,000	100
Four League Bay			140,400	
Vermilion and Cote Blanche bays			469,000	
Gulf (below White Lake)			139,000	
Calcasieu Lake	51,780		310,200	
Tchefuncte River				
Lake Maurepas			88,900	1,000
Intracoastal Canal	45,000		15,400	
Lake Des Allemands			33,600	
Atchafalaya River	702,300		120,000	
Grand Lake (in Iberia and St. Marys parishes)	2,027,900		116,200	
Lake Verret	433,500			
Total pounds	10,856,280	580,600	10,113,700	89,600

Source: National Marine Fisheries Service, 1955-1970, Landing records - Louisiana coastal parishes. Fish & Wildlife Service, U.S. Dept. Commerce, New Orleans, La., Form 2-164 SA&G.

Table 17

Number of Crabbers, by Gear Type, 1957 - 1970[a]

Type of Gear	1957	1960	1964	1967	1970
Crab pot	0	0	0	226	161
Trotline with baits	125	190	294	130	63
Bush lines	105	85	54	40	74
Total crab fishermen[b]	225	275	348	396	298
Total fishermen in parish	700	749	852	736	669

[a]Data pertain only to Jefferson Parish (county) but include most of the crabbers in the basin.

[b]Number of crab fishermen includes both full-time and seasonal crabbers.

Source: National Marine Fisheries Service, 1957-1970, Operating unit data - boats and shore. Fish & Wildlife Service, U.S. Dept. Commerce, New Orleans, La., Form 2-168 SA&G.

crab pots, which catch gravid female crabs and thus reduce the spawn. On the other hand, trotlines, used primarily in summer in the upper estuary, do not catch many gravid females. Crab pots are effective on gravid females near the tidal inlets during the winter. These were introduced in the estuary about 1964. Because they proved to be more productive than trotlines in all months of the year, pots quickly became the main commercial hard-crab gear. Crabmeat processors report that adoption of crab pots resulted in increased winter catches, as well as a greater proportion of female crabs.

Comparison of 1960 and 1970 catches from the Barataria Estuary by water body and gear type (Table 18) indicates a correlation between adoption of the crab pots and decline in the total landings. In 1960, when trotlines with baits were the main hard-crab gear, the tidal crab yield was 5 million pounds. In 1970, when crab pots accounted for about 60 percent of the total landings, the yield was only 1.92 million pounds.

The very high reproductive rate of the blue crab does not substantiate arguments that crab pots decimate the breeding stock. Moreover, in 1966, 1967, 1968, and 1969, when crab pots were in greatest use (Table 17), crab yields in the Barataria Estuary increased (Fig. 19). The crab pots have enabled crabbers to fish the lower estuary more effectively, particularly in winter, and have made possible the harvesting of gravid females. Although this question cannot be conclusively answered at present, similar controversy exists in Chesapeake Bay concerning the effect of harvesting female crabs on subsequent crab populations (Manning, 1968; Cronin and Cargo, 1968).

Evidence exists that the decline in crab landings from the upper estuaries may be associated with pollution and drainage alteration. Biglane and LaFleur (1967) emphasized the seriousness of pollution in coastal Louisiana. Because of low tidal amplitude, poor circulation, and shallow depths, the estuaries of coastal Louisiana are vulnerable to changes in water quality and drainage. Upper-estuary water bodies appear to be more affected than those of the lower estuary, which are closer to the tidal inlets and thus have stronger tidal exchange.

Fishermen from the Barataria Basin believe that pollutants from the Valentine area were responsible for decline of formerly excellent crab

Table 18

Crab Landings by Water Body and Gear Type, 1960 and 1970, Barataria Estuary, Louisiana

	Lake Salvador	Little Lake	Caminada Bay Barataria Bay	Total Pounds
1960				
Crab pots	0	0	0	0
Trotlines	2,631,400	1,138,300	996,820	4,766,520
Drop nets	0	0	116,500	116,500
Bush lines	145,200	54,800	0	200,000
	2,766,600	1,193,100	1,113,320	5,083,020
1970				
Crab pots	284,900	0	790,400	1,075,300
Trotlines	379,000	120,000	158,200	657,200
Drop nets	0	0	155,200	155,200
Bush lines	24,100	13,000	0	37,100
	688,000	133,000	1,103,800	1,924,800

Source: National Marine Fisheries Service, 1955-1970, Landing records - Louisiana coastal parishes. Fish & Wildlife Service, U.S. Dept. Commerce, New Orleans, La., Form 2-164 SA&G.

and shrimp fishing in Catahoula Bay of southwestern Lake Salvador. Foamy, dark-colored effluents were observed west of Lake Salvador near the Intracoastal Canal in the fall of 1969 (Photo 13). During recent years, according to the crabbers, crabs seem to be avoiding Catahoula Bay. Complaints about pollution were made as early as 1962 (Robert, 1962). In May 1970, a local industry was ordered to stop discharging of contaminating effluents (Louisiana Stream Control Commission, 1970).

Soft-shell crab fishermen from Lafitte-Barataria complain that the Gulf Canal leading into western Bayou Gouba has caused a reduction in the number of peeler crabs being caught in the bayou. Hard crabs caught in Lake Des Allemands and Lake Cataouatche frequently turn black inside after they are boiled. Dead fish and foamy, brown scum were reported in eastern Lake Des Allemands in August 1969 (Tregre, 1969). Bayou Segnette, leading into Lake Cataouatche, has been overloaded with domestic sewage and seafood processing wastes for many years (U.S. Department of Interior, 1968).

Pesticides from sugar cane fields (Lauer et al., 1966), oil field and pipeline spills and leaks (Louisiana Stream Control Commission, 1970a), sugar cane mill wastes (Louisiana Wild Life and Fisheries Commission, 1952-1953), and corrosion inhibitors (Louisiana Wild Life and Fisheries Commission, 1964-1965) are other possible sources of pollution. Pesticides and herbicides used for mosquito and water hyacinth control may also be detrimental. Some apparent pollution has been observed around the seafood houses of Lafitte-Barataria and Grand Isle. Except in shedding cars, crabs are rarely killed by pollutants but appear to be driven away

Photo 13. Effluents observed near the Intracoastal Canal, west of Lake Salvador, Louisiana. These effluents drain toward Lake Salvador and Bayou Perot.

from the areas of contamination. However, pollutants may reduce food area, cause eggs to spoil, kill larvae, etc.

Pollution in the estuary is most severe during periods of low water levels followed by heavy rains. When waters are low, runoff drains into the lakes and bayous from surrounding swamplands and marshlands.

Drainage waters play an important role because they transport large quantities of plant detritus, on which the food chain of Louisiana's estuaries is dependent (Darnell, 1967). Many estuarine organisms, including the blue crab, feed on detritus along the shorelines (Darnell, 1961). In Texas estuaries, highest species diversity and biomass production occurs along the shorelines (Parker and Blanton, 1970); presumably this is also true in Louisiana. Nevertheless, drainage waters which carry pollutants into the maturation subhabitat could adversely affect juvenile crabs which feed and molt along the shorelines.

Some research has been done on effects of pesticides on blue crab larvae and small juveniles. Lowe (1965) reported that juvenile blue crabs do not survive in waters containing more than 5 parts per billion DDT. During the period 1962-1965, when the crab catch was lowest (Fig. 19), 0.5 parts per million DDT and related hydrocarbons were measured in the lower Barataria Estuary (Hammerstrom et al., 1967). A significantly high residue of DDT and its metabolites (0.219 parts per million mean concentration) was detected in blue crab samples from 20 South Atlantic stations (Mahood et al., 1970). According to Loesch (1971, personal communication), mirex is toxic to juvenile blue crabs, either as contact poison, stomach poison or by eating grass shrimp poisoned by mirex.

Additional research should be done in the upper estuary on immature crabs growing to commercial size before the problem becomes critical. In Texas, large portions of the upper estuaries have been closed to shellfish production because of extensive pollution (Texas State Department of Health, 1968).

Soft-shell crab fishermen from the Lake Pontchartrain-Lake Borgne area suggest that improper handling of peeler crabs and adverse water quality partially explain the decline in soft-shell crab production. To cope with these factors, many crabbers in the area produce soft crabs in covered floating boxes. The claws of the green crabs are nipped and the crabs are fed. Also, several crabbers have built shedding houses along the lake. Water for the shedding houses is pumped from the bottom of a nearby water body into concrete troughs or plastic tubs (Photo 14) in order to minimize exposure of molting crabs to contaminated surface water.

Although soft-shell crab production is declining, market demand and prices are currently high. Unlike hard crabs, soft-shell crabs require little processing and can be frozen. Freezing of soft-shell crabs in plastic bags (Photo 15) is new in Louisiana, but has been a common method of market processing in Maryland for many years. Unfortunately, operators of shedding houses on Lake Pontchartrain-Lake Borgne are having difficulty catching sufficient numbers of peeler crabs. Adoption of the crab scrape (Dumont and Sundstrom, 1961), a type of gear in use in Chesapeake Bay, may alleviate the problem. However, soft-shell crabbers of the Barataria Basin seem reluctant to investigate new peeler-crab gear or to change their shedding practices.

Because appropriate data on crab populations and landings are sparse, it is not possible to determine causes of apparent changes in the crab catch of the Barataria Estuary. Records of hard- and soft-shell landings in Louisiana are rough estimates of the total annual catch (Orville Allen, 1970, personal communication). Catch data are collected through monthly or yearly canvassing of fishermen, seafood dealers, and crab buyers. Total hard- and soft-shell crab landings by water body are available only on an annual basis because low priority is given to blue-crab catch statistics.

Records of blue-crab landings in Louisiana may contain gross errors. For example, Adkins (1970) reported that the largest hard-crab

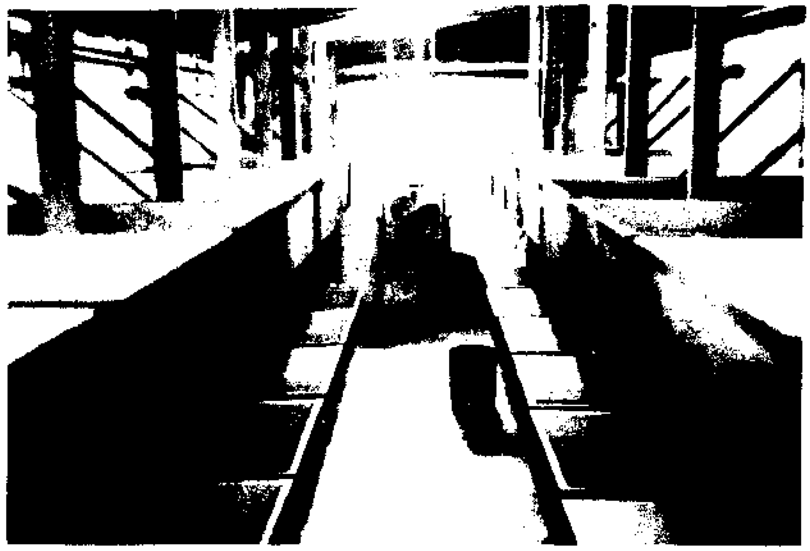


Photo 14. A modern shedding house along Pass Rigolettes, Louisiana.

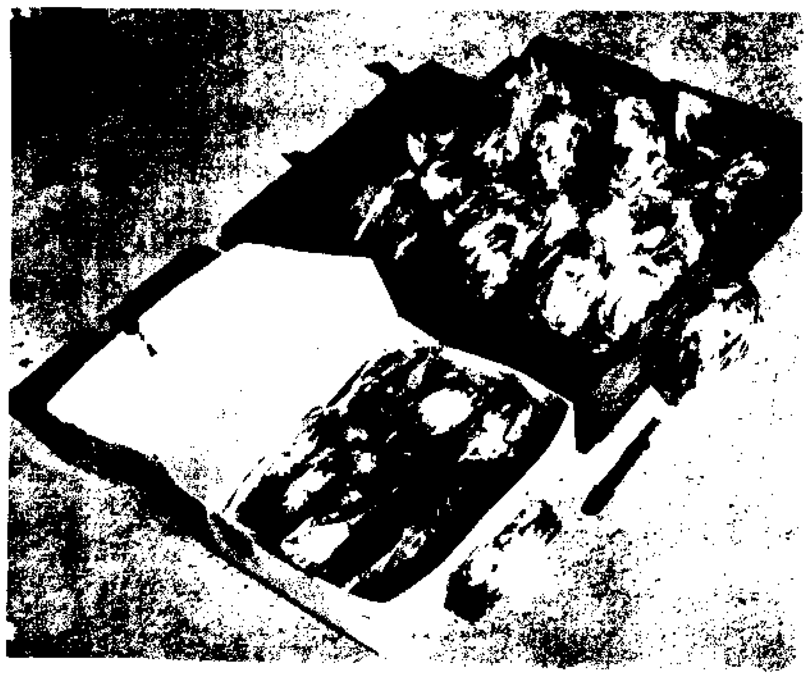


Photo 15. Frozen soft-shell blue crabs from Lafitte, Louisiana, and Crisfield, Maryland (left).

catch was taken in an area east of the Atchafalaya River by shrimp trawls. These catch data, as well as information on catches from the Mississippi River delta region, are not reflected in the landing records (Table 16). Though it was probably overestimated, the 1968 blue-crab catch by recreational fishermen in Louisiana was estimated at 28 million pounds (Bureau of Sport Fisheries and Wildlife, 1970). Also, the quantity of hard crabs shipped out of state is not known. Field observations suggest that soft-shell crab production may be twice as large as the landing records indicate. The author estimated the 1970 harvest of hard crabs to be 19 million pounds and the soft-shell crab production to be 200,000 pounds, for a total value of $1.9 million.

CONCLUSIONS

The significance of the blue crab in estuaries of Louisiana is not fully understood. First, this species occupies a critical link in the estuarine food chain. To a large extent, consumer organisms depend on externally derived plant detritus which is transported into the estuarine waters from surrounding swamplands and marshlands. The blue crab, along with several other species, converts the detritus into animal biomass. Many organisms prey upon the juvenile blue crab, and the crab, in turn, is a major predator and scavenger. Second, the blue crab supports the third largest commercial fishery in Louisiana. Finally, and perhaps most important for the future, the sport fishery potential of this renewable resource is enormous.

The life cycle of the crab population is reflected in seasonal crab-fishing patterns of the Barataria Estuary, Louisiana. An estuary and the adjacent marine area constitute a complete habitat for a crab population. As the blue crab passes through its life stages, it occupies, as sub-habitats, specific environments of the estuarine system. The spawning, wintering, and maturation subhabitats were identified by associating large numbers of crabs in a particular stage with a specific portion of the estuary. The resulting subhabitat model predicts the location of several segments of the crab population at various times and partially explains crab migration patterns.

Adult female blue crabs spawn from March through September in the lower estuary. When the ovaries of gravid females begin to develop this segment of the crab population moves to locations near tidal inlets. Spawning occurs when water temperatures exceed 20°C and the salinity is above 20 ppt. Adult male crabs and large juveniles winter in the lower estuary in areas of tidal exchange. Major wintering areas are associated with water temperatures above 15°C. When water temperatures in the upper estuary rise above 15°C in February and March, up-estuary migration begins. The juveniles mature in the oligohaline waters of the upper estuary. Availability of food is perhaps the most significant factor controlling the distribution and abundance of crabs in the upper estuary. Ontogenetic changes in the food habits, osmoregulatory ability, and water temperature tolerance probably govern the five crab migration patterns that were observed in the estuary.

The hard-crab fishermen in the Barataria Basin are efficiently harvesting the crab stock. The crab pot, introduced in 1964, has enabled crabbing in all seasons. Crab pot fishermen now catch gravid crabs and crabs in the wintering areas, two segments of the population previously not fully exploited. Increases in the harvest may be limited, inasmuch as depletion of the stock already appears to be occurring in spring. However, increased crabbing effort could be productive around the Mississippi River delta and in the Atchafalaya Bay area. The use of crab trawls should be permitted in these two areas.

Soft-shell crab production in the Barataria Estuary is declining, as is the number of soft-shell crab fishermen. However, individual crabbers are fishing more intensively by tying more bushes on their bush lines. The crabbers are having difficulty in catching sufficient numbers of peeler crabs, and the crab mortality in the shedding cars appears to be increasing. Although pesticides such as DDT may be reducing the survival rate of the crab larvae and small juveniles in the lower estuary, declining crab production is probably more directly related to pollution in the upper estuary, which adversely affects the shoreline environments of the maturation subhabitat. The practice of using backswamp areas and marshes for waste disposal must be stopped if water quality is to be maintained suitable for commercial fisheries. When water quality is good, the marketable soft-shell crab yield is almost 95 percent of the peeler crabs taken.

Soft-shell crab production in the Lake Pontchartrain-Lake Borgne area may be increasing. In this area crabbers are coping with pollution by building crab shedding houses equipped with tanks, pumps, and internal circulation systems. However, this group is also unable to catch sufficient numbers of peeler crabs. Adoption of the crab scrape, a device used in Chesapeake Bay, may enable Louisiana crabbers to harvest more peeler crabs. The strong market demand for soft-shell crabs and the feasibility of freezing them should favor expansion of the soft-shell crab fishery. However, working with peeler crabs requires an exceptional ability to recognize shedding signs, which many Louisiana fishermen do not have.

Annual crab landing records for Louisiana indicate that the lower estuaries are replacing the upper estuaries as the main hard-crab fishing areas. This trend is partially explained by adoption of the crab pot. However, hard- and soft-shell crab landing records are only estimates. The actual crab harvest, including the recreational catch, may be twice as high as that indicated in the landing records. It is recommended that crab catch data by water body and gear type be collected monthly. In addition, commercial crab fishermen should be licensed so that the crabbing effort can be approximated by analyzing the data on the license applications. At present little communication or cooperation exists between crab fishermen and the various agencies that regulate the fishery, collect catch statistics, and conduct biological investigations.

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Purple sign - A shedding sign consisting of purplish-pink colorations on the abdomen of the female and on the chelipeds of both sexes.

Red (sign) line - A shedding sign, a red line on the paddle of the swimming legs. Red line crabs will shed in 1 to 2 days.

Ripe crab - A shedding crab in the pink or red line molting stage; the stage just prior to the buster stage. Synonymous with "rank" crab of the Chesapeake Bay area.

Saltwater crab - Crab caught in the high-salinity waters of the lower estuary during the summer months. In hot weather these crabs die easily.

Settler crab - Crab which does not migrate to the lower estuary during the cold season but remains in the deeper portions of the upper estuary.

Shedding (molting) crab - Crab undergoing ecdysis, which takes about 2 to 3 weeks in all; but the actual shedding time is only about 2 hours.

Shedding signs - Visible, external signs exhibited by a blue crab which are recognized by the crabber to be indications of molting. The signs are used to identify shedding stages which, in order of occurrence, are: white line, purple sign, pink line, red line, buster, soft crab, and paper shell.

Sick crab - Crab that exhibits visible signs of disease. Commonly the sick crab will be cream colored on the ventral side, and on the inside the flesh will have a shredded appearance. Many sick crabs are infested with Microsporidia (Nosema sp.).

Soft-shell crab - Crab that has just pulled free of its old exoskeleton and its new shell has not yet hardened. Fishermen refer to their artificially shed crabs as "soft crabs."

Spawned crab - Adult female crab that has completed at least one of its spawning cycles. Most adult females which have never spawned have small, light-colored nemertean Carcinonemertes on their gills, whereas spawned females tend to have large, red nemertean worms on their gills (Hopkins, 1947).

Spent female crab - Adult female that has completed its spawning activity. Most of these crabs probably die soon after their last spawning cycle.

Sponge (berry) crab - Adult female crab with an egg mass extruding into its abdominal swimmeret hairs. The "sponge" refers to the egg case; it changes color from orange to brown to black as the eggs mature and hatch.

Stinky crab - Old, mature crab that gives off an offensive odor. Dying spent females are sometimes so designated.

White (sign) line - The first visible external sign of molting exhibited by a shedding crab. The white line appears near the edge of the paddle on the swimming legs about 10 to 14 days before actual molting. The lines are evidence that a new shell is forming beneath the old exoskeleton.

Wild crab - An ordinary hard crab that is unintentionally caught by a soft-shell crabber as he fishes for peeler crabs.

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