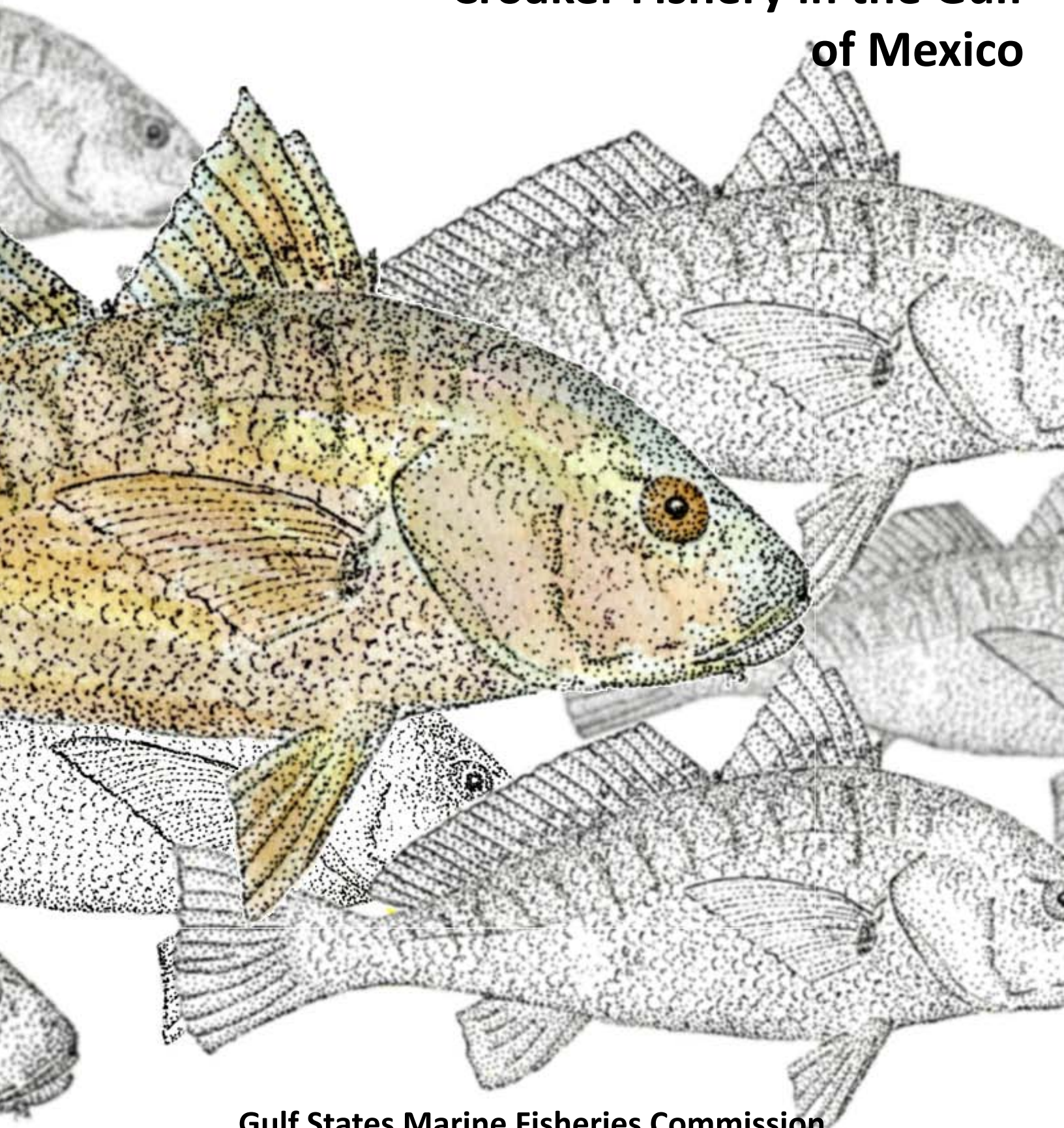
Biological Profile for the Atlantic Croaker Fishery in the Gulf of Mexico



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August 2017

Pub Number 266

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by the

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published by the

Gulf States Marine Fisheries Commission
2404 Government St.
Ocean Springs, Mississippi 39564

August 2017 Publication Number 266

A publication of the Gulf States Marine Fisheries Commission pursuant to National Oceanic and Atmospheric Administration Award Number NA10NMF4070006 and FNA15NMF4070076. This publication is funded by a grant from the National Oceanic and Atmospheric Administration. The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA or any of its sub-agencies.

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Acknowledgments

The Gulf States Marine Fisheries Commission (Commission) would like to thank the members of the Croaker Technical Task Force (TTF) for their many hours of work and dedication in developing the Biological Profile for the Atlantic Croaker Fishery in the Gulf of Mexico. The Commission also thanks members of the Law Enforcement Committee, as well as, Mr. Jeff Rester for taking the time to review, critique, and provide guidance based on their various areas of expertise.

The TTF gratefully acknowledges the assistance in collection and assimilation of fishery-dependent and independent data provided by the various state agencies as well as the commercial and recreational data provided by the NOAA Office of Science and Technology and the NOAA Southeast Fisheries Science Center.

The Croaker TTF would not be able to complete the profile without the support of the various academic libraries and library staff across the five Gulf states and the libraries of our federal partners. We would especially like to thank Ms. Joyce Shaw and Ms. Maryanne Anthony at the Gulf Coast Research Laboratory's Gunter Library. We need to acknowledge Ms. Sherry Owens of the Pascagoula Public Library's Genealogy & Local History Department, and Mr. Charles L. Sullivan and Ms. Melissa Ladner of the Mississippi Gulf Coast Community College in Perkinston, MS.

We could not have provided such a complete history of the croaker fishery without the help of the entire Mavar family, especially Mr. and Mrs. Nick and Nancy Mavar and Mr. Victor Mavar of Kozy Kitty. Additional information and photos were provided by Mr. Glen Williams of the DeJean Packing Company, Captains William Tiroux and Tommy Schultz, Mr. Brent Duet of the Superior Shipyard in Golden Meadow, LA, Mr. Fred Dunham (retired LDWF biologist), and Mr. Ned Hogg (former Ralston Purina employee). A number of the photos included in Chapter 11 were provided with permission by Mr. Val Husley, Mr. Mike Frontiero, Mr. Nick Mavar, and Mr. Jim Page.

Finally, TTF members would like to express their appreciation to Ms. Debora K. McIntyre (Commission) for her support and editorial reviews of the draft profile and Ms. Lucia Hourihan for her extensive final review of the completed document.

Preface

The Gulf States Marine Fisheries Commission (Commission) was established by the Gulf States Marine Fisheries Compact under Public Law 81-66 approved May 19, 1949. Its charge is to promote better management and utilization of marine resources in the Gulf of Mexico.

The Commission is composed of three members from each of the five Gulf states. The head of the marine resource agency of each state is an ex officio member. The second is a member of the legislature. The third is a governor-appointed citizen with knowledge of or interest in marine fisheries. The offices of the chairman and vice chairmen are rotated annually from state to state.

The Commission is empowered to recommend to the governor and legislature of the respective states action on programs helpful to the management of marine fisheries. The states, however, do not relinquish any of their rights or responsibilities to regulate their own fisheries as a result of being members of the Commission.

One of the most important functions of the Commission is to serve as a forum for the discussion of various problems and needs of marine management authorities, the commercial and recreational industries, researchers, and others. The Commission also plays a key role in the implementation of the Interjurisdictional Fisheries (IJF) Act. Paramount to this role are the Commission's activities to develop and maintain regional profiles and plans for important Gulf species.

The Biological Profile for the Atlantic Croaker Fishery in the Gulf of Mexico is a cooperative planning effort of the five Gulf states under the IJF Act. Members of the task force contributed by drafting individually-assigned sections. In addition, each member contributed his/her expertise to discussions that resulted in revisions and led to the final draft of the profile.

The Commission made all necessary arrangements for task force workshops. Under contract with the National Marine Fisheries Service (NMFS), the Commission funded travel for state agency representatives and consultants other than federal employees.

Throughout this document, metric equivalents are used wherever possible with the exceptions of reported landings data and size limits which, by convention, are reported in English units. Recreational landings in this document are Type-A and Type-B1 and actually represent total harvest, as designated by the NMFS. Type-A catch are fish that are brought back to the dock in a form that can be identified by trained interviewers and Type-B1 catch are fish that are used for bait, released dead, or filleted – i.e., they are killed, but identification is by individual anglers. Type-B2 catch are fish that are released alive – again, identifications are by individual anglers and are excluded from the values in this profile.

Abbreviations and Symbols

ADCNR/MRD	**Alabama Department of Conservation Natural Resources/Marine Resources Division**
B	**Billions**
BRD	**Bycatch Reduction Device**
˚C	**degrees Celsius**
DO	**Dissolved Oxygen**
DMS	**Data Management Subcommittee**
EEZ	**Exclusive Economic Zone**
EFH	**Essential Fish Habitat**
FWC/FMRI/FWRI	**Florida Fish and Wildlife Conservation Commission/Florida Marine Research Institute/Florida Fish and Wildlife Research Institute**
FMP	**Fishery Management Plan**
ft	**feet**
g	**gram**
GSI	**Gonadal Somatic Index**
C	**Gulf States Marine Fisheries Commission**
hr(s)	**hour(s)**
ha	**hectare**
IJF	**interjurisdictional fisheries**
kg	**kilogram**
km	**kilometer**
lbs	**pounds**
LDWF	**Louisiana Department of Wildlife and Fisheries**
m	**meter**
M	**Millions**
mm	**millimeters**
min(s)	**minute(s)**
MDMR	**Mississippi Department of Marine Resources**
MRFSS/MRIP	**Marine Recreational Fisheries Statistical Survey/Marine Recreational Information Program**
mt	**metric ton**
n	**number**
NL	**Notocord Length**
NMFS	**National Marine Fisheries Service**
ppm	**parts per million**
‰	**parts per thousand**
PPI	**producer price index**
SAT	**Stock Assessment Team**
SD	**Standard Deviation**
SE	**Standard Error**
sec(s)	**second(s)**
SL	**Standard Length**
S-FFMC	**State-Federal Fisheries Management Committee**
SPR	**Spawning Potential Ratio**
TCC	**Technical Coordinating Committee**
TED	**Turtle Exclusion Device**
TL	**Total Length**
TPWD	**Texas Parks and Wildlife Department**
TTF	**Technical Task Force**
TTS	**Texas Territorial Sea**
TW	**Total Weight**
YOY	**Young-of-the-Year**
yr(s)	**year(s)**

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Chapter 1
SUMMARY

Atlantic croaker (*Micropogonias undulatus*) occur from Cape Cod, Massachusetts to the Bay of Campeche, Mexico and are found throughout the Gulf of Mexico but are most abundant off the coasts of Louisiana and Mississippi. Atlantic croaker belong to the drum family Sciaenidae, which contains 57 species in the western Atlantic Ocean. The size of individual Atlantic croaker is generally related to water depth with croaker commonly found around the mouth of the Mississippi River or in proximity to offshore platforms in depths greater than 40m and smaller croaker found in the shallower depths of the Gulf's nearshore waters, bays, and estuaries. Because Atlantic croaker tolerate a wide range of salinities from 0-70 parts per thousand, temperature appears to be the primary driver in determining distributions and movement patterns throughout their life. Croaker are a very hardy fish and easy to collect. As a result, most of the prevailing research examining croaker has been using them as test subjects for endocrine and toxicology research and to study the effect of chemical toxins, climate change, and environmental variables. There is actually little recent work on the species and currently no management other than through bycatch regulations in the shrimp fisheries and a live bait industry.

The history of the commercial croaker fishery in the Gulf of Mexico began with shrimping and bycatch. Along the east coast of the United States, there has always been a large food-fish fishery for Atlantic croaker. In the Gulf, the majority of commercial landings of croaker were for the purpose of producing pet food. Many tons of Atlantic croaker were captured incidentally in shrimp trawls prior to the 1950s, making up as much as 50-70% of the total finfish bycatch. Beginning in the early 1950s, several processors began to explore turning the discards into a profitable secondary market referred to as the 'Groundfish' fishery. Large croaker were retained and sold in a fresh fish market out of Alabama to the east coast and the smaller fish were cooked, ground, and canned in Mississippi and Louisiana as cat food.

At the height of the groundfish fishery in the late 1950s, approximately 50 vessels or 'croaker boats' were harvesting fish to support the seven plants operating in Louisiana and Mississippi, landing around 122M pounds of groundfish annually. By the early 1970s, roughly 20 vessels were still fishing and, by 1978, there were only 15 croaker boats still in the fleet as the industry declined. The first pet food plant was established in Pascagoula, Mississippi around 1954 and two more opened by 1957. By the late 1950s, there was a total of seven plants (four canning for pet food, three freezing for foodfish, and one reduction plant) in operation handling groundfish along the northern Gulf. The last boatloads of croaker for pet food were unloaded around 1994 and the groundfish fishery effectively disappeared. The foodfish fishery out of Alabama ended around 1974 as the east coast found its own Atlantic croaker populations rebounding to the point of supporting their own local fisheries. There have been minimal commercial landings since the mid-1990s for croaker from the Gulf.

A new fishery has been developing over the last 15 years in the western Gulf for Atlantic croaker. Since about 1996, a significant bait industry has developed targeting juvenile croaker of various sizes for live bait in a number of other recreational fisheries. In Texas in particular, this industry has rapidly expanded to incredible size and value. Traditional bait shrimp trawlers have begun changing their techniques to allow for their maximum bycatch allowance to be filled by young croaker. Sales are made at the bait houses and in turn sold to anglers on an individual fish basis. In some places, live Atlantic croaker are selling for as much as $12.00/dozen.

Future research should focus on the impacts of river discharge and environmental factors on the population dynamics of Atlantic croaker in the Gulf of Mexico. Despite the large scale shrimping effort, impacts of bycatch on the demographics of Atlantic croaker have not been thoroughly investigated in the Gulf of Mexico. Heavy fishing pressure can lead to fisheries-induced evolution leading to decreases

in length-at-age and early maturation. Research should also be directed at identifying the locations and environmental characteristics associated with Atlantic croaker spawning. Atlantic croaker are considered a forage fish given its linkage between upper and lower trophic levels; however, a holistic understanding of the role of croaker in the Gulf ecosystem and consequences for declines in biomass on ecosystem function has yet to be investigated.

Chapter 2
INTRODUCTION

In the late 1970s, following substantial declines in the landings for groundfish, the Gulf of Mexico Fishery Management Council (GMFMC) began development of a fishery management plan (FMP) for the groundfish fishery in the northern Gulf of Mexico. A draft plan was initiated, primarily utilizing first-hand information from the National Marine Fisheries Service (NMFS) and the various state management agencies in the region. Most of the biology, habitat, and fishery information on the species that make up the groundfish fishery was provided directly by Mr. Ernie Gutherz, Mr. Perry Thompson, and Mr. Charlie Roithmayr (respectively) of the NMFS Pascagoula Laboratory. The draft FMP was never completed, however, partly because the fishery dissolved during the drafting process. Landings of Atlantic croaker (*Micropogonias undulatus*) in the Gulf of Mexico steadily declined and have been minimal ever since that time.

Starting in the mid-1990s, there was a notable increase in the region's commercial landings for Atlantic croaker, though not nearly at the magnitude of the previous century. In 2015, with an increased effort resurging for this species, the Commission's State-Federal Fisheries Management Committee (S-FFMC) directed staff to begin development of a Biological Profile for Atlantic croaker in the Gulf of Mexico. The Croaker Technical Task Force (TTF) was subsequently formed, and an organizational meeting was held in September 2015 in Gulfport, Mississippi.

Unless specifically noted, much of the pre-1980s information herein is primarily derived from the GMFMC's original unpublished management plan. This information has been expanded to include more recent research and data derived by academia and state/federal resource agencies. Interviews conducted with former fishery participants also revealed a detailed history of the groundfish and foodfish fisheries of the last century.

Atlantic croaker are distributed from Massachusetts to Mexico and from Texas to Tampa Bay, Florida (McRae 1997). While there is considerable information on this species in general, this profile will focus on the segment of the Atlantic croaker population which occurs in the U.S. Gulf of Mexico. Given genetics and growth similarities across the five Gulf states, Atlantic croaker from the Gulf of Mexico are considered a single stock in this document.

IJF Program and Management Profile and Plan Development

The Interjurisdictional Fisheries Act (IFA) of 1986 (Title III, Public Law 99-659) was approved by Congress to: (1) promote and encourage state activities in support of the management of interjurisdictional fishery resources and (2) promote and encourage management of interjurisdictional fishery resources throughout their range. Congress also authorized federal funding to support state research and management projects that were consistent with these purposes. Additional funds were authorized to support the development of interstate management plans by the marine fishery commissions.

After passage of the IFA, the Commission initiated the development of a planning and approval process for the management profiles and plans. Since the Gulf Commission has no regulatory authority, all authority resides with the state agencies. Three options exist for profiles or plans within the Commission's IJF Program depending on the needs identified by the state management agencies:

(1) Biological Profile
A Biological Profile contains the elements related to the species itself (biology and habitat) and a brief overview of the fisheries that exist in each state (landings, effort, economics, and a

description of participation). This option is provided when biological or fisheries data is limited or unavailable to provide any type of evaluation of the fishery or population. Research and data needs will be highlighted and presented for state agency consideration.

(2) Management Profile
A Management Profile contains the same elements as the Biological Profile plus the addition of any state information related to the stock status but not a regional stock assessment. The Management Profile will identify research and data needs as well as management considerations which are optional for the states should a need arise to change existing management scenarios or to conduct a stock assessment for the resource in the future.

(3) Fishery Management Plan
A Fishery Management Plan (FMP) is the final option should a state or particular sector within the fishing community request a formal stock assessment be facilitated by the Commission. This may be useful only to the states who do not already have their own state-derived management plans or stock assessments and need a traditional FMP for certification or other purposes. Along with a regional assessment will be recommendations on management goals and objectives as well as a suite of potential biological reference points for management which are available to the state as options. The Commission's FMPs continue to have no authority over the states in how they manage their fisheries and participation in development does not obligate any agency to implement the goals, objectives, or reference points for management.

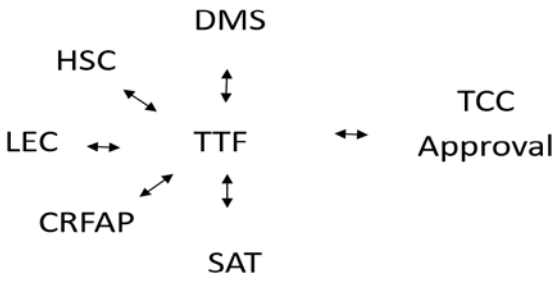
Regardless of which document type, once the profile or plan has received final approval from either the TCC or the Commissioners, the document will be published electronically and made available on the Commission webpage.

The TTF is composed of a core group of scientists from each Gulf state and is appointed by the respective state directors who serve on the Commission. Also, a TTF member from each of the Commission's standing committees (Law Enforcement, Habitat Advisory, Commercial Fisheries Advisory, and Recreational Fisheries Advisory) is appointed by the respective committee. In addition, the TTF may include other experts in economics, socio-anthropology, population dynamics, and other specialty areas when needed. The TTF is responsible for development of the management plan/profile and receives input in the form of data and other information from the Data Management Subcommittee (DMS) and the Stock Assessment Team (SAT).

Once the TTF completes a profile or plan, it enters the Commissions review process and at any point may be returned to the TTF for modification or further revision. In the case of a management plan, the document will be released for a voluntary public review and comment. After public review, the document and all comments are considered by the Commission who may accept the existing draft, accept the draft with modification, or reject the draft and return it to the TCC or the TTF for further revision. Once approved by the Commission, the plan is submitted to the Gulf states for consideration as potential measures for research or management in their respective states.

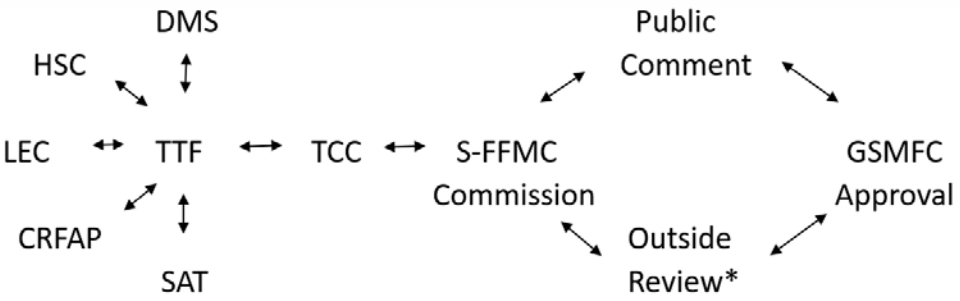
The profile/plan process has evolved to its current form outlined as follows:

Biological and Management Profiles



DMS = Data Management Subcommittee
SAT = Stock Assessment Team
HSC = Habitat Subcommittee
LEC = Law Enforcement Committee
CRFAP = Comm/Rec Fishery Advisory Committee
TTF = Technical Task Force
TCC = Technical Coordinating Committee

Fishery Management Plans



DMS = Data Management Subcommittee
SAT = Stock Assessment Team
HSC = Habitat Subcommittee
LEC = Law Enforcement Committee
CRFAP = Comm/Rec Fishery Advisory Committee
TTF = Technical Task Force
TCC = Technical Coordinating Committee
S-FFMC = State-Federal Fisheries Management Committee
GSMFC = Gulf States Marine Fisheries Commission
*Outside Review = standing committees, trade associations, general public

Biological Profile Objectives

The objectives of the *Biological Profile for the Atlantic Croaker Fishery in the Gulf of Mexico* are:

1. To summarize, reference, and discuss relevant scientific information and studies regarding the management of Atlantic croaker in order to provide an understanding of past, present, and future efforts.

2. To describe the biological, social, and economic aspects of the Atlantic croaker fisheries.

3. To review state and federal management authorities and their jurisdictions, laws, regulations, and policies affecting Atlantic croaker.

4. To ascertain optimum benefits of the Atlantic croaker fisheries of the U.S. Gulf of Mexico to the region while perpetuating these benefits for future generations.

5. To identify gaps in the knowledge regarding the species or the fisheries and suggest to the states research needs or improvements in fishery-dependent and fishery-independent data collection to enhance management strategies for Atlantic croaker in the future.

Chapter 3
DESCRIPTION OF STOCK(S) COMPRISING THE MANAGEMENT UNIT

Geographic Distribution

Atlantic croaker (*Micropogonias undulatus*) occur from Cape Cod, Massachusetts to the Bay of Campeche, Mexico (Chao 1978). They are found throughout the Gulf of Mexico but are most abundant off the coasts of Louisiana and Mississippi (Lassuy 1983). In Florida, they are seldom found south of Tampa Bay on the Gulf Coast or south of Indian River Lagoon on the Atlantic Coast (McRae 1997). Chao (1978) reported that Atlantic croaker can possibly be found from southern Brazil to Argentina but was uncertain if they are found in the southern Gulf of Mexico, Lesser Antilles, and the southern Caribbean. This profile will focus on the segment of the Atlantic croaker population which occurs in the U.S. Gulf of Mexico, from Texas to Florida.

Biological Description

Atlantic croaker belong to the drum family Sciaenidae which contains 57 species in the western Atlantic Ocean (Chao 1978). There are two species of Micropogonias: the Atlantic croaker and the whitemouth Atlantic croaker (*Micropogonias furnieri*). Atlantic croakers are closely related to spot (*Leiostomus xanthurus*); red (*Sciaenops ocellatus*) and black drum (*Pogonias cromis*); spotted (*Cynoscion nebulosus*), sand (*Cynoscion arenarius*), and silver seatrout (*Cynoscion nothus*); and southern (*Menticirrhus americanus*), Gulf (*Menticirrhus littoralis*), and northern kingfish (*Menticirrhus saxatilis*) which all can be found in the Gulf of Mexico. The whitemouth Atlantic croaker (*Micropogonias furnieri*) occur in the Greater Antilles, from Costa Rica to Argentina, and have been reported in Nicaragua (Chao 1978).

The dorsal fin of Atlantic croaker is long and has a deep notch though not completely separated between the spinous dorsal fin with 6-13 spines and the soft dorsal with one spine and 20-35 soft-rays. The anal fin has one or two usually weak spines and 6-13 soft rays. The lateral line in croaker reaches the caudal fin which is slightly emarginated to round. The opercles have a bony upper edge which is forked and the gill opening has a bony flap above it. Atlantic croaker have a patch of small barbels on the chin and possess large cavernous canals in the head. Additionally, the snout and lower jaw have conspicuous pores. The vomer and palatine plates are toothless and the croaker's swim bladder has many branches and is used as a resonating chamber for sound production. Croaker have exceptionally large otoliths for a fish of their size and the vertebral column contains 24-29 vertebrae (Nelson 1994).

In the Gulf of Mexico, the size of individual Atlantic croaker is generally related to water depth. Larger croaker are commonly found around the mouth of the Mississippi River or in close proximity to offshore platforms in depths greater than 40m while smaller croaker are found in the shallower depths (Gutherz 1976). White and Chittenden (1977) reported an average size of 200mm and a maximum size of 300-350mm for croaker off the Texas and Louisiana coasts. The largest Atlantic croaker ever recorded in the northern Gulf of Mexico was an exceptional individual measuring 668mm TL (26.3 inches) captured on a commercial snapper boat (Rivas and Roithmayr 1970).

Along the Atlantic Coast of the U.S., the maximum size for croaker varies. South of Cape Hatteras, individuals reach an average size of 200mm or less and a maximum size of 300-350mm (White and Chittenden 1976). North of Cape Hatteras, individuals reach an average size of 258mm (Haven 1959) and a maximum size of 500mm (Hildebrand and Schroeder 1928). The current world record Atlantic croaker was recreationally caught off Virginia in 2007 and measured 711mm (28 inches) TL (IGFA 2015).

Classification and Morphology

CLASSIFICATION

The following classification is a complete outline of the species according to FishBase (Froese and Pauly 2015)

Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Osteichthyes
Class Actinopterygii
Subclass Neopterygii
Infraclass Teleostei
Superorder Acanthopterygii
Order Perciformes
Suborder Percoidei
Family Sciaenidae
Genus Micropogonias (Bonaparte 1831)
Species *Micropogonias undulatus* (Linnaeus 1766)

The valid name for Atlantic croaker is *Micropogonias undulatus* (Linnaeus 1766).

The following synonymy for Atlantic croaker is provided by FishBase (Froese and Pauly 2015):

Micropogonias undulatus (Linnaeus 1766)
Perca undulata (Linnaeus 1766)
Micropogon undulatus (Linnaeus 1766)
Sciaena croker (Lacepède 1802)
Bodianus costatus (Mitchill 1815)
Micropogon lineatus (Cuvier 1830)
Micropogon opercularis (non Quoy & Gaimard 1825)

Many common and local names exist for *Micropogonias undulatus*, regionally and in the market place; however Atlantic croaker is the only common name recognized by the American Fisheries Society for the U.S. (Page et al. 2013; Table 3.1).

MORPHOLOGY

Atlantic croaker can be described by life history (larval, juvenile, and adult) but could also be described equally well by the habitat they occupy during each life stage (pelagic, estuarine, and offshore). For the purposes of this document, we will define by egg, larvae/juvenile, and adult based on the morphological characteristics published in the literature (Table 3.2 and 3.3). Hildebrand and Cable (1930) provide some of the earliest detailed descriptions of Atlantic croaker from 2.5-110.0mm (Figure 3.1).

Eggs

Information on Atlantic croaker egg morphology is lacking. The eggs are spherical, transparent, and pelagic (Thresher 1984). Gutherz (1976) reported that developing eggs range in diameter from 0.6-0.7mm, with a mean length of emergence of 1.2mm. The eggs are pelagic and, early in development, tend to possess oil globules (Thresher 1984). Middaugh and Yoakum (1974) determined that Atlantic

Table 3.1 Common and market names in the United States reported by FishBase (Froese and Pauly 2015).

Common Name	Country of Origin	Language		Common Name	Country of Origin	Language
Atlantisk trommefisk	Denmark	Danish		波紋絨鬚石首魚	China	Mandarin Chinese
Ørnefisk	Denmark	Danish		波纹绒须石首鱼	China	Mandarin Chinese
Ombervis	Netherlands	Dutch		Mikun	Poland	Polish
Atlantic croaker	Cuba	English		Corvina	Brazil	Portuguese
Atlantic croaker	Mexico	English		Corvina	Portugal	Portuguese
Atlantic croaker	UK	English		Corvina-branca	Brazil	Portuguese
Atlantic croaker	USA	English		Corvina-de-corso	Brazil	Portuguese
Croaker	Cuba	English		Corvina-de-linha	Brazil	Portuguese
Crocus	UK	English		Corvina-de-lista	Brazil	Portuguese
Hardhead	Cuba	English		Cururuca	Brazil	Portuguese
Hardhead	UK	English		Cururuca-lavrada	Brazil	Portuguese
Hardhead	USA	English		Rabeta-brasileira	Portugal	Portuguese
Roncadina	Cuba	English		Corbina	Spain	Spanish
Rumpukala	Finland	Finnish		Corvina	Cuba	Spanish
Tambour brésilien	France	French		Corvina	USA	Spanish
Adlerfisch	Germany	German		Corvinon brasileno	Nicaragua	Spanish
Atlantischer Umber	Germany	German		Corvinón brasileño	Spain	Spanish
Kránios	Greece	Greek		Gurrubata	Mexico	Spanish
Scienidi	Italy	Italian		Roncadina	Cuba	Spanish
Guchi	Japan	Japanese		Roncadina	USA	Spanish
Ishimochi	Japan	Japanese		Havsgös	Sweden	Swedish
Nibe	Japan	Japanese		Iskine	Turkey	Turkish
線紋絨鬚	China	Mandarin Chinese		Mavrusgil baligi	Turkey	Turkish
线纹绒须	China	Mandarin Chinese				

Table 3.2 Description of Atlantic croaker (*Micropogonias undulatus*) larval development (*compiled from* Hildebrand and Cable 1930).

Size	Mouth	Body	Fins	Pigmentation
2.8 mm - 3.6 mm	large and ventral	rather deep; caudal portion slender only near the tip where if forms a sharp point; visceral mass small; hindgut evident and projects prominently but does not appear free	fin folds are visible only along the ventral edge of caudal portion and around slender part of tail; no indication of rays	dark crescent shaped area above visceral mass; row of dark points along ventral edge of caudal body; blackish spot at the articulation of the mandible
3.6 mm - 4.0 mm	oblique	notochord bent upward; viscera more firmly connected with body and smaller in size; hindgut remains conspicuous and connected to body	rudiments of fin rays that are destined to become the caudal fin are evident in fin fold below curved notocord; fin rays not evident elsewhere	no change from above
4.0 mm-6.0 mm	oblique	notochord bent upward prominently; hind-gut remains prominent; vent is becoming situated near anal	caudal fin well-formed and rays now in horizontal plane; tail appears heterocercal	black chromatophores develop around hind-gut
6.0 mm - 10. 0 mm	oblique	backbone visible ending at the base of caudal	soft dorsal and anal fins well developed; caudal fin well developed; pectoral fins evident; ventral fins undeveloped	no change from above

Table 3.3 Description of Atlantic croaker (*Micropogonias undulatus*) development from juvenile to adult stages (size descriptions *compiled from* Hildebrand and Cable 1930).

Size	Mouth	Body	Snout	Scales	Fins	Markings/Pigmentation
10 mm - 15 mm	oblique	more slender than in adults	does not project beyond premaxillaries	not apparent	soft dorsal fully formed; spinous dorsal only partially developed; caudal fin is long; heterocercal character of tail only faintly visible; pectoral fins well developed; ventral fins just becoming visible	dark crescent shaped area above visceral mass; row of dark points along ventral edge of caudal body; blackish spot at the articulation of the mandible; black chromatophores develop around hind-gut
15 mm - 21 mm	no change from above	more slender than in adults	does not project beyond premaxillaries	not apparent	spinous dorsal well formed; heterocercal character of tail has disappeared; pectoral and ventral fins much larger with definitive rays; caudal fin longer and more pointed; anal fin well developed	row of 4 black chromatophores on median line between isthmus and the vent; black chromophore at base of first soft ray of the anal; row of 5 black chromatophores on median line between end of the anal and base of the caudal; 3 black chromatophores at base of caudal of fin
21 mm - 30 mm	no change from above	depth 3.4 times in length; spines on operacle and preoppercle prominent	does not project beyond premaxillaries	not apparent	no change from above	row of 6 dark chromatophores from nape to end of the dorsal base; row of 4 dark spots between point of pectoral and base of caudal
30 mm -50 mm	nearly horizontal; barbels on mandible	more slender than in adults; spines on operacle and preoppercle large and sharp	does not project beyond premaxillaries	visible	middle rays of caudal fin nearly equal to length of head;	dark chromatophores multiplied greatly in number and scattered over body
50 mm - 65 mm	row of barbels on chin evident	more slender than in adults	does not project beyond premaxillaries	fully formed; showing ctenoid character	caudal fin still long and pointed	three rows of dark spots; one along edge of back, one along middle of the side, and one between the other two rows
65 mm - 110 mm	horizontal	back less prominently elevated then in adult; ventral outline scarcely straight	projects slightly beyond premaxillaries	no change	caudal remains pointed but becoming proportionately shorter	sides are silvery, shading into silvery-gray and green toward the back; pale silvery underneath; definite dark blotch on operacle; three rows of dark spots increased in size
Sub Adult and Adult >110 mm	no change from above	back prominently elevated; ventral outline straight	snout projects prominently beyond mouth	no change	margin of caudal fin is double concave	oblique wavy bars on the sides; dark blotch on operacle and another at base of dorsal spine

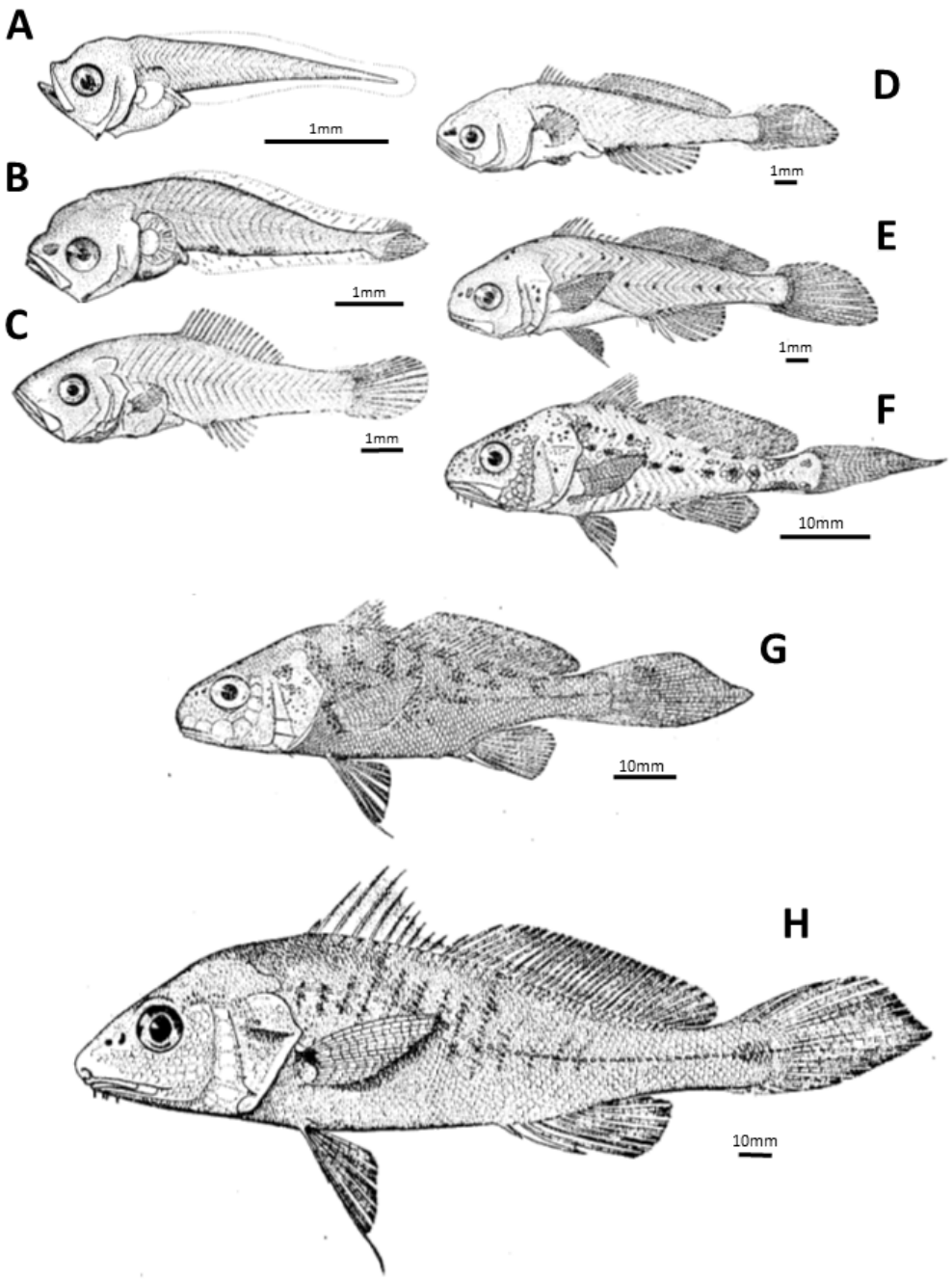


Figure 3.1 Compiled illustrations of Atlantic croaker (Micropogonias undulates) A. 2.5mm, B. 4mm, C. 7mm, D. 12.5mm , E. 20mm, F. 32mm, G. 65mm, H. 110mm (*from* Hildebrand and Cable 1930).

croaker development from egg fertilization to larval emergence occurred in approximately 30 hours. Their detailed stages of development are provided in Figure 3.2 (*from* Middaugh and Yoakum 1974).

Larvae And Juveniles

Middaugh and Yoakum (1974) described Atlantic croaker development from hatchery fish. At 48hrs after larvae emergence, eye pigmentation was apparent, the mouth was gaping open, and fish were observed darting through the water column attempting to forage.

A detailed description of larval and juvenile development of Atlantic croaker can be found in Tables 3.2 and 3.3 respectively.

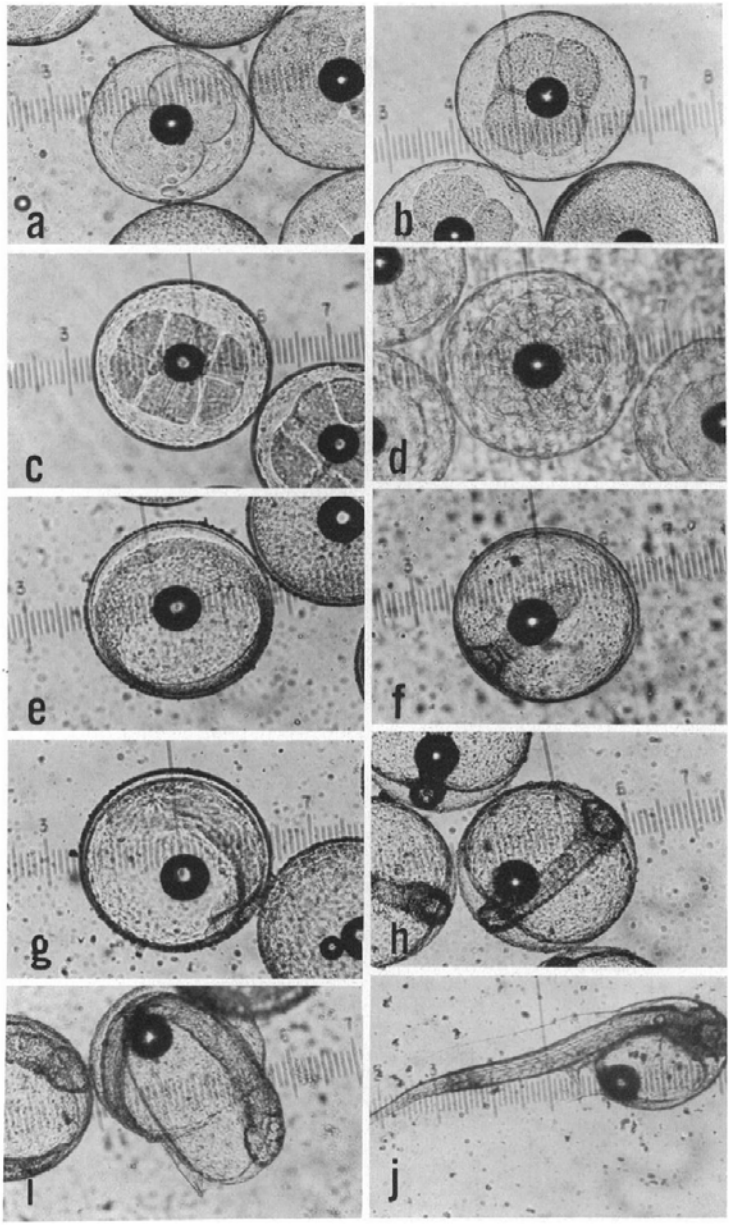


Figure 3.2 Developmental stages of croaker zygotes maintained at 20 ± 1°C. All figures are 55X. a. Two cells, 0hrs 47mins, polar view shows the large oil globule which was present in all viable eggs but lacking in many unfertilized ova. b. Four cells, 1 hour 10mins. c. Eight cells, 1 hour 26mins, this stage results as the 4 cell stage experiences a vertical division parallel to that occurring as the 2 cell stage divided. d. Late blastula, 5hrs 14mins, the blastoderm is flattening out and beginning to spread over the yolk. Peripheral areas are slightly serrated, indicating imminent migration of the periblast outward. e. Initial gastrulation, 7hrs 15mins, as the blastoderm expands over the yolk (polar view) peripheral cells begin to pile up. The thickened ring which can be seen in the lower portion of the photograph indicates that gastrulation has begun. f. Gastrulation, 13hrs 26mins, the blastopore is nearly closed in this stage and the embryonic axis is beginning to differentiate. g. Neural streak, 18hrs 20mins, at this time the extra-embryonic ectoderm covers nearly all of the yolk. The nervous system shield is wide and poorly differentiated. h. Formation of the optic vesicles, 24hrs 45mins, closure of the blastopore is complete. Somites have developed. The fore, mid and hind brain are differentiated and the optic vesicles have developed. i. Emerging larvae, 30hrs 04mins. j. Croaker larvae, 24hrs after emergence, eye pigmentation is beginning to develop. The yolk sac ectoderm is attached just below the mouth. Pectoral fins are differentiated. The anal opening is small and poorly developed. The mouth remains closed. (Figure 1 *from* Middaugh and Yoakum 1974).

Sub Adults and Adults

Once Atlantic croaker reach a length of 100mm or more, they begin to acquire the characteristic shape and color of the adult but that does not necessarily reflect maturity. Hildebrand and Cable (1930) provided the following description.

> "At a length of 110 millimeters the back is prominently elevated; the ventral outline, from the chin to the vent, is straight; the snout projects prominently beyond the inferior horizontal mouth; and the margin of the caudal fin is approaching the slightly double-concave shape of the adult with the upper and middle rays longest. Although serrations on the opercle and preopercle are less prominent than for a somewhat smaller size they are larger than in the adult. The characteristic color of the adult, including oblique wavy bars (dark in preserved specimens, brassy to brownish in life) on the sides, a dark blotch on the opercle and another at the base of the dorsal, is well developed. The fish would be recognized readily at this size by anyone who knows the adult."
>
> Hildebrand and Cable 1930

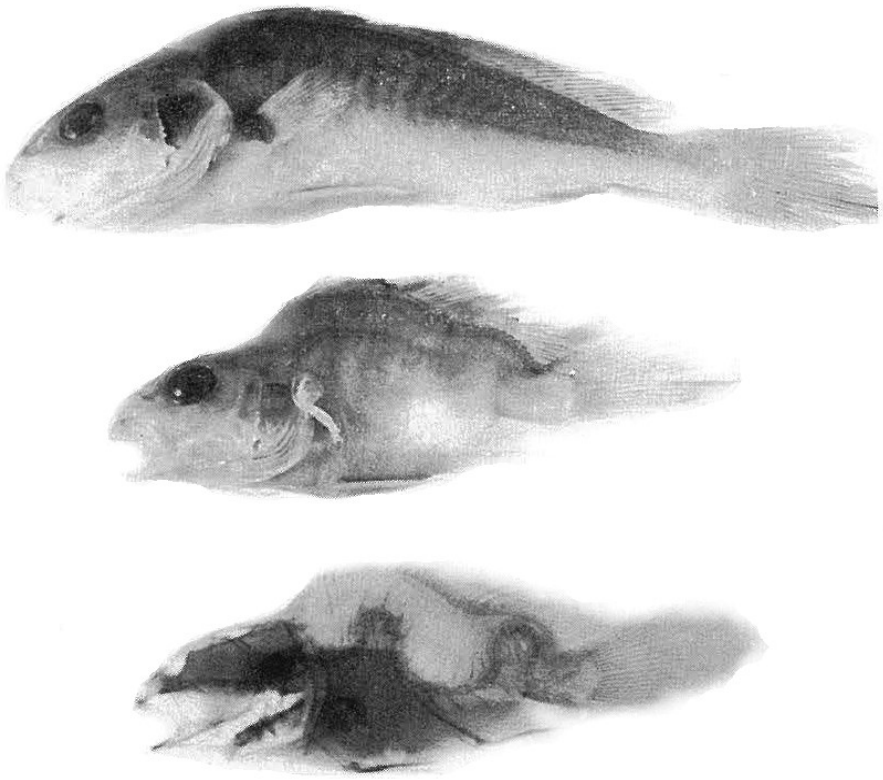


Figure 3.3 Normal (82 mm SL) and humpbacked (44 mm SL) Atlantic croaker and radiograph of the humpbacked specimen (*from* Hansen 1969a).

Anomalies and Abnormalities

Hansen (1969a) observed humpbacked Atlantic croaker in Escambia Bay, Florida. These individuals were plump, had a full intestinal track, and could swim easily but were slower than normal (Figure 3.3). Double dorso-ventral and lateral bends of the spinal column were also observed.

Gunter (1943) described a 'dumpy' or shortened fish that was taken from a trammel net in Rattlesnake Point, Texas (Figure 3.4). The body, excluding the head and fins, was shortened and the placement of scales

Figure 3.4 Normal Atlantic croaker (above) and 'dumpy' croaker (below) (*from* Gunter 1943).

Table 3.4 Comparison of the 'dumpy' Atlantic croaker and a normal Atlantic croaker (*from* Gunter 1943).

Measurements	"Dumpy" Atlantic croaker Length (mm)	Normal Atlantic croaker Length (mm)
Total Length	173	224
Standard Length	128	178
Head	62	63
Depth	58	53
Fin Lengths, longest ray		
Pectoral	43	44
Pelvic	34	36
Anal	32	33
Caudal	42	43
Caudal Peduncle		
Depth	16	16
Length	15	23
Length dorsal base	69	108

was closer than normal. The horizontal bars on the back were closer together than normal. The basal lengths of the fins were less than normal. The abdominal space was more distended than normal. The vertebrae of the fish were much shorter than normal. While infrequent, they are observed occasionally in the Gulf (Somerset personal communication, Ferguson personal communication). Table 3.4 provides an overview of the morphometrics between the normal and 'dumpy' Atlantic croaker from Gunter 1943.

Breder (1924) described a hermaphrodite Atlantic croaker (Figure 3.5). The specimen had a great body depth and upon examination it was determined that a perfect set of both ovaries and testes were present. The junction of the ova, sperm, and urinary ducts appeared to be at the genital pore suggesting that mechanical self-fertilization appears possible. By size and scale examination, it was determined that the specimen was about five years old, and therefore, would have passed through at least one spawning season.

Comparison to Other Sciaenids

The identification of eggs within the Family Sciaenidae can be difficult due to morphological similarities and overlapping spawning seasons, but drum eggs can be set apart as a family due to those characteristics (Lippson and Moran 1974). Sciaenid larvae are well studied, so species identification is easily possible. A detailed comparison of Sciaenid larvae, juveniles, and adults can be found in Table 3.5.

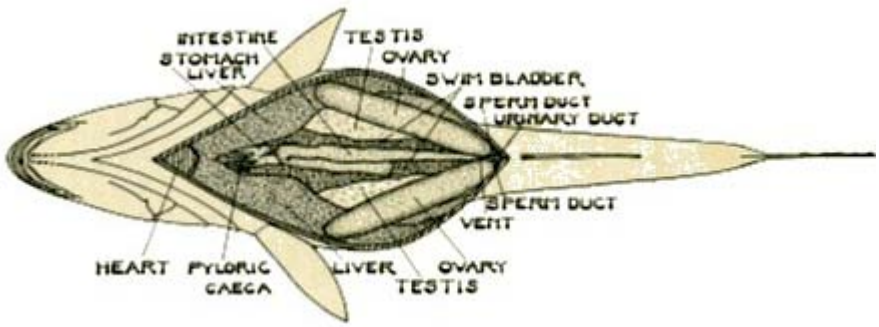


Figure 3.5 Diagram drawing of a hermaphrodite Atlantic croaker (*from* Breder 1924).

Table 3.5 Comparison of Sciaenid larvae, juveniles, and adults (*compiled from* Fahay 2007).

Morphologic Character	Silver perch *Bairdiella chrysura*	Spotted seatrout *Cynoacion nebulous*	Silver seatrout *Cynoscion nothus*	Spot *Leiostomus xanthurus*	Southern kingfish *Menticirrhus americanus*	Gulf kingfish *(Menticirrhus littoralis)*	Northern kingfish *Menticirrhus saxatilis*	Atlantic croaker *Micropogonias undulatus*	Black drum *Pogonias cromis*	Red drum *Sciaenops ocellata*
LARVAE										
body depth	deep-bodied (BD>32% SL)	shallow-bodied (BD<32% SL)	deep-bodied (BD>32% SL)	shallow-bodied (BD<32% SL)	intermediate body depth	intermediate body depth	intermediate body depth	shallow-bodied (BD<32% SL)	shallow-bodied (BD<32% SL)	shallow-bodied (BD<32% SL)
caudal fin	rounded	rounded	central rays longest	rounded	central rays longest	rounded	rounded	central rays longest	rounded	rounded
preanus length	increases from 40% SL to 55% SL	increases from 40% SL to 65% SL	increases from 50% SL to >60% SL	increases from 20% SL to 50% SL	increases from <50% SL to <60% SL	increases from <50% SL to <60% SL	increases from <50% SL to <60% SL	increases from <45% SL to <60% SL	increases from 40% SL to 55% SL	increases from <45% SL to <60% SL
head and snout	head and snout rounded, blunt; head length increases from 27% SL to 35% SL	head and snout moderately pointy; head length increases from 30% SL to <40% SL	head moderately rounded, with slightly pointy snout, head length 40% SL throughout development	head moderate in size with slightly pointy snout	head deep; short, rounded snout	head deep; short, rounded snout	head deep; short, rounded snout	head deep, moderately rounded; head length increases from 30% SL to 35% SL	head moderately large and deep; head length 30-40% SL	head moderately deep; head length 30-35% SL
mouth	large, reaching beyond middle of eye	large, almost reaching posterior edge of eye in later larvae	large, extending to posterior edge of eye	mouth fairly large, reaches mid-point of eye	large, extending beyond mid-point of eye	large, extending beyond mid-point of eye	large to mid-point of eye	large, reaching beyond mid-point of eye	mouth large, extending to mid-point of eye	very large, extending to posterior edge of eye
flexation	3.8-4.5 mm SL	3.7-4.8 mm SL	3.5-5.0 mm SL	3.8-5.3 mm SL	3.0-6.0 mm SL	3.0-6.0 mm SL	2.4-4.0 mm SL	3.8-4.5 mm SL	4.0-5.0 mm SL	3.2-5.1 mm SL
head spines	small, simple spines along posterior edge and lateral ridge of preopercle; weak spine at upper angle of opercle	small, simple spines along posterior edge and lateral ridge of preopercle; weak spine at upper angle of opercle	small spines on posterior edge and later ridge of preopercle; 1-2 weak spines at upper angle of opercle	small spines on posterior edge and later ridge of preopercle; no spines on opercle	small spines on posterior edge and later ridge of preopercle; small spine at upper angle of opercle	very small spines along posterior edge of preopercle	very small spines along posterior edge of preopercle	small spines along posterior edge of preopercle	few, small spines on preopercle	small spines on posterior edge and lateral ridge of preopercle; 1 or 2 weak spines at upper edge of opercle
pigmentation	2 dark, vertical swatches; 1 through cleithral region	mid-lateral and ventral line on caudal peduncle; vague spot anterior to anus	light pigmentation; prominent spot over origin and insertion of anal fin; spot in anus-anal fin gap	ventral row of spots from anus to caudal fin base; triangular pattern anterior to anus	lighter than congeners; lower, lateral gut pigmented; palatine pigment (roof of mouth)	intermediate among congers; lower, lateral gut lightly pigmented; light palatine pigment (roof of mouth)	heavier than congeners; lower, lateral gut well-pigmented; palatine pigment (roof of mouth)	prominent spot at anus; no internal pigment on anterior gut; lacks dorso-lateral pigment; linear pattern anterior to anus	prominent spot over middle of anal fin; no internal pigment on anterior gut; blotches laterally	prominent spot over anal fin insertion; at least 2 spots along dorsum

Table 3.5 Continued

Morphologic Character	Silver perch *Bairdiella chrysura*	Spotted seatrout *Cynoacion nebulous*	Silver seatrout *Cynoscion nothus*	Spot *Leiostomus xanthurus*	Southern kingfish *Menticirrhus americanus*	Gulf kingfish *(Menticirrhus littoralis)*	Northern kingfish *Menticirrhus saxatilis*	Atlantic croaker *Micropogonias undulatus*	Black drum *Pogonias cromis*	Red drum *Sciaenops ocellata*
myomeres	25	25	27	25	25	25	25	25	24	25
vertebrae	11+14=25	12+13=25	15+12=27	10+15=25	10+15=25	10+15=25	10+15=25	10+15=25	10+14=24	10+15=25
dorsal fin rays	XI-XII, 19-23	X-XI, 24-28	XI, 26-31	X-XII, 33-35	XI, 20-26	XI, 21-26	XI, 22-27	XI, 26-31	XI, 18-23	XI, 23-25
anal fin rays	II, 8-10	II, 9-12	II, 8-10	II, 12-13	I, 6-8	I, 6-8	I, 7-9	I, 7-9	II, 5-7	I, 7-9
pectoral fin rays	15-17	18-20	18-19	21-22	18-24	18-21	18-21	17-18	18	17
pelvic fin rays	I, 5	I, 5	I, 5	I, 5	I, 5	I, 5	I, 5	I, 5	I, 5	I, 5
caudal fin rays	8-9+9+8+5+8	9-9+9+8+5-7	7-8+9+8+6-8	6-8+9+8+6-8	8-9+9+8+7	7-8+9+8+6	6-8+9+8+6	8-9+9+8+8	8-9+9+8+7	8-10+9+8+7-9
supraneurals	0/0/0/2	0/0/0/2	0/0/0/2	0/0/0/2	0/0/0/2	0/0/0/2	0/0/0/2	0/0/0/2	0/0/0/2	0/0/0/+2/1+1/1/2/
JUVENILES										
pigmentation	uniform silver-grey over most of body	dark, longitudinal bands on body	blotches on dorsal half of body becomes bars	light; blotches along mid-lateral line; light saddles on dorsum	dark over-all except venter	dark over-all, paler ventrally	dark over-all	spots or dusky bands along dorsum and lateral line	bands form on sides of body; no ventral pigmentation	blotches form on dorsum and along mid-lateral line
caudal fin	rounded	central rays longest	central rays longest	squared off	central rays longest	lower lob longest	lower lobe longest	lower lobe longest	lower lobe longest	central rays longest
anal fin	II, 8-10	II, 9-12	II, 8-10	II, 12-13	I, 6-8	I, 6-8	I, 7-9	II, 7-9	II, 5-7	II, 7-9
barbels	no	no	no	no	yes	yes	yes	yes (>30 mm SL)	yes	no

Physiological Requirements of Atlantic Croaker

SALINITY

Atlantic croaker tolerate a wide range of salinities from 0-70‰; however, this range varies with life history. Given their distributions, pelagic larvae are found in salinities as high as 36‰ (Lassuy 1983), whereas juvenile and sub-adults tend to occupy lower (<20‰) salinities (Lassuy 1983, Eby and Crowder 2002). While the effects of high salinity environments on the physiology of croaker are data limited, Peterson et al. (1999) determined experimentally that juvenile growth is greater in lower (5‰) salinities.

Adult croaker tolerate higher salinities than do juveniles and are most often associated with salinities ranging from 6-20‰ (Lassuy 1983, Eby and Crowder 2002). It is important to note that salinity tolerance of adult croaker remains understudied and that these tolerance estimates are inferred from catches in the wild. Experiments have also demonstrated increased growth of juvenile Atlantic croaker in low salinity conditions (Peterson et al. 1999, Searcy et al. 2007).

TEMPERATURE

Laboratory experiments on Atlantic croaker sampled from the East Florida Coast indicated that survival of young-of-year (30-60mm SL) is greatly reduced at sustained temperatures below 3°C (Lankford and Targett 2001). Optimal temperatures for growth in adults have been reported to be between 27 and 31°C (Wang et al. 1997). Temperatures appear to be the primary driver in determining distributions and movement patterns throughout life.

DISSOLVED OXYGEN (DO)

Limited data are available describing dissolved oxygen tolerance; however, in general, croaker are most likely to be found in normoxic (>4 mg L-1) conditions. Interestingly though, Craig and Crowder (2005) noted that croaker tend to aggregate on hypoxic edges, which may be due to the increased foraging opportunities that outweigh biological risks (see Chapter 4 Threats to Survival; Rahel and Nutzman 1994, Baustian et al. 2009).

Age and Growth

Only a handful of age and growth studies have been conducted on Atlantic croaker within the Gulf of Mexico, with the most recent study conducted nearly 30 years ago. These studies were conducted in different areas of the Gulf and used different ageing techniques. This, coupled with the fact that croaker have an extended spawning period and require considerable subjective interpretation, has led to different conclusions regarding the length-at-age of Atlantic croaker (Table 3.6).

One of the earliest age studies was conducted by Roithmayr (1965) using length frequencies of fish caught by research surveys and commercial vessels. For this study, Roithmayr followed well-defined length distributions and was able to segregate Atlantic croaker length measurements into discrete size groups which show a pattern that shifts regularly with the season and repeats year after year (GMFMC 1980). As a result, the first three size groups could be separated and ages inferred based on an October 1 birthday. The resulting lengths-at-age were: 130mm TL for age-1 fish, 170mm TL for age-2, and 210mm TL for age-3.

A few years later, Herke (1971) used a mark recapture study to examine age and growth of Atlantic croaker. Age was based on fish impounded in the marshes of western Louisiana in the Rockefeller Game Refuge, where croaker were tagged and later recaptured in order to measure growth within their first year. A mean daily growth rate was computed using the tag return data and assumed linear growth for at least the first year. The daily growth rate was then multiplied by 365 to obtain an average size of age-1 fish, which was 252mm TL. However, this size is probably an overestimate of true growth, since the

Table 3.6 Length-at-age (mm TL) of Atlantic croaker from the Gulf of Mexico at listed ages as reported by various sources.

Authority	Ageing Technique	Length (mm TL)				
		Age-1	Age-2	Age-3	Age-4	Age-5
Roithmayr 1965	Length frequencies	130	170	210		
Rohr personal communication in GMFMC 1978	Scales	180	263	324		
Chittenden 1976	Scales	160	275			
Herke 1971	Mark recapture	245				
Warren et al. 1978	Scales	178				
Barger 1985	Otoliths	219	269	304	344	358

observations of growth rate were made on pre-juvenile and juvenile fish, which grow more rapidly than average for the entire year (GMFMC 1980).

Due to the high degree of overlap between age groups, fish size is not a good indicator of age. This led White and Chittenden (1977) and Rohr (personal communication in GMFMC 1978) to attempt to use scales to age Atlantic croaker. However, both studies agreed that scales were difficult to interpret because they can have two annular marks, or circuli, per year and no mark formed during the first year (Figure 3.6A). Dual marks have also been reported on the Atlantic Coast (Haven 1954, Ross 1988).

More recent studies used sagittal otoliths to estimate the age of Atlantic croaker (Barger 1985, Barbieri et al. 1994b). Like scales, otoliths have opaque bands, or annuli, that are formed each year. It is generally agreed that the total number of annuli equals the age of the fish (Figure 3.6B). Validation of annuli formation is based on spawning which typically occurs from August through November (Barbieri et al. 1994b) with a peak in October (Holt et al. 1985). In the Gulf of Mexico, the accepted birthdate for Atlantic croaker is October 1. According to Barger (1985), annuli deposition occurs from December

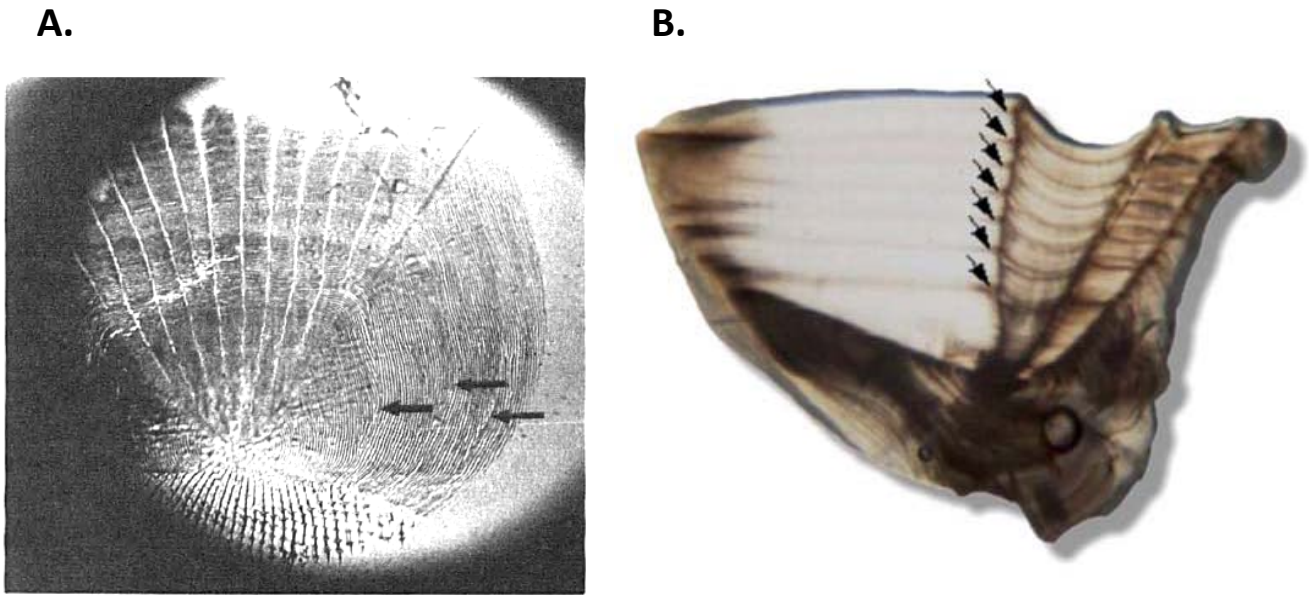


Figure 3.6 A. Scale from age-3 Atlantic croaker (*from* White and Chittenden 1977) and B. otolith section from age-8 Atlantic croaker (*from* Barbieri et al. 1994b). Arrows indicate annuli.

through May since almost no croaker otoliths had annuli on the margins from June to November, but all did by March.

Barger (1985) likely represents the best length at age estimates of Atlantic croaker in the Gulf of Mexico to date. Fish were collected via the RV Oregon II and commercial trawlers along the northern Gulf. Otoliths were aged by two different readers and obtained 99% agreement. The resulting von Bertalanffy growth equation revealed that the theoretical maximum total length ($L\infty$), 419mm, was close to that of the largest specimen observed at 415mm. The growth coefficient (k) was estimated at 0.273, with rapid growth occurring within the first year. The fish ranged in age from 0-8 years old based on Barger (1985), with the age-8 fish being the maximum documented Atlantic croaker in the Gulf of Mexico. More recently, a von Bertalanffy growth equation was created using TPWD age and growth data (unpublished)

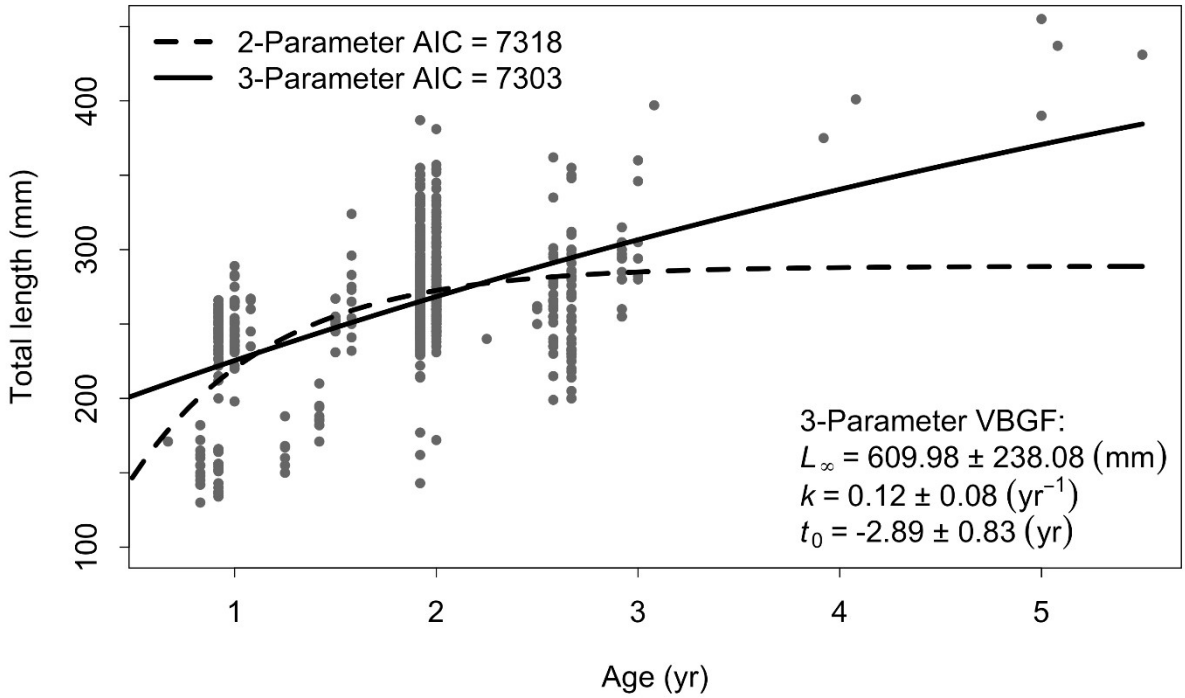


Figure 3.7 Total length at age of 729 Atlantic croaker observed in Texas from 2002-2003. The black line through the data is the fitted von Bertalanffy curve (TPWD unpublished data).

of croaker caught along the Texas Coast. The analysis showed that croaker grew slower (k=0.12 + 0.8) than in Barger's estimate (1985) but reach a larger estimated maximum total length ($L\infty$=610 + 238mm), respectively (Figure 3.7). However, the TPWD data analysis contained a relatively small sample size (n=729) and contained few age-0 individuals, likely skewing the results. For both studies, no significant differences in growth rates between sexes were found and as a result were pooled for the analyses.

Interestingly, differences in growth rates have been observed between Atlantic croaker from the Gulf of Mexico and those found on the Atlantic Coast (Table 3.7). Barbieri et al. (1994b), using sagittal otoliths, estimated the age of Atlantic croaker collected from a combination of commercial pound-nets, haul-seines, and gillnets within the Chesapeake Bay. The results showed that croaker from Chesapeake Bay grew slightly faster than those from the Gulf (k=0.36 + 0.08), but the estimated maximum length ($L\infty$) was smaller at 312 + 7.44mm. This was despite the fact that the largest fish collected was 400mm. Similar to the results from Barger (1985), the oldest fish in the study was also age-8. However, Lee (2005) examined age and growth data for croaker caught along the entire Atlantic Coast from 1981-2002 and found that they grew slower (k=0.25) than Barger (1985), but reached a larger theoretical maximum size

Table 3.7 Published length-at-age (mm TL) of Atlantic croaker on the U.S. Atlantic Coast.

Authority	Ageing Technique	Length (mm TL)				
		Age-1	Age-2	Age-3	Age-4	Age-5
Music and Pafford 1984	Scales	248	268	297	-	389
Ross 1988	Scales	192	271	320	371	430
Barbieri et al. 1994b	Otoliths	201	263	274	285	290

($L\infty$=448mm). Additionally, unlike in the Gulf of Mexico where the maximum documented age is 8 years, croaker in the Atlantic have been aged up to 17 years (ASMFC 2010).

Length-weight relationships have also been examined for Atlantic croaker. Barbieri et al. (1994b) and TPWD (unpublished data) calculated length-weight equations and demonstrated a very linear relationship between weight and length (Figures 3.8 and 3.9). Barbieri et al. (1994b) tested the slope of the regression and found it significantly different from 3.00, indicating Atlantic croaker exhibit allometric growth.

In addition to the studies ageing adult Atlantic croaker, there have also been a few studies that have estimated the daily growth rates of larval croaker. Cowan (1988) examined otolith growth increments within larvae collected in the northern Gulf of Mexico to estimate their daily growth rate. Though daily increments have not been validated, it has been demonstrated in red drum and spot (Peters et al. 1978, Warlen and Chester 1985). Therefore, Cowan (1988) assumed that increments in the otoliths of larval croaker were formed daily. All of the fish examined in the study were estimated to be between 40-80 days old, with a daily growth rate of 0.19mm. These results are similar to those of Warlen (1980), where larvae caught in oceanic waters off North Carolina were found to have a daily growth rate between 0.16mm for late spawned fish and 0.27mm for croaker taken during peak spawning season.

Migration

Atlantic croaker, like many marine species, migrate out of estuaries as adults to nearshore and offshore waters to spawn. Gulf-ward adult migration typically begins in early fall and continues through the winter (Hoese 1965). Larvae emigrate back into the estuaries in the spring (Hoese 1965). Once in the estuaries, the larvae actively begin migrating towards areas of low salinity (Hanson 1969b). Haven (1959) noted that these fish move up the estuary in the salt wedge near the bottom. As croaker grow, they begin to

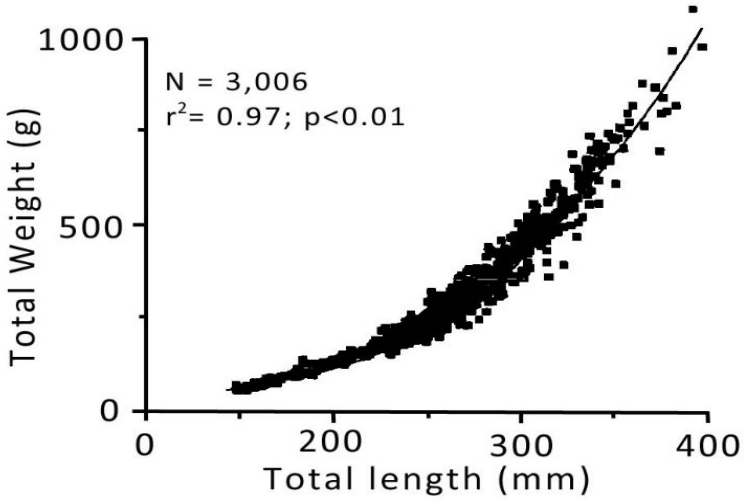


Figure 3.8 Length-weight relationship of Atlantic croaker in Chesapeake Bay Region, 1988-1991 (Figure 6 *from* Barbieri et al. 1994b).

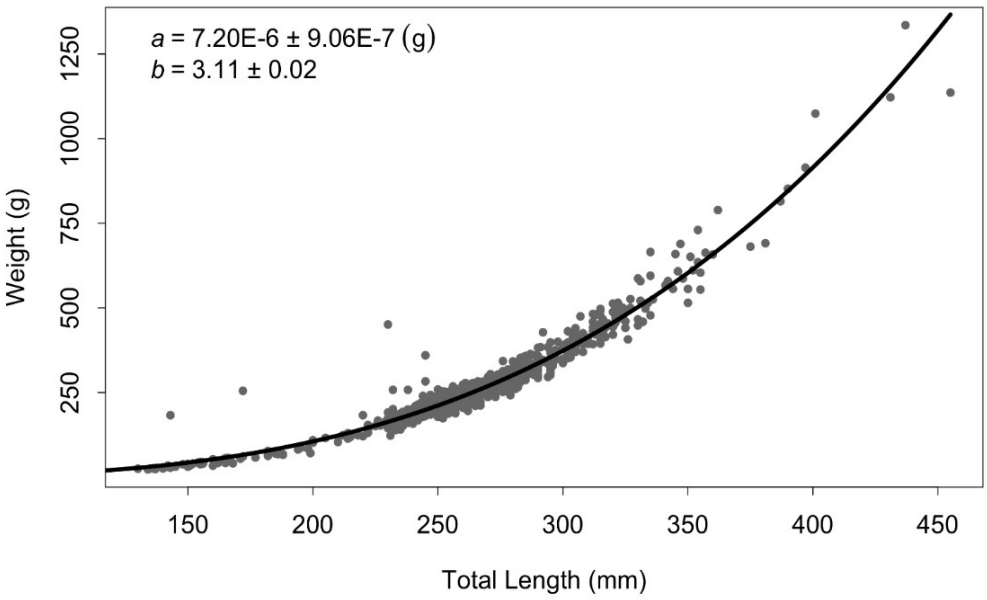


Figure 3.9 Length-weight relationship of Atlantic croaker observed in inshore areas in Texas from 2002-2003 (TPWD unpublished data).

emigrate out of the upper reaches of estuaries and move into higher salinity waters near the mouths of estuaries. Fish older than one year are less abundant inside estuaries and, when present, are usually found around oyster reefs or structures such as bridges or piers in deeper waters (GMFMC 1980).

To date, the only known tagging studies have been conducted along the Atlantic Coast. Miller and Able (2002) observed high site fidelity with juveniles in tidal creeks in Delaware Bay. Although juveniles were observed moving throughout a given creek with tidal activity, little to no movement was observed into or across multiple creeks (Miller and Able 2002). Haven (1959) conducted a tagging study within Chesapeake Bay and the surrounding area and noted croaker movement through estuaries and bays during the spring, limited random movement in the summer, and ocean-ward movement in the fall. No known tagging studies have been conducted on croaker in the Gulf of Mexico.

Reproduction and Genetics

REPRODUCTION

Gonadal Development

Few studies have specifically focused on reproduction of croaker and the majority of information is from older publications. Atlantic croaker mature at a young age, becoming sexually mature by the end of their first or second year (Creswell et al. 2010). Along the Gulf Coast, most croakers spawn at the end of their second year; however, a study conducted around Pensacola, Florida from 1963-1965 found that most of the male and female croakers already had developing gonads in the fall of their first year (Hansen 1969b). Most of the croaker sampled had gonads that were well-developed with the potential for spawning in their first year (Hansen 1969b). On average, age-1 female croakers had approximately 40,000 eggs in their ovaries (Hansen 1969b).

Size and Age at Maturity

Consensus on maturity schedules for Atlantic croaker is highly variable but generally maturity occurs at small sizes and at an early age. Creswell et al. (2010) estimated the mean total length of 50% (L50) of

croaker males at first maturity were 182mm TL and females were 173mm. Most of the published work suggests that the majority of croaker are mature by year one and all by year two (Herke 1971, Juhl et al. 1975, White and Chittenden 1977, Barbieri et al. 1994a, Creswell et al. 2010). Hansen (1969b) reported that young croaker in the Pensacola estuary (Florida) had developing gonads by the fall of their first year of life. Hansen's findings suggest maturity may occur earlier than previous reports by Pearson (1929), Suttkus (1955), and Roithmayr (1965) who reported spawning at the end of the croaker's second year of life.

Fecundity

Fecundity of Atlantic croaker in the Gulf of Mexico has not been absolutely established; however, Hildebrand and Schroeder (1928) reported that a 390mm specimen caught off the mouth of the York River in the Chesapeake Bay had "180,000 uniformly sized eggs in the ovary". Hansen (1969b) reported that 18 Atlantic croaker in Pensacola Bay, Florida, ranging from 101-145mm SL, had an average of 41,200 eggs in their ovaries. Barbieri et al. (1994a) showed that croaker were batch spawners with asynchronous oocyte development and indeterminate fecundity which means that individual females may spawn multiple times during the long spawning season but individuals do not spawn over the entire season for the population (Barbieri et al 1994a).

Hypoxic conditions are found to inhibit reproductive functioning (gonadal growth and gamete production) in both males and females (Thomas and Rahman 2009, 2011). Hypoxia can also lead to skewed sex ratios towards males and to masculinization of ovaries in females (Thomas and Rahman 2011; see Chapter 4 Threats to Survival).

Spawning and Season

In the wild, the duration of croaker spawning can differ depending on location, as water temperature and photoperiod can vary drastically. Spawning peaks also vary annually due to fluctuations in seasonal conditions from year-to-year. Atlantic croaker have a protracted spawning season; along the mid-Atlantic Coast they spawn from July to December, whereas croaker in the Gulf of Mexico tend to begin spawning later in the year starting in fall and extending into early spring with peak spawns from October to November (White and Chittenden 1976, Juhl et al. 1975). A second peak in spawning has also been observed in late January to early February (Warren et al. 1978, Cowan 1988, Barbieri et al. 1994a, Kupchik and Shaw 2016). However, it has been noted that in Florida waters, croaker may spawn year-round (Creswell et al. 2010), although the spawning season for croaker around Pensacola Florida was only in the winter, from November to February (Hansen 1969b).

Courtship and Spawning Behavior

There is limited information about the spawning behavior of Atlantic croaker. Spawning by croaker has been observed in captivity but not in the wild. Sink et al. (2010) observed behaviors prior to the actual spawning event but did not witness spawning as it occurred overnight in tanks with a spawning peak shortly before daylight. It is believed that spawning behavior in croaker is similar to that reported for other Sciaenids which are evening spawners. Holt et al. (1985) theorized that night spawning may reduce predation on the eggs by allowing egg dispersal when predators are less active. Sink et al. (2010) reported that all male and female croakers in the tank were involved in pre-spawning activity; swimming in a tight group in a circular motion just below the water's surface. Males would aggressively bump females and dart in and out of the group. All the fish would occasionally leap from the water and even females that appeared to have already spawned would participate (Sink et al. 2010).

Incubation

According to Middaugh and Yoakum (1974), developing eggs spawned in captivity range in diameter from 0.625-0.7mm and larvae were about 1.2mm at hatching. Middaugh and Yoakum (1974) observed

that eggs hatched around 30 hrs after fertilization. Sink (2011) found that, in captivity, it took 26-32hrs for eggs to hatch after fertilization.

Larval Transport

Cowan and Shaw (1988) observed high densities of larval Atlantic croaker approximately 65-125km offshore Louisiana from December–March, with the highest density in February. Cowan and Shaw (1988) calculated that, based on the average shoreward advection rate, it would take approximately 65 days for larval Atlantic croaker to be transported 98km in the onshore direction. This study also suggested that, due to the west/northwest direction of the current, it was likely that the larvae sampled offshore Louisiana would not recruit to Louisiana estuaries, but instead would be transported toward north Texas.

GENETICS

Although there have been genetic studies done which include Atlantic croaker, most of them have focused on other Sciaenids such as spotted seatrout and red drum. Croaker are a hardy fish and easy to collect making them good test subjects for endocrine and toxicology research to study the effect of chemical toxins, climate change, and environmental variables. Hawkins et al. (2005) examined duplicate estrogen receptors in the forebrain of Atlantic croaker as evidence for sub-functionalization after gene duplication. Nunez and Evans (2007) looked at the hormonal regulation of the StAR protein in gonadal tissues of Atlantic croaker. The effects of hypoxia exposure on CYP1A expression in croaker was studied by Rahman and Thomas (2012).

Of the population genetic studies that have been done on Atlantic croaker, more of them have focused on croaker from the Atlantic Coast than the Gulf of Mexico. Lankford et al. (1999) discovered genetic differences between Atlantic croaker populations in the Atlantic versus the Gulf of Mexico, the study representing the first attempt using DNA-level markers to examine the population genetic structure of Atlantic croaker. There was mtDNA heterogeneity that supports separate populations.

> "The observed genetic break is consistent with a contemporary range discontinuity in southern Florida, where *M. undulatus* seldom occur south of Indian River on the Atlantic coast and are rarely encountered south of Tampa Bay on the Gulf coast." Lankford et al. 1999

The genetic population structure was examined using PCR and RFLP analysis on mtDNA. One sample site of four was in the Gulf of Mexico at Terrebone Bay, Louisiana. Even though there was an observed genetic break between the Atlantic Coast and the Gulf of Mexico, it was a weak differentiation. However, the study did show that the results are consistent with the idea that there is a single genetic stock of Atlantic croaker on the Atlantic Coast and separate stocks exist in the Atlantic and Gulf of Mexico (Lankford et al. 1999). A recent study by Anderson et al. (in prep) on Atlantic croaker genetic structure in the Gulf of Mexico found that there is a lack of observed genetic divergence among samples collected in the Gulf, but there was significant genetic divergence between the Gulf samples and a single Atlantic sample.

Parasites and Diseases

All fish harbor disease organisms, and the potential for outbreak of disease always exists, especially following periods of stress (White and Stickney 1973). Overstreet (1978a) encountered approximately 90 different species of parasites on Atlantic croaker in Mississippi. The most common parasites and infections are detailed below and additional parasites not detailed here are included in Table 3.8.

For parasites with indirect lifecycles, increasing pollution may increase the biota, which in turn causes higher parasitic infections. When the nutrient level reaches a threshold, the water quality decreases. This causes a decrease in biota along with parasitic infection. Toxicants may affect parasites directly by

Table 3.8 Less common parasites of Atlantic croaker parasites and the source of their description.

Species Name	Type of Parasite	Infection Site	Water Body Location	Remarks	Source
Lecithaster confusus	trematode	intestine	Mississippi Sound and adjacent waters		Overstreet 1973
Spirocamallanus pereirai	nematode	digestive tract	Clear Lake, Texas and the channel connecting the lake with Galveston Bay	higher infestation in smaller fish, which are more likely to consume the copepod intermediate host	Joy 1974
Coytlogaster basiri	aspidogastrid trematodes	intestine and rectum	Mississippi, Louisiana, and Georgia	largest parasite found in fish well offshore, so fish aid in completing the life history of the parasite	Hendrix and Overstreet 1977
Lobatostoma rigens	aspidogastrid trematodes	intestine and rectum	Horn Island, Mississippi and Alabama Point, Baldwin County, Alabama	whether the fishes represent accidental or transfer hosts for elasmobranches remain uncertain	Hendrix and Overstreet 1977
Serrasentis sagittifer	ancanthocephalan	mesentery	Gulf of Mexico	parasite utilizes croaker as an intermediate host	Overstreet 1978a
Lernaeenicus radiates	copepod	attaches to the outside	Gulf of Mexico	utilized rock seabass as a host for the larval stage. The abundance of rock sea bass then controls the number of adult infestations	Overstreet 1978a
Spirocamallanus cricotus	camallanid nematode	intestine	estuaries and nearshore habitats of the northern Gulf of Mexico	can live on its host for over a year and probably do not cause excessive mortality.	Overstreet 1978a
Trpanoplasma bullocki	biflagellate	plasma	Gulf of Mexico	transmission appears to occur during confined or stress conditions, infection will rarely cause a disease in the host	Becker and Overstreet 1979
Raphidascaris camura	nematode	stomach and intestine	northern Gulf of Mexico		Deardorff and Overstreet 1981b

Table 3.8 Continued

Species Name	Type of Parasite	Infection Site	Water Body Location	Remarks	Source
Scolex pleuronectis	cestode	midgut	northern Gulf of Mexico	not likely to actively kill the host, but parasites may compete for nutrients and space or cause pathological lesions, which could result in the death of the host	Govoni 1983
Aphanurus sp.	trematode	midgut	northern Gulf of Mexico	not likely to actively kill the host, but parasites may compete for nutrients and space or cause pathological lesions, which could result in the death of the host	Govoni 1983
Homalometron palmeri	digenean	intestine	northern Gulf of Mexico		Curran et al. 2013

reducing their numbers or may stress the host and allow an increase in parasite infection (Overstreet and Howse 1977).

Joy (1974) described *Spirocamallanus pereirai*, a nematode that infected the digestive tract of Atlantic croaker in Clear Lake, Texas and the channel connecting the lake with Galveston Bay. Female nematodes were found in higher concentration than male nematodes. The incidence of infestation was positively correlated with temperature. The peak infestation occurred in the smaller fish. Smaller croaker were more likely to consume copepods, an intermediate host for the nematode.

Lawler and Overstreet (1976) studied the presence of *Absonifibula bychowskyi*, a monogenean worm, attached to the gill filaments of the first gill arch of Atlantic croaker in the Mississippi sound. The prevalence and intensity of infestation was higher in the warm months of June through August. The prevalence and intensity of infestation was also higher in the younger year-class than in the older year-class. The reason for the higher infestation in younger fish could be attributed to differences in biochemistry with age or differences in population density. Young croaker were more densely concentrated, allowing for easier transmission of the parasite.

Norris and Overstreet (1975) observed *Thynnascaris reliquens*, an ascarid nematode, in the digestive tract of croaker sampled in the Mississippi Sound. This nematode can grow to 13cm in length and may occur in the hundreds in a single host (Overstreet 1978a). Egg-producing adults were rarely found croaker suggesting that it was not the normal definitive host (Norris and Overstreet 1975). When a host was caught or placed under severe stress, the worms would evacuate the host through the mouth, gill cavities, and anus. Cooking the fish would alleviate any potential threat to human health (Overstreet 1978a).

Hendrix and Overstreet (1977) discovered two new aspidogastrid trematodes in croaker from the northern Gulf of Mexico. *Coytlogaster basiri* was found in the intestine and rectum of croaker off Mississippi and Louisiana. *Lobatostoma rigens* was found in croaker off Mississippi, Louisiana, and Georgia and utilized the clam *Donax reomeri* as an intermediate host. *D. reomeri* can be found on Horn Island, Mississippi and Alabama Point, Baldwin County, Alabama.

Overstreet and Howse (1977) observed that parasite infestation in croaker by helminths from Mississippi was greater in fish found in estuaries near Ocean Springs versus the Pascagoula River. He attributed this to black anaerobic soil in the Pascagoula and low dissolved oxygen for more than half of the year. Fish from the Pascagoula River fed on small crustaceans, while fish from the Ocean Springs area fed on amphipods and mollusks, which the helminths utilized as intermediate hosts.

Overstreet (1978b) described *Pseudogrillatia heteracanthum*, a trypanorthynch plerocercoid larva that infected Atlantic croaker in the northern Gulf of Mexico. Croaker acted as an intermediate host for the cestode larvae, and the adult matured in elasmobranches (Overstreet 1978a). The larvae could often be found in the middle of the fillet or adjacent to the vertebral column. The infections were known to last from one to three years (Overstreet 1978b) and the worms did not harm the adult fish. Once a fish became infested, it acquired resistance to future infestations (Overstreet 1978a). Prevalence, but not intensity, increased with increasing host length (Overstreet 1978b). Few individual fish had more than three to four larvae (Overstreet 1978a). Infection could also be positively correlated to salinity. When salinity levels were high, the percentage of infected individuals was high because higher salinity waters supported more potential intermediate hosts (Overstreet 1978a). The appearance of the cestode could be very displeasing to consumers, causing fish to be discarded rather than consumed (Overstreet 1978b). This larva does not pose a threat to human health and does not even need to be cooked to be rendered harmless (Overstreet 1978a).

Overstreet (1978a) reported that the digenean fluke, *Metadena spectanda*, was among the most common animals in estuaries near Ocean Springs, Mississippi. In February of 1971, an average of 54.3 parasites infected 53% of the Atlantic croaker examined.

Overstreet (1978a) discussed an ancanthocephalan, *Dollfusentis chandleri*, that infected the rectum of Atlantic croaker in large numbers with one specimen discovered to have 450 individual parasites. The infestation did not appear to harm the host and remained in the host for over a year. Infestation occurred in low salinity habitats during early summer. Amphipods were utilized as the intermediate hosts and transmission occurred when Atlantic croaker injested an infected amphipod.

Overstreet (1978a) identified *Serrasentis sagittifer*, an ancanthocephalan that utilized Atlantic croaker as a transfer host. Juveniles were found in the mesentery of croaker and transmission occurred when cobia, the final host, ingested infected individuals.

Overstreet (1978a) described *Lernaeenicus radiates*, a parasitic copepod that utilized rock seabass as a host for the larval stage. The abundance of rock sea bass then controlled the number of adult infestations in Atlantic croaker. The parasite attached to the outside of its host and its anterior end extended into the host's flesh to obtain a rich blood supply. The adult parasites could kill the host if vital organs were disturbed or if too many individuals infected the host.

Overstreet (1978a) also reported that *Spirocamallanus cricotus*, a camallanid nematode, infected juvenile Atlantic croaker in estuaries and nearshore habitats of the northern Gulf of Mexico. The nematode was found in the intestine where it fed on the blood of its host. Copepods and penaeid shrimp acted as intermediate hosts and transmission occurred when croaker ingested the intermediate host. The nematode could live on its host for over a year and probably not cause excessive mortality.

Becker and Overstreet (1979) identified *Trpanoplasma bullocki*, a biflagellate blood parasite, in the plasma of Atlantic croaker in the Gulf of Mexico. Most infections occurred in younger inshore fish. The biflagellate utilizes a leech, *Calliobdella vivada*, as its intermediate host and transmission appeared to occur during confined or stress conditions. Overstreet (1978a) indicated that a biflagellate infection would rarely cause a disease in the host species.

Deardorff and Overstreet (1981b) identified a nematode, *Raphidascaris camura*, in the stomach and intestine of Atlantic croaker in estuaries in the Gulf of Mexico.

Overstreet and Meyer (1981) noted that one parasite (*Hysterothylacium* sp. type MB), an ascaridoid nematode, was reported as a potential threat to public health. Transmission occurred when an infected host was eaten and the worm encysted and had the ability to infect predatory fishes without maturing in them. *Hysterothylacium* sp. type MB larvae were capable of infecting primates that ingest infected organisms. Larvae of *Hysterothylacium* sp. type MB were administered to the rhesus monkey and within hours, they had penetrated the stomach wall causing hemorrhaging and increased levels of eosinophilis. Deardorf and Overstreet (1981a) identified nematodes *Hysterothylacium* sp. type MB from the mesentery of Atlantic croaker in Tampa Bay, Florida, Mississippi Sound, Mississippi, and Galveston Bay, Texas.

Overstreet (1982) determined that the intensity of infestation of Atlantic croaker in Mississippi estuaries by the external dinoflagellate protozoan, *Amyloodinium ocellatum*, was influenced by environmental factors. Infestation increased with increasing precipitation values in a nearly pristine habitat. Infestation also increased with increasing temperatures in a relatively polluted habitat. Overstreet (1993) indicated that the parasite attached to the gills of its host and heavy infestations could cause extensive damage or even the death of the host.

Govoni (1983) described helminth infections of larval Atlantic croaker in the northern Gulf of Mexico. The parasites belonged to two taxa: cestode *Scolex pleuronectis* and trematode *Aphanurus* sp. The parasites were located in the midgut of larval fish. Infection rates were low but increased with larval fish length. These parasites were not likely to actively kill the host but could do so passively. The parasites compete for nutrients and space and can cause pathological lesions which could result in the death of the host.

Thoney (1991, 1993) compared the parasite abundances of juveniles and adult Atlantic croaker in estuaries and offshore along the Atlantic Coast. Adult croaker collected offshore had greater species-richness, diversity, and total number of individuals with parasites (Thoney 1993) than juveniles collected in adjoining estuaries (Thoney 1991). The greater abundances of parasites offshore indicated that the parasites had been accumulating over time or that a greater number of intermediate hosts were available. Several species of parasites found in the adults were not recovered in the juveniles, and vice versa. The absence of certain parasites in juveniles could be explained by the fact that the juveniles fed on different prey or that the intermediate hosts did not occur in the estuarine systems. The absence of certain parasites in offshore adults could be explained by the fact that these parasites have direct life cycles (Thoney 1993). Species-richness, diversity, and species evenness tended to increase with host size (Thoney 1991). This suggests that these parasites either lived long enough to accumulate as the host grew or that larger fish consumed larger numbers of infected prey (Thoney 1993). Juvenile fish had less time to acquire parasites and inhibit less diverse habitats which resulted in lower parasite diversity (Thoney 1991). Thoney (1993) reported a mean number of parasite species in Atlantic croaker which was greater than what Kennedy et al. (1986) found in freshwater fishes but fewer than those for most birds and mammals.

Overstreet (2007) described the parasite composition of Atlantic croaker in the Mississippi Sound post-Hurricane Katrina. Atlantic croaker usually had a high species richness in terms of parasite infestation, but the first parasites to show up post-Hurricane Katrina were *Metadena spectanda* and *Opecoeloides fibriatus*, which did not reappear until July of 2006. The monorchiid trematode, *Diplomonorchis leistomi,* did not reoccur in Atlantic croaker until March of 2007, and, when it did, it occurred in low prevalence and intensity. After the hurricane, sediments were suspended, mobilized, and redeposited, which had an effect on the intermediate hosts. This trematode required a bivalve as an intermediate host. When the sediment was perturbed, the intermediate host may have been killed, eliminated, or inhibited from reproducing. *Macrovalvirematoides nicropogoni*, a helminth that reproduces on the Atlantic croaker, was first recorded post-Hurricane Katrina in March 2007. *Dollfusentis chandleri*, an acanthocephalan, occurred in large Atlantic croaker post-Katrina, but no young individuals or fish born after the storm exhibited infection through June 2007. This could have been attributed to the surge of high salinity water in the estuaries that affected the small crustaceans, the intermediate host of acanthocephalan.

Curran et al. (2013) discovered a new species, *Homalometron palmeri*, in Atlantic croaker from the Gulf of Mexico. The new digenean was previously believed to be *Homalometron pallidum*. Since the intermediate host, a hydrobiid snail (*Hydrobia truncate*), of *H. pallidum* was absent in the Gulf of Mexico, previous identifications of this species had been wrong. *H. palmeri* have been found in the intestine of croaker.

Howse and Christmas (1970a, 1970b) described lymphocytes on Atlantic croaker from estuaries of the Mississippi Gulf Coast. Lymphocystis is a viral disease that is characterized by numerous tumors distributed on the fins and body. Overstreet (1977) proposed that the appearance of the lymphocytes can be related to temperature stress as a high percentage of fish exhibited infections during periods of low temperatures. Edwards and Overstreet (1976) cited that increased lymphocytes in fishes from the Mississippi Sound suggested a relationship between the disease and increased pollution. The viral infection rarely killed the host outright but could make it more susceptible to predation (Overstreet

1978a). Also, the tumors could be sloughed off the skin and fins making the host more susceptible to infection (Overstreet 1978a).

Keel and Cook (1975) discovered *Vibrio parahaemolyticus* from Atlantic croaker samples collected in Biloxi Bay, Mississippi. *V. parahaemolyticus* had been known to cause food poisoning in humans.

Plumb et al. (1974) concluded that frequent and widespread fish kills in estuarine bays along Florida and Alabama during the summer of 1974 could have been caused by a high number of *Streptococcus* sp. isolated from dead fish. Atlantic croaker was one of the species heavily affected, displaying hemorrhagic lesions, distended abdomens, peritoneal cavities filled with bloody fluid, lumen of intestines filled with bloody fluid, and exophthalmia.

Couch and Nimmo (1974) described high prevalence of fin rot syndrome associated with mortalities of Atlantic croaker during periods of warm weather and low oxygen in Escambia Bay, Florida. They contributed the presence of the disease to contamination by PCB Aroclor 1254. Overstreet (1978a) described fin rot syndrome as a condition in which the rays of fins had erosion, disintegration, abrasion, bleeding, and could result in death (Overstreet 1978a).

Feeding, Prey, and Predators

The feeding habits of Atlantic croaker have been studied and discussed by many investigators, but due to differences in methodology and locale, different conclusions have been made (Roussel and Kilgen 1975, Overstreet and Heard 1978, Mercer 1987). However, all agree that croaker are opportunistic feeders. Atlantic croaker have an inferior wide opening mouth, sensory barbels, and coarse-straining gill rakers, all adaptations useful for feeding in and on the substratum (Overstreet and Heard 1978). Aquarium observations revealed a “plunge and sort” feeding behavior where fish dive into the bottom, grab a mouthful of material, and sift it through the gills (Roelofs 1954, Chao and Musick 1977).

During ontogeny, croaker make several shifts in foraging which reflect morphological growth. Smaller fish typically feed within the water column on zooplankton and other small invertebrates. Adult fish feed predominantly on the bottom and their diet changes to ingesting larger bottom dwelling organisms. The dietary transition is accompanied by movement of the mouth from a terminal position in the smallest fish to an inferior position in adults (GMFMC 1980).

Stomach contents of Atlantic croaker have been documented for populations throughout the species range and vary between sampling locations with no specific food preference being evident. In general, young-of-the-year croaker feed on polychaetes, copepods, and mysids, while adult fish feed on crustaceans, molluscs, and fish (Mercer 1987). Overstreet and Heard (1978) showed that there were significant differences in diet between croaker caught offshore compared to those caught inshore, but only in proportion of organisms consumed. Interestingly, previous studies also showed that marine detritus is common in most stomachs of croaker (Roussel and Kilgen 1975, Darnell 1958, Reid et al. 1956). This material may represent a significant energy source rather than merely debris that was inadvertently swallowed while feeding (Reid et al. 1956). Darnell (1958) noted that debris comprised over 40% of the stomach contents of croaker from 50-200mm in length and was present in fish of all sizes. Penaeid shrimp were seen infrequently in Atlantic croaker stomachs and did not appear to represent one of the major food items. There appeared to be some competition for similar food organisms between juvenile croaker and adult spot (Chen 1976). All of these studies demonstrated that croaker will feed on any prey.

In addition to feeding on a wide variety of prey, Atlantic croaker are also preyed upon by a long list of other fishes. Predators of juvenile and adult croaker include several species of sharks, yellow bass (*Morone interrupta*), spotted seatrout, red drum, black drum, flounder (*Paralichthys* sp.), and larger

Atlantic croaker, just to name a few (Pearson 1929, Darnell 1958, Klima and Tabb 1959). Atlantic croaker did not appear as a major food item in any of these studies, but in Lake Pontchartrain, Atlantic croaker constituted 7-14% of the food of spotted seatrout. Adult croaker are also preyed upon by some of the larger sport fish such as cobia (*Rachycentron canadum*) and king mackerel (*Scomberomorus cavalla*).

Chapter 4
DESCRIPTION OF THE HABITAT OF THE STOCK(S)

Gulf of Mexico

Much of the material summarized in this chapter was taken from the Cooperative Gulf of Mexico Estuarine Inventory and Study (GMEI; Barrett et al. 1971, McNulty et al. 1972, Christmas 1973, Deiner 1975) unless otherwise noted. Galtsoff (1954) summarized the geology, marine meteorology, oceanography, and biotic community structure of the Gulf of Mexico. Later summaries include those of Jones et al. (1973), Beckert and Brashier (1981), Holt et al. (1983), and the Gulf of Mexico Fishery Management Council (GMFMC 1998). In general, the Gulf is a semi-enclosed basin connected to the Atlantic Ocean and Caribbean Sea by the Straits of Florida and the Yucatan Channel, respectively. The Gulf of Mexico has a surface area of approximately 1,510,000km2 (Wiseman and Sturges 1999), a coastline measuring 2,609 km, one of the most extensive barrier island systems in the United States, and is the outlet for 33 rivers and 207 estuaries (Buff and Turner 1987). Water depths range from 3,000 to >4,300m with an average depth of 1,655m (Turner 1999). Oceanographic conditions throughout the Gulf are influenced by the Loop Current and major episodic freshwater discharge events from the Mississippi/Atchafalaya Rivers. The Loop Current directly affects species dispersal throughout the Gulf while discharge from the Mississippi/Atchafalaya Rivers creates areas of high productivity that are used by many commercially and recreationally important marine species.

The Gulf Coast wetlands and estuaries provide habitat for an estimated 95% of the finfish and shellfish species landed commercially in the Gulf and 85% of the recreational catch of finfish (Thayer and Ustach 1981). Commercial fishing accounted for an estimated 1.76B lbs of harvested fish and shellfish in 2011 or 17.8% of the nation's total commercial landings (NMFS 2012). These landings were worth an estimated $817M in dockside value (NMFS 2012). Gulf Coast wetlands, estuaries, and barrier islands also provide important feeding, breeding, and cover habitat to wildlife species such as waterfowl, shorebirds, and wading birds; improve water quality; and play a significant role in lessening flood and storm surge damage, and minimizing erosion.

Gulf tides are small and noticeably less developed than along the Atlantic or Pacific coasts. Tides range from 0.5-1.0m and are driven mostly by atmospheric pressure and wind direction (Solis and Powell 1999). Despite the small tidal range, tidal current velocities are occasionally high, especially near the constricted outlets that characterize many of the bays and lagoons. Tide type varies widely throughout the Gulf with diurnal tides (one high tide and one low tide each lunar day of 24.8 hours) existing from St. Andrew's Bay, Florida, to western Louisiana. The tide is semi-diurnal in the Apalachicola Bay of Florida and mixed in western Louisiana and Texas.

Estuaries

The U.S. Gulf of Mexico contains 31 major estuarine systems extending from the Rio Grande River in Texas eastward to Florida Bay in Florida. Estuaries typically include wetlands and open bay waters in which nutrients from river inflows, adjacent runoff, and the sea support a productive community of plants and animals. Estuarine tidal mixing is limited by the small tidal ranges that occur within the Gulf of Mexico, but shallow estuarine depths tend to amplify the mixing effect. Estuaries in Florida and south Texas generally are clearer and have lower nutrient concentrations than those in other parts of the Gulf. A detailed description of the estuaries in each Gulf state can be found in Perry and VanderKooy (2015). Additional information regarding the Gulf of Mexico in general can be found in the Commission's Habitat Profile for the Gulf of Mexico (Rester in prep).

Circulation Patterns

Water currents and circulation patterns are vital components to the success of fish populations. Within the U.S. Gulf of Mexico these features furnish transport mechanisms, food availability, and invoke behavioral responses in the majority of fish species. These factors directly influence recruitment and year-class success (Norcross and Shaw 1984). The Loop Current and its rings are the most influential currents in the Gulf of Mexico. These circulation patterns either directly or indirectly affect "just about every aspect of oceanography of the Gulf" (Oey et al. 2005).

Loop Current

Moving clockwise, the Loop Current dominates surface circulation in the northeast Gulf and generates permanent eddies over the northwest Gulf (Figure 4.1). The progressive expansion and intrusion of the loop can reach as far north as the continental shelf off the Mississippi River Delta and Desoto Canyon. This can lead to the entrainment of highly productive plume waters and the subsequent transport of phytoplankton, nutrients, dissolved organic matter, and suspended sediments from northern to central and southern Gulf regions. The loop current can also impact the distribution of pelagic finfish larvae (Domingues et al. 2016) and can transport tropical species from the Caribbean into the Gulf. Cyclonic eddies that regularly break from the Loop Current can create local upwelling and support increased primary production.

Nearshore currents are driven by the impingement of regional Gulf currents across the shelf, passage of tides, and local and regional wind systems. The orientation of the shoreline and bottom topography may also place constraints on speed and direction of shelf currents. Hydrographic studies depicting general circulation patterns of the Gulf of Mexico include those of Parr (1935), Drummond and Austin (1958), Cochrane (1965), Jones et al. (1973), Ochoa et al. (2001).

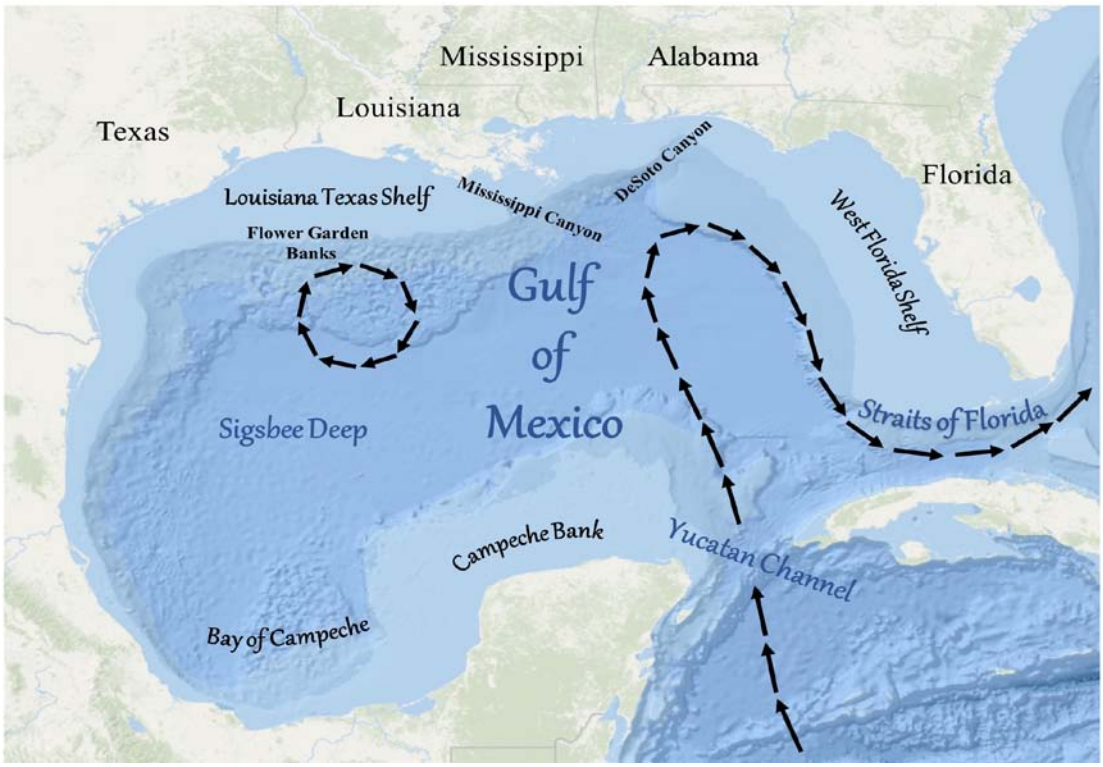


Figure 4.1 Generalized circulation pattern in the Gulf of Mexico. Also included are some geologic features of the Gulf of Mexico including shallower continental shelf regions and geologic breaks such as DeSoto Canyon off the panhandle of Florida and Mississippi Canyon on the Mississippi River Delta.

River Discharge

A total of 33 major rivers drain into the Gulf of Mexico and act as a major driver of coastal productivity. In the northern region of the Gulf of Mexico, where Atlantic croaker are commonly found, the Mississippi, Atchafalaya, and Mobile Rivers are the major sources of discharge. River discharge brings high concentrations of organic material from much of the continental U.S. These nutrients and organic material provide the basis for coastal primary and secondary production (Lohrenz et al. 1997, Zhao and Quigg 2014). The Mississippi and Atchafalaya River Plume also structures coastal habitat for many fisheries (menhaden, drum, shrimp, etc.), due to associated physical properties and food availability, and influences much of their life history and population dynamics (Govoni and Grimes 1992, Govoni 1997, Hitchcock et al. 1997, Lohrenz et al. 1997, de Mutsert et al. 2012). Variations in the productivity, distribution, and extent of the plume area are driven, in part, by variations in river discharge, local wind conditions, El Niño Southern Oscillation, and the Loop Current (Hitchcock et al. 1997, Lohrenz et al. 1997, Sanchez-Rubio et al. 2011).

Atlantic Croaker Ecology

Spawning Habitat

Atlantic croaker have a protracted spawning season that begins in fall and extends into early spring, with peak spawning from October to November. A second peak in spawning has also been observed in late January to early February (Cowan 1988, Barbieri et al.1994a, Kupchik and Shaw 2016). Although not clearly defined, croaker spawning grounds range from several hundred kilometers offshore to tidal inlets (Cowan 1988, Petrik et al. 1999). However, distributions of recently hatched larvae (<3mm total length) suggest spawning occurs most frequently in offshore continental shelf waters with depths ranging from 15-115m (Cowan and Shaw 1988).

Pelagic Larval Habitat

Atlantic croaker have a relatively short, offshore, pelagic larval stage. Throughout their range in the Gulf of Mexico, larvae have been reported to have a uniform distribution across the continental shelf (Cowan and Shaw 1988) and throughout the water column (Al-Yamani 1988) during late fall and early winter. Cowan and Shaw (1988) also reported significant changes in pelagic larval abundance relative to time of day. In this study, catches were nearly five times greater at night when compared to day. While these diurnal differences have been reported for many species (Morse 1989), drawing conclusions on day versus night abundance changes has been cautioned throughout literature due to the possibility of net avoidance behaviors (Thayer et al. 1983, Morse 1989).

Off the Mississippi Delta, high concentrations of croaker larvae are often found in river plume fronts (Grimes and Finucane 1991). Pelagic larvae are likely transported to the plume front due to hydrodynamic convergence. These fronts are associated with the highest concentrations of chlorophyll and macrozooplankton which provide an abundant supply of food for larval growth.

Estuarine Larval and Juvenile Habitat

By late spring in the Gulf of Mexico, larval croaker have a more pronounced shoreward distribution as they begin to emigrate towards estuaries (Cowan and Shaw 1988). Timing of these migrations appears to be highly dependent on spawning period and occurs anywhere from 30-90 days post-hatch (Cowan and Shaw 1988, Kupchik and Shaw 2016) when larvae are approximately 20mm SL (Overstreet and Heard 1978). Upon immigration, juveniles recruit to upper estuarine habitats.

Larval and juvenile croaker are a demersal estuarine-dependent species that inhabit a wide variety of habitats throughout their range. These estuarine habitats have been reported to include seagrass meadows, salt marshes, tidal creeks and rivulets, and areas with both mud and sand substrates (Weinstein

1979, Rooker et al. 1998, Petrik et al. 1999). In general, Atlantic croaker have been described to be habitat generalists and show little to no preference for a specific habitat type (Petrik et al. 1999). Instead, they utilize multiple habitats throughout various estuarine larval and juvenile life stages (Gutherz 1976).

Recruitment of larvae to habitats likely is influenced by tidal activity and currents, and may vary temporally. For example, Rooker et al. (1998) observed croaker to be among the top five most abundant sciaenids (drums) found in seagrass meadows in Aransas Estuary, Texas; however, the lack of larger larvae (>20mm SL) led these authors to conclude that croaker moved to an alternate habitat shortly after settlement into the estuary. This short-term recruitment to seagrass meadows may reflect temporal patterns as larval croaker immigrate further into upper estuaries (i.e., tidal creeks and salt marshes) with growth.

In tidal creeks, juveniles tend to exhibit high site fidelity. Tagging studies of YOY Atlantic croaker, by Miller and Able (2002), suggest frequent tidal movement within a given tidal creek; however, little to no movements out of, or between, individual creeks were observed in this study. In highly stratified waters, larvae are found in the salt wedge, an area of colder, saltier, inward flowing water near the bottom of the water column (Norcross 1991); whereas, in non-tidal systems, juveniles tend to remain near the bottom of channels and holes throughout the estuary (GMFMC 1980). Evidence suggests juveniles prefer deeper tidal creeks over shallow marsh creeks and tidal flats (Currin et al. 1984, Diaz and Onuf 1985) and there is a positive relationship between juvenile distributions and benthic organic matter (Weinstein 1979). Juveniles remain in upper estuaries until recruiting to the coastal population as waters begin to cool.

Sub Adult and Adult Habitat

As they develop, Atlantic croaker emigrate out of the upper estuaries to areas of greater salinity and disperse throughout the lower estuaries and bays. During this stage, croaker are found in a wide variety of inshore habitats ranging from bridge or pier pilings, coastal shorelines, and in other benthic habitat such as oyster reefs or natural hard-bottom. Young croaker tend to remain inshore until approximately 60-80mm in length (Gutherz 1976, Lassuy 1983), after which they begin transitioning to offshore environments as water temperatures drop in the fall. While the largest distributions are most frequently found offshore, sub adults, and occasionally adults, can also be found in inshore estuaries and bays, which support inshore fisheries.

As adults, croaker are found offshore and inhabit muddy or sandy bottoms. While their range has been reported to include the entire Gulf of Mexico, they are generally not found south of Tampa, Florida in the eastern Gulf (McRae 1997). The highest abundances are reported to be along the northern Gulf Coast and range from Perdido Bay, Florida to Point Au Fer, Louisiana, as inferred by primary fishing grounds (GMFMC 1980).

According to Gutherz (1976), throughout the year larger croaker can be found near the mouth of the Mississippi River or near offshore platforms in greater depths. Smaller croaker often are found throughout the same range but in shallower depths (Gutherz 1976, GMFMC 1980).

Environmental and Habitat Requirements for Croaker

Salinity

Atlantic croaker are found in a broad range of salinity and can tolerate ranges from 0-70‰ throughout various life stages (Parker 1971, Diaz and Onuf 1985, GMFMC 1980). While the effects of lower salinity environments have been well documented for Atlantic croaker, the effects of higher salinity (>20‰) are limited (Lassuy 1983).

Given their offshore distribution in early life stages, pelagic larvae tolerate salinities equivalent to their adult counterparts and have been observed in salinities as high as 36‰ (Lassuy 1983). Post-settlement, in estuaries, larvae and juveniles inhabit oligohaline and mesohaline environments where salinity can vary between 0.5-18.0‰ (Diaz and Onuf 1985).

Peterson et al. (1999) demonstrated that somatic (body) growth is optimized in salinities of 5‰ versus higher (20‰) or varying (5-20‰) salinities. Recent work has demonstrated a negative correlation between growth rate of larvae and juveniles and salinity (Kupchik and Shaw 2016) indicating that continental shelf waters are associated with lower growth rates. However, larvae and juveniles actively avoid areas of fluctuating salinities. Drastic changes (± 5‰ hr-1) have been shown to significantly alter activity and influence distributions (Nelson 1969, Perez 1969), which may explain some preference, at least in part, towards deeper tidal creeks versus shallow tidal flats where salinities may be more stable.

Adult croaker occupy higher salinities than juveniles but salinity tolerance of the adults remains understudied. Salinity preference, inferred by catch rates, appears to vary with season (Miglarese et al. 1982). In spring, catches were highest in salinities ranging from 3-9‰ while summer catches were bimodal and peaked in salinities ranging from both 6-12‰ and 24-27‰. Adult croaker are most commonly found in salinities ranging from 6-20‰ (Lassuy 1983, Eby and Crowder 2002).

Temperature

Temperature has been suggested to be the largest driver between distributions of Atlantic croaker throughout all life stages. Between the late spring and early fall, inshore temperatures are relatively high and croaker are found inshore at depths of around 20m. When inshore bottom temperatures drop during the late fall and winter, croaker move offshore where they remain until the following spring (GMFMC 1980). Inshore bottom temperatures in the spring have a similar range as offshore areas in the fall and the movement patterns of croaker coincide with this seasonal temperature shift (Gutherz 1976).

Larval and juvenile Atlantic croaker have been described as a “cooler-water species” which can be found in a broad range of temperatures. Although often caught in temperatures ranging from 0 to 36°C (Parker 1971, Diaz and Onuf 1985), Raynie and Shaw (1994) reported post-larval croaker abundances, in Louisiana, to be highest in water temperatures <23°C. This trend is reflected in previous work by Kupchik and Shaw (2016), which demonstrated that growth rate of larval and juvenile croaker is negatively correlated with temperature.

As with many estuarine species, prolonged or sudden exposure at the extremes of their thermal tolerance often results in mortality. In laboratory studies, Lankford and Targett (2001) determined survival of young (age-0) croaker was decreased from 90% at 5°C to only 1.3% at 3°C, suggesting that even subtle differences at the lower end of their thermal tolerance have drastic effects on survival. No juvenile croaker survived in 0°C.

Winter mortality may not be as frequent an occurrence in the Gulf of Mexico as compared to the Atlantic Coast, but these events can have significant effects on year-class strength and subsequent recruitment to the fishery. On the Atlantic Coast, warm winters can lead to greater juvenile survival in mid-Atlantic estuaries that would otherwise not occur due to the lower limit of thermal tolerance (Lankford and Targett 2001, Hare and Able 2007). This ‘thermal opening,’ as described by Hare and Able (2007), allows for greater survival and results in large year classes.

Data are more limited with regards to heat tolerance of young croaker; however, mortality has been reported to occur at temperatures greater than 38°C (Sink 2011). Regardless, it has been inferred through these studies and others, that early life stage Atlantic croaker are most adapted for temperatures ranging

from 6-20°C (Parker 1971, Raynie and Shaw 1994) and exhibit optimal growth between 27 and 31°C (Craig and Crowder 2005).

In general, juveniles tolerate a broader range of temperatures than adults (Lassuy 1983, Sink 2011). Adult Atlantic croaker inhabit a wide range of temperatures from 7-32°C (Bearden 1964, Miglarese et al. 1982, Craig and Crowder 2005) but are most abundant in temperatures >24°C (Miglarese et al. 1982). Croaker older than one year generally are absent in temperatures below 10°C (Lassuy 1983).

Dissolved Oxygen (DO)

Data are limited regarding DO tolerances for Atlantic croaker. While often found in areas that are favorable to low DO, juveniles will shift their distributions towards higher oxygen levels when hypoxic conditions are present (Diaz and Onuf 1985). In general, as with juveniles, adult croaker are most likely to be found in normoxic conditions >4mg L-1 and shift distributions in response to unfavorable concentrations (Craig and Crowder 2005). Croaker are generally absent in DO concentrations lower than 2.0mg L-1 (Eby and Crowder 2002), thus suggesting this is the lower tolerance limit for Atlantic croaker. Recent modelling efforts have also indicated a slight reduction in Atlantic croaker biomass as a result of hypoxia (de Mutsert et al. 2016).

Wannamaker and Rice (2000) experimentally tested the preference of croaker towards varying oxygen concentrations. These authors determined that croaker exhibit a strong preference for higher (4mg L-1) versus lower (≤ 2mg L-1) DO concentrations, but displayed no preference between 4 and 6mg L-1 treatments. It is important to note, however, that Wannamaker and Rice (2000) did not allow croaker time to acclimate to differing concentrations. Therefore, 'preference' may only be in response to rapidly changing oxygen concentrations (Wannamaker and Rice 2000).

The effects of low DO conditions have been well documented for many aquatic organisms. These effects include a variety of physiological impacts ranging from decreased metabolic activity, reduced growth, inhabitation of reproductive function, and mortality (Wannamaker and Rice 2000, Taylor and Miller 2001, Wu 2002; see Threats to Survival below). However, croaker tend to aggregate on the hypoxic edge (Craig and Crowder 2005), which may be due to increased foraging opportunities that outweigh the biological risks of remaining near hypoxic condition.

Depth

The size of Atlantic croaker is related to the depth at which they are found, with larger individuals found at greater depths. While there are temporal trends in the depth distribution of Atlantic croaker, depth does not appear to be a significant factor in the abundances of juvenile croaker (Diaz and Onuf 1985). Instead, distributions likely are influenced by other abiotic properties (e.g., tidal activity, temperature, salinity, freshwater influx, etc.) of the estuaries (Diaz and Onuf 1985, ASFMC 2005). However, Parker (1971) noted that juveniles generally were found in depths <1.2m.

In general, during warmer months Atlantic croaker are found in depths <20m (Gutherz 1976). When temperatures drop in the fall, croaker move to deeper areas between 20-60m, possibly to follow optimal thermal ranges. Atlantic croaker can also be found at much greater depths than 60 m (Stanley and Wilson 1991) but are uncommon in depths >120m (Gutherz 1976).

Substrate

Substrate is an important factor in determining suitable juvenile habitat. Parker (1971) reported that larvae and juveniles in Texas were usually concentrated in shallow waters consisting of soft mud and large quantities of detritus. Juvenile croaker were rarely found on sandy or hard substrates (Diaz and Onuf

1985). This was likely due to the high organic content of muddy substrates that support suitable prey items for juvenile croakers.

As adults, croaker prefer sand or muddy bottoms (GMFMC 1980) but are often associated with hard-bottom habitats such as oyster beds, sponge and coral reefs, and near bridges, piers, or other man-made structures. Abundance, near oil and gas platforms in the Gulf of Mexico, is positively correlated with habitat size and complexity (Stanley and Wilson 1991).

Vegetation

Juvenile Atlantic croaker extensively use marshes primarily composed of cordgrasses (*Spartina alterniflora*, *S. patens*), bulrush (*Scripus maritimus*) and other black needlerush (*Juncus roemerianus*) in the Gulf of Mexico. In these systems, primary production is not a limiting factor for estuarine stage croaker in tidal and non-tidal systems because algal production is sufficient to support the macroinfauna on which they feed (Currin et al. 1984). Rozas and Zimmerman (2000) reported that croaker densities were higher on non-vegetated substrates along the Gulf Coast, thus suggesting croaker prefer non-vegetated habitat more than vegetated. However, when found in vegetated habitats, it is likely for protection from predators.

As discussed in the Estuarine Larval and Juvenile Habitat section above, Rooker et al. (1998) observed post-settlement larvae and juveniles utilizing seagrass meadows composed of turtle grass (*Thalassia testudinum*) and shoal grass (*Halodule wrightii*) in Texas estuaries. Croaker were significantly larger in *T. testudinum* than *H. wrightii*, 14.1mm versus 12.6mm SL, respectively.

Similar to juveniles, structural cover and vegetation does not seem to be a habitat requirement for adult Atlantic croaker. According to Diaz and Onuf (1985)

> "Behavioral and morphological adaptations of the Atlantic croaker for feeding are directed toward the exploitation of the surface layers of soft muddy bottoms and are not useful where vegetation or rocks replace or interfere with access to a soft bottom."

Threats to Survival

Atlantic croaker face a myriad of threats to survival given their wide habitat usage throughout their life span. As with many marine species, croaker are sensitive to mortality during pelagic egg and larval stages. Given the inability, or reduced ability, to control their distribution, pelagic eggs and larvae face many threats from climate-associated changes and anthropogenic activity. Most obvious, large- and small-scale unfavorable currents can alter distributions resulting in advection towards less hospitable environments such as further offshore, hypoxic zones, or unsuitable nursery habitats (Rahel and Nutzman 1994). Currents and discharge also influence distribution of prey items. For example, decreased rainfall along the Gulf Coast due to La Niña events can limit the availability of detritus washed to open waters by flooding events. Reductions in detritus can represent a nutrient limitation for estuarine and coastal ecosystems and food limitation for species such as Atlantic croaker (Sanchez-Rubio and Perry 2015).

Threats from anthropogenic activities to offshore fishes in the Gulf of Mexico were highlighted following the 2010 Deepwater Horizon disaster (DWH). While data are limited, research indicates the DWH negatively affected biological processes and behavior of a range of species, and throughout multiple life stages (Incardona et al. 2014, Murawski et al. 2014, Norberg 2015, Tarnecki and Patterson 2015). These effects present a threat to survival of croaker as offshore oil exploration continues to expand, especially given the fact that the greatest abundance of croaker are found in areas of heavy exploration activity in the Gulf of Mexico. More so, the impacts observed in coastal estuaries from oil that made landfall likely affected critical larval and juvenile habitat.

Other longstanding anthropogenic effects that threaten survival of offshore Atlantic croaker include discharge from the Mississippi River watershed. Contaminants and other pollutants have been demonstrated to impede sexual maturation and gonadal development of croaker (Thomas 1988, Thomas and Budiantara 1995, Thomas and Rahman 2009, 2011).

Increased nutrient loads in river discharge contribute to the 'dead zone' area of hypoxic conditions (Rabalais and Turner 2001) which has been shown to further impact croaker. Recent work by Thomas and Rahman (2009, 2011) has indicated that chronic exposure to hypoxia can impair reproduction of Atlantic croaker in the Gulf of Mexico. Specifically, Thomas and Rahman (2009) collected a number of female and male Atlantic croaker during periods of relatively strong hypoxia in the summer of 2006 off Louisiana near and in the hypoxic zone as well as from areas without hypoxia. Hypoxia was associated with impaired reproduction and endocrine function in females and impaired gametogenesis and decreased sperm production in males (Thomas and Rahman 2009). Croaker collected in the hypoxic zone showed reduced testicular growth and spermatogenesis in males. Female ovaries (around 19% of samples) contained male germ cells with both developing and fully developed spermatozoa suggesting they were becoming masculinized (Thomas and Rahman 2011). These results indicate that the reproductive output of croaker was depressed in and around the hypoxic regions of the northern Gulf of Mexico and that long-term hypoxic conditions could negatively affect the reproductive capacity for the relatively short-lived species (Thomas and Rahman 2011). More so, nutrient pollution from the watershed has led to persistent hypoxic zones which have been shown to negatively affect survival and distributions of Atlantic croaker as described previously.

Inshore, habitat loss and coastal development will lead to reduced recruitment through removal of nursery habitats. Changes in refuge area may increase predations on larval and juvenile croaker; whereas alteration of suitable inshore adult habitat can shift distributions to less favorable areas. A study by Peterson et al. (1999) observed significant difference in abundance between altered versus unaltered habitats. In this study, shorelines that were reinforced by bulkheads or rubble had fewer croaker than unaltered, natural, shorelines. Habitat loss and development may also reduce water quality, such as DO concentrations, temperature, and salinity which may exacerbate potential threats to survival of estuarine and inshore-dependent life stages.

Recreational fishing and both inshore and offshore commercial shrimping can impact the population dynamics of coastal fisheries. While the impacts of recreational fishing have not been examined for Atlantic croaker in the Gulf of Mexico, bycatch from commercial shrimping has been shown to increase mortality and lower biomass of croaker (Diamond et al. 2000).

Chapter 5
FISHERY MANAGEMENT JURISDICTIONS, LAWS, AND POLICIES AFFECTING THE STOCK(S)

Atlantic croaker are found in a wide range of habitats from nearshore, low salinity waters to offshore open ocean. Considering the distribution of croaker throughout the Gulf and EEZ, a number of state and federal management institutions have jurisdiction over this species. This chapter provides a partial list of some of the most important agencies and a brief description of the laws and regulations that directly or indirectly affect Atlantic croaker throughout the Gulf of Mexico and the EEZ. Individual Gulf states and federal agencies should be contacted for specific and up-to-date state laws and regulations, which are subject to change on a state-by-state basis. Additional U.S. laws, treaties, and agencies may have jurisdiction over habitat and the environment affecting Atlantic croaker and can be found in detail in the Commission's other fishery management plans available on the Commission's website (www.gsmfc.org).

Federal Management Institutions

Atlantic croaker are found throughout the Gulf of Mexico but they are most abundant in state waters. The commercial and recreational fisheries are almost exclusively conducted within the jurisdictions of the states; consequently, federal regulations primarily affect croaker populations by maintaining and enhancing habitat, preserving water quality and food supplies, and abating pollution. Federal laws may also be adopted to protect consumers through the development of regulations to maintain the quality of croaker as seafood.

National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce (USDOC)

The Secretary of Commerce, acting through the NMFS, has the ultimate authority to approve or disapprove all FMPs prepared by regional fishery management councils. Where a regional council fails to develop a plan, or to correct an unacceptable plan, the Secretary may do so. The NMFS also collects data and statistics on fisheries and fishermen. It performs research and conducts management authorized by international treaties. The NMFS has the authority to enforce the Magnuson-Stevens Fishery Conservation and Management Act of 1996 (Mag-Stevens) and the Lacey Act and other federal laws protecting marine organisms, including the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) and is the federal trustee for living and non-living natural resources in coastal and marine areas.

The USDOC, in conjunction with coastal states, administers the National Estuarine Research Reserve and National Marine Sanctuaries Programs as authorized under Section 315 of the Coastal Management Act of 1972. Those protected areas serve to provide suitable habitat for a multitude of estuarine and marine species and serve as sites for research and education activities relating to coastal management issues.

The NMFS exercises no management jurisdiction other than enforcement with regard to Atlantic croaker in the any of the regions in which it occurs.

Regional Fishery Management Councils

Eight regional fishery management councils were established by the Magnuson-Stevens Fishery Conservation and Management Act to advise the NOAA Fisheries Service on federal fishery management issues. The regional councils include the Gulf, Caribbean, South Atlantic, Mid-Atlantic, New England, Pacific, Western Pacific, and North Pacific. These Councils develop FMPs and submit recommended regulations to the U.S. Secretary of Commerce based on public comment and scientific data. NOAA and the councils have jurisdiction in the EEZ to manage federal fish species. In the absence of a federal management plan,

state management can supersede and states are free to set their own regulations which is the situation with the U.S. Atlantic croaker fishery. State landing requirements (bag, size, and possession limits) apply to all Atlantic croaker harvested from state waters and may include fish landed in federal waters. Check with your state marine resources agency for exact landing requirements.

Treaties and Other International Agreements

There are no treaties or other international agreements that affect the harvesting or processing of Atlantic croaker. No foreign fishing applications to harvest Atlantic croaker have been submitted to the United States.

Federal Laws, Regulations, and Policies

The following federal laws, regulations, and policies may directly and indirectly influence the quality, abundance, and ultimately the management of Atlantic croaker.

Magnuson Fishery Conservation and Management Act of 1976 (MFCMA); Magnuson-Stevens Fishery Conservation and Management Act of 1996 (Mag-Stevens) Also Called the Sustainable Fisheries Act (P.L. 104-297)

The MFCMA mandates the preparation of FMPs for important fishery resources within the EEZ. It sets national standards to be met by such plans. Each plan attempts to define, establish, and maintain the optimum yield for a given fishery. The 1996 Mag-Stevens reauthorization included three additional national standards (eight through ten) to the original seven for fishery conservation and management, included a rewording of standard number five, and added a requirement for the description of essential fish habitat and definitions of overfishing.

1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry;
2. Conservation and management measures shall be based on the best scientific information available;
3. To the extent practicable, an individual stock shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or close coordination;
4. Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various U.S. fishermen, such allocations shall be:
   - fair and equitable to all such fishermen;
   - reasonably calculated to promote conservation; and
   - carried out in such a manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.
5. Conservation and management measures shall, where practicable, consider efficiency in the utilization of the resources; except that no such measures shall have economic allocation as its sole purpose.
6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fisheries resources, and catches.
7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.
8. Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to:
   - provide for the sustained participation of such communities, and
   - to the extent practicable, minimize adverse economic impacts on such communities.

9. Conservation and management measures shall, to the extent practicable,
   - minimize bycatch and
   - to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.
10. Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

The 2006 reauthorization builds on the country's progress to implement the 2004 Ocean Action Plan which established a date to end over-fishing in America by 2011, use market-based incentives to replenish America's fish stocks, strengthen enforcement of America's fishing laws, and improve information and decisions about the state of ocean ecosystems.

Interjurisdictional Fisheries Act (IFA) of 1986 (P.L. 99-659, Title III)

The IFA of 1986 established a program to promote and encourage state activities in the support of management plans and to promote and encourage regional management of state fishery resources throughout their range. The enactment of this legislation repealed the Commercial Fisheries Research and Development Act (P.L. 88-309).

Federal Aid in Sport Fish Restoration Act (SFRA); the Wallop-Breaux Amendment of 1984 (P.L. 98-369)

The SFRA, passed in 1950, provides funds to states, the USFWS, and the three interstate marine fisheries commissions to conduct research, planning, and other programs geared at enhancing and restoring marine sportfish populations. The 1984 amendment created the Aquatic Resources Trust Fund which is a 'user pays/user benefits' program. The amendment allows transfer of fishing and boating excise taxes and motorboat gas taxes (user pays) to the improvement of fishing and boating programs (user benefits) and provides equitable distribution of funds between freshwater and saltwater projects in coastal states.

State Management Institutions

The following sections outline the specific state information related management of any commercial and recreational fisheries for Atlantic croaker. Table 5.1 outlines the various state management institutions and authorities in the Gulf of Mexico with jurisdiction over Atlantic croaker.

Florida

Florida Fish and Wildlife Conservation Commission (FWC)

Florida Fish and Wildlife Conservation Commission
620 South Meridian Street
Tallahassee, FL 32399
Telephone: (850) 487-0554
MyFWC.com

The agency charged with the administration, supervision, development, and conservation of natural resources in Florida is the FWC. This commission is not subordinate to any other agency or authority of the state's executive branch. The administrative head of the FWC is the executive director. Within the FWC, the Division of Marine Fisheries Management is empowered to manage marine and anadromous fisheries in the interest of the people of Florida. The Division of Law Enforcement is responsible for enforcement of all marine, resource-related laws, rules, and regulations of the state.

The FWC, a seven-member board appointed by the governor and confirmed by the senate, was created by constitutional amendment in November 1998, effective July 1, 1999. This Commission was

Table 5.1 State management institutions - Gulf of Mexico.

STATE	ADMINISTRATIVE BODY AND ITS RESPONSIBILITIES	ADMINISTRATIVE POLICY-MAKING BODY AND DECISION RULE	LEGISLATIVE INVOLVEMENT IN MANAGEMENT REGULATIONS
Florida	**FWC**		
	-administers management programs -enforcement -conducts research	-creates rules in conjunction with management plans -seven member commission	-responsible for setting penalties and fees, including for licenses
Alabama	**ADCNR**		
	-administers management programs -enforcement -conducts research	-Commissioner of department has authority to establish management regulation -Conservation Advisory Board is a thirteen-member board and advises the commissioner -has authority to amend and promulgate regulations	-authority for detailed management regulations delegated to commissioner -statutes concerned primarily with licensing
Mississippi	**MDMR**	**COMMISSION ON MARINE RESOURCES**	
	-administers management programs -enforcement -conducts research	-five-member board establishes regulations on recommendation of executive director (MDMR)	-authority for detailed management regulations delegated to commission statutes concern licenses, taxes and some specific fisheries laws
Louisiana	**LDWF**	**WILDLIFE AND FISHERIES COMMISSION**	
	-administers management programs -enforcement -conducts research -makes recommendations to The Louisiana Wildlife and Fisheries Commission (LWFC)	-seven-member board establishes policies and regulations based on majority vote of a quorum (four members constitute a quorum) consistent with statutes	-detailed regulations contained in statutes -authority for detailed management regulations delegated to commission
Texas	**TPWD**	**PARKS AND WILDLIFE COMMISSION**	
	-administers management programs -enforcement -conducts research -makes recommendations to Texas Parks & Wildlife Commission (TPWC)	-nine-member body establishes regulations based on majority vote of quorum (five members constitute a quorum) -granted authority to regulate means and methods for taking, seasons, bag limits, size limits and possession	-licensing requirements and penalties are set by legislation

delegated authority over all aspects of rulemaking concerning marine life with the exception of requiring fees.

Florida has habitat protection and permitting programs, and a federally-approved Coastal Zone Management program.

Legislative Authorization

Prior to 1983, the Florida Legislature was the primary body that enacted laws regarding management of marine species in state waters. In 1983, the Florida Legislature established the Florida Marine Fisheries Commission (MFC) and provided the MFC with various duties, powers, and authorities to promulgate regulations affecting marine fisheries. On July 1, 1999, the MFC, parts of the Florida Department of Environmental Protection (DEP) including the Florida Marine Patrol, and the Florida Game and Freshwater Fisheries Commission (GFC) were merged into one commission, the FWC. Marine fisheries rules of the FWC are now codified under Chapter 68B, Florida Administrative Code (FAC).

Reciprocal Agreements and Limited Entry Provisions

Reciprocal Agreements

Florida statutory authority provides for reciprocal agreements related to fishery access and licenses. Florida has no statutory authority to enter into reciprocal management agreements.

Limited Entry

Florida has no provisions for limited entry in the Atlantic croaker fishery.

Commercial Landings Data Reporting Requirements

Florida requires wholesale dealers to maintain records of each purchase of saltwater products by filling out a Marine Fisheries Trip Ticket (Chapter 379.361 of the Florida Statutes grants rule making authority and Chapter 68E-5.002 of the Florida Administrative Code specifies the requirements). Information to be supplied for each trip includes the harvester's Saltwater Products License number; vessel identification; wholesale dealer number; date; time fished; area fished; county landed; depth fished; gear fished; number of sets; whether a head boat, guide, or charter boat; number of traps; aquaculture or lease number; species code; species size; amount of catch; unit price; and total dollar value (optional). The wholesale dealer is required to submit trip tickets weekly if the tickets contain quota-managed species such as Spanish mackerel; otherwise trip tickets must be submitted every month.

Penalties for Violations

Penalties for violations of Florida's fishing laws and regulations are established Section 379.407, Florida Statutes. Additionally, upon the arrest and conviction of any license holder for violation of such laws or regulations, the license holder is required to show just cause why their saltwater license should not be suspended or revoked.

License Requirements

In the state of Florida, a license is required to land Atlantic croaker recreationally or commercially along either the Gulf or Atlantic coast. Recreational saltwater fishing licenses are required of residents and non-residents fishing in state territorial waters or the EEZ off the state, and current regulations must be adhered to. All children under the age of 16, regardless of residency, and resident seniors who are 65 or older are not required to purchase most recreational licenses. Other exemptions exist for active military and individuals with disabilities; *check with the FWC for details*.

A commercial fishing license (Saltwater Products License; SPL) is required to harvest commercial quantities and/or sell Atlantic croaker from Florida waters or from the EEZ and landed in Florida. There

are also reporting requirements (outlined above). *Check with the FWC prior to participating in any commercial harvest of Atlantic croaker*.

Laws and Regulations

Florida's laws and regulations regarding the harvest of Atlantic croaker apply statewide. The following discussions are general summaries of laws and regulations, and the FWC should be contacted for more specific information. The restrictions discussed in this section are current through the publication of this profile, and are subject to change at any time thereafter.

Size Limits

There is no minimum size limit established for Atlantic croaker in Florida.

Gear Restrictions

There are no specific gear regulations established for Atlantic croaker in Florida.

Closed Areas and Seasons

There are no closed areas for the harvest of Atlantic croaker in Florida with the exception of areas of Everglades National Park, the sanctuary preservation areas (SPA) within the Florida Keys National Marine Sanctuary, other state and national parks and reserves, and the waters of Warren Bayou in Bay County (January, February, November, and December only).

Quotas and Bag/Possession Limits

No recreational harvester shall harvest in or from state waters more than 100 lbs. per person per day. There is no quota or bag limit applicable to the commercial harvest of Atlantic croaker in Florida.

Other Restrictions

None

Historical Changes to Regulations in Florida Affecting Atlantic Croaker

Prior to 1983:

- Established a 100 lb per day recreational limit for species with no specific bag limits.

August 9, 1989 – June 11, 1990:

- Requires the use of Turtle Excluder Devices (TED) on any trawl vessel 25 feet or greater in length in any offshore waters and prohibited possession of a trawl rigged for fishing that does not have a qualified TED

October 1, 1989:

- Prohibited the use of any trawl, except a trawl used for live bait shrimping, from October 1 – May 31 each year, in certain state waters of the southwest coast of Florida (c.f. 68B-38.002, FAC, formerly CH 46-38, FAC)
- Established five zones to regulate shrimp trawling in state waters of Citrus and Hernando counties

June 11, 1990:

- Prohibited persons from operating or fishing in any state waters a trawl that is not equipped with a TED, and prohibited possession of a trawl rigged for fishing that does not have a qualified TED. (Exceptions apply c.f. 68B-31.004, FAC, formerly CH 46-31, FAC)

January 1, 1991:

- Prohibited the use of any trawl gear in an area offshore of Taylor County from mean high water out to certain offshore navigational sea buoys (c.f. 68B-38.003, FAC, formerly CH 46-38, FAC)

February 12-May 13, 1991:

- Prohibited use of gill or trammel nets with a total length greater than 600 yards.

- No more than two nets to be possessed aboard a boat.
- No more than one net to be used from a single boat.
- Required net to be tended and marked according to certain specifications in the waters of Brevard through Palm Beach Counties.

January 1, 1993:

- Set a maximum mesh size for seines at two-inches stretched mesh, excluding wings.
- Set a minimum mesh size for gill and trammel nets at three inches stretched mesh beginning January 1, 1995.
- Set a maximum length of 600 yards for all gill net, trammel nets, and seines.
- Allowed only a single net to be fished by any vessel or individual at any time.
- Prohibited the use of longline gear.

March 16, 1993:

- Prohibited the harvest of marine fish from any waters of Warren Bayou (Bay County) from November through February each year.

September 1, 1993:

- Prohibited the use of gill and trammel nets in any bayou, river, creek, or tributary waters between Collier and Pinellas counties from November 1 – January 31 each year.

July 18, 1994:

- Prohibited the use of gill nets, trammel nets, and seines in state waters of Martin County.

July 1, 1995:

- Prohibited the use of any gill or entangling net in Florida waters.
- Prohibited the use of any net with a mesh area greater than 500 square feet.

July 3, 1995:

- Emergency Rule (July 3, 1995 – September 30, 1995) prohibited the use of any trawl in inshore and nearshore state waters that contains more than 500 square feet of mesh area; prohibited the use of any otter trawl that has a perimeter around its mouth greater than 66 feet; and, prohibited the use of more than two unconnected otter trawls including any try net. Final rule implemented January 1, 1996.

April 27, 1998:

- Prohibited the use of any seine with a mesh size larger than two-inches stretched mesh

August 17, 1998:

- Required bycatch reduction devices (BRD) to be installed and used in all otter trawls rigged for fishing by food and live bait shrimp producers in all state waters.

January 19, 2010:

- Allowed the use of BRDs for shrimp trawls that have been certified for use in adjacent federal waters and automatically allows future federally approved BRDs to be used in state waters.

Alabama

Alabama Department of Conservation and Natural Resources (ADCNR); Alabama Marine Resources Division (MRD)

Alabama Department of Conservation and Natural Resources
Marine Resources Division
P.O. Box 189
Dauphin Island, Alabama 36528
(251) 861-2882
www.outdooralabama.com

Management authority of fishery resources in Alabama is held by the Commissioner of the ADCNR. The Commissioner may promulgate rules or regulations designed for the protection, propagation, and

conservation of all seafood. He may prescribe the manner of taking, times when fishing may occur, and designate areas where fish may or may not be caught; however, all regulations are to be directed at the best interest of the seafood industry.

Most regulations are promulgated through the Administrative Procedures Act approved by the Alabama Legislature in 1983; however, bag limits and seasons are not subject to this act. The Administrative Procedures Act outlines a series of events that must precede the enactment of any regulations other than those of an emergency nature. Among this series of events are: (a) the advertisement of the intent of the regulation; (b) a public hearing for the regulation; (c) a 35-day waiting period following the public hearing to address comments from the hearing; and (d) a final review of the regulation by a Joint House and Senate Review Committee.

Alabama also has the Alabama Conservation Advisory Board (ACAB) that is endowed with the responsibility to provide advice on policies and regulations of the ADCNR. The board consists of 10 members appointed by the Governor for alternating terms of six years, and three ex-officio members in the persons of the Governor, the Commissioner of Agriculture and Industries, and the Director of the Alabama Cooperative Extension System. The Commissioner of the Department of Conservation and Natural Resources serves as the ex-officio secretary to the board.

The Marine Resources Division (MRD) has responsibility for enforcing state laws and regulations, for conducting marine biological research, and for serving as the administrative arm of the commissioner with respect to marine resources. The Division recommends regulations to the Commissioner.

Alabama has a habitat protection and permitting program and a federally-approved CZM program.

Legislative Authorization

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

Reciprocal Agreements and Limited Entry Provisions

Reciprocal Agreements

Alabama statutory authority provides for reciprocal agreements with regard to access and licenses. Alabama has no statutory authority to enter into reciprocal management agreements.

Limited Entry

Alabama law provides that commercial net and seine permits shall only be issued to applicants who purchased such licenses in two of five years from 1989 through 1993 and who show proof (in the form of Alabama state income tax returns) that they derived at least 50% of their gross income from the capture and sale of seafood species in two of the five years; or applicants that purchased such licenses in all five years and who (unless exempt from filing Alabama income tax) filed Alabama income tax returns in all five years. Furthermore, beginning June 1, 2008, resident gillnet licenses were no longer available to anyone other than a current license holder. Each license holder must renew the license annually or the license becomes void. In addition, non-resident gill net licenses were no longer available for purchase, thereby eliminating the non-resident fishery. Other restrictions are applicable; *the ADCNR, MRD should be contacted for details*.

Commercial Landings Data Reporting Requirements

Alabama law requires that wholesale seafood dealers file monthly reports by the tenth of each month for the preceding month. Under a cooperative agreement, records of sales of seafood products are now collected jointly by NMFS and ADCNR port agents.

Penalties for Violations

Violations of the provisions of any statute or regulation are considered Class A, Class B, or Class C misdemeanors and are punishable by fines up to $6,000 and up to one year in jail.

License Requirements

In Alabama waters, a license is required to land Atlantic croaker commercially or recreationally. Recreational saltwater fishing licenses are required of residents and non-residents fishing in state territorial waters as well as the EEZ and current regulations must be adhered to. *Check with the ADCNR, MRD for current Atlantic croaker limits and license requirements.*

Residents and non-residents under the age of 16 and residents over the age of 65 are exempt from the purchase of a recreational license. Saltwater angler registration is required for residents who are not required to purchase an annual saltwater license, such as those 65 or older, have a lifetime saltwater license, or fish exclusively on a pier that has purchased a pier fishing license.

Laws and Regulations

Alabama laws and regulations regarding the harvest of Atlantic croaker are very limited. The following is a general summary of these laws and regulations and are current through the publication of this profile. *The ADCNR MRD should be contacted for specific and up-to-date information.*

Size Limits

Alabama does not have a minimum size limit for recreationally and commercially caught Atlantic croaker.

Gear Restrictions

Gill nets must be marked every 100 feet with a color-contrasting float and every 300 feet with the fisherman's permit number. Recreational nets may not exceed 300 feet in length and must be marked with the licensee's name and license number. Commercial gill nets, trammel nets, and other entangling nets may not exceed 2,400 feet in length; however, depth may vary by area.

During the period January 1st through October 23rd of each year, gill nets, trammel nets, and other entangling nets used to catch any fish in Alabama coastal waters under the jurisdiction of the MRD must have a minimum mesh size of 1.5 inch bar (knot to knot). A minimum mesh size of two inch bar is required for such nets used to take mullet during the period October 24 through December 31 of each year for all Alabama coastal waters under the jurisdiction of the MRD as provided in Rule 220-2-42 and defined in Rule 220-3-04(1), and any person using a two inch or larger bar net during the period October 24 through December 31 of each year shall be considered a roe mullet fisherman and must possess a roe mullet permit. These net-size restrictions do not apply to coastal rivers, bayous, creeks, or streams. In these areas, the minimum mesh size shall be six inch stretch mesh.

The use of purse seines to catch Atlantic croaker is prohibited. Commercial and recreational gill net fishermen may use only one net at any time; however, commercial fishermen may possess more than one such net. No hook and line device may contain more than five hooks when used in Alabama coastal waters under the jurisdiction of the ADCNR MRD.

Atlantic croaker may also be taken by ordinary hook and line, cast net, gig, and spear and bow and arrow.

Closed Areas and Seasons

Gill nets, trammel nets, seines, purse seines, and other entangling nets are prohibited in any marked

navigational channel, Theodore Industrial Canal, Little Lagoon Pass, or any man-made canal; within 300 feet of any man-made canal or the mouth of any river, stream, bayou, or creek; and within 300 feet of any pier, marina, dock, boat launching ramp, or certain 'relic' piers. Recreational gill nets may not be used beyond 300 feet of any shoreline, and they may not extend into the water beyond the end of any adjacent pier or block ingress or egress from any of the aforementioned structures.

From October 24 through December 31 of each year, it shall be unlawful to use any set nets (gill nets, trammel nets, or other entangling nets, etc.) in the waters of Bon Secour Bay south of the Gulf Intracoastal Waterway from Oyster Bay west to the last Waterway navigational marker and from that point southwestward to the northwestern tip of the Fort Morgan Peninsula. During this time period, this area shall be open to strike nets but these nets cannot be used within 300 feet of any pier, wharf, dock, or boat launching ramp in this area. 'Strike net' means a gill net, trammel net, or other entangling net, that is set and used from a boat in a circular pattern and is not anchored or secured to the water bottom or shore and which is immediately and actively retrieved. This is to protect the flounder spawning area.

From January 1 through the day after Labor Day of each year, entangling nets are prohibited in certain waters in and around Dauphin Island.

All inside waters close to commercial and recreational shrimping from 6:00 am May 1 to 6:00 am June 1 of each year. The area in Mobile Bay from the center of May Day Pier out to 1/2 nautical mile then south to the northern edge of Point Clear Channel shall be closed from 6:00 a.m., August 15th, until 6:00 a.m., October 1st of each year.

Areas permanently closed to shrimping are as follows:

All rivers*, streams, bayous, and creeks within the State (except Bayou St. John, Old River in Baldwin County and that portion of Blakeley River designated by law as an exclusive bait shrimp area). *The mouth of the Mobile River is defined as a line running from the southernmost point of Pinto Island due west to a point of the mainland. The mouth of Blakeley River channel is defined as a line running westward from the charted position of the Blakeley River channel marker #18 to a point of intersection with land on the southern tip of Big Island (30038.305'N, 87055.503'W).

All of Portersville Bay inside a line running from Barron Point west along the south shores of Cat and Marsh Island then west to the south end of Coffee Island (Isle aux Herbes) then north along the western shore of Coffee Island to a point on the mainland directly north of the northernmost tip of Coffee Island.

Heron Bay and that portion of Mississippi Sound north of the Gulf Intracoastal Waterway and east of a line extending from Barron Point on Mon Louis Island southeasterly to range marker "D" on the Intracoastal Waterway.

All of Weeks Bay.

Theodore Industrial Canal.

Bon Secour Bay within 2500 ft. of the mouth of Weeks Bay.

All waters north of the Battleship Parkway.

That portion of Mobile Bay north and west of a line running from the intersection of the Dog River Bridge with the Dog River Channel east along the northern edge of the Dog River Channel to its intersection with the Mobile Ship Channel (MSC) then north along the west side of the MSC to the Upper Reach Rear Range (located on the north side of the Arlington Channel) then north and east of a line running southeast to the charted position of MSC marker #78 then southeast to the charted position of Blakeley River Channel marker #2 then eastward to the center of Mayday Pier (30035.966'N, 87054.851'W) then eastward along the center of the Mayday Pier to its intersection with land. There shall be a 300 foot safety buffer along the western edge of the MSC where towing a trawl shall be allowed for turning by vessels.

All waters in Mobile County north of a line beginning at the Mississippi State Line running east to the eastern tip of South Rigolets (30021.120'N, 88023.490'W) then northeast to the southwest tip of Point Aux Pins (30022.271'N, 88018.888'W) then east to the charted position of the "BC" Beacon in the Bayou La Batre Ship Channel and then southeast to the northwest point of the middle cut that bisects Coffee Island (Isle aux Herbes) defined as 30020.785'N, 88015.721'W.

North of the Lillian Bridge in Baldwin County.

Little Lagoon Pass in Baldwin County.

Perdido Pass in Baldwin County which is defined as those waters north of Perdido Pass Channel markers #1 and #2 and south of the chartered position of channel marker in Terry Cove.

Exclusive bait areas are permanently closed to commercial shrimping. For other seasonal closures, contact ADCNR, AMRD.

Quotas and Bag/Possession Limits

There is not a bag/possession limit for the recreational and commercial Atlantic croaker fishery.

Other Restrictions

All nets must be constantly attended by the licensee, and no dead fish or other dead seafood may be discarded within 500 feet of any shoreline; or into any river, stream, bayou, or creek.

Historical Changes to Regulations in Alabama Affecting Atlantic Croaker

There have been no regulatory changes that directly affect the take of Atlantic croaker in Alabama, it is an unregulated species. Other regulations regarding gear modification and fisherman participation could indirectly affect the take of Atlantic croaker in Alabama.

1989: Federal regulation went into effect and required all shrimp trawlers in state and federal waters must use a Turtle Excluder Device (TED).

June 1, 2008: Resident gillnet licenses were no longer available to anyone other than a current license holder. Each license holder must renew the license annually or the license becomes void. In addition, non-resident gill net licenses were no longer available for purchase therefore eliminating the non-resident fishery.

February 9, 2004: Federal regulation went into effect that required shrimp trawls in the Gulf EEZ to have a Bycatch Reduction Device (BRD) installed.

Mississippi

Mississippi Department of Marine Resources (MDMR)

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www.dmr.ms.gov

The MDMR administers coastal fisheries and habitat protection programs. Authority to promulgate regulations and policies is vested in the Mississippi Commission on Marine Resources (MCMR), the controlling body of the MDMR. The MCMR consists of five members appointed by the Governor. The MCMR has full power to "manage, control, supervise and direct any matters pertaining to all saltwater aquatic life not otherwise delegated to another agency" (Mississippi Code Annotated 49-15-11).

Mississippi has a habitat protection and permitting program and a federally-approved CZM program. The MCMR is charged with administration of the Mississippi Coastal Program (MCP) which requires authorization for all activities that impact coastal wetlands. Furthermore, the state has an established Coastal Zone Management Program (CZMP) approved by NOAA. The CZMP reviews activities which would potentially and cumulatively impact coastal wetlands located above tidal areas. The Executive Director of the MDMR is charged with administration of the CZMP.

Legislative Authorization

Title 49, Chapter 15 of the Mississippi Code of 1972, annotated, contains the legislative regulations as related to the harvest of marine species in Mississippi. Chapter 15 also describes the regulatory duties of the MCMR and the MDMR regarding the management of marine fisheries. Title 49, Chapter 27 involves the utilization of wetlands through the Wetlands Protection Act and is also administered by the MDMR.

Title 49, Chapter 15 of the Mississippi Code of 1972 §49-15-2 "Standards for fishery conservation and management; fishery management plans," was implemented by the Mississippi Legislature on July 1, 1997 and sets standards for fishery management as related to Mag-Stevens (1996).

In 1993 the Mississippi Commission on Wildlife, Fisheries and Parks, pursuant to the authority in Miss. Code Ann. §25-43-9 (1972), adopted Public Notice No. 3306 (re-codified as Miss. Admin. Code 40-4:2.5) and established the dividing line between marine and fresh waters. Specifically, Public Notice No. 3306 provides: "Be it ordered that the southern boundary of Interstate 10 extending from the Alabama state line to the Louisiana state line is hereby declared to be the boundary line between salt and fresh waters for the purposes of the game and fish laws of this state. Be it further ordered that on all waters south of I-10 and north of U.S. Highway 90, either a salt or fresh water sport fishing license will be valid for the purpose of recreational fishing." This adopted Public Notice became effective on September 24, 1993.

Reciprocal Agreements and Limited Entry Provisions

Reciprocal Agreements

Section §49-15-15 (h) provides statutory authority to the MDMR to enter into or continue any existing interstate and intrastate agreements, in order to protect, propagate, and conserve seafood in the state of Mississippi.

Section §49-15-30 (1) gives the MCMR the statutory authority to regulate nonresident licenses in order to promote reciprocal agreements with other states.

Limited Entry

Section §49-15-16 gives the MCMR authority to develop a limited entry fisheries management program for all resource groups.

Section §49-15-29 (3), when applying for a license of any kind, the MCMR will determine whether the vessel or its owner is in compliance with all applicable federal and/or state regulations. If it is determined that a vessel or its owner is not in compliance with applicable federal and/or state regulations, no license will be issued for a period of one year.

Section §49-15-80, no nonresident will be issued a commercial fishing license for the taking of fish using any type of net, if the nonresident state of domicile prohibits the sale of the same commercial net license to a Mississippi resident.

Commercial Landings Data Reporting Requirements

Title 22 Part 9 of the MDMR establishes data reporting requirements for marine fisheries' operations, including confidentiality of data and penalties for falsifying or refusing to make the information available to the MDMR. Furthermore, Title 22 Part 9 Chapter 06 Section 100 states that each seafood dealer/processor is hereby required to complete Mississippi trip tickets provided by the MDMR. Commercial fishermen who sell their catch to individuals other than a Mississippi dealer/processor or transport their catch out-of-state, are hereby required to complete Mississippi trip tickets provided by the MDMR and be in possession of a fresh product permit.

Mississippi implemented a trip ticket program under these guidelines beginning January 1, 2012. Under this rule, fishermen and Dealer/Processors must submit their completed trip tickets, as well as a monthly summary form, to the MDMR by the tenth of the following month.

Penalties for Violations

Section §49-15-63 provides penalties for violations of Mississippi laws and regulations regarding Atlantic croaker in Mississippi.

License Requirements

A license is required to land Atlantic croaker commercially or recreationally from all Mississippi marine waters and the EEZ. Recreational saltwater fishing licenses are required of residents and non-residents fishing in state territorial waters as well as the EEZ; current regulations must be adhered to. *Check with the MDMR for current Atlantic croaker regulations*. A saltwater fishing license is required to fish south of Highway 90. Above Highway 90 and below Interstate 10, either a saltwater or freshwater license will suffice, and above Interstate 10, a freshwater license is required. Persons under the age of 16 are exempt. Residents 65 years of age or older can purchase a lifetime license for a one-time fee. *Check with the MDMR for all current license requirements*.

Laws and Regulations

Mississippi laws and regulations regarding the harvest of Atlantic croaker are very limited. The following is a general summary of these laws and regulations and is current through the publication of this profile. *The MDMR should be contacted for specific and up-to-date information.*

Title 49 Chapter 15 of the Mississippi Code of 1972 section §49-15-96 allows licensed shrimpers to retain for personal consumption up to 25 pounds of Atlantic croaker which are caught in shrimp trawls. Shrimp fishermen are required to purchase a commercial net boat license in order to harvest Atlantic croaker commercially with a trawl.

SIZE LIMITS

Mississippi does not have a minimum size limit for recreationally and commercially caught Atlantic croaker.

Closed Areas and Seasons

Areas permanently closed to commercial and recreational shrimping activities include all waters north of a line beginning at a point one-half mile due South of the shoreline at the Mississippi-Alabama state boundary; thence running westerly following the meanderings of the shoreline one-half mile therefrom to Light "5" in the Bayou Casotte Channel; thence running northerly to Light "7" in the Bayou Casotte Channel; thence running westerly following the meanderings of the shoreline one-half mile therefrom to the intersection with the Pascagoula Channel; thence running northwesterly to Beacon "50" in the Pascagoula Channel; thence running southwesterly to Beacon "49" in the Pascagoula Channel; thence running in the most direct line to the northeast point of Singing River Island; thence running westerly along the north shoreline to the northwest point of Singing River Island; thence running northwesterly to a point one-half mile due south of the mouth of Graveline Bayou; thence running westerly following the meanderings of the shoreline one-half mile therefrom to Beacon "18" in the Biloxi Bay Channel; thence running northwesterly to Beacon "22" in the Biloxi Bay Channel; thence running northwesterly to Beacon "26" in the Biloxi Bay Channel; thence running westerly to Beacon "34", exclusive of the Biloxi Channel itself; thence running westerly to Beacon "30" in the Biloxi Channel, exclusive of the Biloxi Channel itself; and thence running due South to a point on the north shore of Deer Island; thence running westerly following the north shore of Deer Island to the westernmost tip; thence running westerly in the most direct line to Biloxi Beacon "8"; thence running westerly following the meandering of the shoreline at a distance of one-half mile therefrom to a point on the centerline of the CSX Railroad Bridge over St. Louis Bay; thence running westerly along the centerline of said bridge to a point one-half mile south of the western abutment; thence running southwesterly following the meanderings of the shoreline, at a distance of one-half mile therefrom, to a point one-half mile due East of the mouth of Bayou Caddy; thence running due West to the mouth of Bayou Caddy; thence running southwesterly following the meanderings of the shoreline to the southernmost point of the Mississippi shoreline on the east bank of the mouth of the Pearl River thence following the meanderings of the east bank of the Pearl River to a point where the east bank of the Pearl River intersects the centerline of the Highway 90 bridge; thence westerly along the centerline of the highway 90 bridge to a point that intersects the Mississippi/Louisiana State boundary,

Shrimping season in waters under the territorial jurisdiction of the State of Mississippi north of the Intracoastal Waterway shall be closed in accordance with § 49-15-64.1 of the Mississippi Code Ann. of 1972, as amended, each year from January 1 until it is opened by the MCMR. The shrimp season shall be closed south of the Intracoastal Waterway and west of the Gulfport Ship Channel from May 1 until it is opened by the MCMR.

All commercial fishing is prohibited north of the CSX railroad track in coastal Mississippi. Gill nets, trammel nets, purse seines, and other commercial nets may not be used within 1,200 feet of any public pier or hotel/motel pier, and they are prohibited within 300 feet of any private piers that are at least 75 feet in length. These nets are also prohibited within 1,200 feet of the shoreline of Deer Island and within 1,500 feet of the shoreline between the U.S. Highway 90 bridge and the north shore of Bayou Caddy in Hancock County. These aforementioned nets are prohibited within 100 feet of the mouth of rivers, bays, bayous, streams, lakes, and other tributaries to Mississippi marine waters: Point aux Chenes Bay, Middle Bay, Jose Bay, L'Isle Chaude, Heron Bay, Pascagoula Bay (south of the CSX railroad bridge), and Biloxi Bay (south of a line between Marsh point and Grand Bayou). The nets must not be used in a manner to block any of these bays, bayous, rivers, streams, or other tributaries.

No gill or trammel nets, seines, or like contrivance may be used within an area formed by a line running 1.85 km from the shoreline of Cat, Ship, Horn, Petit Bois, and Round islands, or from the shoals

of Telegraph Keys and Telegraph Reef (Merrill Coquille) during the period from May 15 to September 15 of each year.

There are no closed seasons for the harvest of Atlantic croaker; however, gear restrictions include: from 6:00 a.m. to 6:00 p.m., no trammel nets shall be set or otherwise used for the taking of aquatic life within 0.93 km of the shoreline or any manmade structure attached to the shoreline from Bayou Caddy in Hancock County to Marsh Point in Ocean Springs, Jackson County. From 6:00 p.m. to 6:00 a.m., no trammel nets shall be set or otherwise used for the taking of aquatic life within 0.46 km of the shoreline or any manmade structure attached to the shoreline from Bayou Caddy in Hancock County to Marsh Point in Ocean Springs, Jackson County.

Section 49-15-78 states gill nets cannot be set within 0.93 km of shoreline in the state of Mississippi.

It is illegal to use a gill or trammel net in the marine waters of Mississippi or to possess fish in, or in contact with, a gill or trammel net in a boat in the marine waters of Mississippi between 6:00 a.m. on Saturday mornings and 6:00 p.m. on Sunday evenings or on any legal holidays established by the Mississippi Legislature and as set forth in Mississippi Code Annotated §3-3-7. No gill or trammel net shall be set within 0.46 km of another gill or trammel net. Gill and trammel nets must be attended at all times from a distance of no greater than the length of the boat in use. All gill and trammel nets must be constructed of an approved degradable material. All degradable materials must be approved by a MDMR biologist. Any net deemed approved must be tagged on both ends with a MDMR tag. An approved degradable materials list will be on file with the Executive Director of the MDMR or his designee.

Historical Changes In Regulations In Mississippi Affecting Atlantic croaker

The following regulatory changes may have notably influenced the landings during a particular year and are summarized here for interpretive purposes.

2014: MS Code § 49-15-96 (2014). Keeping of certain fish caught in shrimp nets for personal consumption.

Vessels licensed under Section 49-15-64.5 may keep in whole, for personal consumption only the following types of fish which are caught in the shrimp nets or trawls of the vessel: white trout; croaker, black drum, and ground mullet (Family Sciaenidae); sheepshead (Family Sparidae); gaftopsail catfish (Family Aridae); and flounder (Family Bothidae and Family Pleuronectidae). The cumulative total of fish shall not exceed 25 pounds. In addition, a vessel may keep 36 blue crabs (Portunidae family). This exemption for personal consumption does not apply to fish or crabs that are otherwise illegal to possess or catch.

Louisiana

Louisiana Department of Wildlife and Fisheries

Louisiana Department of Wildlife and Fisheries
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Marine Fisheries: (225) 765-2384
Law Enforcement: (225) 765-2989
www.wlf.state.la.us

The Louisiana Department of Wildlife and Fisheries (LDWF) is one of 21 major administrative units of the Louisiana government. The Governor appoints a seven-member board, the Louisiana Wildlife and

Fisheries Commission (LWFC). Six of the members serve overlapping terms of six years, and one serves a term concurrent with the Governor. The commission is a policy-making and budgetary-control board with no administrative functions. The legislature has authority to establish management programs and policies; however, the legislature has delegated certain authority and responsibility to the LWFC and the LDWF. The LWFC may set possession limits, quotas, places, seasons, size limits, and daily take limits based on biological and technical data. The Secretary of the LDWF is the executive head and chief administrative officer of the department and is responsible for the administration, control, and operation of the functions, programs, and affairs of the department. The Governor, with consent of the Senate, appoints the Secretary.

Within the administrative system, an Assistant Secretary is in charge of the Office of Fisheries. This office performs:

> "The functions of the state relating to the administration and operation of programs, including research relating to oysters, water bottoms and seafood including, but not limited to, the regulation of oyster, shrimp, and marine fishing industries."

The Enforcement Division, in the Office of the Secretary, is responsible for enforcing all marine fishery statutes and regulations.

Louisiana has habitat protection and permitting programs and a federally-approved CZM program. The Department of Natural Resources is the state agency that monitors compliance of the state Coastal Zone Management Plan and reviews federal regulations for consistency with that plan.

Legislative Authorization

Title 56, Louisiana Revised Statutes (L.R.S.) contains statutes adopted by the Legislature that govern marine fisheries in the state that empower the LWFC to promulgate rules and regulations regarding fish and wildlife resources of the state. Title 36, L.R.S. creates the LDWF and designates the powers and duties of the department. Title 76 of the Louisiana Administrative Code contains the rules and regulations adopted by the LWFC and the LDWF that govern marine fisheries.

Section 320 of Title 56 (L.R.S.) establishes methods of taking freshwater and saltwater fish. Additionally, Sections 325.1 and 326.3 of Title 56 (L.R.S.) give the LWFC the legislative authority to set possession limits, quotas, places, season, size limits, and daily take limits for all freshwater and saltwater finfish based upon biological and technical data.

Reciprocal Agreements and Limited Entry Provisions

Reciprocal Agreements

The LWFC is authorized to enter into reciprocal management agreements with the states of Arkansas, Mississippi, and Texas on matters pertaining to aquatic life in bodies of water that form a common boundary. The LWFC is also authorized to enter into reciprocal licensing agreements.

Louisiana seniors, 65 years of age and older, are not required to purchase a non-resident license to fish in all public waters in Texas. These anglers will be allowed to fish Texas water bodies with a Louisiana Senior fishing license but shall comply with Texas law. Senior anglers are advised that anglers turning 60 before June 1, 2000 are also required to possess a Louisiana Senior fishing license when fishing in Texas, except in border waters. Louisiana residents from 17-64 years of age will still be required to purchase a non-resident fishing license when fishing in Texas, except when fishing in border waters.

In all border waters, except the Gulf of Mexico, Texas and Louisiana anglers possessing the necessary resident licenses, or those exempted from resident licenses for their state, are allowed to fish the border waters of Louisiana and Texas without purchasing non-resident licenses. Border waters include Caddo Lake, Toledo Bend Reservoir, the Sabine River, and Sabine Lake.

Louisiana is also allowing Texas senior residents 65 years of age and older, to fish throughout Louisiana's public waters if they possess any type valid Special Texas Resident licenses for seniors as issued by Texas Parks and Wildlife, any type of water, saltwater or freshwater. Even Texas residents born before September 1, 1930 must possess the Texas Special Resident Fishing license when fishing in Louisiana, except in border waters.

Limited Entry

No limited entry exists to commercially take Atlantic croaker with legal commercial gear other than with a commercial rod and reel. Louisiana has adopted limited access restriction for the issuance of a commercial rod and reel license. Sections 325.4 and 305B (14) of Title 56 (L.R.S.), as amended in 1995, provide that rod and reel licenses may only be issued to a person who has derived 50% or more of his income from the capture and sale of seafood species in at least two of the years 1993, 1994, and 1995 and has not applied for economic assistance for training under 56:13.1(C). Additionally, any person previously convicted of a Class 3 or greater violation cannot be issued a commercial rod and reel license.

Commercial Landings Data Reporting Requirements

Wholesale/retail seafood dealers who purchase Atlantic croaker from fishermen are required to report those purchases by the tenth of the following month on trip tickets supplied by the LDWF for that purpose. Commercial fishermen who sell Atlantic croaker directly to consumers must be licensed as a wholesale/retail seafood dealer or Fresh Products Licensee and comply with the same reporting requirements.

Penalties for Violations

Violations of Louisiana laws or regulations concerning the commercial or recreational taking of Atlantic croaker by legal commercial gear shall constitute a Class 3 violation which is punishable by a fine from $250 to $500 or imprisonment for not more than 90 days, or both. Second offenses carry fines of not less than $500 or more than $800 and imprisonment of not less than 60 days or more than 90 days and forfeiture to the LWFC of any equipment seized in connection with the violation. Third and subsequent offenses have fines of not less than $750 or more than $1,000 and imprisonment for not less than 90 days or more than 120 days and forfeiture of all equipment involved with the violation. Civil penalties may also be imposed.

In addition to any other penalty, for a second or subsequent violation of the same provision of law, the penalty imposed may include revocation of the permit or license under which the violation occurred for the period for which it was issued, and barring the issuance of another permit or license for that same period.

License Requirements

A license is required to land Atlantic croaker commercially or recreationally from all Louisiana marine waters and the EEZ. Recreational saltwater fishing licenses are required of residents and non-residents fishing in state territorial waters as well as the EEZ and current relations must be adhered to. Check with the LDWF for current Atlantic croaker regulations. Residents and non-residents younger than 16 years of age and residents who have reached 60 years of age prior to June 1, 2000 and have lived in the state for two years prior to application are not required to obtain a saltwater fishing license. However, proof of age must be carried on person. Other exemptions may exist for active military and the disabled but check with the LDWF for details.

Commercial fishermen must have appropriate fishing licenses and permits, gear licenses, and vessel permits to be properly licensed whenever taking or possessing fish for sale in Louisiana saltwater areas. All Atlantic croaker possessed by a commercial fisherman shall have the head and caudal fin intact until set or put on shore or when sold and are subject to mandatory reporting. Contact the LDWF for specific regulations regarding the commercial harvest and/or sale of Atlantic croaker from Louisiana waters.

Laws and Regulations

Louisiana laws and regulations regarding the harvest of Atlantic croaker include gear restrictions and other provisions. The following is a general summary of these laws and regulations. *They are current to the date of this publication and are subject to change at any time thereafter. The LDWF should be contacted for specific and up-to-date information.*

Size Limits

There is no recreational and commercial size limit for Atlantic croaker in Louisiana.

Gear Restrictions

Licensed commercial fishermen may take Atlantic croaker commercially with a pole, line, yo-yo, hand line, trotline wherein hooks are not less than 24 inches apart, trawl, skimmer, butterfly net, cast net, scuba gear using standard spearing equipment, and rod and reel (if permitted). It is also legal to harvest Atlantic croaker with hoop nets with the proper gear license.

Licensed recreational fishermen may take Atlantic croaker recreationally with a bow and arrow, scuba gear, hook and line, and rod and reel.

Closed Areas and Seasons

Commercial activities including harvest of Atlantic croaker are prohibited on designated refuges and state wildlife management areas.

Quotas and Bag/Possession Limits

There is no recreational bag limit and no commercial trip limit on Atlantic croaker.

Other Restrictions

The use of aircraft to assist fishing operations is prohibited. Atlantic croaker must be landed 'whole' with heads and tails attached; however, they may be eviscerated and/or have the gills removed. For the purpose of consumption at sea aboard the harvesting vessel, a person shall have no more than two pounds of finfish parts per person on board the vessel, provided that the vessel is equipped to cook such finfish. The provisions shall not apply to bait species.

Commercial Bait Regulations

A. Policy

The special bait dealer's permit is intended solely for the benefit of the recreational fishing public which desires to use live shrimp and live croaker as bait during the closed shrimp seasons. Its purpose is to allow the uninterrupted operation of those commercial establishments which sell live bait shrimp and live croaker to the fishing public during the closed shrimp seasons. The permit is not intended for the direct use of recreational fishermen, charter boats, commercial fishermen who sell dead shrimp or croaker, or for any other entity which may wish to catch shrimp or croaker for their own use during the closed shrimp seasons.

B. Application

1. Applicants wishing to sell live shrimp or live croaker harvested from Louisiana waters during closed shrimp season must apply for a special bait dealer permit from the LDWF for a fee of $110.00.
2. The special bait dealer's permit shall be valid for one year beginning January 1 and ending December 31 of that same calendar year. The permit may be purchased at any time during the year for the current permit year and beginning November 15 for the immediately following permit year.
3. Applications will be accepted only from the owner of an onshore business which sells or plans to sell live shrimp or live croaker to recreational fisherman.
4. Applicant shall be responsible for acquiring and possessing all proper licenses including the wholesale/retail seafood dealer's license.
5. Any person convicted of any class three or greater wildlife or fisheries violation within the previous three years prior to the date of application shall not qualify to obtain a special bait dealer's permit or be onboard any vessel engaged in permitted activities.
6. Applicant must post a $1,000 cash bond before the permit is issued. This bond will be forfeited if the permittee, his employee, or his contractor violates any provision of the rules and regulations concerning the special bait dealer's permit or if the permittee, his employee, or his contractor violates any commercial fishing law or regulation while operating under the permit.
7. All new applications shall require an inspection by the LDWF of their onshore facility and vessel prior to permit being issued. Subsequent inspections may be required at renewal. Inspection requirements shall verify applicant is operating a commercial establishment which sells live shrimp or live croakers to the fishing public for use as bait and shall include:
    a. onshore facility able to maintain live shrimp or live croakers;
    b. onshore facilities and vessel tanks must have provisions for aeration and/or circulation of the water in which live shrimp or live croakers are held;
    c. onshore facility holding tanks must have a minimal combined capacity of 300 gallons. Tanks having less than 30 gallon capacity will not be included in combined on shore facility capacity;
    d. vessel tanks must be carried on or built into the vessel and have a minimum of one compartment or tank with a minimum capacity of 30 gallons;
    e. notice to the public must be posted that live bait is available.
8. Only the vessel and those commercial fishermen specified at the time of application shall operate under the permit. Amendments to vessel or commercial fishermen listed under the permit must be submitted to the LDWF and approved before the new vessel or commercial fisherman can operate under the permit. The permit is not transferable to any other person or vessel. The entire original permit must be carried on the vessel while in operation.

C. Operations

1. The entire original permit must be in the possession of the commercial fisherman while operating under the conditions of the permit. Only the vessel and those commercial fisherman specified at the time of application shall operate under the permit. No other vessel or commercial fisherman shall be used under this permit.
2. Live wells, aeration tanks, and other vessel facilities to maintain live shrimp or croaker must be carried on or built into this vessel while operating under the conditions of the permit.
3. No person shall transfer any shrimp or croaker taken under a permit from one vessel to another unless both vessels are permitted under the same wholesale/retail seafood dealer,

and the captain of the harvesting vessel has signed a trip ticket for the harvested bait, and the bait is then transported directly to the wholesale/retail seafood dealer under which both vessels are operating; upon receiving the harvested bait the dealer shall complete the trip ticket.

4. While operating under the conditions of the permit, no shrimp or croaker may be sold from the vessel to anyone other than the licensed wholesale/retail seafood dealer listed on the permit during the closed shrimp seasons.
5. Signs which identify the vessel as working under the special bait dealer's permit shall be posted on the vessel. These signs shall be visible from either side of the vessel and from the air; the word "BAIT" and the permit number shall be placed on these signs in letters at least 12 inches high.
6. No more than two gallons of dead shrimp or croaker or combination thereof may be aboard the vessel while it is operating under the permit. All dead shrimp or croaker or combination thereof in excess of two gallons must be immediately returned to the water. Shrimp or croaker dying in onshore holding facilities may be sold for bait use only.
7. Permitted gear is limited to one trawl not to exceed 25 feet along the cork line 33 feet along the lead line or two skimmer nets having an individual net frame size not more than 16 feet measured horizontally or 12 feet measured vertically or 20 feet measured diagonally. These are the only commercial fishing gears which can be used or carried aboard the permitted vessel while the vessel is operating under the permit; no other commercial fishing gear other than unserviceable crab traps as described in R.S. 56:322(G) may be on the vessel when it is being used under the permit.
8. Bait shrimp or croaker may be taken only from official sunrise to official sunset; however, the LDWF at its discretion, may designate the areas and hours of night time operations under the permit provided permitted vessels are equipped with a working vessel monitoring system as described in LAC 76:VII.371.
9. Each time the permit is used the permittee must notify the department by contacting the Communications Section on the designated toll free telephone number provided on the permit and recording the confirmation number received. Before the vessel departs the dock under the permit, the department must be advised of the time of departure and the sub-basin code corresponding to the LDWF's trip ticket sub-basin map in which trawling or skimming will take place; immediately after the permitted vessel returns to the dock the LDWF must be notified of the time of return by contacting the Communications Section on the designated toll free telephone number provided on the permit.
10. The permittee shall maintain an up-to-date record of the activities conducted under the permit on forms provided by the department for that purpose. These records shall be kept onboard the vessel and made available for inspection by agents of the department upon request by said agents at any time and shall include the permittee's name and permit number, date, departure time, fishing location, gear used, confirmation number, return time, and number of live shrimp or live croaker harvested. All applicable record information shall be completed before fishing operations begin. In addition, any agent of the department shall be allowed to make an onsite inspection of any facilities operating under the permit, at any time. Nothing herein this Section shall exempt the permittee from trip ticket reporting requirements as provided for in R.S. 56:306.4.

D. Penalties

No person shall violate any provision of this Section. Violations of any provision of this Section shall constitute a class 4 violation as defined in R.S. 56:34.

Historical Changes to Regulations In Lousiana Affecting Atlantic Croaker

The following regulatory changes may have notably influenced the landings during a particular year and are summarized here for interpretive purposes.

Prior to 1976: Commercial regulations allowed a minimum bar-mesh size of 1.5 inches for saltwater gillnets, a 1.0 inch minimum for the inside wall of saltwater trammel nets, and a 0.875 inch minimum for saltwater fish seines. All nets used in the fishery were restricted to maximum lengths of 2,000 ft. No creel limits, size restrictions, or quota were placed on properly licensed fishermen. Recreational fishermen were required to possess a basic fishing license.

1958: Defined the inside/outside shrimp line. Made it illegal for a boat to use two or more trawls at the same time in inside waters. Prohibited the use of trawls greater than 50 ft in inside waters. Established two seasons in inside waters, December 21 – April 30 and July 1 to the third Monday in August.

1977: Monofilament webbing was banned in all saltwater nets except those on properly permitted vessels engaged in the pompano and black drum underutilized species program. Maximum net lengths were reduced to 1,200 ft, and new minimum bar-mesh sizes of 2.0 inches for saltwater gillnets, 1.0 inch for the inside wall of trammel nets, and 1.0 inch for saltwater fish seines were enacted.

1980: Established a minimum mesh size of 3.0-inch bar in the outer wall of saltwater trammel nets.

1983: Required all saltwater trammel nets to consist of three walls. A Saltwater Seller's License at a cost of $105 was established for the sale of commercial finfish.

1984: Required minimum bar-mesh sizes of 1.75 inches for saltwater gillnets and 1.625 inches for the inside wall of saltwater trammel nets and a maximum mesh size of 12 inch bar for the outer wall of trammel nets. Mandated a mesh size of 1.0-inch bar for saltwater fish seines, discontinued Commercial Angler's License, and gear license fees were increased.

1986: Saltwater Seller's License discontinued.

1987: Established minimum bar-mesh sizes of 1.75 inches for saltwater gillnets, saltwater fish seines and the inside wall of saltwater trammel nets.

1987: Prohibited LDWF from enforcing any federal regulations requiring commercial or recreational shrimper in state waters to use TEDs.

1988: Prohibited the use of unattended gill and trammel nets in saltwater areas.

1995: Use of 'set' gill nets or trammel nets prohibited in saltwater areas. Use of 'strike' gill nets to harvest specified fishes limited to the period between the third Monday in October and March 1 of the following year.

1997: Reduced the minimum mesh size to 0.625 square or 1.25 inch stretched except in Zone 2 west of the Atchafalaya River.

2015: Allowed LDWF to enforce federal regulations requiring the use of TEDs. In lieu of TEDs, shrimpers fishing with test trawls and skimmer and butterfly nets must limit their tow times to 75 minutes from November 1 through March 31 and 55 minutes from April 1 through October 31 to reduce potential impacts on sea turtles.

Texas

Texas Parks and Wildlife Department (TPWD)

Texas Parks and Wildlife Department
Coastal Fisheries Division
4200 Smith School Road
Austin, Texas 78744

(512) 389-4863
www.tpwd.texas.gov

The TPWD is the administrative unit of the state charged with management of the coastal fishery resources and enforcement of legislative and regulatory procedures under the policy direction of the Texas Parks and Wildlife Commission (TPWC). The commission consists of nine members appointed by the Governor for staggered six-year terms. The commission selects an Executive Director who serves as the administrative officer of the department. The Executive Director selects a Deputy Executive Director for Natural Resources who, in turn, selects the Director of Coastal Fisheries, Inland Fisheries, Wildlife, and Law Enforcement Divisions. The Coastal Fisheries Division, headed by a Division Director, is under the supervision of the Deputy Executive Director for Natural Resources.

Texas has habitat protection and permitting programs and a federally-approved Coastal Zone Management (CZM) program. The Texas General Land Office (TGLO) is the lead agency for the Texas CZM. The Coastal Coordination Council monitors compliance of the state Coastal Management Program and reviews federal regulations for consistency with that plan. The Coastal Coordination Council is an 11-member group whose members consist of a chairman (the head of TGLO) and representatives from Texas Commission on Environmental Quality, TPWC, the Railroad Commission, Texas Water Development Board, Texas Transportation Commission, and the Texas Soil and Water Conservation Board. The remaining four places of the council are appointed by the governor and are comprised of an elected city or county official, a business owner, someone involved in agriculture, and a citizen. All must live in the coastal zone.

Legislative Authorization

Chapter 11, Texas Parks and Wildlife Code, established the TPWC and provided for its make-up and appointment. Chapter 12, Texas Parks and Wildlife Code, established the powers and duties of the TPWC, and Chapter 61, Texas Parks and Wildlife Code, provided the commission with responsibility for marine fishery management and authority to promulgate regulations. Chapter 77, Texas Parks and Wildlife Code, provided for the commercial licenses required to catch, sell, and transport shrimp and saltwater nongame fish commercially, and Chapter 66, Texas Parks and Wildlife Code, provided for the sale, purchase, and transportation of nongame fish in Texas. All regulations pertaining to size limits, bag and possession limits, and means and methods pertaining to nongame are adopted by the TPWC and included in the Texas Statewide Shrimp Fishery Proclamation and Statewide Recreational and Commercial Fishing Proclamation.

Reciprocal Agreements and Limited Entry Provisions

Reciprocal Agreements

Texas statutory authority allows the TPWC to enter into reciprocal licensing agreements in waters that form a common boundary, i.e., the Sabine River area between Texas and Louisiana. Texas has no statutory authority to enter into reciprocal management agreements.

Limited Entry

Chapter 77, Texas Parks and Wildlife Code, provides that no person may operate a commercial bay or bait shrimp boat for the purpose of catching or assisting in catching shrimp and other edible aquatic products from the inside water unless the owner has obtained a commercial shrimp boat license. No captain of a licensed commercial shrimp boat may operate a licensed commercial shrimp boat while catching or attempting to catch shrimp from the public water of this state or unloading or attempting to unload in this state shrimp and other aquatic products taken from saltwater outside this state for pay or for purposes of sale, unless the person holds a commercial shrimp boat captain's license issued by the TPWD. Beginning September 1, 1995, a commercial bait or bay shrimp boat license could only be sold to a person who documented, in a manner acceptable to the TPWD, that the person documents to the satisfaction of the TPWD that the vessel for which the license is sought:

(1) is owned by the person;
(2) was under construction and at least 50 percent completed on April 1, 1995; and
(3) is intended to be licensed and used as a commercial bay or bait shrimp boat.

For the license year ending August 31, 1996, the TPWD may renew a commercial bay or bait shrimp boat license only if the person seeking renewal of the license:

(1) owns the commercial bay or bait shrimp boat for which the license renewal is sought; and
(2) held the license to be renewed on April 1, 1995, or, after that date, obtained the license to be renewed by a transfer authorized by Section 77.113.

Commercial Landings Data Reporting Requirements

Section 66.019, Chapter 66, Texas Parks and Wildlife Code, provides:

a) The TPWD shall gather statistical information on the harvest of aquatic products of this state.
b) The TPWD shall prescribe the method or methods used to gather information and shall produce and distribute any applicable report forms.
c) Unless otherwise required by the TPWD, no dealer who purchases or receives aquatic products directly from any person other than a licensed dealer may fail to file the report with the TPWD each month on or before the tenth day of the month following the month in which the reportable activity occurred. The report must be filed even if no reportable activity occurs in the month covered by the report. No dealer required to report may file an incorrect or false report. A culpable mental state is not required to establish an offense under this section.
d) Unless otherwise required by the TPWD, no dealer who purchases, receives, or handles aquatic products (other than oysters) from any person except another dealer may fail to:
    1) maintain cash sale tickets in the form required by this section as records of cash sale transactions; or
    2) make the cash sale tickets available for examination by authorized employees of the TPWD for statistical purposes or as a part of an ongoing investigation of a criminal violation during reasonable business hours of the dealer.
e) All cash sale tickets must be maintained at the place of business for at least one year from the date of the sale.
f) A cash sale ticket must include:
    1) name of the seller;
    2) the general commercial fisherman's license number and the commercial finfish fisherman's license number or the general commercial fisherman's license number and the commercial crab fisherman's license number, as applicable, if the holder of the general fisherman's license is selling finfish or crabs;
    3) the general commercial fisherman's license number, the commercial crab fisherman's license number, the commercial finfish fisherman's license number, the commercial shrimp boat captain's license number, or the commercial fishing boat license number of the seller or of the vessel used to take the aquatic product, as applicable;
    4) the number of pounds sold by species;
    5) date of sale;
    6) water body or bay system from which the aquatic products were taken; and
    7) price paid per pound per species.
g) Any person who violates subsection (c) or (d) of this section is guilty of a Class C misdemeanor

Penalties for Violations

Penalties for violations of Texas' proclamations regarding Atlantic croaker are provided in Chapter 61, Texas Parks and Wildlife Code, and most are Class C misdemeanors punishable by fines ranging from $25

to $500. Under certain circumstances, a violation can be enhanced to a Class B misdemeanor punishable by fines ranging from $200 to $2,000; confinement in jail not to exceed 180 days; or both.

Annual License Fees

A license is required to land Atlantic croaker, commercially or recreationally, from all Texas marine waters and the EEZ. Recreational saltwater fishing licenses are required of residents and non-residents fishing in state territorial waters as well as the EEZ and current regulations must be adhered to. Residents of Texas under the age of 17 and residents who were born before January 1, 1931 are not required to obtain a recreational fishing license. Other exemptions may exist for active military and the disabled, but check with the TPWD for details.

Senate Bill 1750 authorizes the Texas Parks and Wildlife Commission under Parks and Wildlife Code 77, to establish a license limitation plan for the Texas commercial bait and bay shrimp boat fishery. Commercial fishermen must have appropriate fishing licenses and permits, gear licenses, and vessel permits to be properly licensed whenever taking or possessing shrimp and nongame fish for sale in Texas saltwater areas. *Contact the TPWD for specific regulations regarding the commercial harvest and/or sale of Atlantic croaker from Texas waters.*

Laws and Regulations

Various provisions of the Statewide Fishing Proclamation and Shrimp Fishery Proclamation adopted by the TPWC affect the harvest of Atlantic croaker in Texas. The following is a general summary of these laws and regulations. It is current through the end of August, 2016, and is subject to change at any time thereafter. *The TPWD should be contacted for specific and up-to-date information*.

Size Limits

There is no minimum size limit for Atlantic croaker in Texas.

Gear Restrictions

Gill nets, trammel nets, strike nets, and seines (other than minnow seines) may not be possessed within 500 yards of any public coastal waters. Atlantic croaker is a nongame fish and may be legally taken by any lawful means and methods. There is no daily bag or possession limit specific to Atlantic croaker, limitations exist for the number of nongame fish that may be taken by certain means and methods. The daily bag and possession limit of nongame fish is 200 with use of a recreational bait shrimp trawl.

Closed Areas and Seasons

There are no closed areas or seasons for the taking of Atlantic croaker in Texas.

Quotas and Bag/Possession Limits

Recreational

Bag limit – none

Possession limit – none, except 200 nongame fish from recreational bait trawls (see Gear Restrictions).

Commercial

There is no bag limit or possession limit for Atlantic croaker. Nongame fish and other aquatic products taken incidental to legal shrimp trawling operations may be retained, provided the total weight of aquatic products retained, in any combination, does not exceed 50% by weight of shrimp on a “Bay” shrimping vessel. During the time period of May 1st – September 30th, 1,500 nongame fish may be retained incidental to a legal bait shrimping operation.

Other Restrictions

Atlantic croaker must be kept in a 'whole' condition with heads and tails attached until landed on a barrier island or the mainland; however, viscera and gills may be removed.

Historical Changes to Regulations In Texas Affecting Atlantic Croaker

The following regulatory changes may have notably influenced the landings during a particular year and are summarized here for informative purposes.

1981: House Bill 1000, prohibition of red drum and spotted seatrout sale (game fish status), therefore commercial pressure on Atlantic croaker would have been increased.
1988: Gill net ban, affecting immediate commercial as well as future commercial and recreational landings.
1990: Limit on nongame fish and other aquatic products retained in by-catch onboard a commercial shrimp vessel to not exceed more than 50% by weight of shrimp.
1994: Established a time period, from May 1st to September 30th, when a licensed commercial shrimp vessel may retain 1,200 live nongame.
1994: Increased the quantity of live nongame fish that may be retained onboard a commercial shrimp vessel during the period of May 1st to September 30th to 1,500 live nongame.
1995: Senate Bill 750, limited entry for shrimpers may have redistributed commercial pressure.
2001: Turtle Excluder Devices and Bycatch Reduction Devices required in shrimp nets.

Regional/Interstate

Gulf States Marine Fisheries Compact (P.L. 81-66)

The Gulf States Marine Fisheries Commission (Commission) was established by an act of Congress (P.L. 81-66) in 1949 as a compact of the five Gulf states. Its charge is

> "to promote better utilization of the fisheries, marine, shell and anadromous, of the seaboard of the Gulf of Mexico, by the development of a joint program for the promotion and protection of such fisheries and the prevention of the physical waste of the fisheries from any cause."

The Commission is composed of three members from each of the five Gulf states. The head of the marine resource agency of each state is an ex-officio member, the second is a member of the legislature, and the third, a citizen who shall have knowledge of and interest in marine fisheries, is appointed by the governor. The chairman, vice chairman, and second vice chairman of the Commission are rotated annually among the states.

The Commission is empowered to make recommendations to the governors and legislatures of the five Gulf states on action regarding programs helpful to the management of the fisheries. The states do not relinquish any of their rights or responsibilities in regulating their own fisheries by being members of the Commission.

Recommendations to the states are based on scientific studies made by experts employed by state and federal resource agencies and advice from law enforcement officials and the commercial and recreational fishing industries. The Commission is also authorized to consult with and advise the proper administrative agencies of the member states regarding fishery conservation problems. In addition, the Commission advises the U.S. Congress and may testify on legislation and marine policies that affect the Gulf states. One of the most important functions of the Commission is to serve as a forum for the discussion of various problems, issues, and programs concerning marine management.

Croaker Technical Task Force

The Croaker Technical Task Force (TTF) is organized to include one scientific representative from each of the five Gulf states, appointed by each state's director serving on the State-Federal Fisheries Management Committee (S-FFMC). In addition, a representative from each of the Commission's Commercial Fisheries and Recreational Fisheries Advisory Panels, the Law Enforcement Committee, and the Habitat Subcommittee (the representative is chosen by action of the respective committees). In addition, other experts from other disciplines may be included on the TTF as needed (i.e., public health, economics, sociology, etc.). As with all of the Commission's TTFs, the committee becomes inactive until there is a need for revision of a profile or work is deemed necessary on specific issues related to Atlantic croaker in the region. The members of the TTF may be called upon to advise the Technical Coordinating Committee (TCC), the SFFMC, or the Commission on Atlantic croaker issues in the Gulf of Mexico.

Interjurisdictional Fisheries Act (IFA) of 1986 (P.L. 99-659, Title III)

The IFA of 1986 established a program to promote and encourage state activities in the support of management plans and to promote and encourage regional management of state fishery resources throughout their range. The enactment of this legislation repealed the Commercial Fisheries Research and Development Act (P.L. 88-309).

Development of Biological and Management Profiles for Fisheries (Title III, Section 308(c))

Through P.L. 99-659, Congress authorized the USDOC to appropriate funding in support of state research and management projects that were consistent with the intent of the IFA. Additional funds were authorized to support the development of interstate management plans by the Gulf, Atlantic, and Pacific States Marine Fisheries Commissions.

Chapter 6
DESCRIPTION OF THE FISHERY

Atlantic croaker are found throughout the Gulf of Mexico and the Atlantic Coast from Texas to Maine. Landings of croaker have fluctuated widely across the U.S., especially by region (Figure 6.1). In the Gulf of Mexico, croaker have long been utilized as food fish similar to their Sciaenid cousins red drum and spotted seatrout, and harvested both recreationally and commercially. However, as various commercial trawl fisheries increased throughout the middle of the 20th century, benthic associated species like croaker experienced high fishing mortality as bycatch at all early life history stages. In this chapter, both the commercial and recreational fishing sectors in the Gulf of Mexico which targeted or incidentally impacted Atlantic croaker will be highlighted.

Commercial Fishery

Atlantic croaker do not make up a large component of the total commercial landings in the U.S. today, accounting for less than 0.4% of the total U.S. finfish landings since the late 1990s. From 1950 to 2000, the total annual contribution rarely exceeded 1.0%. Across the U.S., the Gulf region only produced significant landings of 'Atlantic croaker' for food fish from the late 1960s until the late 1970s, contributing as much as 70-80% of the total U.S. production at that time. However, these numbers do not include croaker discarded from shrimp trawls from the 1970s forward or those fish landed for the pet food industry in the 1950s through 1980s. Therefore, determining the total impact of fishing effort on this species looking only at 'Atlantic croaker' is difficult and any total mortality estimates are underrepresented. NOAA commercial landings utilize a category of '*Finfishes, UNC Bait and Animal Food*' which historically, in the Gulf, referred almost exclusively to the Groundfish fishery through the 1980s; therefore, '*Groundfish'* will be used throughout this chapter for all landings and values tied to '*Finfishes, UNC Bait and Animal Food*'.

History

Atlantic croaker have a long history of utilization along the Gulf Coast. Early accounts indicated that relatively large schools of Atlantic croaker existed throughout the estuarine waters of the Gulf of Mexico.

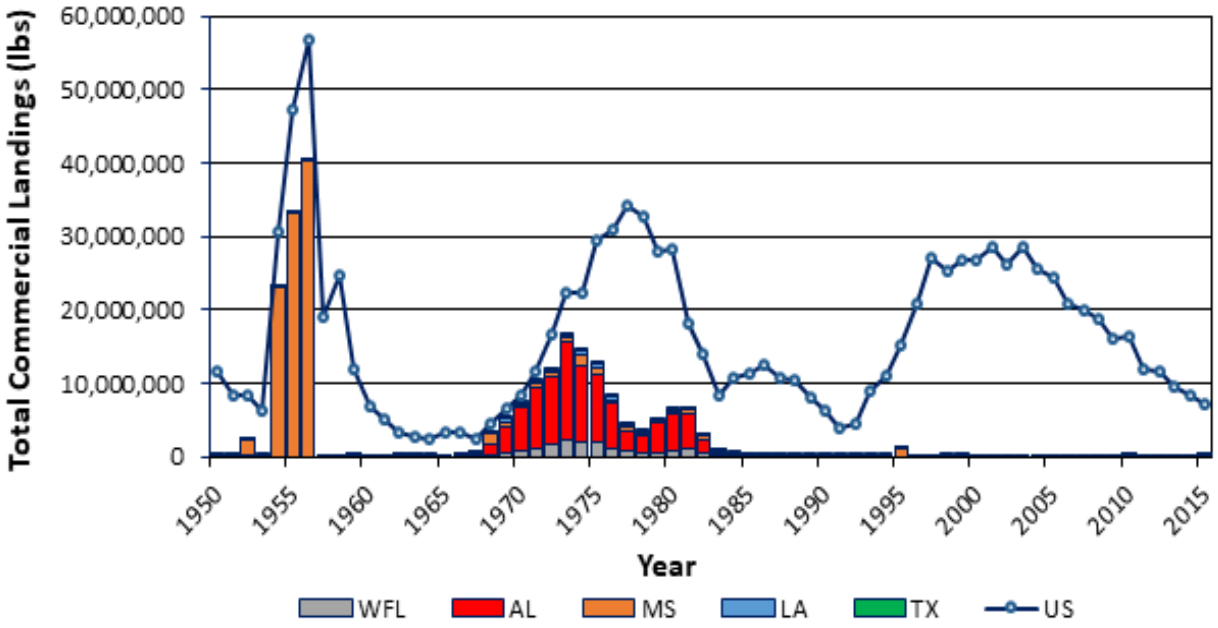

Figure 6.1 Commercial Atlantic croaker landings (lbs) for the five Gulf states and the total U.S. from 1950-2015.

Goode (1887) reported croaker being very common in the Gulf and South Atlantic and stated that it "is found everywhere in the bays and bayous throughout the year".

There is evidence that croaker were sought as a food fish along the prehistoric Gulf Coast in and around Biloxi and Pascagoula, Mississippi. Like most other Sciaenids, croaker have very large otoliths which can be found in the remains of historical encampments and dwelling areas. Jewell (1997) notes the occurrence of croaker bones in archeological digs in Mississippi dating back to the 1300s. While not the most abundant species, their remains occur in earth-shell middens, indicating they were part of the regular diet of indigenous people in the north-central Gulf. Croaker were most likely caught using the nets, traps, and possibly poisons available to native people of that time. Some of the material recovered from the early American middens provided size estimates based on relative sizes of the skeletal structures recovered. Jewell (1997) found the maximum size for age-1 Atlantic croaker between the two sites he sampled were around 10-15cm (3-6 inches). Similar work in the coastal plains and prairies around Corpus Christi, Texas has identified fish otoliths in indigenous peoples' fish camps, suggesting that, at least during the fall and winter months around the year 1300AD, fishing for drum (black drum, red drum, Atlantic croaker, and seatrout) was a primary source of food (Ricklis 1992). The indigenous people relied on the seasonality of estuarine species and moved between the shoreline and inland prairie sites to take advantage of the regularity of food sources such as fish and inland game (Ricklis 1992).

According to the GMFMC (1980), the first commercial fishery for croaker started as early as the 1920s in Louisiana.

> "Commercial fishermen, primarily of Italian descent, are known to have sought 'bull' croakers (croaker larger than 454 g, or 1.0 lb) (Rohr, 1977) during seasonal runs in Lake Pontchartrain during the early and mid-1920s. The fishermen operating small day boats based in Milneburg [currently the area of Gentilly near Elysian Fields Avenue] and Mandeville, Louisiana, caught 0.34-0.68 kg (0.75 to 1.5 lb) fish on hand lines in 'red' water which was created by the fish agitating the bottom of the lake (E. Smith, NMFS, Pascagoula, Mississippi, pers. comm.). Gowanloch in 1933 confirmed the size of these earlier catches by stating 'Few croakers exceed a foot in length' or about a pound.
>
> Edible croaker has been sold in small quantities in local fish markets for many years along the Gulf coast."
>
> GMFMC 1980

Croaker, while very similar in taste and texture to the other Sciaenids, have never been a staple of the diet along the Gulf Coast. However, they are prized in other areas of the country where large fish still occur. The Atlantic Coast has had an active commercial fishery for many years for larger croaker as food fish. It was reported that a large amount of the croaker harvested along the northern Gulf of Mexico were exported directly to markets in the Northeast when they were available (Overstreet personal communication).

Groundfish Fishery

While the Sciaenids have been a long sought species group throughout the Gulf of Mexico, the record of significant landings of Atlantic croaker for commercial purposes does not occur often in NOAA records until the 1950s when they became targeted for the pet food industry in the northern Gulf of Mexico (Porch 2009). More commonly referred to as the 'Groundfish' fishery, early accounts report the development of industry was derived directly from the Gulf's shrimp trawl fishery (Gunter 1956), of which the bycatch was dominated by croaker and the various seatrout. The six most abundant of these fish are Atlantic croaker, spot (*Leiostomus xanthurus*), sand seatrout (*Cynoscion arenarius*), silver seatrout (*C. nothus*), Atlantic cutlassfish (*Trichiurus lepturus*), and hardhead catfish (*Ariopsis felis*) (GMFMC 1980).

Gunter provided a short narrative about the early fishery, which he referred to as the 'trash fish' fishery, which harvested fish to be processed into cat food. At that time, a number of old shrimp trawling vessels were being converted in order to direct their effort towards harvest of 'trash fish'. Gunter (1956) noted that:

> "Years ago, as a beginning fishery worker, I was dismayed at the waste of trash fish caught by the shrimp trawlers and even wrote a paper on the subject [Gunter 1936], in which I tried to calculate the amount of fishes destroyed. The chief fish was the croaker. Since that time the shrimp industry has expanded enormously, and larger and better boats with larger and more efficient trawls have been devised."
>
> Gunter 1956

Gunter completed a number of population surveys in the early 1950s and found that croaker was still one of the most abundant fish in the estuary, suggesting that the expansion of shrimping had not affected the population (Gunter 1956). These results led Gunter to hypothesize that a developing cat food industry would not negatively impact existing fish populations. He stated:

> "…the supply [of trash fish] is vast and it is renewable. The present trash fish catch on the Gulf is about 40,000,000 pounds per annum. I believe, therefore, that there are enough trash fish within this circumscribed area of the Gulf to support a vastly increased catch for a great many years to come, without any diminution of supply for the cats of America or the sport and commercial fishes which subsist upon this fish population."
>
> Gunter 1956

Gunter's 'trash fish' fishery in the northern Gulf of Mexico quickly expanded into the fully developed pet food industry centered in Mississippi. According to Lyles (1976), the Groundfish fishery began first in Mississippi. He wrote:

> "The Bureau of Fisheries established a station at Pascagoula, Mississippi in late 1949 and began exploratory fishing in the Gulf of Mexico. An employee of the agency, who had formerly worked for Quaker Oats, called attention to that company's California office the enormous quantities of fish discarded in the shrimp fishery and their suitability for use as pet food. As a result of this and overtures from elected officials of Jackson County [Mississippi], Quaker Oats established a plant on the east bank of the Pascagoula River in 1952."
>
> Lyles 1976

The landings supporting the Groundfish industry ranged from over 50M lbs in 1957 to over 122M lbs by 1976. The landings were primarily dominated by two states, Louisiana and Mississippi, with Mississippi landing as much as 80M lbs annually (Figure 6.2C and D). Groundfish landings suddenly declined from 122M lbs in 1976 to 8M lbs Gulf-wide in 1977, and in 1976, disappeared from Mississippi altogether (Figure 6.2C). Not all the fish included in the aggregate Groundfish landings are Atlantic croaker but estimates by Roithmayr (1965) and Gutherz et al. (1975) indicated that as much as 50 and 70% of the total harvest was croaker, respectively. It should be noted however that the ratio of croaker in the bycatch, which was determined in the early part of the fishery by Roithmayr and Gutherz, no longer held true by the mid-1980s which ultimately led to the decline in the fish-based pet food in the Gulf (Mavar personal communication).

Groundfish Vessels

At the height of the Groundfish fishery in the late 1950s, approximately 50 vessels (Roithmayr 1965, Gutherz 1976), or 'croaker boats' were harvesting fish to support seven plants operating in Louisiana and Mississippi (Austin et al. 1978). By the early 1970s, roughly 20 vessels were still fishing (Gutherz 1976)

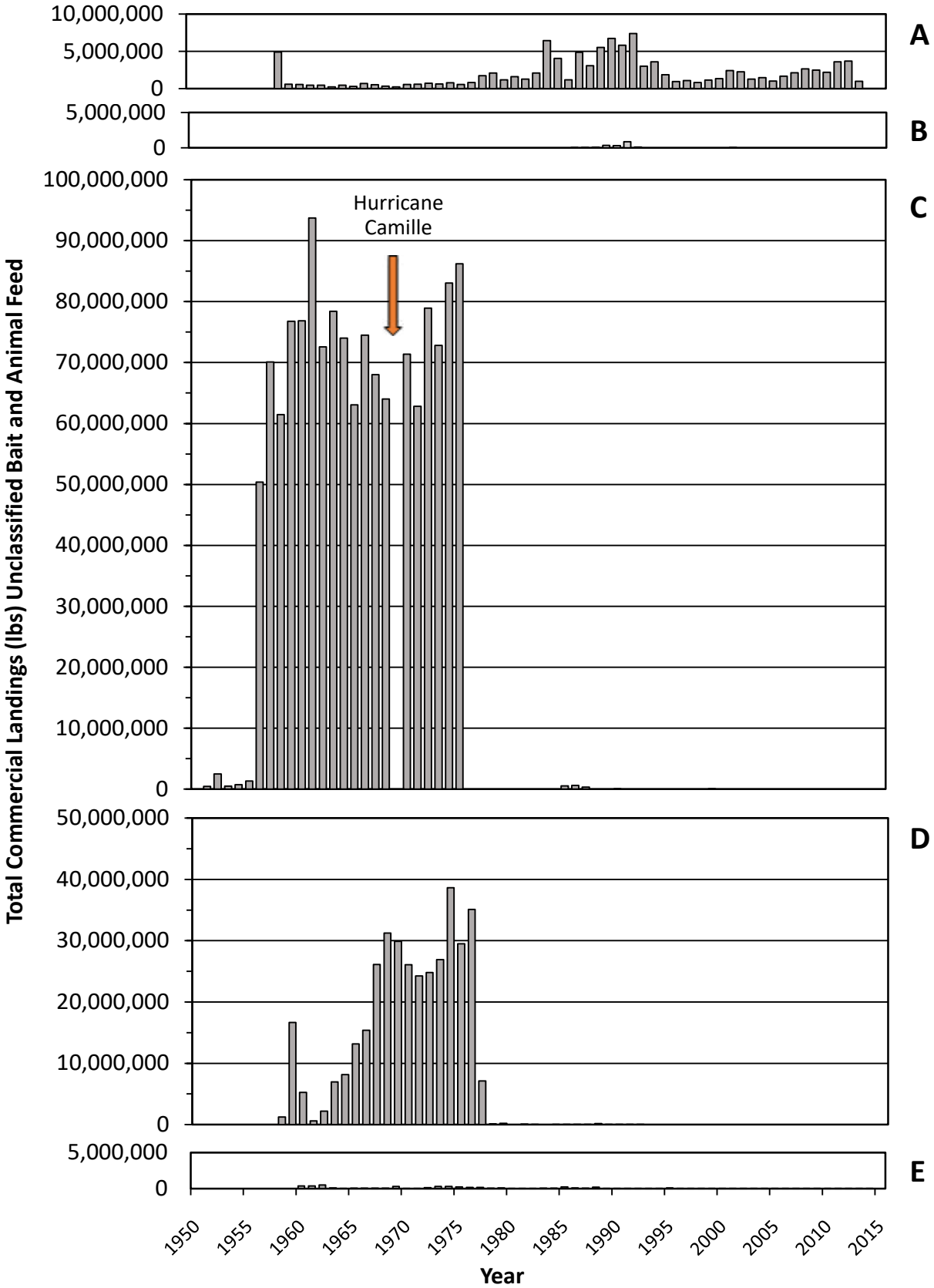

Figure 6.2 Total landings (lbs) of "Unclassified Bait and Animal Feed" which represents the Groundfish species group by state from 1950 to 2015 for A) West Florida Coast, B) Alabama, C) Mississippi, D) Louisiana, and E) Texas (NOAA unpublished data).

and by 1978, there were only 15 croaker boats still in the fleet (GMFMC 1980). At the start of the fishery in the 1950s, vessels averaged 50ft in length and by the early 1970s vessel size had increased to 75-145ft (Gutherz 1976). Gutherz (1976) noted that, although there were fewer vessels near the end of the fishery, they had capacity to haul 100-400 tons of fish. Reports from local residents in the Biloxi area indicated croaker boats returning to port had so much fish that there was little to no freeboard as the vessels set so low and the wake would wash the deck (Figure 6.3; Franks personal communication). At the height of the fishery, the processors would limit landings from certain areas as early as May, when the catches of fish began to exceed processing capacity (Austin et al. 1978).

The first boats used to harvest Groundfish in 1952 were converted wooden hull shrimp trawlers which were capable of carrying 10-30mt of iced fish (GMFMC 1980) but, as demand increased, more and larger vessels were recruited to target fish. According to Mr. Tommy Schultz (personal communication) who ran a croaker boat out of Biloxi, Mississippi, early croaker boats pulled single rigged otter trawls which were exactly the same as existing shrimp trawls and were commercially available. Croaker vessels later switched to pulling two seam balloon fish nets in double rigs (Gutherz 1976). Schultz (personal communication) reported that the original shrimp nets used for Groundfish had a tendency to deteriorate rapidly in the wings of the trawl as a result of the very rough opercular margins of the larger croaker they were targeting. He indicated that the webbing and tar would be fine on the outside of the net but the tar along the inside of the wings quickly became weak and threadbare. Schultz reported that, by the late 1960s, nets were modified to the tri-net configuration with much heavier webbing but larger mesh in the wings to guide fish down into the throat and cod of the net. The upper portion of the net, which is typically flat in a shrimp net, only allows the lower few feet to be swept by the net, whereas the tri-net design resulted in a much higher ballooning of the headline to allow much more of the water column to be fished (Schultz personal communication).

Croaker boats typically fished within 40m of the shoreline but would venture into deeper water in the winter months (Gutherz 1976). Those vessels fishing offshore in the winter used standard flat, balloon, or semi balloon nets that were setup in a double rigged fashion (Klima and Ford 1970).

When croaker fishing, the boats generally towed nets from ten minutes to five hours depending on the abundance of fish available in an area (Schultz personal communication). Gutherz reported that longer tows resulted in higher catches, averaging about 14 hours a day during the peak (Gutherz 1976). There was some culling done onboard the croaker boats as the catch passed over an excluder grid to prevent undesirable fish like sharks or large edible fish like red drum from entering the hold. The hold was filled with refrigerated seawater (RSW) to maintain the product during the cruise which averaged seven days per trip (Gutherz 1976). During seasons of high abundance, trips were as short as three days but could be a long as nine or ten days during the winter.

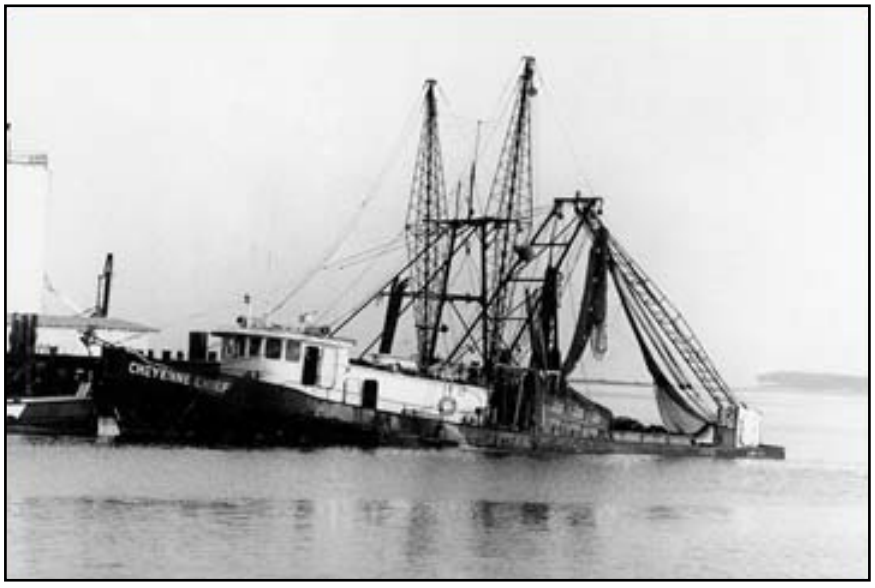

Figure 6.3 The Cheyenne Chief unloading at the Kozy Kitty factory in Biloxi, MS prior to 1988 with approximately 130 tons of croaker on board. The vessel is loaded with "Water on deck", the phrase used to describe large quantities of fish on board (photo courtesy Mr. Nick Mavar).

Mr. Schultz reported that when he began working on croaker boats in 1964, boats carried 100-lb blocks of ice every time they left port to fish. Over time, the effort required to maintain fish onboard resulted in converting croaker boats to have onboard refrigeration (Schultz personal communication). Mr. Schultz noted there were very specific requirements related to the quality of fish brought to the pet food plants. At sea, it was just as important to the plant that small fish be handled as carefully as larger croaker which would end up in the food-fish market. Improperly iced fish would rupture or have the belly split causing the plant to reject them as improper for canning (Schultz personal communication). In the Mississippi fleet, larger croaker were gutted and iced immediately at sea and small croaker were iced as well, but there was little to no culling of the smaller fish; that was done at the plant (Schultz personal communication).

A number of Groundfish reports were published by NOAA and the GMFMC (Gutherz 1976, Austin et al. 1978, GMFMC 1980), but very little was written about the pet food operation (Unen Products which produced *Tabby Cat*) in Louisiana. Residents of Golden Meadow, Louisiana have provided some insight into the plant that operated along Bayou Lafourche, about 60 miles southeast of New Orleans, from 1967-1978. Mr. Fred Dunham, a former biologist for LDWF, examined bycatch on the croaker boats that offloaded at the *Tabby Cat* plant from 1972-1975 (Dunham 1975) and provided direct insight into vessel and plant operations. Dunham (personal communication) noted that in Louisiana, croaker boat captains took advantage of a word-of-mouth communication network within the shrimping fleet to stay informed of areas where shrimp abundance was low and, conversely, finfish abundance was high. A shipyard now occupies the property and the owner, Mr. Brent Duet, provided some additional information on the history of the *Tabby Cat* plant. Throughout the 1960s and 1970s (Duet personal communication, Dunham personal communication), the plant owned three or four vessels which fished year-round, targeting both croaker and spot using double rigger nets similar to those techniques used in Mississippi. These boats were placed on quotas most of the year based on the demands of the pet food market as the *Tabby Cat* plant used other sources of proteins in a few varieties of their cat food line; therefore, the plant would restrict the fish harvest during those periods when producing these products (Dunham personal communication). Another resident, Mr. Jack Jambon, owned a convenience store near the *Tabby Cat* plant which was frequented by the vessel crews and plant workers. He noted that, when the plant first began operating, it contracted 8-10 vessels on a regular basis (Jambon personal communication).

Pet Food Plants

According to Roithmayr (1965) and Lyles (1976), the first pet food plant was established in Pascagoula, Mississippi in 1954 and relied exclusively on shrimp trawl bycatch. Most of the plants in the northern Gulf began as converted shrimp and oyster canning facilities although the *Tabby Cat* plant in Golden Meadow was built specifically for pet food (Times-Picayune May 28, 1967). As the canned seafood markets began to decline with the development of fresh products markets, additional factories were retooled to handle finfish and the Gulf's pet food industry began (Table 6.1). Roithmayr (1965) noted that the early plants were unable to meet demand of the canning facility utilizing shrimp bycatch only and began to enlist boats to target Groundfish specifically. At the height of the Groundfish fishery in the late 1950s, there were a total of seven plants in operation (four canning pet food, three freezing for food fish, and one reduction plant; Austin et al. 1978). As the fishery began to decline, only five Groundfish plants remained in operation by the mid-1970s: two in Biloxi, Mississippi, one in Pascagoula, Mississippi, one in Golden Meadow, Louisiana, and a reduction plant in Dulac, Louisiana (GMFMC 1980, Dunham personal communication). The pet food industry was very competitive and a number of plants were shut down as a result of buyouts by larger national brands. In addition, Mr. William 'Billy' Thiroux, who crewed one of the early croaker boats, indicated that at least one plant only canned pet food as part of their total annual production and utilized their equipment to also can shrimp and oysters during the height of those seasons (Thiroux personal communication). The ownership of the plants and duration they operated are difficult to track at times due to high turnover and buyouts (Table 6.1). According to Schultz (personal communication), one reason the pet food industry focused on the northern Gulf was the decline in other species of fish from the Great Lakes (yellow perch *Perca flavescens* and alewife *Alosa pseudoharengus*)

Table 6.1 The ownership and period of operation of the Groundfish plants in the northern Gulf of Mexico by location. *Italics* indicate the brand produced. The parent companies, when applicable, are in parentheses. **Note:** Plants may have been in operation prior to the dates denoted which only represent the period of croaker fishing to support the pet food production.

Years	Golden Meadow, LA	Gulfport, MS	Biloxi, MS	Biloxi, MS	Vancleave, MS	Pascagoula, MS
1950		*Catlife* -1959 (Fairhaven Fisheries)			*Red Heart* 1953-1961 (Bluff Creek Canning Company)	*Puss'n Boots* 1952-1955 (Coast Fisheries)
1955			*Catlife* 1959-1963 (High Life)	*Kozy Kitten* 1957-1988 (Mavar)		*Puss'n Boots* 1955-1982 (Quaker Oats)
1960					1961-1963 (John Morrell & Company)	
1965	*Tabby Cat* 1967-1978 (Unen Products)		*Friskies* 1963-1970 (Purina)			
1970						
1975			*Happy Cat* 1971-1975 (DeJeans)			
1980						Sun Coast 1982-1984
1985				*Star-Kist* 1988-1992 (Heinz)		*Alpo* 1985-1988 (Ralston-Purina)
1990						*Star-Kist* 1988-1994 (Heinz)
1995						*Finicky* 1995-2004 (Finicky Pet Food)
2000						

which national brands had relied on previously (Smith 1970). As those fish populations returned in lakes Huron, Michigan, and Superior, interest in canning moved away from the Gulf region (Schultz personal communication).

Though unconfirmed, an additional plant may have opened in Apalachicola, Florida, to supply much of the food for the Midwest's mink farms (Schultz personal communication). This plant was not a canning operation but would flash freeze individual croaker in boxes which were then trucked to mink farms throughout the 1950s and early 1960s. Roithmayr (1965) seems to verify this by reporting that a significant amount of Groundfish was left whole and frozen in 50lb boxes to supply the mink farm industry in the Midwest, although he does not provide a point of origin for the processor. The preferred fish for mink food was Sciaenids, especially smaller fish such as croaker, spot (*Leiostomus xanthurus*), various seatrout, and kingfish (*Menticirrhus* spp.). Austin et al. (1978) notes that there was a market channel for frozen fish directly from the Gulf to the Midwest for fur farms but that market channel closed once horse meat, a better food for mink, became available.

Processing of Groundfish was relatively simple with fish pumped directly from boats onto conveyors at waterfront plants. At the Golden Meadow plant, a suction system was used to pump fish out of a vessel hold similar to the techniques employed by the menhaden reduction fishery (Dunham personal communication, VanderKooy and Smith 2015). Centrifugal pumps would pull the useable catch from boats and into dump bins dockside. The catch was then conveyed into the plant where workers lined the belts inside the factory and culled undesirable fish from the pumpout stream. Sharks and other 'off tasting' fish were discarded along with 'spiny' fish such as searobins (*Triglidae*) and hardhead catfish (*Ariopsis felis*) that could be choking hazards in the final product (Dunham personal communication). At some plants, larger, more valuable fish and shellfish, including large croaker, were occasionally removed for the food fish market rather than processed for canning (Franks personal communication; Figure 6.4). Small fish would continue down the line for processing (packed into cans, cooked, and labeled). In some cases, marketable catch was returned to the vessel and crew for direct sale to fish houses (Gutherz 1976). Dunham (personal communication) reported on one observation session at the *Tabby Cat* plant in Golden Meadow, a crew member got very excited and was heard yelling from the hold during the pumpout. Upon investigation, the boat had harvested a spiny lobster (Palinuridae) which the happy crew member planned to eat for dinner that evening.

Figure 6.4 Inspecting croaker on conveyor belt into processing plant (*from* NMFS 1978).

Whole fish were deposited from a conveyor and then run through brine holding tanks and eventually conveyed to a mincing machine where the fish were blended with grains and other meals as well as vitamin supplements (Roithmayr 1965). This blend was then precooked and canned. The cans were then sealed and the contents were finished cooking which sterilized the processed product. The canning process was completed with a label and the final product was packed for shipment (Roithmayr 1965). An anecdotal report from a former worker at the Pascagoula plant

indicated that croaker heads and otoliths were to be removed from most of the products before canning to prevent a potential choking hazard for pets (VanderKooy personal communication). Additionally, some of the less desirable catch that did not end up canned may have been ground and reduced to fish meal and sold elsewhere (Roithmayr 1965, Gutherz 1976).

There have been unconfirmed reports that pet food canning operations supplied a large food fish market while operating as pet food canners in order to avoid meeting certain FDA regulations pertaining to the processing of food for human consumption. Overstreet (personal communication) indicated that at least one of the plants canned fish in one gallon cans as 'pet food' and shipped them directly to Brazil and other South American countries where the fish were marketed for residents in those areas. It is unclear, however, whether the product was in fact croaker or was instead bonito (*Sarda sarda*) as some reports indicate was canned elsewhere along the Mississippi Coast (Schultz personal communication).

Food Fish Fishery

A fishery targeting larger croaker for the fresh and frozen fish market began to develop in the late 1960s and 1970s in order to supply the northeastern U.S. with croaker (Diamond et al. 1999). However, around 1975, the food fish fishery expanded along the North Carolina Coast and the Gulf fishery was no longer profitable (NCDMF 1993, Diamond et al. 1999). Today, the majority of the commercial Atlantic croaker landings originate in North Carolina and Virginia (ASMFC 2010).

According to the draft fishery management plan for the Groundfish fishery developed by the GMFMC (1980),

> "The first large trawl fishery for edible croaker began [in the Gulf] in 1967. Shrimp trawlers based in Bayou La Batre, Alabama, landed croaker which they formerly discarded. As the fishery grew, the trawlers fished primarily for croaker. Some vessels were modified to handle heavier nets and increase the cargo capacity. Alabama landings rose from 47mt in 1967 to 6,000mt in 1973. There were approximately 26 vessels in the fleet in 1973 (Juhl 1974).
>
> The principal fishing ground for large croaker is near Southwest Pass, Louisiana, in nine to 37 m. Some trawling also occurs off Mississippi. Trawling takes place year round and generally occurs in deeper water during fall, winter, and spring. Drag time varies from 20 minutes to three hours. After the net is hauled aboard and emptied on deck, the catch is sorted to separate croaker, other edible species, and shrimp. Undersized croaker are thrown overboard. Sorting of croaker into categories of large, medium, and small occurs on shore. Juhl (1974) found that the size distribution of trawl-caught croaker was as follows: large, 18 percent; medium, 29 percent; small, 26 percent; and discards, 27 percent."
>
> GMFMC 1980

The food fish croaker boats were initially traditional shrimp trawlers but grew to be larger boats with larger trawls as the fishery expanded. Food fish trawlers never utilized the techniques of the Groundfish fishery because of the need to keep fish in top condition. As a result they towed a larger mesh net and employed shorter tow times. Fish were immediately iced, unlike the Groundfish boats which pumped the catch into RSW [refrigerated sea water] (Gutherz 1976).

Although anecdotal, Schultz (personal communication) suggested that large croaker primarily occurred around the mouth of the Mississippi River; "Once you get about 20 miles west of the Pass, you just didn't see them." Schultz and other croaker fishermen believed that the large fish were up in the rivers and stayed there most of their lives and large croaker would only come out when the river flooded.

> "The rivers run different today. Back then, you rarely saw saltwater at the bottom in the passes, you had a lot more freshwater coming down river which kept the salinities lower, very little saltwater

intrusion. You don't see those large croaker any longer and they just don't come out. Those fish were available all the way to 60 fathoms when the fish came out primarily in the spring. When the summer riverflow went back down, the croaker moved back up the rivers and they couldn't get them any longer."

Schultz (personal communication)

In 1973, at the height of the fishery in Alabama, 26 trawlers were landing croaker for the fresh fish market, but by 1976, only three full-time vessels remained (GMFMC 1980). This decline was in part due to competition from croaker harvesters in North Carolina; additionally, the prices for food croaker were highly variable. In Bayou La Batre, fish were wholesaled through New York's markets, but Gulf suppliers could not count on consistent demand and value for the product once it shipped, so the fishery declined but persisted locally as a source of cheap fresh fish product (Austin et al. 1978). In addition to trawlers, there were a number of 'snapper' boats that encountered croaker as bycatch while fishing near the oil rigs off the Mississippi Delta. These snapper vessels relied on mechanical fishing reels and would fish deep water with up to 20 hooks on a single line. Swingle (1976) indicated that while encounter rates were frequent, the magnitude and actual contribution of croaker landings from the snapper boats was unknown. Croaker landed by the snapper boats were generally consistent in size and boxed for shipment out of Bayou La Batre, Alabama, lending to the high landings from that state.

Traditional entangling net fishermen (gill nets, trammel nets, strike nets, etc.) landed large croaker routinely throughout Alabama, Mississippi, and Louisiana (GMFMC 1980). Entangling nets were fished in relatively shallow water and they fished the whole water column. Entangling nets provided an average of 400,000 lbs of croaker annually during the 1970s, but were a minimal contributor compared to other gear such as trawls (NOAA unpublished data, Figure 6.5). Records indicate the use of gill and trammel nets for fishing croaker in Big Lagoon, Alabama and Pensacola Bay, Florida until about 1975 (Austin et al. 1978).

During the operation of some of the pet food plants in Mississippi, significant culling occurred as Groundfish were separated from larger and more valuable food fish which included large croaker, flounders, and trout (Overstreet personal communication). Factories processed the large croaker as a gutted frozen product which was boxed and exported from the Gulf to markets in the Northeast as far as New York and the Chesapeake (Overstreet personal communication). Atlantic croaker landings from Alabama and Florida continued well after the pet food industry ceased, with volumes between 7.0M and 1.2M from 1971-1981 and a maximum of around 14.0M lbs in 1974 off Alabama (Figure 6.6A and B). Fish were clearly identified as 'Atlantic croaker' in NOAA landings and were not a combination of Groundfish, unlike the landings in the pet food industry.

Croaker for minced surimi product began in the early 1970s in order to supply more product to the Japanese markets overseas (Juhl 1974). Small croaker were harvested during the late fall and winter by medium sized trawlers as shrimp fishing slowed down. The fleet consisted of about 40 vessels which averaged 75ft in length (Juhl 1974). The larger trawlers (averaging 95ft) were fewer, but supplied most of the industrial fish detailed above (Juhl 1974). According to NOAA reports, the NMFS seafood marketing program at the Pascagoula Lab attempted to build interest in developing a surimi market, sending test samples to a Japanese processor (USGAO 1976). There were already some frozen breaded products utilizing coarsely minced croaker mixed with minced shrimp in the domestic market (King 1977), but eventually the interest in pursuing croaker in the Gulf declined as fewer large fish were available in the population. Austin et al. (1978) reported that the minced fish and surimi markets were limited by the equipment used to head and gut fish, which could only process fish over six inches, and that only about 30% of the Groundfish landed by the fleet qualified for minced fish processing.

Live Bait Fishery

In the last 15 years, a significant bait industry has developed which targets Atlantic croaker juveniles of various sizes for use as live bait in a number of recreational fisheries. In Texas in particular, this industry has rapidly expanded in size and value (Figure 6.7). Traditional bait shrimp trawlers have begun changing

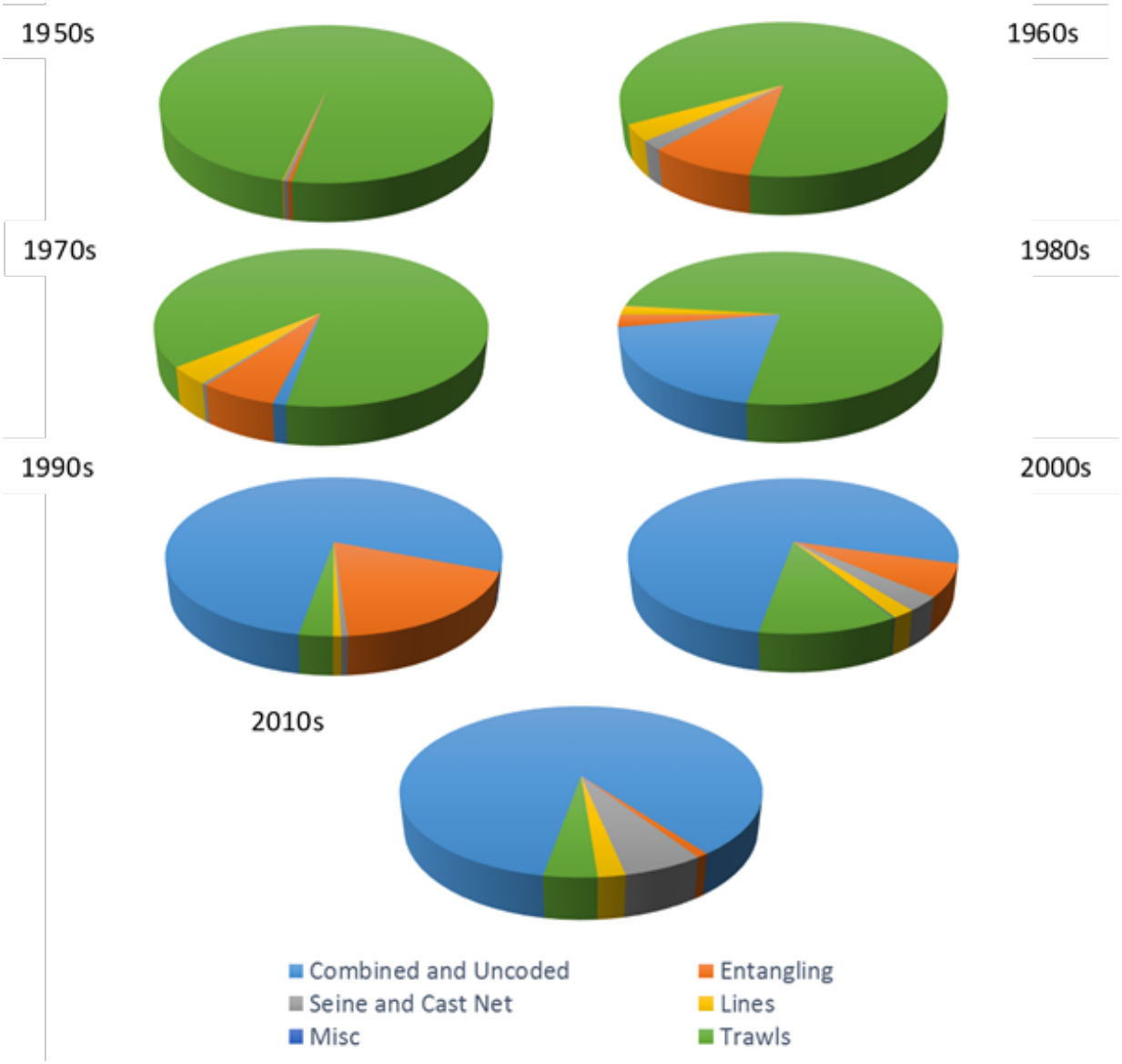

Figure 6.5 Major commercial gears (combined by similar type) landing croaker by decade (1950-2015) from the U.S. Gulf of Mexico. **Note:** the "Combined and Un-coded" gears were likely trawls which landed croaker in Texas as bait throughout the 1990s and 2000s (see Live Bait Fishery).

their techniques to allow for their maximum bycatch allowance to be filled by young croaker. Bait trawlers sell their catch to bait houses which in turn sell these live croaker to anglers on an individual fish basis. In some places, live Atlantic croaker are selling for as much as $12.00/dozen. The increase in overall commercial values in Louisiana and Texas for Atlantic croaker are attributable to the demand for live bait.

Anglers fishing for a variety of species seek out croaker of specific sizes (Sink 2011). In Florida, spotted seatrout and flounder (*Paralichthys* spp) anglers desire live croaker in the 5.0-7.5cm range while 10-15cm croaker are utilized for red drum and snook (*Centropomus undecimalis*) (Ohs et al. 2013). Those anglers targeting offshore snapper/grouper and pelagic anglers prefer croaker in the 15.5-20.0cm size range (Ohs et al. 2013). The bait 'season' is short however as juvenile croaker grow through the size windows making them more or less valuable (Sink 2011). One dealer in Texas indicated that guides around the mid-Texas Coast prefer smaller 'four-inch' (≈10cm) croaker available in June and July to target spotted seatrout between 2-3lbs (VanderKooy personal communication). Along the southern Texas Coast, guides prefer slightly larger croaker to target much larger trout in the 4-5lb range.

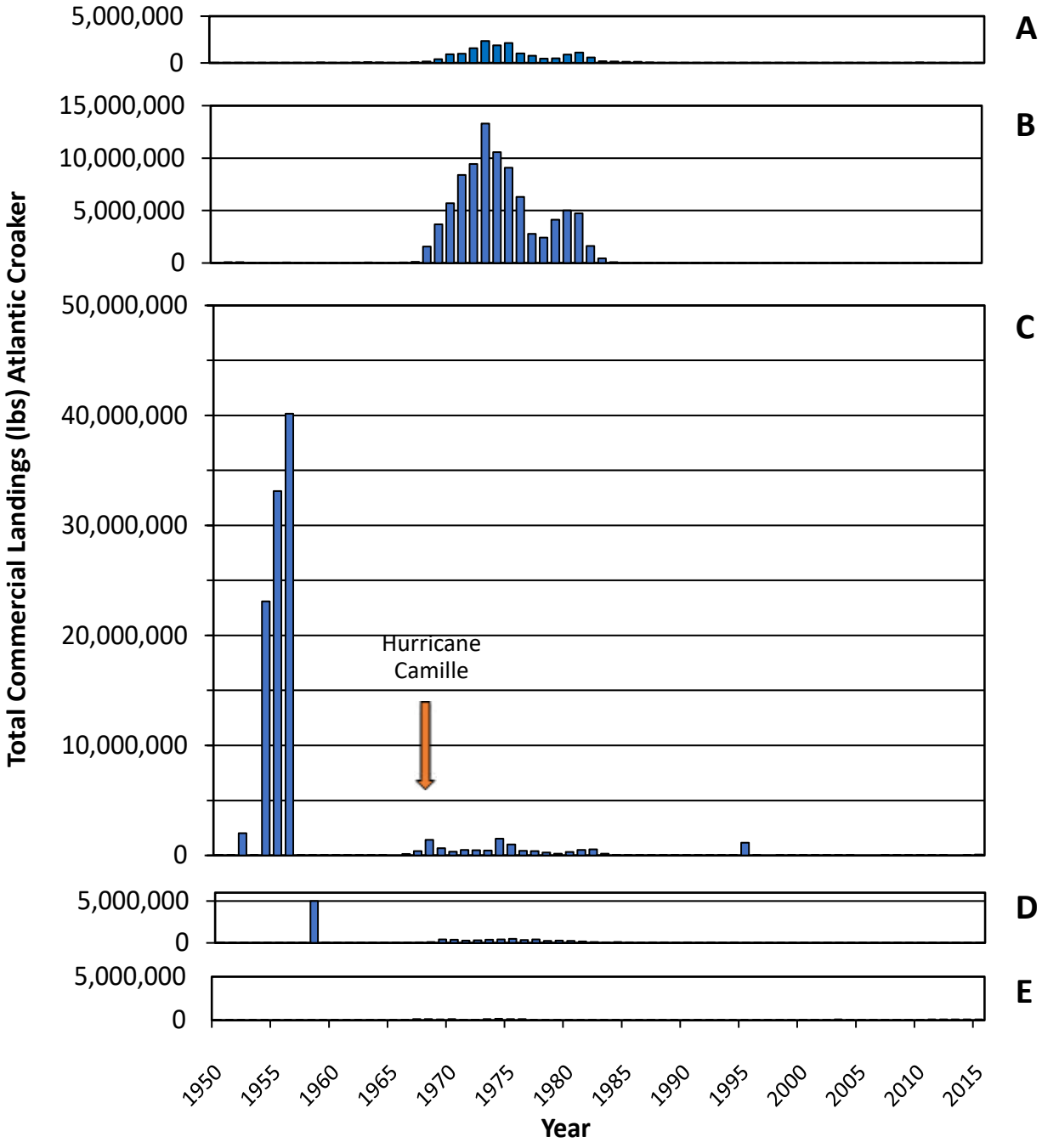

Figure 6.6 Individual state landings (lbs) of 'Atlantic croaker' from 1950 to 2015 for A) West Florida Coast, B) Alabama, C) Mississippi, D) Louisiana, and E) Texas (NOAA unpublished data).

The croaker live bait fishery seems to have started along the mid-coast of Texas. Some anglers theorize that spotted seatrout 'hate' croaker because they target seatrout eggs specifically and therefore are the ultimate bait (Pustejovsky 2007, Jones 2013, Kent 2014). The live bait industry began targeting juvenile croaker as recreational fishing guides and anglers began asking for them in the late 1990s (VanderKooy personal communication). Shrimpers began retaining croaker to meet the requests but had trouble keeping them alive. As a result, shrimpers began making shorter drags in an effort to prevent damage to catches of croaker. Juvenile croaker were immediately placed into live boxes and culled to only include the four inch fish.

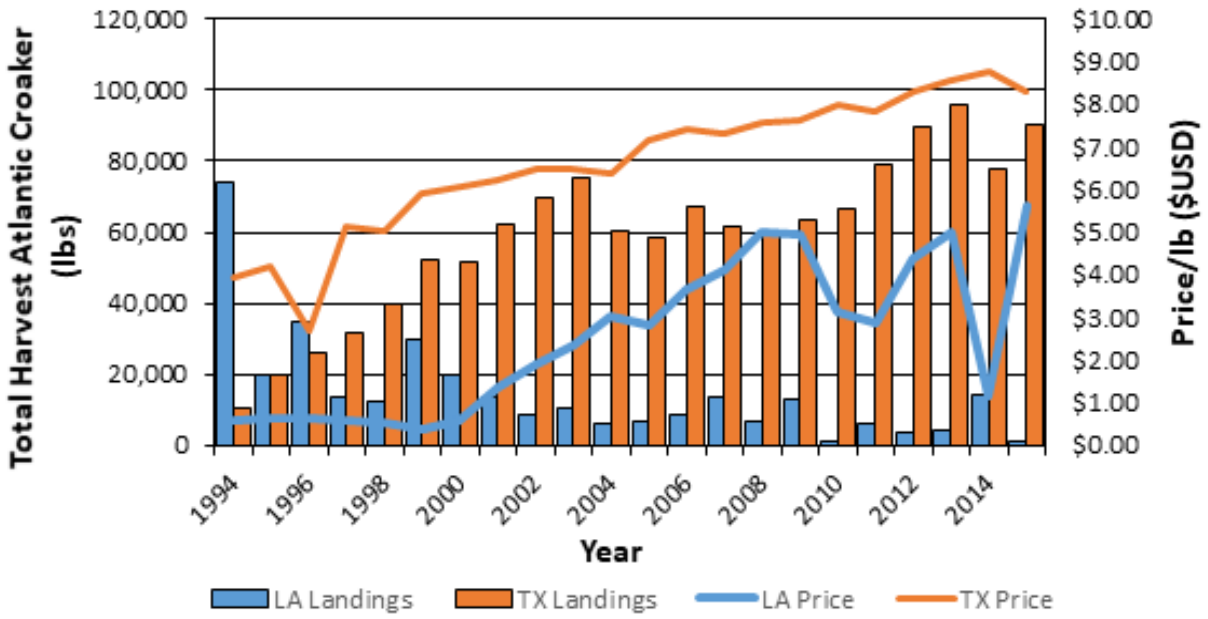

Figure 6.7 Annual Atlantic croaker landings (lbs) and price per lb ($USD) in Louisiana and Texas from 1994 to 2015 (NOAA unpublished data).

The boats targeting croaker for live bait today do not use the small inshore nets typically associated with the traditional live shrimp fishery. Live croaker trawlers utilize 25-35ft nets and only drag for less than 15 minutes (VanderKooy personal communication). In the Galveston, Texas area, there are only two boats operating but across the entire state, anywhere from 10 to 15 boats target live croaker (VanderKooy personal communication). Bait boats that target croaker do not target live shrimp; they seem to fish for croaker exclusively in spring and early summer when small fish are abundant. The boats targeting larger croaker for the Texas red drum fishery and the offshore reef fish fishery continue to trawl later into the summer. There are essentially three different bait categories for live croaker in Texas: small croaker which are used to fish for spotted seatrout inshore, medium croaker which are fished off the jetties, and large 'sow croaker' which are fished for snapper and grouper at midwater over reefs and along structures (VanderKooy personal communication).

Outside Texas and the most western part of Louisiana, there is much less demand and interest in live croaker as bait. In an informal survey, a number of bait shops in Mississippi, Alabama, and Louisiana were contacted and asked about sales of live croaker (Hode personal communication). In general, croaker were very seasonal as a live bait and if they did not sell immediately, they experienced almost total mortality in tanks (Hode personal communication). For most shops contacted, even though croaker were available during certain times of the year, they were not exceptionally profitable considering the amount of effort required to keep them alive. It is possible that there could be a higher demand during short windows of time when specialized recreational fishing tournaments occurred, but there is no way to generate a link using commercial landings data and tournament calendars (NOAA unpublished data). In Texas, several bait dealers rebuilt and configured their tanks to specifically keep croaker alive longer (Ferguson personal communication). In addition, these dealers have developed special refrigerated fish haulers to move croaker from the northern coast to dealers further south where summer temperatures would normally kill the fish during transport (Ferguson personal communication).

State Commercial Fisheries

West Florida Coast

Commercial harvest of Atlantic croaker on the West Florida Coast occurs in both state and federal waters; however, the waters where the majority of the landings originate has fluctuated over time. In the

1980s, landings primarily were harvested from state waters but, from 2010-2014, the majority of harvest occurred in federal waters (FWC personal communication). Atlantic croaker became a hot commodity in the early 1970s, with peak landings occurring in 1973 at about 2.4M lbs (Figure 6.6A). Harvest remained high for the next couple of years before declining to 500,000lbs in 1978. There was a small burst of landings in 1980 and 1981 with just over 1M lbs harvested; however, landings plummeted thereafter and have remained low (NOAA unpublished data).

During the 1970s, the canned pet food industry became the primary user of Groundfish of which approximately 69% were Atlantic croaker (Figure 6.2A). Other uses included fishmeal and the Surimi industry (GMFMC 1980, Lassuy 1983). At that time, Florida's Atlantic croaker fishery in the Gulf was centered on Perdido Bay and the fish were sold predominantly in Escambia County; landings regionally remain similar through today (Figure 6.8 and 6.9; Lassuy 1983, FWC personal communication). In an environmental impact statement report from the Navy regarding Pensacola, Florida (U.S. Navy 1986), it was indicated that as much as 36% of all the croaker landed in Florida from 1980-1985 originated from Escambia County alone.

In the 1970s, and still today, Atlantic croaker have no harvest limits for the commercial fishery. The Net Limitation Amendment (Amendment) to the Florida Constitution, implemented in 1995, prohibited the use of gill and entangling nets in state waters and limited the use of all nets in nearshore and inshore waters to no more than 500ft^2 of mesh area, but these limitations were implemented two decades after the aforementioned industries had diminished. Prior to the Amendment, gill nets were the primary gear used to catch Atlantic croaker. After implementation of the Amendment in 1995, trawls landed the greatest amount of Atlantic croaker in West Florida. The number of wholesale dealers buying Atlantic croaker drastically decreased in 1995 and has remained low, averaging around 30 annually.

When compared to historical landings, the total commercial harvest of croaker has declined significantly from around 2.4M lbs in 1973 to around 25,000lbs in the years between 1990 and 2000 (Figure 6.6A). Despite the decline since the height of the fishery, the Panhandle counties (Escambia-Gulf County) have continued to account for the majority of the commercial landings on the West Florida Coast, averaging just over 40,000lbs annually (Figure 6.9).

Atlantic croaker are harvested commercially year round on the West Florida Coast, but the harvest peaks in April and July, with another slightly lower peak in the fall (NOAA unpublished data; Figure 6.10).

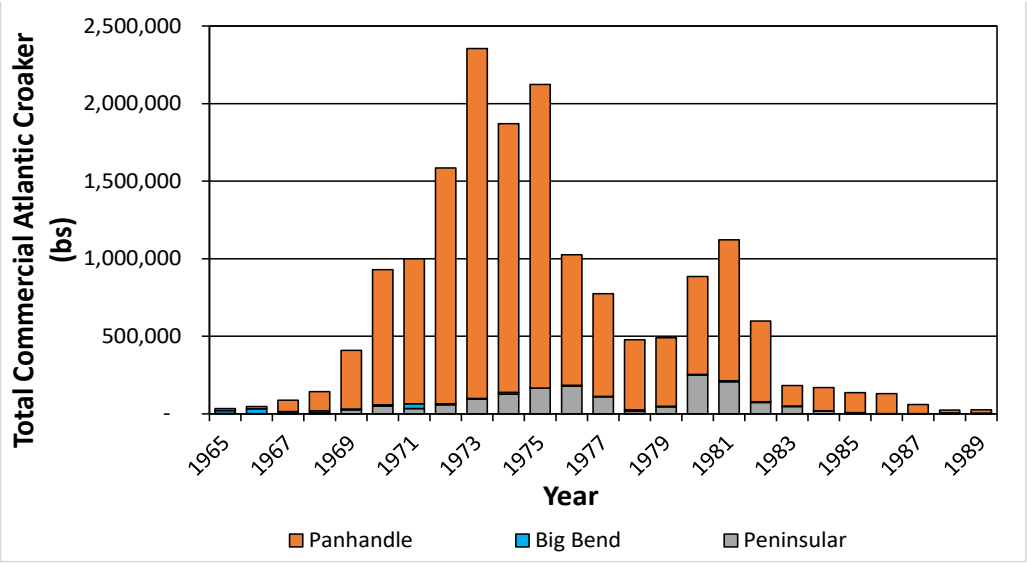

Figure 6.8 Total landings of Atlantic croaker in the three regions of the West Florida Coast (Panhandle [Escambia-Gulf County], Big Bend [Franklin-Levy County], and Peninsular [Citrus-Monroe County]) from 1965-1989 (FWC personal communication).

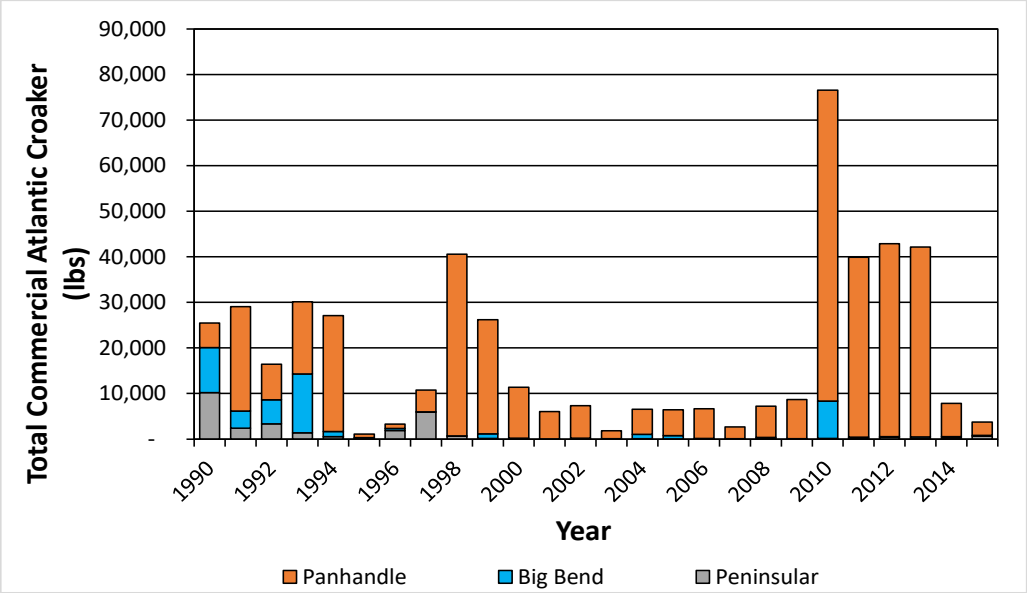

Figure 6.9 Pounds of Atlantic croaker landed in three regions of the West Florida Coast (Panhandle [Escambia-Gulf County], Big Bend [Franklin-Levy County], and Peninsular [Citrus-Monroe County]) from 1990-2015 (FWC personal communication).

Alabama

In Alabama waters, a license is required to commercially land Atlantic croaker. Alabama laws and regulations regarding the commercial harvest of Atlantic croaker are very limited. Alabama has never had any minimum size limit or bag/possession limit for commercially caught Atlantic croaker. Seafood dealers are required to report Atlantic croaker landings even if using them for bait. Live bait dealers are not required to report landings however.

Atlantic croaker commercial landings in Alabama peaked from 1967-1982, with an average of 5.9M lbs landed annually (Figures 6.2B and 6.6B). These landings coincide with the emergence of a trawl fishery for edible croaker which began in 1967. The fishery was highly developed in Alabama but not as robust as in other Gulf states (Swingle 1977). From 1964-1971, the number of seafood processing and wholesale

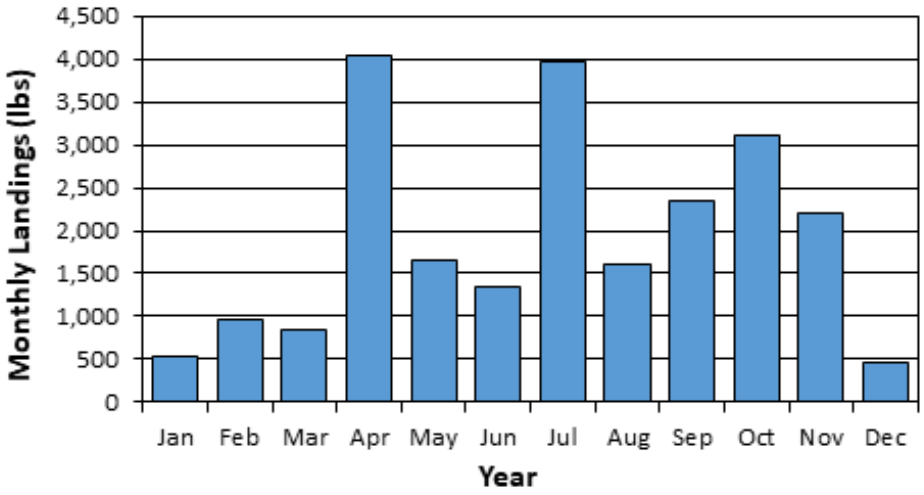

Figure 6.10 Average monthly commercial harvest of Atlantic croaker on the West Florida Coast (1990-2015) (NOAA unpublished data).

plants ranged from 56-70, and the number of fishermen engaged in the food fish industry ranged from 1,733-2,290 (Swingle 1976). From 1969-1982, at least 50% of the total annual Gulf landings of Atlantic croaker were landed in Alabama (Figure 6.6B). The highest recorded landings year was 1973 in which 80% of the 16.6M lbs landed in the Gulf were landed in Alabama (NOAA unpublished data).

In 1973, at the height of the fishery in Alabama, 26 trawlers were landing croaker at Bayou La Batre processors (GMFMC 1980). After 1973, landings declined dramatically (Figure 6.6B). By 1976, only three full-time vessels remained fishing for edible croaker (GMFMC 1980). Alabama croaker were wholesaled through New York's markets but Gulf suppliers could not count on consistent demand and value for the product once it shipped so the fishery became a minor component of Alabama's landings and became a local inexpensive fresh fish product (Austin et al. 1978). The decline can also be attributed to competition from increased landings in North Carolina (GMFMC 1980). Another reason for the decline in croaker landings could be competition with the shrimp industry. The same boats that fished for croaker, fished for shrimp. When it was more profitable to catch shrimp, the vessels switched to shrimp fishing. The significant decline in landings in 1977-1978 (Figure 6.6B) was due to a significantly high abundance of shrimp during those years (Austin et al. 1978). Operating expenses could have also contributed to the drop in Atlantic croaker landings.

A report by Summey (1979) summarized the history of Alabama supplying most of the croaker to fresh fish dealers in North Carolina, at least through 1974. Summey (1979) indicated that, while local croaker were preferred by dealers, when local supply was low, Alabama fish were purchased as a 'fresh iced' product and delivered to North Carolina dealers along the main interstate (I-85). The majority of these croaker were for home consumption and not restaurants according to a market survey. They were so popular that croaker generally out-competed flounder for consumer preference (Summey 1979). North Carolina dealers were impressed with the consistency of the croaker and the professionalism coming from their Alabama sources. However, the availability of croaker as a 'local product' eventually eliminated the need for an 'out-of-state' (Alabama) source for croaker. Summey (1977) noted that croaker brought in from elsewhere

> "has a noticeably different flavor when caught in different waters. The Alabama or Gulf Coast croaker has a higher iodine content than the North Carolina croaker and consequently has a somewhat different flavor."
>
> Summey 1977

Warren and Griffin (1980) examined the landings of croaker in the Gulf and noted that the food fish market driven by the Alabama fleet began to lose the North Carolina component as their own fleet increased croaker production fourfold from 4.0-19.0M lbs from 1974-1977. Their report further explains that:

> "With recent increases in production, North Carolina and other east coast states have been able to meet the requirements of the east coast food fish market. Given that these fisheries possess a considerable advantage over Alabama in transportation costs, Alabama producers are effectively excluded from the market except for very limited and sporadic quantities to meet temporary shortages in the east coast and northeastern markets."
>
> Warren and Griffin 1980

The Bayou La Batre trawl fleet switched back to shrimping as North Carolina no longer purchased croaker, only landing fish as incidental catch (Warren and Griffin 1980). In addition to croaker in its 'whole form', Austin et al. (1978) indicated that other 'value added' attempts were made in Alabama to utilize croaker. They reported that a breaded product made of mixed croaker and shrimp pressed into a 'shrimp shape' was produced in Bayou La Batre until the company went out of the business due to quality control issues. Since the decline of the trawl fishery for edible croaker, the commercial landings declined from a few hundred thousand pounds in 1983 to less than 20,000lbs in 1986. From 2002-2010, the Atlantic

croaker landings declined to less than 2,000lbs per year. Since 2010, Atlantic croaker landings in Alabama have been virtually non-existent (Figure 6.6B).

Mississippi

The story of croaker fishing in Mississippi is a history of the pet food industry as detailed above. Commercial landings of Atlantic croaker varied widely reaching nearly 40M lbs in 1956 and as much as 15M lbs in the mid-1970s (Figures 6.2C and 6.6C). It is difficult to separate the landings of food fish versus landings for the pet food industry, but combined, the totals averaged around 80M lbs in Mississippi for the 20 years from 1956-1975.

Increasing numbers of landings classified as "Atlantic croaker" in Mississippi were specifically identified in the commercial harvest from 1954-1956 as part of the early developing pet food industry (Figure 6.6C). It is believed, however, that Atlantic croaker landings were more correctly classified within the aggregate of Groundfish landings, identified by NOAA as *Finfishes, UNC Bait and Animal Feed* starting in 1957. Croaker were suspected to comprise as much as 50-70% of that species group (Roithmayr 1965, Gutherz et al. 1975). Early landings of fish labeled 'Atlantic croaker' were likely a part of aggregate landings which ranged from over 90M lbs in 1957 to around 87M lbs by 1976, and then disappeared from Mississippi altogether (Figure 6.2C). As a result, both landings categories must be considered when examining the total impact commercial fishing had on Atlantic croaker in Mississippi. A decline in Groundfish landings in 1969 was the result of Hurricane Camille which devastated the Mississippi Coast in August of that year (Figures 6.2C and 6.6C).

As pet food plants in Mississippi began decreasing their reliance on croaker for pet food production, commercial landings of croaker declined to a few hundred thousand pounds by the early 1980s and to less than 20,000lbs by about 1990 (Figure 6.2C). With the exception of 1995, commercial landings of croaker since 1991 have been virtually absent. During a single year, in 1995, 1.1M lbs of 'Atlantic croaker' were reported landed at a value of almost $70,000. It is unclear where these landings originated and for which part of the market they were intended. MDMR staff speculate that this may have been a single harvest for a single year of operation of a pet food company which then left the Gulf shortly after restarting production, though this is not confirmed. Since 2000, so few croaker have been landed commercially in Mississippi that most of those data are considered confidential and harvest of croaker is most likely incidental during other fishing activities such as shrimping (NOAA unpublished data, MDMR unpublished data).

While the canned pet food industry continued consolidating plants into a single plant in Pascagoula by 1992, the harvest of Groundfish for canning also significantly declined. According to Mr. Ned Hogg, a former plant engineer for Ralston Purina, after the Heinz Company purchased the Pascagoula plant in 1988, they refurbished the fish processing equipment and continued purchasing fish from the remnant Biloxi croaker boat fleet which was still owned by the Mavar family (Hogg personal communication). The various pet food formulas at this point were a combination of protein sources from fish, as well as chicken and beef by-products, and grains. Hogg (personal communication) indicated that Heinz soon eliminated wild caught fish from their *Alpo* line of cat and dog food products so much so that the fleet ceased fishing for croaker around 1994.

Louisiana

Atlantic croaker have been a relatively small portion of the commercial landings in Louisiana historically, although many of the Groundfish which supplied the pet food industry were actually harvested from Louisiana waters and landed in Mississippi (Figure 6.2C and D). A single year of very high commercial landings identified as Atlantic croaker (almost 5.0M lbs) is likely associated with a small canning operation in Golden Meadow. Unen Products opened in 1967 to make pet food for Lipton Pets under the *Tabby Cat* label (Austin et al. 1978; Figure 6.2D). In addition to those fish identified as Atlantic croaker, several million pounds of additional fish were landed annually in Louisiana from 1958-1977 (the duration of the pet food plant) which were included in Groundfish, similar to how landings were reported in Mississippi

(Figure 6.2D). Those Groundfish landings were comprised of an aggregate in which croaker made up 50-70% of the total (Roithmayr 1965, Gutherz et al. 1975).

There are reports that some Groundfish were landed around Dulac, Louisiana for the reduction and fish meal markets (Juhl et al. 1975). The majority of Louisiana's 'Atlantic croaker' landings occurred from 1969 until the early 1980s with around 90% of those fish being landed from the trawl fishery. There were also reports of large croaker being commercially harvested from Lake Pontchartrain for the food fish market (GMFMC 1980). Since 2000, less than 8,000lbs on average, have been landed annually in Louisiana (Figure 6.6D). One newspaper article from the Times Advocate (1977) describes a venture to develop a pilot plant in Golden Meadow, Louisiana to process "20 tons of fish [croaker] meat a week to be frozen into blocks for shipment to Japan for further processing". It is unclear whether the 'fish paste' plant ever materialized however. The *Tabby Cat* operation in Golden Meadow ceased production in 1978 (Table 6.1).

Since 2010, the LDWF has been reporting landings of croaker for live bait from licensed dealers. Bait landings are reported in numbers of fish, not pounds. There is little information to quantify the extent of the commercial live bait harvest in Louisiana at this time. Differentiating commercial landings for use as bait from those being sold as food fish when not identified specifically as live bait, is difficult. While the market for Atlantic croaker as a food fish in Louisiana is very small, some do occasionally appear in fish markets; however, market is generally driven by incidental catch.

Texas

Atlantic croaker in Texas were landed commercially in small numbers prior to the early 1960s (Figure 6.6E). Similar to the other Gulf states, Austin et al. (1978) suggested that the majority of the Texas landings moving into the 1970s originated from snapper boats which harvested them incidentally around petroleum structures or targeted large croaker when red snapper were less available. Unlike the other states, commercial croaker landings in Texas have never reached the magnitude of the landings as the rest of the Gulf. However, since about the late 1990s, there has been a steady increase in the reported landings of Atlantic croaker in Texas, which far surpass the landings from Alabama, Mississippi, and Louisiana for the same time period. Recent landings for the West Florida Coast are similar to the quantity of croaker currently landed in Texas.

Additionally, there are a number of fish reportedly landed in Texas that were part of the *Finfishes, UNC Bait and Animal Feed* fishery (Figure 6.2E); however, it is not clear if those fish were part of the Groundfish fishery or some other industry. Reporting of that category in Texas has been persistently low through the years, unlike the neighboring states of Louisiana and Mississippi which stopped reporting the category at all after the mid-1970s.

The increase in Atlantic croaker landings in the late 1980s is believed to be directly tied to the availability of live croaker at bait shops along the upper and middle Texas Coast (Ferguson personal communication; Figure 6.11). By the 1990s, the number of saltwater anglers in Texas began to increase as did the demand for live croaker and, as a result, so did harvest by bait dealers. The value of those landings has skyrocketed in recent years, increasing from around $0.30/lb in the early 1990s to over $9.00/lb today dockside. The average size of live croaker for bait in Texas is approximately four inches which is around 33 individual croaker/lb (Figure 6.12). The current cost for live croaker in Texas is around $12.00/dozen. Since 1994, nearly all commercial landings of Atlantic croaker in Texas were destined for the live bait market (Figure 6.12).

Recreational Fishery

Today, very few recreational anglers 'target' Atlantic croaker due to the infrequent occurrence of large individuals. Historic croaker runs no longer occur for anglers to target possibly due in part to the high mortality associated with the commercial Groundfish fishery and bycatch in the shrimp trawl fishery

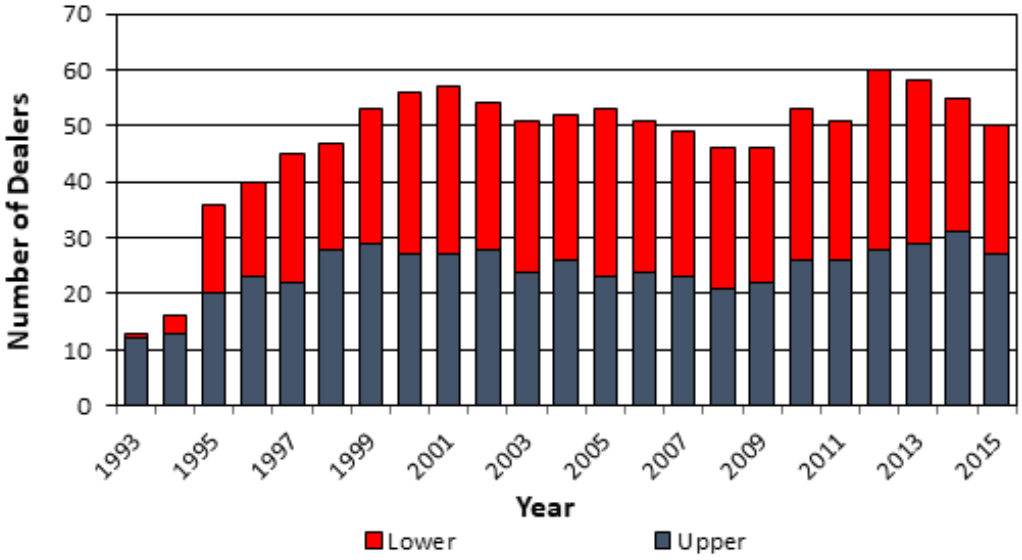

Figure 6.11 Total number of bait dealers in the upper coast (Sabine – San Antonio Bay) and the lower coast (Aransas Bay – Lower Laguna Madre) Texas selling live croaker (TPWD unpublished data).

(Roithmayr 1965, Gutherz et al. 1975, Tompkins 2013). Anglers, from the late 1950s through the early 1970s recall that croaker could easily reach two pounds or better (Pustejovsky 2007, Jones 2013, Kent 2014). Compared to more popular, high profile species like spotted seatrout (*Cynoscion nebulosus*), Atlantic croaker are an almost negligible component of the total recreational catch in the Gulf (Figure 6.13). Since 2000, the number of anglers who indicated that they were making trips targeting Atlantic croaker in the Gulf of Mexico as a first or second priority was almost 175 times less on average than those making trips targeting spotted seatrout. However, croakers have gained popularity by recreational anglers as a live bait in certain regions, specifically for targeting trophy size spotted seatrout. Their use has even become somewhat controversial in some areas due to their perceived effectiveness (Ferguson 2016).

State records from the region suggest Atlantic croaker are capable of achieving sizes ranging from 4-8lbs (Table 6.2); however, the recreational catch data collected by NOAA from 1981-2015 indicate

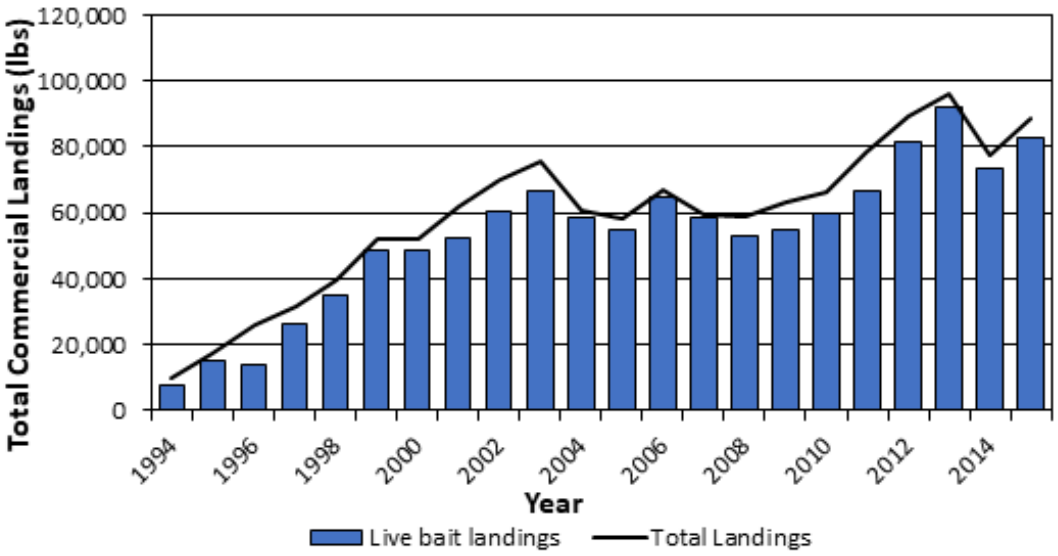

Figure 6.12 Total commercial landings of Atlantic croaker and total live bait landings (lbs) in Texas waters (TPWD unpublished data).

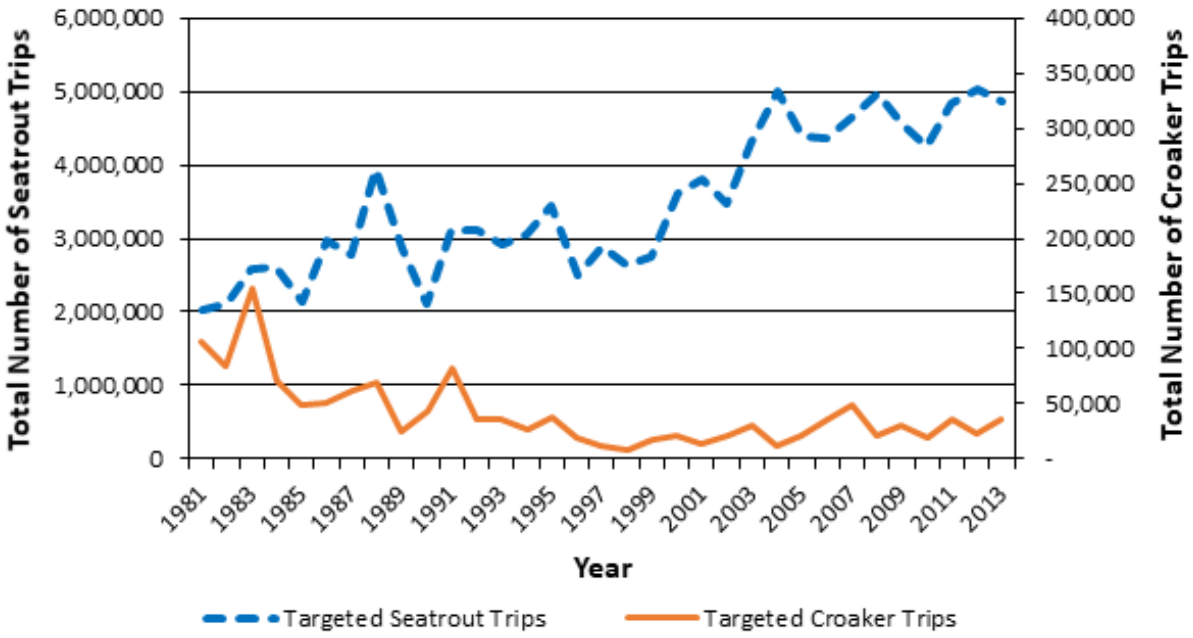

Figure 6.13 The total number of fishing trips for spotted seatrout (left axis) and Atlantic croaker (right axis) in the Gulf from 1981-2013 excluding Texas (NOAA unpublished data).

a yearly average size of the few fish that are retained by anglers is around 2-3lbs (NOAA unpublished data). The total recreational harvest has continually decreased over the last 30 years from 3.5M lbs down to 500,000lbs by 2013 (Figure 6.14). Several factors may have contributed to the decline in interest of croaker in our region.

One factor is the perception in the Gulf region that croaker are viewed as 'trash' fish, as noted by Gunter (1956) during the origins of the shrimp and Groundfish fisheries. Most anglers kept decent sized croaker and some targeted them; however, as more opportunities opened to fish for a wider variety of species, croaker may have been down-graded in angler perception to a 'poor man's fish' similar to black drum (*Pogonias cromis*), sand seatrout (*Cynoscion arenarius*), and silver seatrout (*C. nothus*) (Leard et al. 1993, VanderKooy 2001). In general, there is a dichotomy of recreational fishing between subsistence fishermen and sport anglers. For this document, 'subsistence' fishing is defined as fishing that uses simple fishing techniques to capture fish to feed family and relatives of the fishermen while 'sport fishing' is defined here as fishing that is for enjoyment and competition. Little has been done to document the social and economic motivations/context of the Atlantic croaker subsistence and sport fisheries, however, Fedler and Ditton (1994) reviewed a number of published studies which attempted to describe the 'motivation' for recreational anglers in general. They reported that, among shore-based anglers for black drum in Texas, consumption was the highest motivation. Conversely, consumption was the lowest motivator in tournament billfish anglers. These motivations likely represent the two extremes of recreational fishing at every level (investment, time, skill, etc.) of the angler populations examined; therefore, there is likely high overlap between the 'subsistence' and 'sport' Atlantic croaker fishery in the Gulf of Mexico.

Another potential factor contributing to the reduced recreational harvest of Atlantic croaker in recent years may be the intense focus on reef fish, rather than a wider variety of species when fishing around the Gulf's oil and gas platforms offshore. Most of today's sport anglers are interested in the highly prized reef fish such as red snapper (*Lutjanus campechanus*), gray triggerfish (*Balistes capriscus*), cobia (*Rachycentron canadum*), and a variety of grouper species, and may be ignoring benthic species such as various drum and croaker which also occupy the structures (Adkins et al. 1990, Stanley and Wilson 1991). In addition, the increased management and stocking efforts of other inshore species like red drum and spotted seatrout have led to increases in those populations over the last several decades. Hence, the

Table 6.2 Current Atlantic croaker state recreational saltwater records for the Gulf of Mexico and the current IGFA World Record (IGFA 2015).

State	Year	Record Holder	Weight
Florida	Dec 2002	A. de Foster	4lbs 15.0oz
Alabama	Sept 1994	C.N. Billings	4lbs 0.0oz
Mississippi	Sept 2012	M. Glenn	5lbs 1.0oz
Louisiana	Aug 1972	D.J. Bertrand	8lbs 0.0oz
Texas	Apr 2002	P. Straw	5lbs 7.5oz
IGFA World Record Virginia	2007	N. Jenkins	8lbs 11.0oz

availability of species that are often seen as more desirable may have impacted catches in areas that were traditionally croaker fishing areas (Hode personal observation).

Decreased interest in croaker as a target species may also be due to changes in the availability of fishing opportunities in the form of affordable fishing vessels to the general public. Dugas et al. (1979) described the changes to fishing opportunities off Louisiana between 1940 and 1980. Historically, very few people had access to offshore areas. The anglers who could afford it utilized small boats with minimal horsepower, while others were relegated to fishing from shore. Dugas et al. (1979) point out that in the 1940s, offshore fishing was essentially non-existent. There were few charter boats large enough to handle the offshore waters and there were few petroleum based platforms to target on trips. At that time, few anglers owned vessels capable of fishing in offshore waters and the majority of trips made to the 'oil rigs' were aboard charter boats even until the late 1970s. The U.S. Coast Guard tracks the number of registered vessels throughout the U.S. and in 1980, there were approximately 8.58M registered recreational vessels throughout the U.S and that number reached 12.94M by 2005 (USCG 2011, USCG unpublished data).

History

Early accounts of croaker fishing around the Gulf include references about their abundance as a food

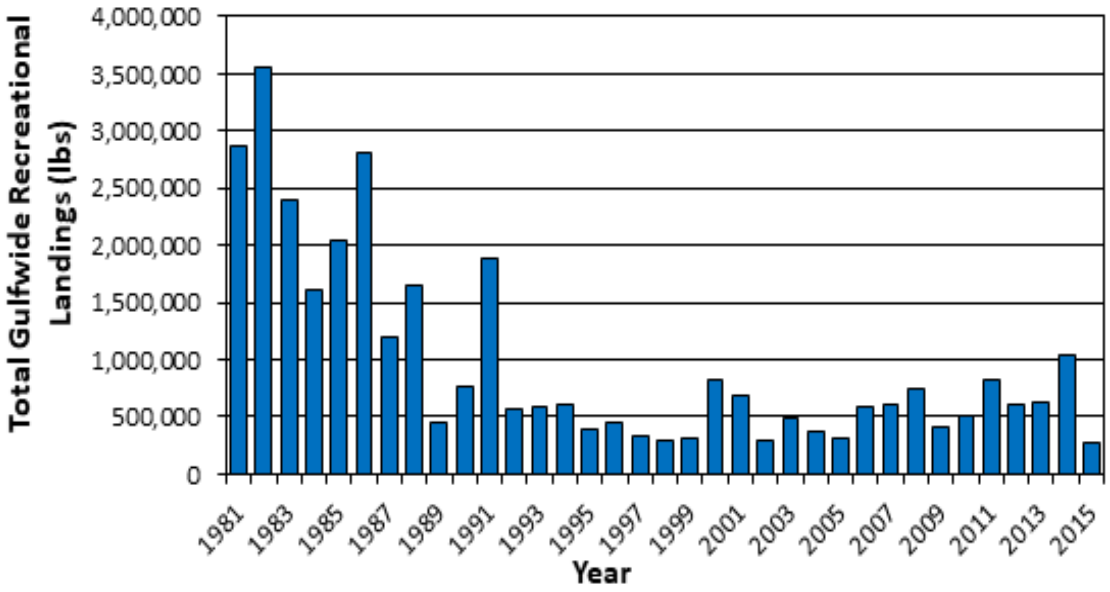

Figure 6.14 Total recreational Atlantic croaker landings (lbs) in the Gulf of Mexico from 1981-2015 (NOAA unpublished data). **Note:** landings exclude Texas (all years) and Louisiana for 2014/2015.

fish for tourist anglers in Florida (Hallock 1876). Hallock noted in his *Handbook for Sportsmen and Settlers* that croker (*Micropogon undulatus*), were

> "…small, pan fish, which can be taken in vast numbers in the bays and creeks, but the larger species being numerous few persons seek for these, though they are all nice eating."
>
> Hallock 1876

Despite their excellent flesh, Atlantic croaker have always been an underappreciated fish by most people in the Gulf region (Overstreet personal communication, Bozka 2005). With few exceptions, most Atlantic croaker landed in the Gulf of Mexico by recreational anglers are either incidental to other target species such as red drum and spotted seatrout or caught by subsistence anglers with no target species. Ditton et al. (1990) reported on recreational angler preferences in Texas waters and noted that croaker, while not in the top five, were on the list of alternate species with around 4% of survey respondents listing them as their third choice. In a Louisiana creel survey, Adkins et al. (1990) found that in 1984, 50% or more of recreational anglers preferred red drum and spotted seatrout but croaker were in the top five most desirable species, comprising 75% of the total catch surveyed. They also noted that in estuarine passes and the Gulf proper, croaker were the second most abundant species captured behind sand and silver seatrout and that croaker were kept by anglers 69% of the time.

In Texas, anglers often referred to the fall run of Atlantic croaker as 'golden croaker' because of their spawning coloration (Bozka 2005). The run around Galveston occurred in mid-October through early November as mature fish began moving through the passes en route to spawning grounds offshore (Bozka 2005). In other regions, anglers reported heading to the water to target large croaker as soon as the baseball World Series opened, which was coincidental with the movement of fish for spawning (Hode personal communication). In Mississippi and other parts of the Gulf of Mexico, large Atlantic croaker were often referred to as 'bull croaker' when they reached sizes approaching two pounds and resembled small red drum.

Anglers who historically targeted large Atlantic croaker primarily fished near offshore oil and gas production platforms (rigs), which occurred in deeper water off Louisiana (Adkins et al. 1990). Stanley and Wilson (1990) determined that while most anglers fishing around the rigs off Louisiana targeted reef fish (snapper/grouper), a large number of croaker were harvested in association with the deep water structures. They reported that croaker were not typically caught by anglers at shallower rigs where spotted seatrout dominated the catches. Interestingly, while very few anglers seem to have an interest in croaker today, there are some directed trips noted in the MRIP survey data accounting for approximately 20,000-30,000 trips annually since 2005 (NOAA unpublished data). Of those targeting croaker as their first or second priority species, nearly all reported in the interview that they were harvesting for personal consumption and were primarily shore based (Table 6.3; NOAA unpublished data). However, in relation to the other priority species, croaker trips are negligible. For example, targeted spotted seatrout ranged from 4.5 to 5.0M trips annually since 2005, while croaker trips during the same period made up around 3% by comparison (Figure 6.13; NOAA unpublished data).

State Recreational Fisheries

Recreational fishing data for landings and effort are derived using NOAA's Marine Recreational Information Program (MRIP), its predecessor, the Marine Recreational Fisheries Statistics Survey (MRFSS), and the Texas Recreational Harvest Monitoring Program. The Texas program has been in place since 1974 while the MRFSS was used to sample anglers from Florida to Louisiana from 1979 until 2011. With the implementation of MRIP, the MRFSS landings since 1994 have been revised using the new protocols and are reported below. Since 2014, Louisiana has not participated in the MRIP survey and has conducted their own recreational survey called LA Creel. Together, these four programs provide the best estimates of landings and effort by recreational anglers in the five Gulf states. Texas is often excluded from regional

Table 6.3 The annual recreational landings (lbs) of Atlantic croaker by area fished in the Gulf of Mexico from 2005 to 2015 (NOAA unpublished data). **Note:** Landings exclude Texas (all years) and Louisiana for 2014/2015.

Year	Total croaker landings (lbs) by Area Fished			
	Inland	State Waters	EEZ	Grand Total
2005	288,355	20,491	-	308,846
2006	568,378	21,688	1,816	591,882
2007	567,440	45,981	3,456	616,877
2008	721,464	17,986	2,099	741,549
2009	406,407	11,165	1,120	418,692
2010	479,933	30,949	4,604	515,486
2011	704,909	70,326	40,991	816,226
2012	570,061	35,253	5,191	610,505
2013	591,746	26,403	12,081	630,230
2014	739,475	286,148	5,302	1,030,925
2015	187,692	77,017	-	264,709

totals of recreational harvest because the Texas survey uses numbers of fish, not weight. Texas harvest is handled separately in the sections below.

Unlike commercial landings information, the reported recreational landings in the MRFSS/MRIP include both retained (type 'A' and 'B1' that are the fish observed and reported catch not observed by samplers) and released fish (type 'B2'). Recreational landings presented in the recreational figures and tables are type A+B1 and represent total harvest, as designated by the NOAA.

In general, NOAA recreational data indicate that recreational landings have been declining since 1981, although there were some distinct peaks in harvest in 1982, 1986, and 1992 (Figure 6.15). Since the early 1990s, however, the recreational harvest has remained relatively stable at around 500,000lbs annually Gulf-wide (excluding Texas). The availability of croaker seemed to shift between years and states with West Florida and Louisiana dominating the catches early, a slight shift away from Florida since the 1990s, and steady increase in Alabama waters since about the mid-2000s.

The number of discards of Atlantic croaker from recreational anglers remains high suggesting that a majority of croaker encountered are either very small or not desired by anglers. NOAA's MRIP data provides some interesting insight when examining those fish that anglers report to have released alive (type 'B2' in the catch data). When reviewing the numbers of croaker harvested compared to the number released alive, the percent of released fish is very high, averaging nearly 70% of the total catch from 2010-2015 (Figure 6.16). In addition, the total harvest of croaker (dead) can be split into those fish returned to the dock and observed by fishery staff (type 'A' in the catch data) and those fish retained by anglers but used for bait, released dead, or filleted (type 'B1' in the catch data). The number of croaker (type 'B1') that are potentially kept by anglers for bait (live or dead/cut bait) is relatively high compared to those returned to the dock (type 'A'; ≈56% since 2010). On average, the total amount of croaker that are retained by anglers and returned to the dock is only around 15% of the total croaker encountered by recreational anglers annually (NOAA unpublished data).

The following sections describe the state recreational efforts and contributions to the total Atlantic croaker harvest.

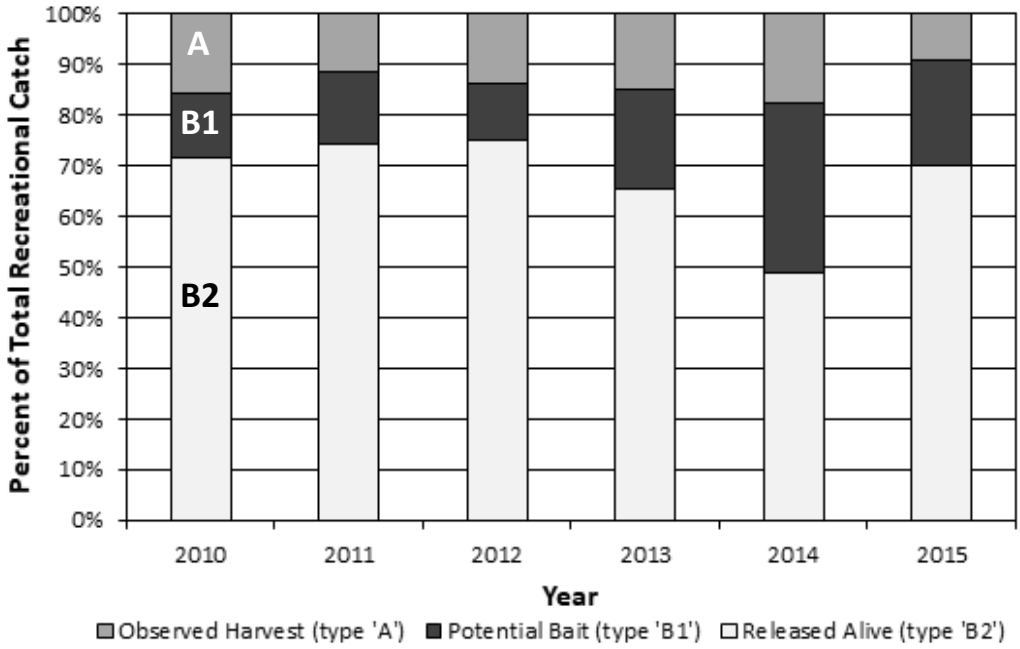

Figure 6.15 Total recreational Atlantic croaker landings from 1981-2015 (NOAA unpublished data). **Note:** Totals do not include Texas landings which are reported in numbers of fish rather than pounds through the Texas Recreational Harvest Monitoring Program and 2014-2015 Louisiana landings which were conducted through the LA Creel Survey.

West Florida Coast

Recreational anglers on the West Florida Coast target Atlantic croaker year-round, but peak harvest is during the months of May through October (Figure 6.17; NOAA unpublished data). They are primarily caught from shore in the surf using hook and line (Sempsrott personal communication); though, seine nets may be used by Florida residents with a recreational fishing license or by out-of-state residents that have a saltwater products license (SPL). There are no harvest restrictions on Atlantic croaker regarding

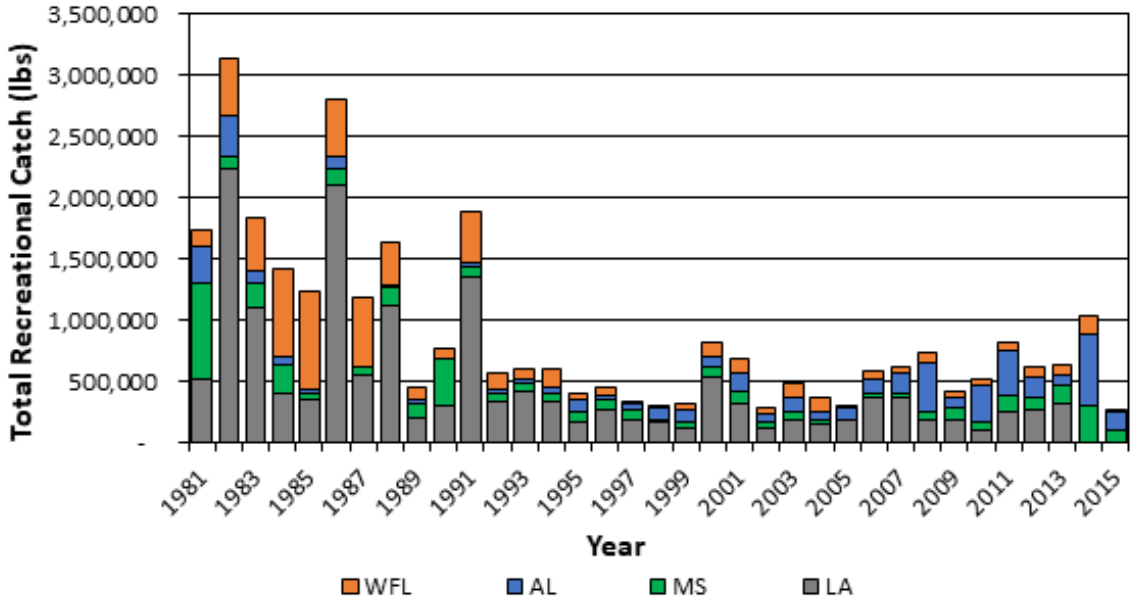

Figure 6.16 Final disposition of the recreational Atlantic croaker catch in the Gulf from 2010-2015 (NOAA unpublished data; does not include any Texas data or Louisiana data for 2014/2015). **Note:** types 'A', 'B1', and 'B2' are NOAA designations for final disposition of the recreational catch.

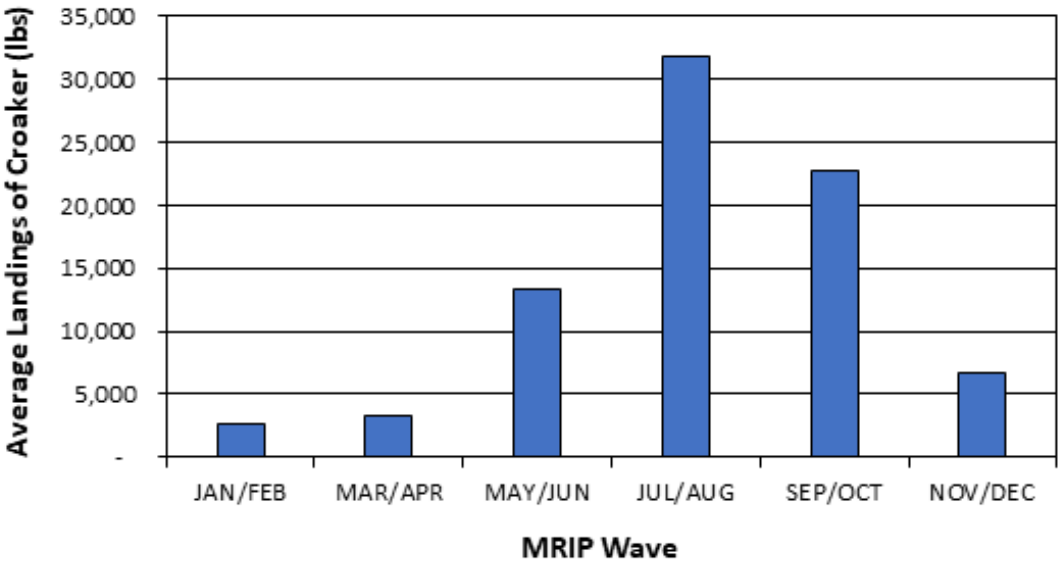

Figure 6.17 Average recreational harvest (lbs) of Atlantic croaker on the West Florida Coast by two month wave (2000-2015) (NOAA unpublished data).

size or bag limit; however, in Florida, an SPL is required to harvest more than 100lbs/day of any species for which no bag limit has been established.

The majority of Atlantic croaker harvested in Florida are harvested by recreational anglers in the northeastern and northwestern areas of the state where there are extensive salt marshes within the estuaries (McRae 1997). Recreational landings from the West Florida Coast between 1981 and 2014 were highest in the early to mid-1980s averaging around 550,000lbs. In 1989 and 1990, landings sharply declined to about 140,000 lbs. There was a spike in 1991 at 400,000lbs, but starting in 1992 landings have remained low and have fluctuated without any apparent trends averaging around 80,000lbs. In 2014, landings increased to 150,000lbs, which is still well below peak landings in the 1980s that averaged around 550,000lbs (Figure 6.18A; NOAA unpublished data).

Recreational catches have fluctuated greatly since 2000 with a reversal in trend of Atlantic croaker landings coming from shore based anglers versus boat anglers (Figure 6.19). In the early 2000s, the majority of recreational catches originated from shore but by the mid-2000s had shifted to a boat dominated catch. Since 2010, the percent contribution by either boat or shore has inverted and flipped multiple times but no real pattern can be determined. It is unclear whether the croaker harvested were consumed or retained for bait but the shore based anglers tend to be more subsistence in nature in other fisheries, such as noted above.

On average, there have been more active participants in Florida's recreational fishery (Figure 6.20) and fishing trips (Figure 6.21) taken on the West Florida Coast from 2000-2015 than in the previous two decades. Participation in the 1990s averaged between 2-3M anglers per year. From 2000-2015, the average number of participants increased to over 4M anglers per year (Figure 6.20). There was a noticeable decrease from 2009-2011 when the economy took a hit and the Deepwater Horizon (DWH) disaster occurred which shut down much of the fishing in the Gulf of Mexico in 2010, but then increased to over 4M once again in 2013 and 2014.

The number of fishing trips taken between 2000 and 2015 was on average higher than the number of trips taken in the previous two decades (Figure 6.21). During the 1980s and 1990s, the average number of recreational fishing trips taken on the West Florida Coast was 12.6M with the peak occurring in 1984

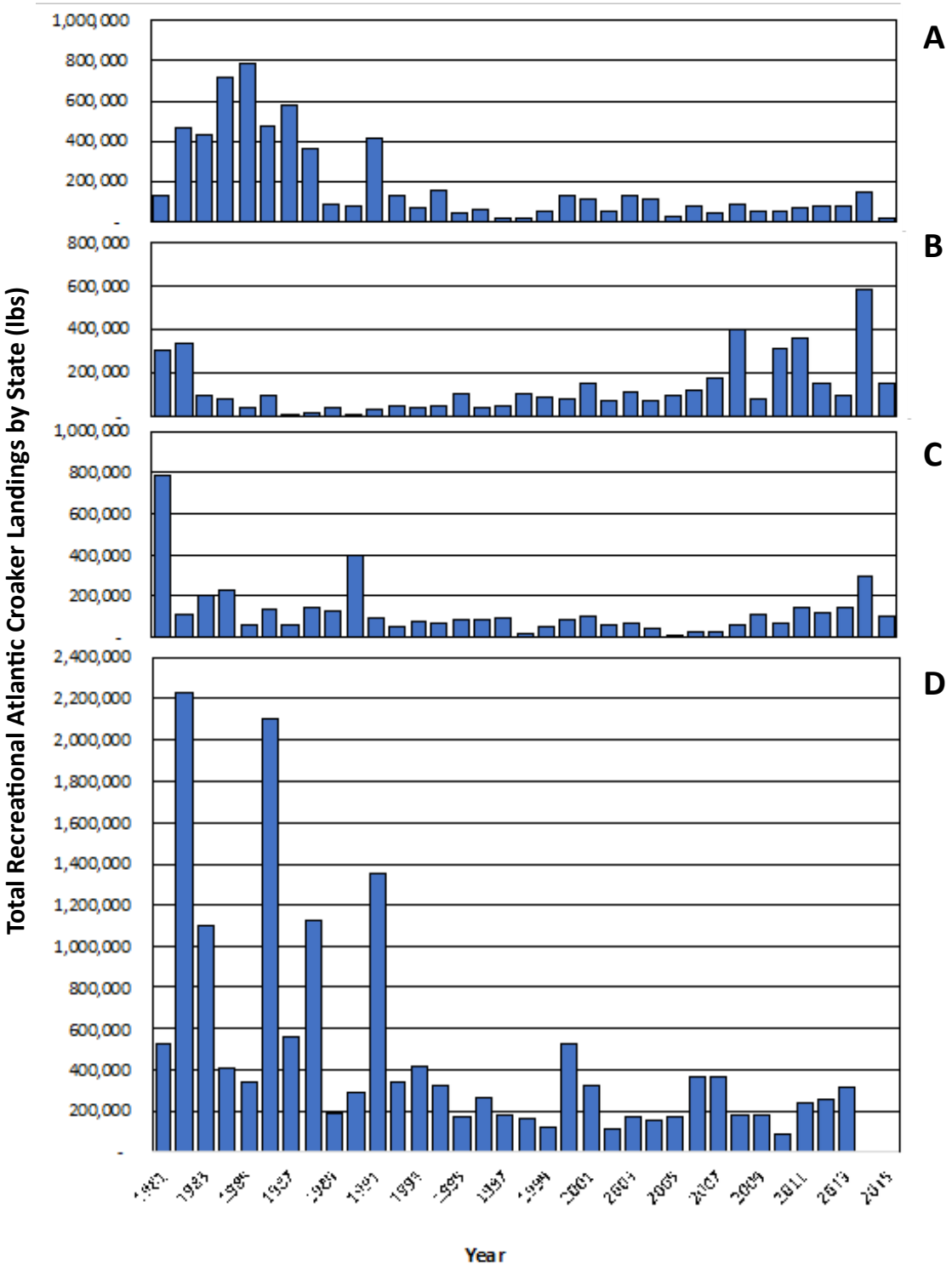

Figure 6.18 The total recreational landings (lbs) for Atlantic croaker in A) West Florida Coast, B) Alabama, C) Mississippi, and D) Louisiana from 1981-2015 (NOAA unpublished data; excludes Texas for all years and Louisiana in 2014-2015).

of 16.5M trips. During the period from 2000-2014, the average number of trips increased to 15.8M, with the peak occurring in 2004 of 17.8M trips (NOAA unpublished data).

Alabama

Alabama has a long history of recreational Atlantic croaker harvest although the relative abundance and occurrence in the recreational catch have varied considerably since 1981 (Figure 6.18B). Alabama's

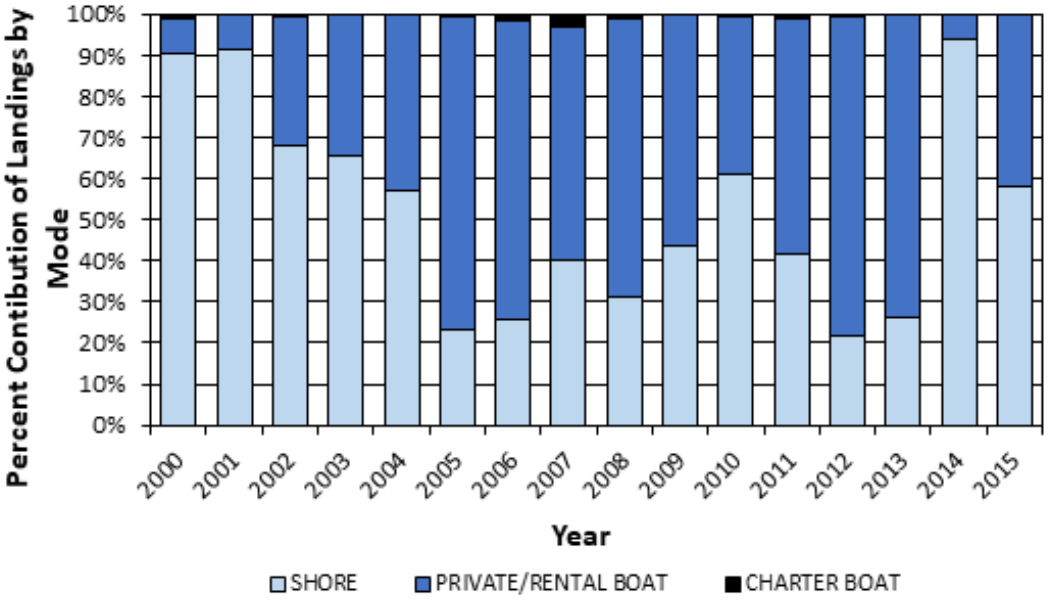

Figure 6.19 Percent contribution of total catches of Atlantic croaker in West Florida Coast waters by mode from 2000-2015 (NOAA unpublished data).

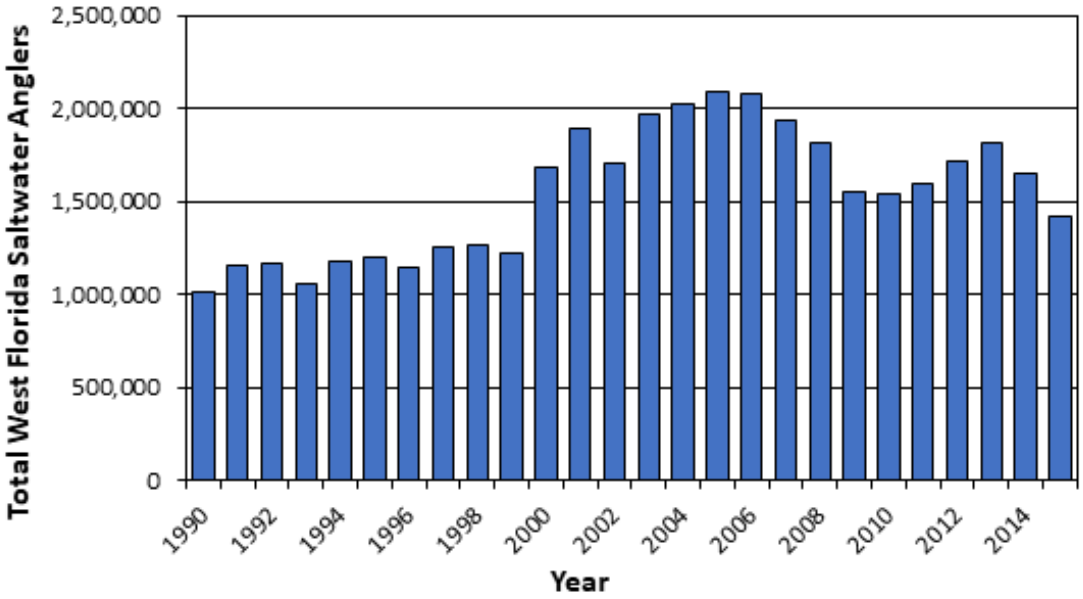

Figure 6.20 Total number of resident participants in recreational saltwater fishing activities on the West Florida Coast from 1990-2015 (NOAA unpublished data).

landings have been relatively similar to those of Mississippi throughout the time period although harvests have been higher since about 2005. Like most of the states, there was more croaker recreationally harvested in the early 1980s which was about the time most of the commercial landings declined as well. With respect to Gulf-wide Atlantic croaker harvests, Alabama have comprised around 20% of the total from the 1990s through 2010. Since 2000, Alabama anglers harvest the most Atlantic croaker during May-December (Figure 6.22). Like most states, there is less recreational fishing in general during the winter months from January-April.

Some of the increase in recreational harvest could be tied to the steady increase in people participating in recreational saltwater fishing in Alabama since 1999 (Figure 6.23; NOAA unpublished data). An average

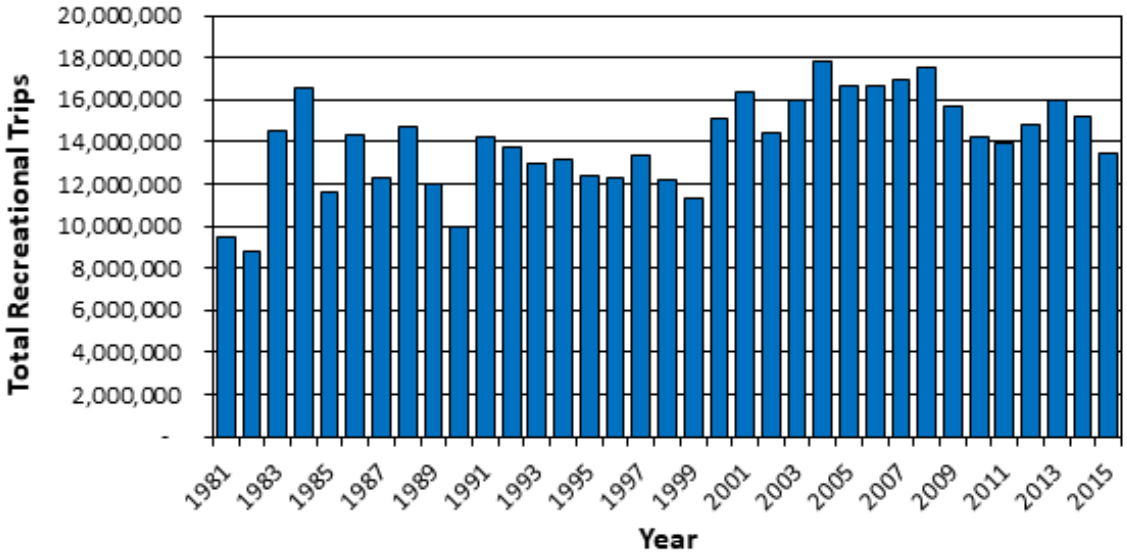

Figure 6.21 Total number of recreational fishing trips that were taken on the West Florida Coast from 1981-2015 (NOAA unpublished data).

of 170,000 anglers were estimated to have participated in saltwater fishing in Alabama throughout the 1990s but that number more than doubled by 2015, reaching an estimate of around 500,000 participants. Based on the data for target species, few of these anglers were actively fishing for Atlantic croaker; however, it is likely that the increase in croaker landings resulted from a higher incidental catch rate by more active anglers.

In addition, Atlantic croaker are widely distributed throughout Alabama from the EEZ to brackish waters, including upper bays and tidal rivers and are therefore accessible to a wider range of anglers both by boat and from shore. A summary of the 2000-2015 recreational croaker landings indicate that while many fish are taken from private boats, a large proportion are also taken from shore-based anglers (Figure 6.24).

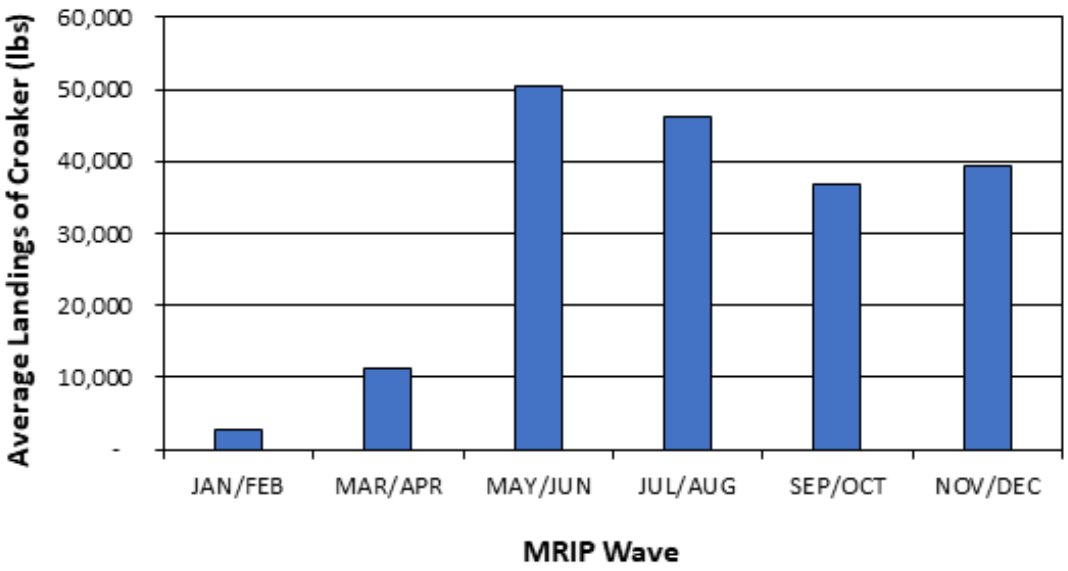

Figure 6.22 Average recreational harvest (lbs) of Atlantic croaker in Alabama by two month wave (2000-2015) (NOAA unpublished data).

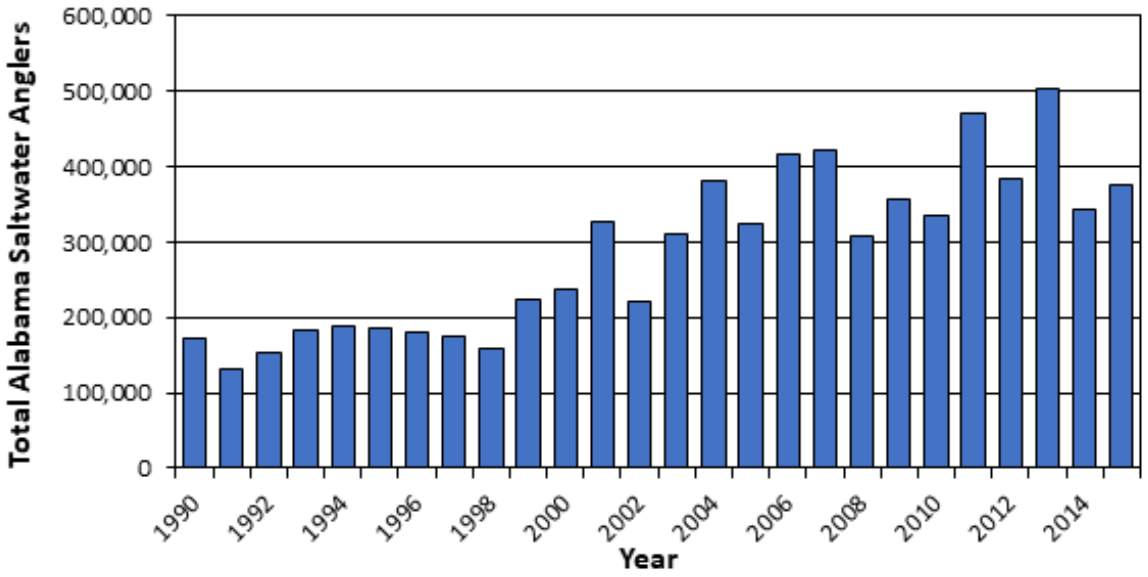

Figure 6.23 Total estimate of Alabama residents participating in recreational saltwater fishing from 1990-2015 (NOAA unpublished data).

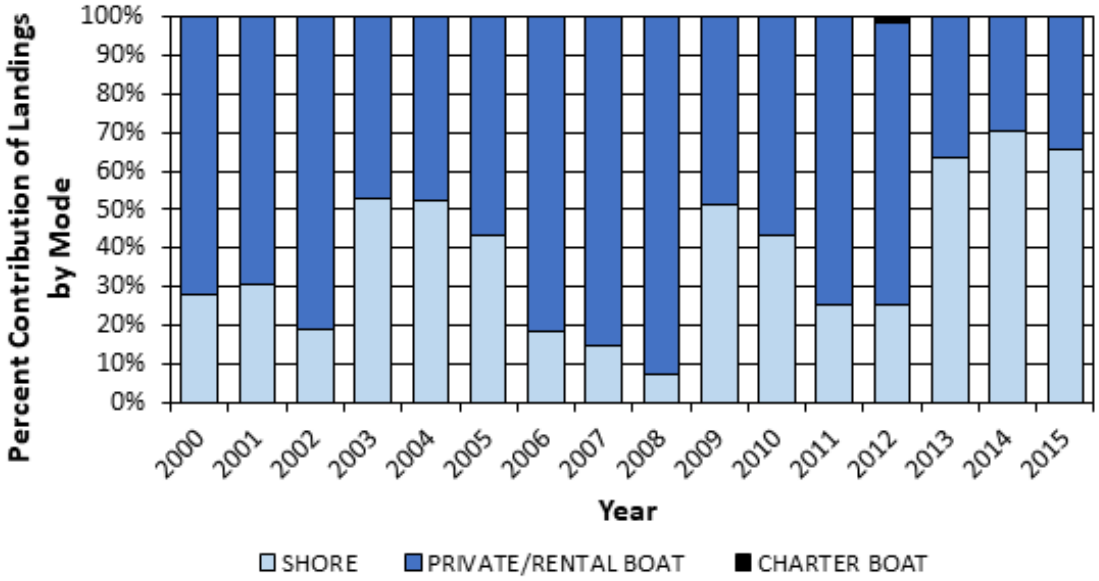

Figure 6.24 Percent contribution of total catches of Atlantic croaker in Alabama waters by mode from 2000-2015 (NOAA unpublished data).

Mississippi

In Mississippi, Atlantic croaker make up a minor portion of the total finfish landings when compared to preferred targets like red drum, flounder, and spotted seatrout. However, very similar trends in the catches exist when compared to the West Florida Coast and Alabama (Figure 6.18C). The recreational data suggest that there were generally higher catches in the 1980s, although only slightly, and relatively steady but lower through the 1990s, and a minor increase in more recent years. Anecdotal reports suggest annual runs of large spawning fish pass through Mississippi in the late fall near enough to the shore that they could be caught on hook-and-line from the Highway 90 seawall in Gulfport and Long Beach, Mississippi (Hode personal communication). This corresponds well with the MRIP landings estimates since 2000 which suggest that the most Atlantic croaker are caught recreationally in Mississippi from July through October (Figure 6.25).

At least since 1990, the estimates of the number of anglers participating in recreational saltwater fishing in Mississippi has fluctuated widely but was, on average, between 150,000-200,000 people annually (Figure 6.26; NOAA unpublished data). As in the other Gulf states, very few anglers who were interviewed indicated that they were targeting Atlantic croaker, and most of the catches were likely incidental in nature. Again, it is difficult to determine if the slight increase in recent years is because fish were larger and kept for consumption or if the fish were kept more often with the intent to use them as live or cut bait for other target species.

When examining the source of the harvest, there is about a 50:50 split on average for shore-based and boat anglers landing croaker, although there is a lot of variability annually (Figure 6.27). Again, shore-based anglers, in general, tend to be more subsistence-based and may be retaining croaker for

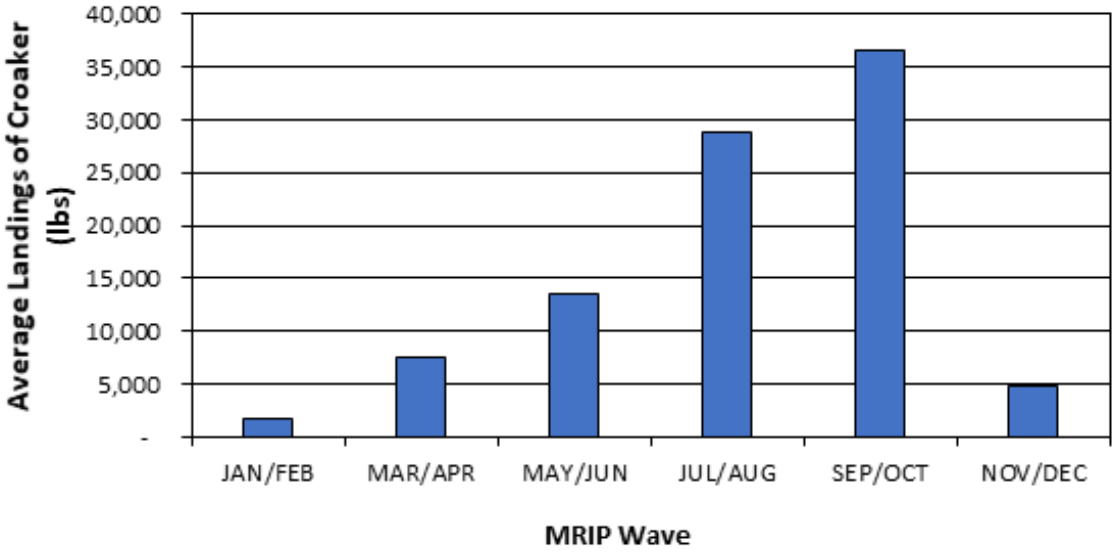

Figure 6.25 Average recreational harvest (lbs) of Atlantic croaker in Mississippi by two month wave for 2000-2015 (NOAA unpublished data).

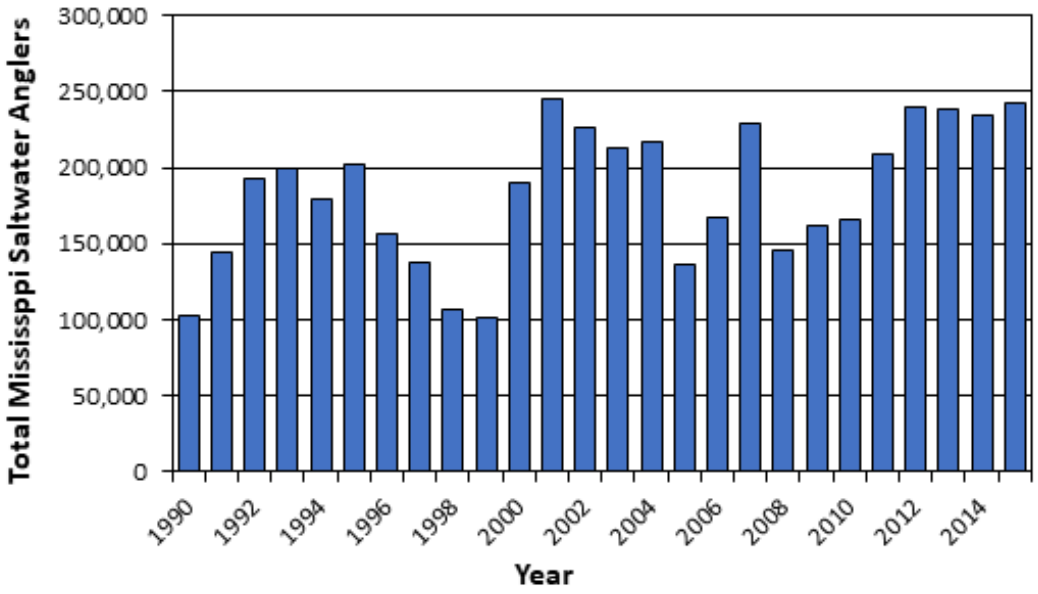

Figure 6.26 Total estimate of Mississippi resident anglers participating in recreational saltwater fishing from 1990-2015 (NOAA unpublished data).

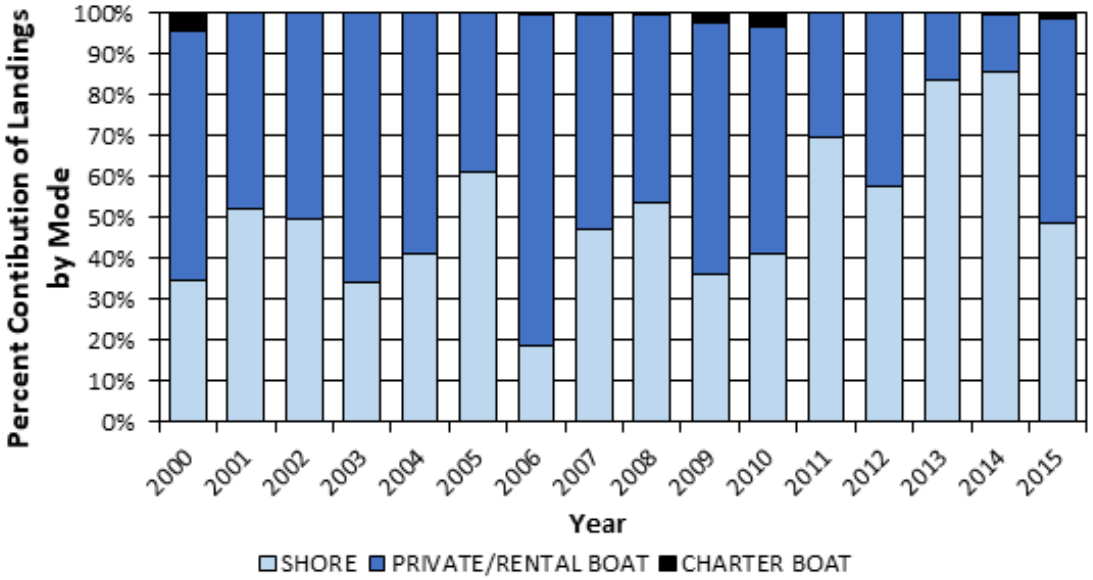

Figure 6.27 Percent contribution of total catches of Atlantic croaker in Mississippi waters by mode from 2000-2015 (NOAA unpublished data).

consumption, whereas boat anglers may be keeping the fish as bait. Hode (personal communication) noted that among older anglers (seniors), there is a tendency to keep all the croaker they catch for the purposes of consumption. Hode relayed his family preferred the smaller croaker to fry whole and would frequently come home with coolers full of the smaller fish for that purpose.

LOUISIANA

Louisiana generally has the highest recreational landings of all five of the Gulf states for Atlantic croaker throughout the 1980s and 1990s (Figure 6.18D). While the West Florida Coast experienced a steady increase and decrease peaking in the mid-1980s of around 800,000lbs (Figure 6.18A), Louisiana had large landings jumping from between 200,000-500,000lbs up to 2.1M and 2.2M lbs in 1983 and 1986. Additional high points included 1984, 1988, and 1991. Examining the MRIP landings estimates by wave from 2000-2013, the majority of all Atlantic croaker are taken by recreational anglers from May through October (Figure 6.28).

According to NOAA recreational data since 2000, Louisiana anglers fished more consistently from boats than the shoreline for croaker (Figure 6.29). Considering the vast amounts of otherwise inaccessible marshes, this is not surprising. Unlike Mississippi, Alabama, and Florida, much of coastal Louisiana requires a boat and this is reflected in the mode of the recreational landings. As with other states, it is unclear whether croaker caught by Louisiana anglers are utilized for food or for bait. After talking with several bait shop owners/dealers across Louisiana, there seems to be a greater interest in using live croaker in the western portion of the state (Hode personal communication). Several bait dealers and fishermen reported that in the eastern and central waters of Louisiana, from Breton Sound to about the Atchafalaya River, the majority of anglers prefer live shrimp over any other bait and “don’t seek out live croaker when fishing for spotted seatrout” (Hode personal communication). While the number of dealers reporting live croaker sales remains relatively low, numbers have slowly risen from 5 in 2010 to 12 in 2015, according to LDWF (unpublished data), likely indicating an increasing interest in live croaker in Louisiana.

Initiated in 2014, the purpose of LA Creel is to obtain recreational saltwater harvest estimates for the state through dockside and phone surveys. The dockside survey produces estimates of catch effort (i.e. number of fish caught per trip) while phone calls to current Louisiana saltwater fishing license holders produce estimates of effort (number of trips per angler). These two estimates are combined to obtain harvest estimates for a species.

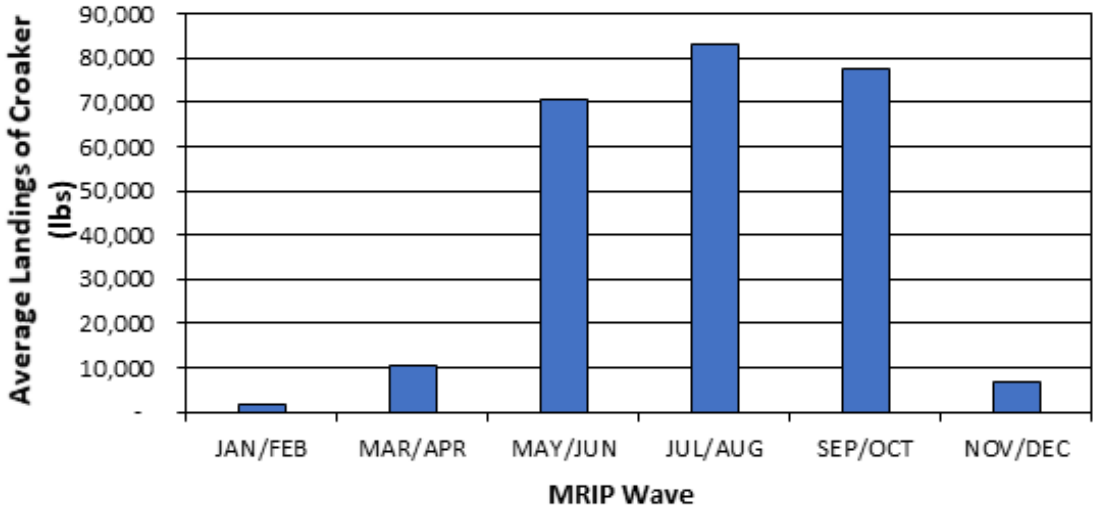

Figure 6.28 Average recreational harvest (lbs) of Atlantic croaker in Louisiana by two month wave (2000-2013) (NOAA unpublished data; 2014-2015 is not included from LA Creel).

Peak seasonal recreational landings in LA Creel data are May to October, which corresponds with peaks in landings from MRIP data. Since the initiation of LA Creel, croaker have comprised approximately 2.9% of recreationally landed fish in Louisiana, with 442,925 being harvested (Table 6.4).

Like the other Gulf states, participation in recreational saltwater angling in Louisiana has generally increased, while nearly doubling since the 1990s to a little less than 800,000 anglers annually, on average, since 2000 (Figure 6.30; NOAA unpublished data).

Texas

Texas anglers have a greater fondness for Atlantic croaker than other Gulf states anglers. Tompkins (2013) wrote in the Houston Chronicle regarding the apparent return of the Texas croaker populations.

"Most coastal anglers 50 years old and older can remember a time when the fall migration of croaker, and croaker fishing, was an event not to be missed. Places such as Rollover Pass, Bolivar

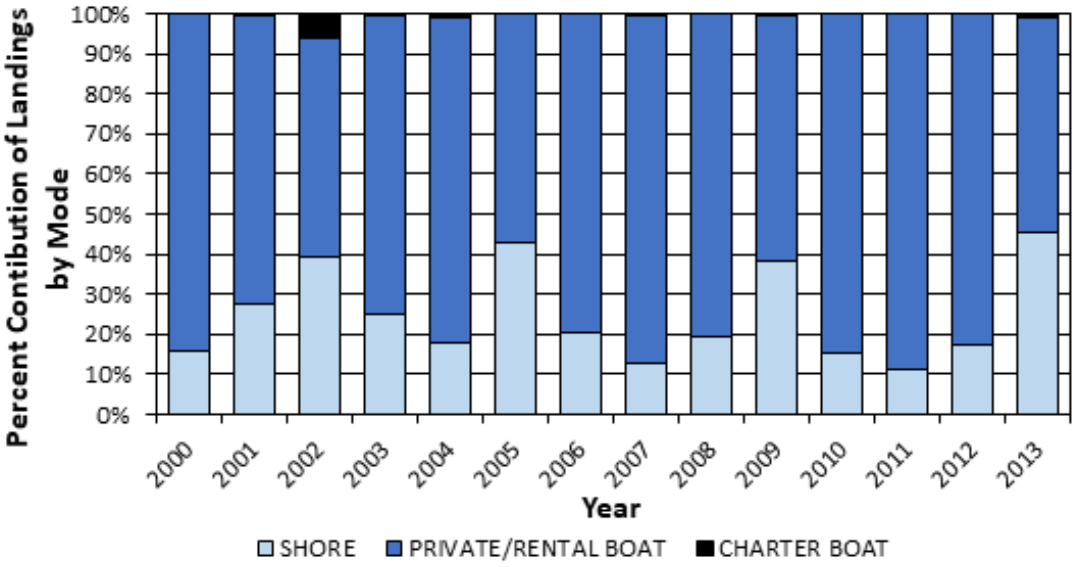

Figure 6.29 Percent contribution of total catches of Atlantic croaker in Louisiana waters by mode from 2000-2013 (NOAA unpublished data; 2014-2015 is not available from LA Creel).

Table 6.4 Contribution of Atlantic croaker to all Louisiana landings from 2014-2015 LA Creel (LDWF unpublished data).

Year	Atlantic croaker	All Species Landings	Percent croaker of total catch
2014	235,081	7,405,895	3.17%
2015	207,844	8,051,978	2.58%
Grand Total	442,925	15,457,873	2.87%

Roads, San Luis Pass, Aransas Pass and other bay/Gulf connections would be lined, often shoulder to shoulder, with anglers plunking hooks baited with live or dead shrimp into the water and almost immediately connecting with a flapping, growling 'golden' croaker."

Tompkins 2013

That phenomenon began fading in the 1960s, sputtered into the early 1970s and was gone by the end of that decade. He continues,

"But, as good as it is, the croaker population is not back to the level it was a half-century or so ago, when the fall migration of 'golden croaker' was the Texas equivalent of an Alaskan salmon run."

Tompkins 2013

Recreational catches of croaker have been monitored by the TPWD through the Texas Recreational Harvest Monitoring Program. Their data indicate a steady decline in the recreational catches from the late-1980s through the mid-2000s (Figure 6.31). The decline continued until only 100,000 individual croaker were landed by 2007 in Texas waters. Nearly all the Atlantic croaker harvested recreationally in Texas waters originate from Texas bays at 99% on average for the entire monitoring program starting in 1983/1984 and virtually none from Texas Territorial Seas (TTS) or the EEZ (TPWD unpublished data). It should be noted that, although the overall numbers of croaker landed have declined over time, the size of the fish that were harvested have not changed overall and have increased slightly since the mid-1980s (Figure 6.32).

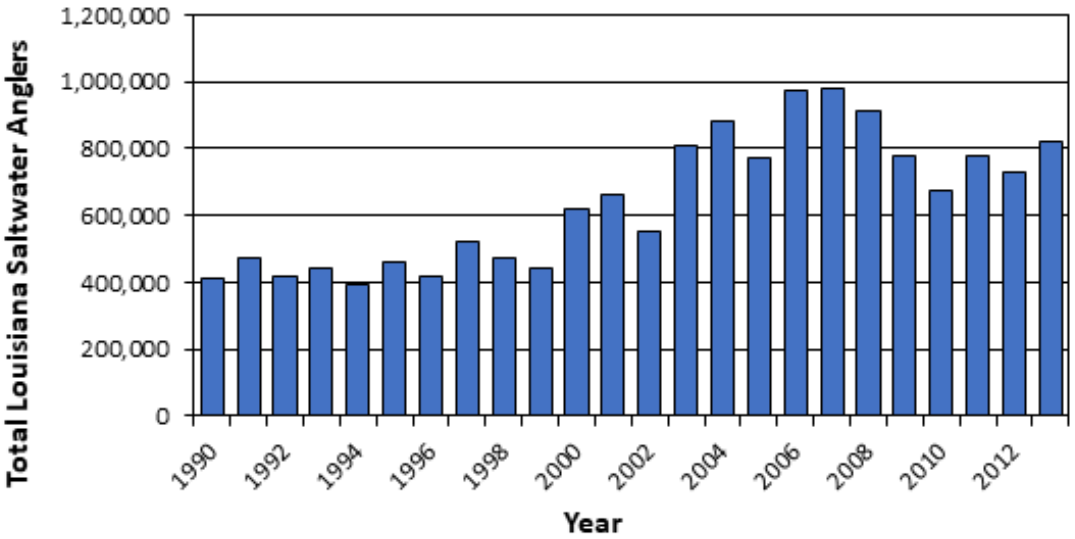

Figure 6.30 Total estimate of Louisiana residents participating in recreational saltwater fishing from 1990-2013 (NOAA unpublished data). **Note**: Participation data from 2014-2015 were collected through the LA Creel and not currently comparable.

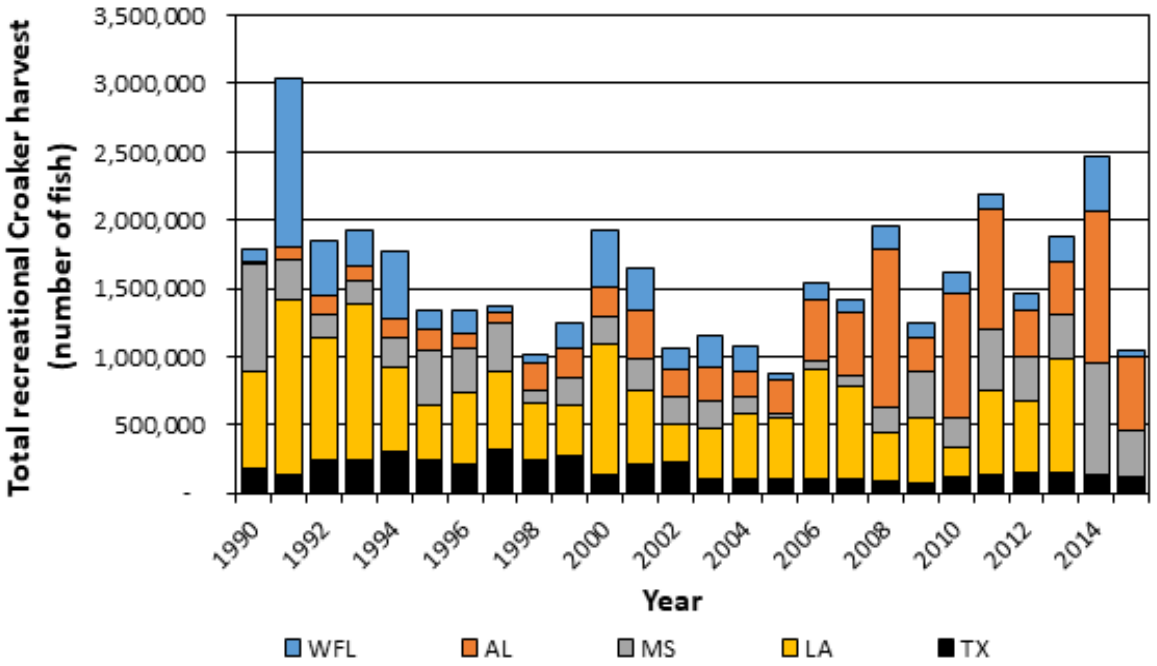

Figure 6.31 Total recreational harvest of Atlantic croaker from the Gulf states in numbers of fish from 1990-2015 (NOAA unpublished data, TPWD unpublished data). **Note:** There are no harvest estimates in number of fish for Louisiana for 2014 and 2015 using LA Creel data.

Texas is the stronghold for the belief that croaker are the 'ultimate bait' for spotted seatrout. As a result, the live bait industry along the north and central Texas coasts has exploded in recent years. Tompkins (personal communication) notes that for decades, prior to being able to purchase live croaker, Texas anglers caught live croaker for bait with cast nets. He indicates that one "could regularly buy live mullet and killifish (mud minnows) back then, but does not recall ever seeing live croaker for sale until at least the mid or late 1980s." Tompkins (personal communication) relayed a story that when he purchased 'live croaker' at a bait shop recently, "at least half of them were spot and not croaker, not that it probably matters much as live bait goes; they are equally effective."

There is a long-held belief among many Texas anglers that Atlantic croaker are the only bait you will ever need for big spotted seatrout. They claim croaker are 'mortal enemies' and a trout will 'inhale a live croaker' because croaker eat trout eggs as soon as they are laid (also a false belief that trout 'lay eggs in nests' on the bottom). As a result, conservation minded anglers have tried to outlaw the use of live croaker as bait because they are considered an 'unfair' advantage and catch more of the larger females, which produce proportionately more eggs than smaller trout. However, there is no scientific evidence to support this claim. In fact, one study conducted along the southern Texas Coast concluded that live croaker did not catch significantly more or larger spotted seatrout than any other bait types utilized (Ferguson 2016).

The estimated number of saltwater anglers in Texas ranged from 816,728 in 1978 to a high of 1.1M in 1983 but, since 2000, the number has averaged just under 1M (Table 6.5). As in the other Gulf states, few of those anglers directly target Atlantic croaker. The overall sport boat fishing pressure (in man-hours) generally increased throughout the 1980s and 1990s to a high in 2000 of about 8.1M man-hours but has averaged around 6.3M man-hours since (Figure 6.33).

Bycatch

Bycatch in a fishery can be classified into two different types: 1) incidental catch and 2) discarded catch. Incidental catch refers to retained or marketable catch of non-targeted species. Discarded catch is

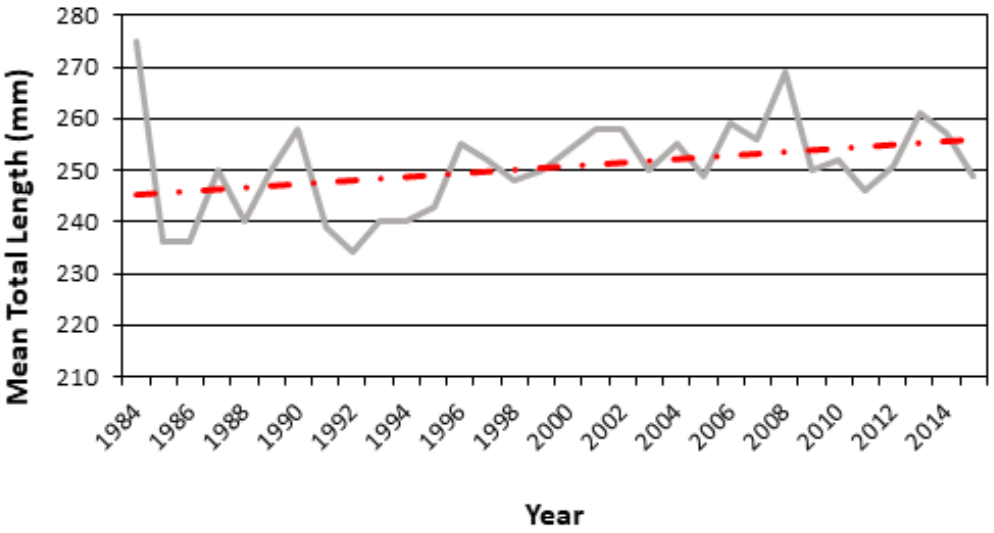

Figure 6.32 The average length of Atlantic croaker harvested recreationally in Texas waters from 1984 to 2015. The dashed line represents the linear trend (TPWD unpublished data).

the portion of the catch returned to the sea because of regulatory, economic, or personal considerations. When possible, these terms will be used in this section; otherwise, the overall catch of non-targeted species will be described as bycatch.

Commercial

Unwanted fish caught in commercial harvests, or bycatch, is not a new problem to the U.S. fishing industry. Efforts to find a solution resulted in a 1907 report published by the U.S. Bureau of Fisheries, suggesting that the only practical solution was to develop the utilization of those species having no market (Field 1907). In the U.S., Atlantic croaker is probably best characterized as an 'opportunity' species, meaning Atlantic croaker, while not targeted, have not necessarily been wasted when they are captured.

The history of the commercial Atlantic croaker fishery in the Gulf began with shrimping and bycatch. As noted in the Groundfish fishery history, many tons of croaker were captured incidentally in shrimp trawls in certain areas (Gunter 1956). Of the finfish that made up shrimp bycatch, as much as 50-70% were Atlantic croaker (Roithmayr 1965, Gutherz et al. 1975). Large fish were retained and sold to the food fish market while the smaller fish were retained and turned into pet food products starting in the 1950s.

Bycatch in the shrimp fishery was significant during the height of the fishery and studies estimating the mortality rates on non-target species suggested that 34-43% of the total catch off Texas was non-shrimp (Sheridan and Ray 1981). Fish to shrimp ratios were calculated at an annual average of 4:1 (Blomo and Nichols 1974). Many of the fish captured during trawling were juveniles, generally undesirable to the shrimp industry because of increased time and labor to sort and discard from the more valuable shrimp. The perceived waste (discards) from the commercial fishery resulted in protest and action from the recreational fishing and environmental communities in the early 1980s (Pearce et al. 1989). One action to reduce discards and to specifically address mortality of threatened sea turtles was to require turtle excluder devices (TEDs) in shrimp trawls. TEDs were hotly debated but eventually implemented in 1989 and 1990 throughout most of the Gulf's shrimp fleet. In the end, TEDs were successful in keeping sea turtles out of the shrimp catch and greatly reduced their incidental mortality. However, TEDs did little for the non-target finfish species like Atlantic croaker and other Groundfish.

In 1996, Congress specified that bycatch in all fisheries be reduced and that unavoidable bycatch mortality be minimized. Federal regulations that reduce shrimp trawling bycatch were finalized in late 1997 and bycatch reduction devices, or BRDs, were implemented for all Gulf waters west of Cape San Blas,

Table 6.5 Total estimated number of recreational saltwater anglers in Texas from 1977-1978 to 2013-2014 (Green and Campbell 2010 for 1977-1978 through 2007-2008 and TPWD unpublished data for 2008-2009 through 2014-2015).

Fiscal Year	Estimated number of Saltwater Anglers[1]
1977-1978	816,728
1978-1979	972,772
1979-1980	989,967
1980-1981	1,019,736
1981-1982	1,092,419
1982-1983	1,133,226
1983-1984	1,029,843
1984-1985	1,037,203
1985-1986	1,053,828
1986-1987	1,037,414
1987-1988	1,072,518
1988-1989	1,044,619
1989-1990	1,070,922
1990-1991	1,080,071
1991-1992	989,645
1992-1993	1,007,227
1993-1994	1,029,095
1994-1995	983,715
1995-1996	952,397

Fiscal Year[1]	Estimated number of Saltwater Anglers[1]
1996-1997	914,927
1997-1998	929,768
1998-1999	951,818
1999-2000	943,490
2000-2001	957,045
2001-2002	945,614
2002-2003	940,763
2003-2004	923,808
2004-2005	913,834
2005-2006	895,963
2006-2007	917,238
2007-2008	1,002,793
2008-2009	1,006,601
2009-2010	981,925
2010-2011	1,019,885
2011-2012	780,000
2012-2013	816,000
2013-2014	841,000
2014-2015	865,000

Florida and included all waters 3-200 miles offshore. The implementation of BRDs in commercial shrimp trawls should have reduced mortality for all finfish species, but were primarily developed for the release of juvenile red snapper (*Lutjanus campechanus*). Coleman et al. (1992) tested several BRDs in Tampa Bay, Apalachicola Bay, Pensacola Bay, and St. Andrews Bay, Florida where Atlantic croaker was consistently one of the top five and, in several cases, the top species entrained in shrimp trawls without BRDs. One of the devices tested did reduce finfish bycatch by around 13% in Apalachicola Bay but everywhere else, the authors noted that trash seemed to hamper the effectiveness of the devices.

In recent years, the bait shrimp fishery has realized the value of live Atlantic croaker for bait and much of that industry is based on the ability to retain a certain amount of bycatch. Techniques and methods have changed related to trawling for bait which allows for the captain to not only retain their croaker, but retain them alive. The bait shrimp industry also has the advantage of no TED or BRD requirements since they mostly operate inshore and have relatively short tow times, reducing any mortality on their catch and preserving both shrimp and finfish for bait.

Recreational

It is difficult to examine 'bycatch' of Atlantic croaker in the recreational fisheries in the Gulf of Mexico since those fish of sufficient size are likely retained as food or cut bait by anglers and anything too small

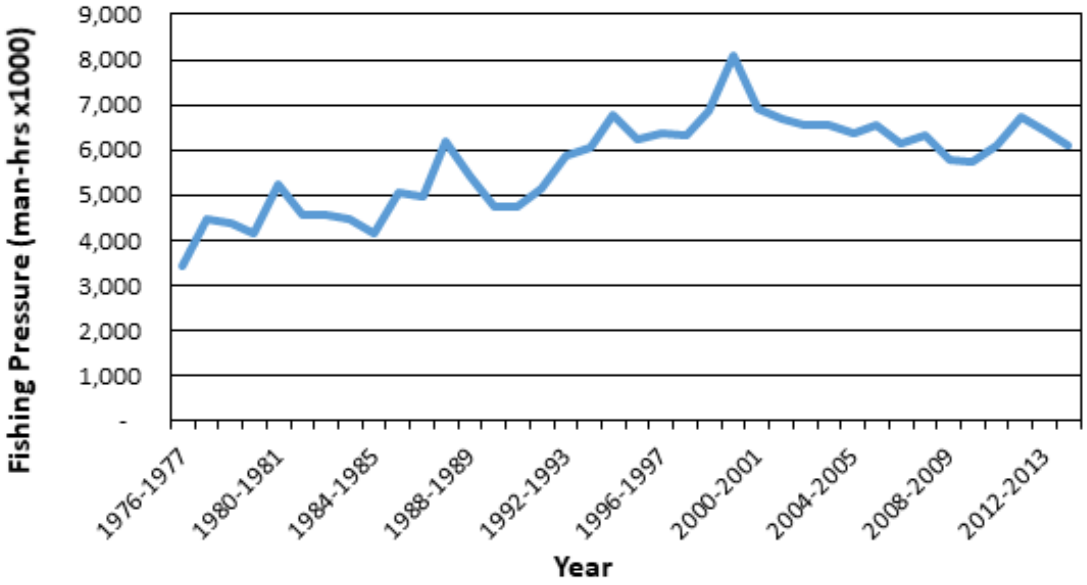

Figure 6.33 Sport boat fishing pressure and finfish landings in Texas marine waters from May 1976 to May 2014. Sport boats = private boats and party boats combined. Texas marine waters = bays/passes (1976-1977 through 2013-2014), Texas Territorial Sea (1983-1984 through 2013-2014), and U.S. Exclusive Economic Zone (1983-1984 through 2013-2024). [Green and Campbell 2010 (1976-1977 through 2007-2008) and TPWD unpublished data (2008-2009 through 2013-2014)]. Survey year = May 15 of one year to May 14 of next year.

to fillet could be kept for live bait. However, as noted above, the majority of fish captured by recreational anglers are released alive (type 'B2' in the catch data) presumably because they are too small to be useful (Figure 6.16).

Mariculture

Few studies, or at least readily available studies, have been done to determine the feasibility of raising Atlantic croaker in a controlled environment. However, with the increase in popularity and monetary value of croaker as live bait, and as a potential food fish, more research is being done on this species for commercial production. When captive production is studied, experiments are usually done to determine how well the species in question can be spawned naturally as well as actively by inducing maturation and spawning. A study was done by Sink et al. (2010) at the University of Arkansas (Pine Bluff) on making hatchery methods more efficient for natural and hormonally induced spawning of captive croaker. Overall, the goals of the experiments in the study were to determine the feasibility of aquaculture to eliminate seasonal ability, provide a steady supply, provide certain sizes of bait, decrease pressure on wild stocks, provide croaker as food fish, and diversify aquaculture businesses. Because there have been few studies on optimization of hatchery methods to increase spawning, techniques used are usually based on spawning protocols for the closely related red drum (Sink et al. 2010). Experimental treatments altered the temperature and hormonal treatments (implants or injection) to determine the optimal spawning temperature in captivity. Results of the study indicated that captive croaker will spawn passively but the more efficient method is to actively induce maturation and spawning to improve success, egg production, fecundity and synchronization of spawning events. Even though advances are being made on croaker growout, wild fish are still being caught for broodstock. In the future, attempts need to be made to use completely captive croaker for broodstock (Sink et al. 2010). Optimization of croaker egg production, larval rearing techniques, growout, and ova and sperm storage has been done at the USM Gulf Coast Research Laboratory over a period of several years. Specifically, the genetics laboratory in cooperation with the Thad Cochran Marine Aquaculture Center conducted several experiments to determine optimal methods to spawn, grow, and rear captive croaker. During strip-spawn experiments, sperm concentration

was determined spectrophotometrically and methods to increase short-term cold-storage of croaker sperm were examined by diluting milt samples from six males in HBSS, then finding the correlation between sperm absorbance and concentration. This experiment was done to optimize sperm usage and attain predictable artificial fertilization protocols (Leclerq et al. 2014).

Optimization of short-term preservation of ova was also studied to synchronize fertilization, transport gametes, and conduct large mating experiments (Saillant unpublished data). Once females are strip-spawned, ova quality declines rapidly during the first hour of storage at 20°C; it is important to strip the ova and fertilize directly after ovulation to increase the success of artificial fertilization (Saillant unpublished data).

The IFAS Extension at the University of Florida has compiled information on culture methods to optimize Atlantic croaker for hatchery production (Creswell et al. 2010). Standard protocols have been established for the feeding of red drum that can be used for croaker feeding but some work has been done on specific feeding practices for croaker. Croaker larvae cannot ingest newly hatched Artemia because the nauplii are too large (Creswell et al. 2010). Croaker larvae were successfully reared by Houde and Ramsey (1971) by keeping them in a dense culture of Chlorella phytoplankton then exchanging through water transfer to various wild zooplankters. Feeding copepod nauplii to early croaker larval stages may suffice but more research is needed. Some of the greatest results have been achieved using a static culture of *Isochrysis galbana* or a similar algae with high levels of DHA. Rotifers can also be used at first feeding then a microparticulate diet added to the feeding regime on day six. Eventually, Artemia nauplii can be added to wean larvae off rotifers. Finally, larvae can be transitioned to dry feed with an increase in size as they grow (Creswell et al. 2010). Experiments have also been done on feed conversion efficiency (Chamberlain et al. 1990, Davis and Arnold 1997) to optimize growth in order to maximize growout time if raising croaker for the baitfish industry.

Chapter 7
ECONOMIC CHARACTERISTICS OF THE COMMERCIAL AND RECREATIONAL FISHERIES

Atlantic croaker is a species that has a history of being targeted by both commercial harvesters and recreational anglers. Available data suggest that croaker is currently of modest economic importance in the Gulf of Mexico region; however, this has not always been the case. A majority of the total U.S. commercial economic value was historically derived from activity and sales associated with the harvesting of croaker for the processing of pet foods in the Gulf. These processors, who operated primarily during the 1960s and 1970s in the northern Gulf region, generated significant sales of pet food products. Lesser commercial value has likely been generated by the sale of croaker for human consumption. In addition, recreational economic value would be partly generated by the economic activities associated with anglers who target croaker as food fish and anglers who target/purchase croaker as a live bait for other species. In addition, economic value associated with the willingness of consumers and anglers to accept or pay a price different from what they may confront in the market, e.g., non-market valuation, further contributes to the economic values associated with croaker. This report, however, will focus almost exclusively upon the economic values generated by market transactions associated with commercial harvest and sale of croaker during the 1950-2015 period.

For the purposes of the following discussion, the commercial economic value includes only the total amount paid by the first handler to the harvester during the initial off-loading of croaker. This is often referred to as the ex-vessel or dockside value, hereinafter referred to as value. Markups that might have occurred in the subsequent market levels, from the first handler to the consumer, are not included due to the paucity of data. Expenditures to target croaker by recreational anglers are not available. In addition, the non-market-related values of both commercial and recreational sectors are not available. Through the 1980s, NOAA commercial landings in the Gulf utilized the category of '*Finfishes, UNC Bait and Animal Food*' which, historically, referred almost exclusively to the Groundfish fishery which was dominated by Atlantic croaker; therefore, '*Groundfish*' will be used throughout this chapter for all landings and values tied to '*Finfishes, UNC Bait and Animal Food*'.

Annual and monthly nominal (not adjusted for inflationary changes) values are discussed for each state and the Gulf, in general. Annual and monthly nominal prices (i.e., the price per pound received by the harvester for the whole fish) are discussed for the Gulf region, by state, and harvest gear type, as allowed by confidentiality concerns. Information on prices and value provides basic insight into the economic importance of the commercial croaker harvest sector. Information describing trends in Gulf landings (lbs) of croaker is found in Chapter 6 (Description of the Fishery) (Figure 6.1, 6.2, and 6.6).

Discussion focuses on commercial landings, value, and prices within the Gulf of Mexico region (NOAA unpublished data). However, additional data are available that provide insight into commercial landings and sale of croaker in the south Atlantic region. These data are described where appropriate. This non-Gulf of Mexico information was included to provide a more complete picture of the commercial market for croaker in the southeastern U.S. region, and to provide preliminary insight into the role that croaker landings in the south Atlantic region may have in sales and prices for croaker originating from the Gulf of Mexico. In addition, unless specified, the discussion of annual and monthly value and price data pertains to croaker destined for the human consumption market, which are the only data available that provide information specific to Atlantic croaker. Too few data are available to allow a discussion of value and price of croaker used for pet foods and live bait markets.

Commercial Sector

Annual Value

Annual Value by Region

Atlantic croaker is a species that is, and has been, harvested for a variety of uses including human consumption, pet food products, and live bait. As discussed in Chapter 6 (Groundfish Fishery), the harvesting of croaker for the pet food industry peaked in the mid-1970s. Atlantic croaker have more recently become a live bait, popular with recreational anglers throughout the Gulf region. To the best extent possible, this section discusses the value of croaker harvests for each of these markets.

Value Associated with Landings Destined for Human Consumption

From 1950 to 2015, the majority of the value generated by Atlantic croaker landings (not Groundfish) occurred in the south Atlantic region, rather than the Gulf of Mexico (Figure 6.1). This is due to greater landings in the Atlantic region, particularly during more recent years. In fact, since 1990, the cumulative value of croaker landed in the Gulf of Mexico totaled $10.5 M, while the cumulative value of croaker landed in the Atlantic region during the same period was $186.8M.

The total annual value of Atlantic croaker in the Gulf region was modest from 1950-1967, with the exception of the three-year period during 1954-1956 (Figure 7.1 and 7.2). During these three years, average annual value was approximately $570,000, as compared to an approximate average annual value of $17,400 during the other years. These landings and value were actually Groundfish landings that were initially reported as Atlantic croaker, but categorically changed in subsequently years. However, beginning in 1968, value increased dramatically as the pet food industry began to demand larger quantities of Groundfish, including croaker, as input for increased production. During the 1970-1976 period, the value

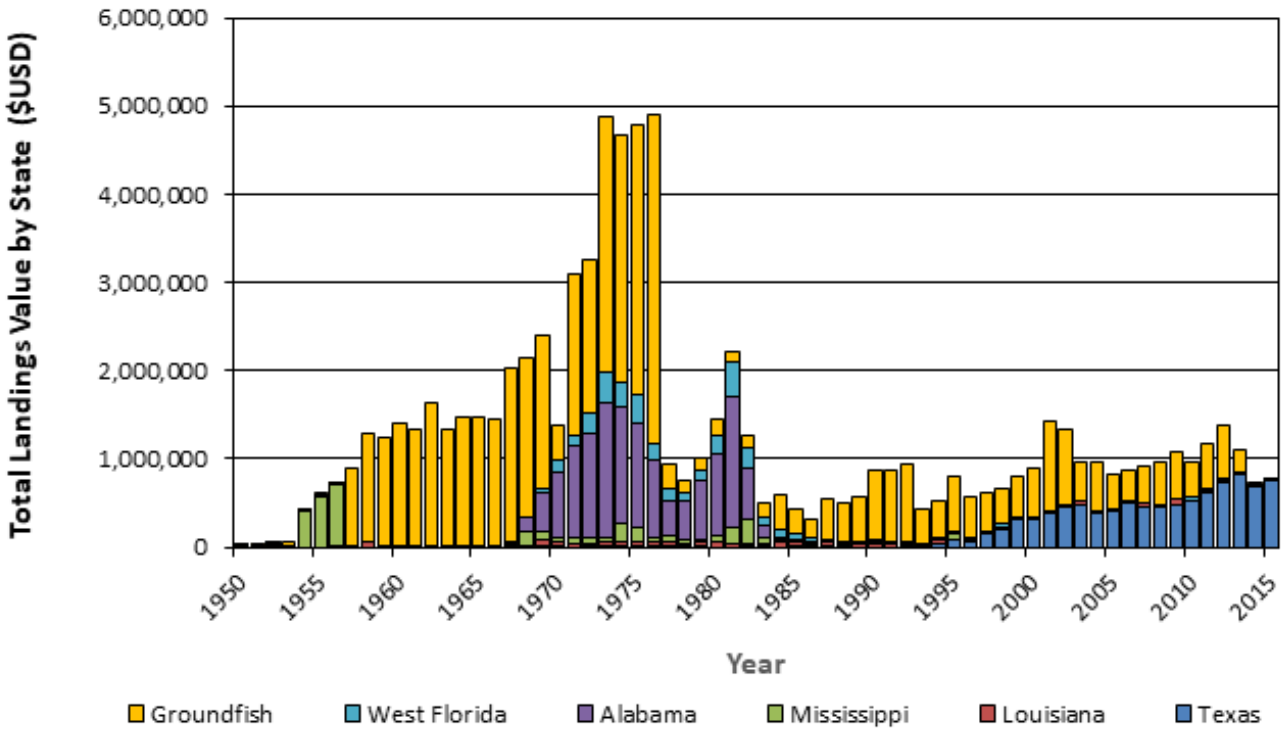

Figure 7.1 The total value ($USD) for Groundfish and Atlantic croaker from 1950-2015 by Gulf state (NOAA unpublished data).

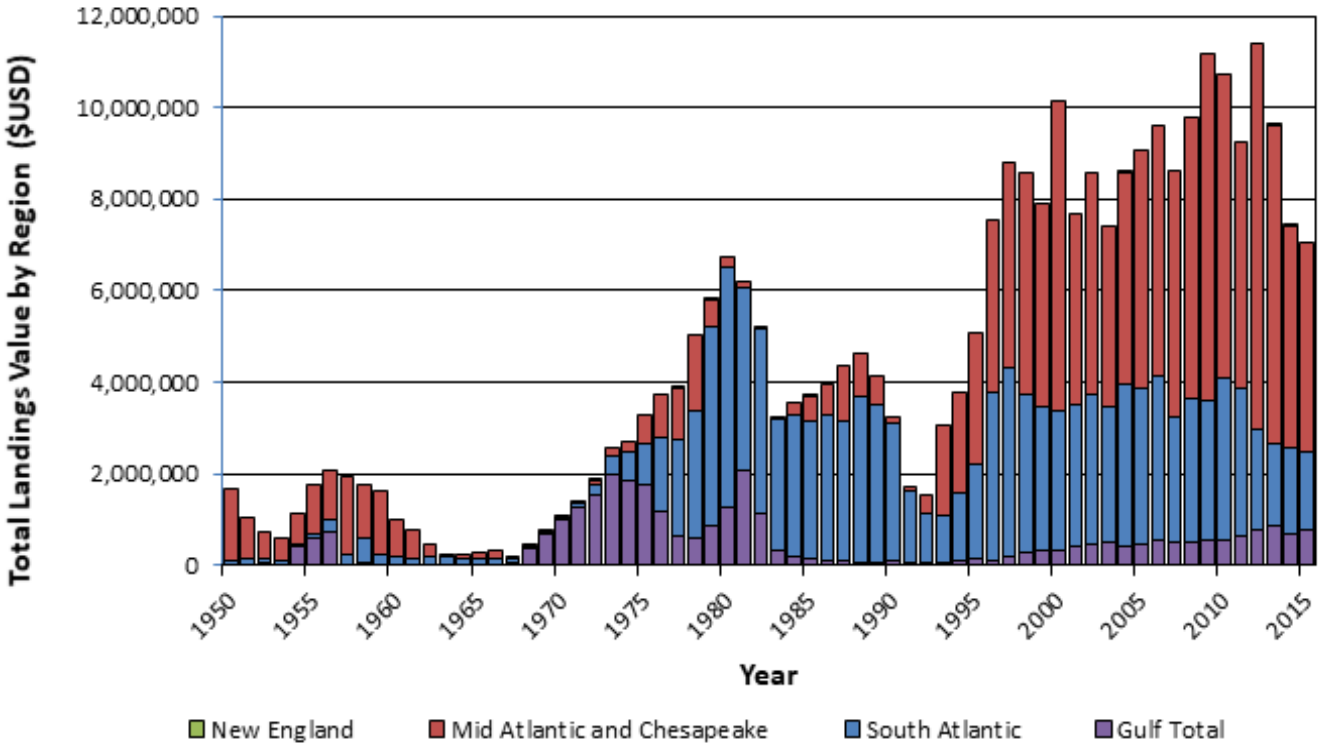

Figure 7.2 Total value ($USD) for Atlantic croaker from 1950-2015 by region (NOAA unpublished data).

for croaker approached or exceeded $1.0M, with an average annual value of approximately $1,274,000 from 1969-1982. The two years with the greatest value were 1973 and 1981, with values of $1,994,000 and $2,092,000, respectively. Following 1982, value declined dramatically, with an average annual value during 1983-1993 of $113,000. Following this period, annual value began a steady increase over the next 21 years, increasing from $107,000 in 1994 to $849,000 in 2013. This most recent increase in value may be due to strengthening of the food market demand for croaker, as well as a growing demand for croaker as a live bait, with the latter likely being the most important factor contributing to recent price increases.

Commercial landings of croaker also occur in the Atlantic region. The average annual value of croaker landings for the entire Atlantic region was approximately $883,000 from 1950-1967, where values exceeded $1.0M during the 1950s, with the exception of 1952-1954 (Figure 7.2). From 1950-1962, the majority of the value attributed to croaker landed within the mid-Atlantic and Chesapeake regions (New York, New Jersey, Delaware, Maryland, Virginia), a lesser share of the Atlantic values being associated with the south Atlantic region (North Carolina, South Carolina, Georgia, East Florida coast), and virtually no landings from the New England states (Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut). During this period, the south Atlantic region represented an average of 12% of the average annual value for the entire Atlantic region. However, from 1963-1992, with the exception of 1965 and 1966, the value of croaker landings was dominated by the south Atlantic region. During this period, the average, annual value for the south Atlantic region was approximately $1.8M, representing an average of 78% share of the total annual Atlantic region croaker value. Beginning in 1993, the south Atlantic share of the Atlantic region croaker value began to diminish, with the value of croaker representing less than 50% of the total Atlantic croaker value. For example, from 1993-2015, the south Atlantic region never contributed more than 49% of the total regional value, with the average annual share being 37% and the average annual value being approximately $2.8M. The mid-Atlantic region once again became the dominant share of croaker value, with an average annual value of $5.0M during the same period.

Value Associated with Groundfish

The use of croaker as a main input for pet food product is well known (Chapter 6 Groundfish Fishery). However, demonstrating the volume of croaker that was harvested for that industry is difficult. This is because the various species of finfish that were utilized by the pet food industry were not disaggregated within the landings statistics and were reported as Groundfish by NOAA and represented the Groundfish Fishery. Thus, quantifying the landings and value of croaker included in this broad category destined for the pet food industry can only be speculated. However, Gunter (1956), Roithmayr (1965), and Gutherz et al. (1975) suggest that greater than 50% of the Groundfish landings utilized for pet food products in the Gulf of Mexico during the period of greatest volume were comprised of Atlantic croaker. Also note that Groundfish includes 'unclassified bait', with the relative proportion of non-croaker bait comprising the total landings being unknown.

The total value of Groundfish for the Gulf region drastically increased from an average of $19,000 during 1950-1956 to $882,000 by 1957 (Figure 7.1). The value continued to increase from $1.2M in 1957 to $3.7M in 1976, with an average estimated value of $1.7M during this period. Value fell to $281,200 in 1977 and, with the exception of 2001, remained below $1.0M through 2014. Value for the Atlantic region typically exceeded $1.0M during 1954-1967 period, but only exceeded $1M sporadically thereafter through 2015.

Additional anecdotal and confidential data for the Gulf region provide some insight into the actual market for Atlantic croaker as a live bait item (Chapter 6 Live Bait Fishery). These data, particularly after 2000, suggest increased landings and sale of croaker as live bait, with primary regions of activity being Texas and Louisiana (Figure 6.7). Prices associated with live croaker have reportedly been significantly higher per unit (e.g., dozen, each, etc.) than might be expected for human consumption. These reported higher prices may have contributed to contemporaneous increases in nominal prices for croaker in general. No such anecdotal data for the live bait market in the Atlantic region are available.

Annual Values by State

The following discussions of value by state refer to Figure 7.1 Note that values for Louisiana, Mississippi, Alabama, and West Florida Coast increased during the late 1960s through the early 1980s. This increase in value was likely associated with an increased demand for croaker by the pet food industry. Though the aforementioned increase was not as noticeable in Texas, the value did increase dramatically during the last 20 years for which data are available. That increase may have been caused by another market shift associated with croaker; however the latter is associated with the live bait market. A brief discussion for each state follows.

West Florida Coast

West Florida Coast has been a less than significant source of croaker in the Gulf of Mexico during the 1950s to 2015. Only during the years 1962-1965, and again in 1986, was the majority of total croaker value attributed to Florida. During the remaining years, the Florida share of croaker value was relatively small, averaging only 13%. The value of croaker landed in Florida increased from 1970-1982, when the average annual value was $214,000, with the highest values being $329,000 and $381,000 during 1975 and 1981, respectively. West Florida Coast was not an important contributor to the production of finfish destined for the pet food market during that industry's Gulf-region 'heyday', particularly during the 1957-1976 period. However, the value associated with Groundfish increased from 1989-2013, with an average annual value of $497,000. While these landings are included in the Groundfish category, they are likely bait and not necessarily the croaker dominated species group associated with the extinct pet food industry.

Alabama

The value of croaker in Alabama has been relatively low outside of the 1968-1983 period. For example, during 1950-1967, the average annual value for Atlantic croaker in Alabama was $2,000, while the average annual value from 1984-2015 was $5,400. During 1968-1983, the average annual value was $821,000, and exceeded $1.0M during 1971-1975 and again in 1981. Alabama was attributed with the dominant share of the total Gulf-wide value during 1968-1983, with an average annual share of 70% which were specifically Atlantic croaker utilized for human consumption and not the Groundfish fishery.

Mississippi

As with West Florida Coast, Mississippi has not been an important source of commercial Atlantic croaker harvest. Aside from the years 1953-1956 (which were likely misreported Groundfish) and 1967, the Mississippi share of the Gulf-wide total for Atlantic croaker value has not exceeded 50%. During those remaining 56 years, the average annual share of Gulf value was 7%. The value for croaker in Mississippi increased to $157,000 in 1968 and remained at an annual average of $103,000 until declining to $18,000 in 1984. With the exception of 1995, the year when the annual value increased to $69,000, the average annual value between 1984 and 2014 was $2,600, and increased to $21,623 in 2015 - the highest level since 1995. Mississippi was also the Gulf-region leader in the production of Groundfish (Figure 6.2). From 1957-1976, the average annual value for this category was $1.5M, significantly greater than that reported for any other state in the Gulf region.

Louisiana

The value for Atlantic croaker in Louisiana never exceeded $100,000 during 1950-2015. The years with the highest values were 1969 ($85,600), 1975 ($60,200), 1984 ($65,200), and 2009 ($63,300). During the remaining years, average annual value for croaker was $23,000. Value increased from 1969-1985, then decreased thereafter, with another brief period of increased values during 2007-2009. Louisiana accounted for greater than a 50% share of total Gulf value only during 1988-1993; however, total value in the Gulf was relatively low during this period. Even though Louisiana was the leader during this time, values averaged $33,700 over the six-year period. The landings and value of Groundfish were the greatest from 1967-1976 (Figure 6.2), with an average annual value of $597,000 during this period.

Texas

Texas has historically not been an important contributor to the total commercial value of Atlantic croaker in the Gulf. Prior to 1994, the average annual value for croaker in Texas was $8,200. However, the value began a dramatic and steady rise in 1994, increasing from $40,000 to $819,000 in 2013. During this period, the average annual value for croaker in Texas was $395,000. In addition, the average annual share of the Gulf-wide value attributed to Texas was 87% from 1994-2015. This sudden increase in value for croaker in Texas is due to the increase in demand for croaker as a live bait for other more sought after sport fish, such as speckled trout (Figure 6.12). Further discussion of this specific market can be found in Chapter 6 (Live Bait Fishery).

Atlantic States

Since 2000, the value of Atlantic croaker has been much greater than that recorded for the Gulf region (Figure 7.2). The two most important states with regard to croaker value were Virginia and North Carolina, with average annual values from 2000-2015 of $4.7M and $2.8M, respectively. Value in both states has been relatively stable during that time period. The other states within the region that report commercial croaker landings have exhibited much lower values as compared to Virginia and North Carolina. The average annual value for croaker for the East Florida coast, Maryland, and New Jersey during the 2000-2015 period were $30,510, $506,700 and $435,900, respectively. Much lower values for croaker were

reported for South Carolina, Delaware, New Jersey, and New York. Virtually no landings were reported in the region to the north of New York (e.g., New England). The total croaker value in the New England region was $7,800 for the entire 1950-2015 period.

Average Monthly Values

Average monthly value for Atlantic croaker in the Gulf of Mexico region was computed for the five-year periods: 2000-2004, 2005-2009 and 2010-2014, as well as 2015 separately (Table 7.1). These time periods were chosen due to the most recent dominance of Texas in the overall value of croaker in the Gulf region and the cessation of pet food processing that dominated the Gulf market during earlier years. Monthly values are not discussed on a state level, but rather on a Gulf-wide basis. Also, a discussion of monthly value for the Atlantic region is not provided.

Monthly value increased dramatically from April through October, with the greatest values being reported in June and July. In addition, the monthly average values increased over the three time periods,

Table 7.1 Average monthly value ($) and price ($/lb) for Atlantic croaker in the Gulf of Mexico (NOAA unpublished data).

Time Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Monthly Value ($)												
2000-2004	493	900	764	9,499	67,157	112,410	114,280	80,710	33,616	8,805	1,521	139
2005-2009	625	151	1,039	9,744	97,275	148,856	123,028	87,484	28,804	6,219	1,709	134
2010-2014	578	34	1,309	12,851	116,408	182,461	186,576	132,815	51,711	17,926	2,720	120
2015	0	0	499	5,914	85,775	210,611	189,471	157,977	70,162	29,323	4,855	173
Average Monthly Price ($/lb)												
2000-2004	0.71	0.74	0.66	4.39	5.61	5.65	5.31	4.72	3.78	2.59	1.01	0.80
2005-2009	0.93	0.76	1.96	3.73	7.07	6.90	6.86	6.57	5.53	2.69	1.43	0.76
2010-2014	0.11	1.22	0.62	1.91	7.55	7.92	6.33	7.34	4.58	1.47	0.43	1.75
2015	0.00	0.00	1.16	2.02	6.61	8.49	8.19	8.75	8.16	7.47	6.47	1.00

particularly during April through September. Reflecting back on the trends in monthly value by state, the values generated in Texas appear to be dominating the values and trends on a monthly basis within the Gulf, particularly during these most recent time periods.

Annual Prices

Annual prices are defined as those that are received by the harvester upon the sale of Atlantic croaker to the first buyer. Such prices are often recorded when the required trip ticket is completed by the first buyer, who most often is a licensed wholesale seafood dealer. However, the prices utilized in this analysis are generated as the quotient of value ($) and landings volume (lbs). Thus, the prices generated are the average dollars per pound ($/lb) for the region or time period of interest. In addition, the prices for this discussion represent sale of whole fish, not otherwise processed or altered (gutted, head-off, filets, etc.). Finally, the prices in this discussion have not been adjusted for inflation (real) and are considered nominal prices.

Regional Prices

The nominal price (per pound, whole weight) for Atlantic croaker has shown a steady increase over the period from 1950-2015 (Figure 7.3). The Gulf-wide price remained less than $0.10/lb until 1968, when a gradual increase in price for croaker was initiated. Price in the Gulf region continued to increase, with prices approaching $0.30/lb by 1981 and then exceeding $1.00/lb by 1996. Prices increased dramatically from 1996-2015, increasing from $1.31 in 1996 to $7.01 by 2014. Average price declined to $4.30 in 2015, the lowest since 2010. Again, the rapid increase in average regional price is likely associated with the development of the live bait market for croaker which exerted strong upward pressure on croaker prices on a per fish rather than per pound basis. Prior to this most recent time period, prices were most likely associated with market pressures emanating from the table food and pet food markets, with the latter dominating prices during the mid-1950s and late 1960s through the early 1980s. In contrast, the live bait market may be the dominant source of upward pressure on average price more recently.

The pattern for prices in the Atlantic region was considerably different than that found for the Gulf region (Figure 7.3A). Prices for croaker remained below $0.20/lb from 1950-1978. Prices then increased steadily from 1979 ($0.21) to 1990 ($0.52). Beginning in 1991, prices for croaker in the Atlantic region declined somewhat to $0.24/lb in 2003. Prices then began a steady increase until reaching $0.92/lb in 2012 and 2013. Croaker prices for the Atlantic region appear not to be influenced by the same market signals as found within the Gulf region, with prices never exceeding $1.00/lb during the entire 1950-2015 time period. Average price for the Atlantic region increased from $0.35 in 2010 to $0.91 in 2015.

Prices by State

Prices for croaker in the Gulf region have exhibited two distinct patterns during the past several decades (Figure 7.3B). Prices were initially relatively low during earlier years, then initiated a gradual increase in the early 1980s. For West Florida Coast, Mississippi, and Alabama, prices continued to increase in a relatively steady manner until the 2010s, only rarely exceeding $1.00. In contrast, prices for Texas and Louisiana increased dramatically beginning in the 1990s, reaching prices approaching $9.00 and $5.00/lb for Texas and Louisiana, respectively. A brief, detailed discussion of the price trends for each Gulf state follows. In addition, a brief summary of prices for key Atlantic states is also provided (Figure 7.3A).

West Florida Coast

West Florida Coast prices for croaker remained approximately $0.10 or less during 1950-1971, then initiated an erratic increase to $0.46/lb in 1982 and remained relatively steady through 1993 (Figure 7.3B). Prices then began another erratic increase, reaching highs of $1.11 and $1.04 in 1997 and 2010, respectively. Prices have declined substantially since 2010, only reaching $0.19/lb in 2014. However, the price for croaker had a small increase to $0.81 in 2015.

Alabama

In Alabama, croaker prices remained relatively low, below $0.20/lb, until 1981 when prices reached $0.31/lb. 1993 (Figure 7.3B). Prices then generally increased, though remaining mostly less than $0.50/lb until 2004, when prices increased to $0.58. Prices then increased erratically until reaching $0.81 in 2013, declining again to $0.77 in 2014. Alabama did not report landings (Figure 6.6B) or value during 2015, thus no price data are available for 2015.

Mississippi

The general pattern found for price trends in Mississippi was nearly identical to that found for Alabama (Figure 7.3B). Prices for Mississippi remained less than $0.10/lb from 1950-1967, increased to $0.11/lb in 1968, and increased to $0.22/lb by 1979. Prices then increased erratically to $0.96 and $0.94/lb in 1989

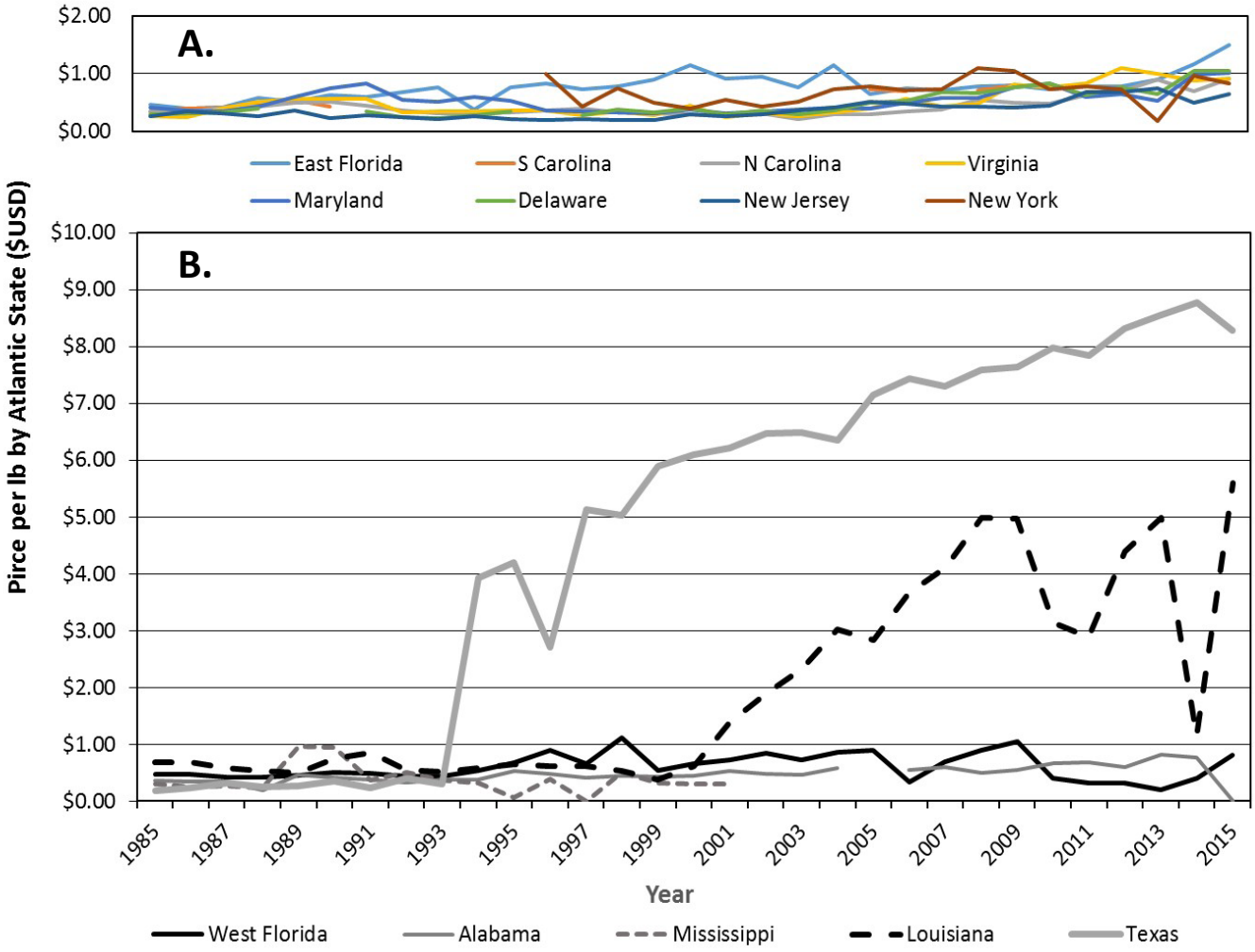

Figure 7.3 A) Atlantic states price per pound and B) Gulf states price per pound for Atlantic croaker from 1985-2015 (NOAA unpublished data).

and 1990, respectively. Following those record highs, prices declined and remained erratic, declining to $0.06/lb during 1995 and increasing to $0.56/lb in 2007. Croaker prices then remained steady until 2014, when price increased to $0.73/lb. However, landings increased (Figure 6.6C) more than value during 2015, resulting in a price decline to $0.25/lb.

Louisiana

Prices for Louisiana were a bit erratic from the 1950s to 1979 and remained less than $0.20/lb (Figure 7.3B). However, beginning in 1980, prices increased to $0.22/lb and continued to increase to $0.68/lb by 1985. Croaker prices remained steady until 2001 when they reached $1.38/lb, exceeding the $1.00 benchmark for the first time. Prices then increased steadily to $4.98 by 2008 and averaged $4.22/lb until 2014 when they declined to $1.14/lb. In 2015, croaker prices increased dramatically in Louisiana to $5.60/lb.

Texas

As with other states in the Gulf region, the prices for croaker in Texas remained under $0.20/lb until the early 1980s (Figure 7.3B). Prices reached $0.21/lb in 1981 and increased to $0.40/lb in 1992. However, beginning in 1994, prices for croaker in Texas initiated a dramatic increase reaching $3.93/lb by 1994 and

continuing to increase steadily over the next two decades. Prices reached $6.49/lb in 2003, $7.98 by 2010, and an all-time high of $8.77/lb by 2014. There was a slight decline in 2015 to $8.28/lb. The recent Texas prices are the highest price for croaker recorded for any state in the Gulf region since 1950. NOAA commercial data indicate that the Texas croaker landings were coded in a "Combined Gears" category but interviews with bait harvesters from the area suggest that the live fish were landed using standard commercial shrimp trawls. The coding change in 2015 further supports the observation that croaker were in fact landed with trawls for live bait (Table 7.2).

Select Atlantic States

The Atlantic states with the most significant values associated with croaker landings during 2000-2015 were North Carolina and Virginia (Figure 7.3A). During this period, the price for croaker in North Carolina ranged from $0.20/lb in 2003 to $0.91/lb in 2015. Price in Virginia during the same period ranged from $0.26/lb in 2003 to $1.09/lb in 2012. The lowest average value during this period was for North Carolina ($0.37/lb), while the highest average value for the period was associated with East Florida ($0.90/lb).

Table 7.2 Texas croaker landings volume, value, and price by Gear Type (1990-2015; NOAA unpublished data).

Year	Gear	Pounds	$	Price
1990	Otter Trawl Bottom, Shrimp	479	$173.00	$0.36
1991	Otter Trawl Bottom, Shrimp	910	$101.00	$0.11
1992	Otter Trawl Bottom, Shrimp	14,357	$5,920.00	$0.41
1993	Combined Gears	5,891	$1,751.00	$0.30
1994	Combined Gears	10,191	$40,057.00	$3.93
1995	Combined Gears	19,797	$82,939.00	$4.19
1996	Combined Gears	25,959	$70,387.00	$2.71
1997	Combined Gears	31,394	$160,855.00	$5.12
1998	Combined Gears	39,896	$200,455.00	$5.02
1999	Combined Gears	51,974	$306,389.00	$5.90
2000	Combined Gears	51,713	$314,912.00	$6.09
2001	Combined Gears	62,009	$385,297.00	$6.21
2002	Combined Gears	69,755	$450,651.00	$6.46
2003	Combined Gears	75,341	$488,887.00	$6.49
2004	Combined Gears	60,109	$381,859.00	$6.35
2005	Combined Gears	58,174	$415,399.00	$7.14
2006	Combined Gears	67,331	$500,365.00	$7.43
2007	Combined Gears	61,753	$450,386.00	$7.29
2008	Combined Gears	58,871	$446,165.00	$7.58
2009	Combined Gears	63,393	$484,016.00	$7.64
2010	Combined Gears	66,558	$531,221.00	$7.98
2011	Combined Gears	79,273	$621,598.00	$7.84
2012	Combined Gears	89,341	$742,527.00	$8.31
2013	Combined Gears	95,877	$819,425.00	$8.55
2014	Combined Gears	77,724	$681,403.00	$8.77
2015	Otter Trawl Bottom, Shrimp	89,624	$744,713.00	$8.31

Average Monthly Gulf Prices

Average monthly prices for croaker in the Gulf of Mexico region were computed for the five-year periods: 2000-2004, 2005-2009 and 2010-2014, as well as 2015 separately (Table 7.1). Similar to the preceding discussion for monthly prices, this 16-year time period was chosen due to the most recent dominance of Texas in the overall value of croaker in the Gulf region and the cessation of pet food processing that dominated the Gulf market during earlier years. Monthly prices are not discussed on a state level, but rather on a Gulf-wide basis. Monthly prices for the Atlantic region are not provided.

Monthly prices increased dramatically for all three periods during April through October, with the greatest values being reported during May through August. Prices appear to have declined for January, March, April, June, July, October, and November during the 2010-2015 period, while prices increased for the remaining months. Reflecting back on the Gulf-wide trends in monthly prices by state, the prices generated in Texas appear to be dominating the magnitude and trends on a monthly basis within the Gulf, particularly during these most recent time periods.

Processing and Marketing

The market for Atlantic croaker for food fish has likely always been a relatively small portion of the food, finfish market in the Gulf of Mexico region. There are no data with which to describe the volumes, values, and prices for croaker as the species moves through the Gulf-region seafood markets. Some dated information suggests that the Gulf region had some importance as a source of croaker for the southeast Atlantic region. Summey (1977, 1979) provides information on the volumes of croaker that were obtained by the North Carolina seafood market directly from Alabama. Though the volumes were relatively small compared to local sources, the Gulf region did play a role in providing supply for finfish markets in other regions. In addition, Atlantic croaker made up a large portion of the Groundfish from the Gulf region which was a major input into the canned pet food industry that existed in Louisiana and Mississippi until the 1990s.

Recreational Sector

The recreational targeting of croaker in the Gulf appears to be minimal compared to other, more preferred species, such as red snapper, red drum, and spotted seatrout. The few trips that are reported as targeting croaker (Figure 6.12) in the MRIP data, do not indicate if croaker were being targeted for foodfish or for bait by anglers intending to target other finfish species. Therefore, there are no expenditures data associated with efforts to target croaker. In the bait fishery, the anecdotally reported price per pound of croaker for bait provides insight into what the angler may be willing to pay to target 'other' species, as opposed to the value associated with croaker as a targeted species. For some nearshore and shore-based anglers, targeting croaker may be desired strategy. However, there are no data available to allow an assessment of the economic values associated with targeting croaker.

Civil Restitution Values and Replacement Costs

Some states have assigned monetary values wherein they assess damage for the loss of finfish resulting from negligence or illegal activities. These values are determined in a variety of ways for both recreationally and commercially important species. Cost of replacement may be assessed based on the costs associated with hatchery production, willingness to pay by users and non-users, or travel cost expenditures by recreational users. The individual states may employ additional methods for estimating the value associated with an individual fish for the purpose of damage assessment, such as utilizing existing market prices for commercially important species and estimated hourly valuation of fishing for recreationally-important species (LDWF 1989, TPWD 1996). The American Fisheries Society (AFS 2003)

has estimated replacement values for certain species (primarily freshwater) and provides the methods for determining these values. State civil restitution values may be linked directly with these published estimates and methods.

Restitution values for Atlantic croaker vary considerably by state. In Florida and Louisiana, a fixed per each restitution value is assessed for all sizes of croaker. The Florida Administrative Code (62-11.001, https://www.flrules.org/gateway/ruleno.asp?id=62-11.001) indicates that Atlantic croaker is valued at $10.10 each for damage valuation purposes, regardless of size. Similarly, Louisiana Code Title 76, Chapter 3, Section 315, assigns a value of $4.61 per fish regardless of size. Texas assigns restitution values to croaker on a per pound basis ($1.90) and on a size basis, which covers a range of 1 to 39 inches, including values of $2.24 and $95.02 for 6-inch fish and 24-inch fish, respectively (Table 7.3). Mississippi and Alabama have no values assigned for croaker. These values provide at least some means for assessing the damage to stocks of Atlantic croaker.

Table 7.3 Restitution values for Atlantic croaker in Texas waters (TPWD unpublished data).

Size	Base Value ($)	Size	Base Value ($)
0 lbs	1.90	20 in	57.10
1 in	0.12	21 in	65.33
2 in	0.12	22 in	74.36
3 in	0.24	23 in	84.24
4 in	0.38	24 in	95.02
5 in	0.84	25 in	106.75
6 in	2.24	26 in	119.47
7 in	3.53	27 in	133.23
8 in	5.08	28 in	148.09
9 in	7.07	29 in	164.08
10 in	9.34	30 in	181.25
11 in	11.94	31 in	199.67
12 in	14.92	32 in	219.37
13 in	18.30	33 in	240.40
14 in	22.14	34 in	262.82
15 in	26.48	35 in	286.68
16 in	31.35	36 in	312.03
17 in	36.81	37 in	338.91
18 in	42.89	38 in	367.39
19 in	49.64	39 in	397.51

Chapter 8
SOCIAL AND CULTURAL FRAMEWORK OF DOMESTIC FISHERMEN AND THEIR COMMUNITIES

There is a substantial amount of information available which describes the historic socio-cultural characteristics of a number of the components of the Atlantic croaker fishery in the Gulf of Mexico. However, since most of these fisheries are essentially extant at this point, they will be summarized briefly and the published resources which provide more detail will be provided.

The majority of impacts related to fishing for Atlantic croaker were derived from the various trawl fisheries which operated in the Gulf region through the end of the 20th century. The shrimp fishery was an early source of fishing mortality and those participating in the fishery have been well documented. The Groundfish fishery, which had its beginnings in the commercial shrimp fishery, was similar in nature as shrimpers retooled their vessels to exclusively target 'bycatch' finfish for the pet food industry beginning in the 1950s. Other fishing for croaker came from traditional gillnet fishermen and those operating snapper boats in the northern Gulf. While there is not a lot of demographic information on those directly participating in the croaker fishery in the Gulf of Mexico, there are some generalizations which can be extracted from those using the gears for a number of target species.

Shrimp Trawling

As noted above, socio-demographic profiles do not exist in the Gulf region for those participating directly in the historic Atlantic croaker fishery. Croaker comprised a large portion of the traditional shrimp fishery bycatch (around 70%); therefore, some assumptions can be made using published information related to fisheries such as the Gulf shrimp fishery. A short history of the shrimp fishery can be found in a number of publications such as Landry 1990, Condrey and Fuller 1992, Nuwer 2006, and Maril 2010.

An excellent overview of shrimping in Louisiana was provided by Landry (1990) who relayed that

> "In 1774, an early traveler in Louisiana, Le Page du Pratz, noted that shrimp were being fished in the lakes south of New Orleans with large nets brought from France."
>
> Landry 1990

Nuwer (2006) described the people of the Mississippi Coast who participated in the seafood industry in general from about the mid-1800s to World War II which included much of the development of the Gulf's shrimp industry. Maril (2010) described the bay shrimp fishery in Texas and provided a characterization of the participants from the mid-1970s through the 1990s.

While many of these histories provided the industry changes, there is still little information on the makeup of the communities participating in early shrimp fishing. It would be safe to say that the majority of the seafood industry was made up of immigrants and their subsequent families. Along the northern Gulf, two ethnic groups stood out: white Americans (Greeks, Slavs, Scandinavians, Italians, and Nova Scotians) throughout the 20th century with the addition of those of Southeast Asian origin in the early 1970s (Starr 1981).

As Nuwer (2006) described the early shrimp fishery in Mississippi, the following could be said of most of the fishing communities around the Gulf of Mexico.

> "Entire families worked in the industry, with a clear division of labor along gender lines. The male members of a household were boat owners or fishermen, while women and children of the family usually worked in the factories. Young children worked alongside adults until a 1908 Mississippi

law made it illegal to hire children under age 12 to work in factories. The success of the seafood harvest was dependent on the entire family."

Nuwer 2006

From this eclectic group of shrimping families rose the Groundfish fishery of the 1950s. Always innovative and making the most of what they caught, shrimpers realized that there was monetary value in what they were returning to the sea. Many shrimpers retained finfish for sale and personal consumption but, when the interest in pet food took hold, the traditional trawl fishery changed significantly (Chapter 6).

Despite the low numbers of croaker landings today (Chapter 6), the majority of those landings since the mid-1990s originated from shrimp trawls and a combination of trawl gears (NOAA unpublished data). Since the 1970s, the ethnic composition of the trawl fishery in the northern Gulf changed from a collection of Caucasian families to include an unknown number of immigrants from Southeast Asia who made the U.S. home and entered the fishery (Starr 1981, Osburn et al. 1990, Moberg and Thomas 1993, Durrenberger 1994). In his description, Starr (1981) pointed out that several groups were lumped into a 'Vietnamese' category for simplicity but included individuals of Laotian and Cambodian descent. Since the mass exodus from Southeast Asia to the United States in 1975, the new immigrants have played an integral role in Gulf coastal fisheries. As the 'local' fishermen and recent immigrants expanded their families and became more integrated in their communities, fewer and fewer children moved into the family fishing business. At the beginning of the 21st century, new immigrant groups from other areas such as Central and South America, many of whom were undocumented, have been joining the Gulf fisheries in Texas, Louisiana, and Mississippi (Maril 2010, VanderKooy and Smith 2015).

Groundfish Trawling and Processing

The Quaker Plant in Pascagoula began canning *Puss N' Boots* cat food in 1952 utilizing shrimp bycatch as the primary ingredient. The plant began production with 22 employees and six boats and, by 1972, had about 100 employees and 30 boats with 80 crew members supplying them with Groundfish (Mississippi Press 1973). By 1977, Quaker boasted 170 employees, running five large refrigerated vessels contracted to the plant by George Castigliola (Quaker Oats 1977).

The Fishermen and Allied Workers Union was part of the National Maritime Union which many of the Gulf watermen and fishermen joined beginning in the 1940s (Baunach 2013). Several strikes occurred related to the pet food industry on the Mississippi Coast including a suit filed in 1957 by croaker boat crews who were employed by the Castigliola family. They operated the Castigliola Shrimp Company in Pascagoula, Mississippi which supplied the Quaker Oats plant exclusively (SCM 1959). The complaint was related to raw product prices and vessel quotas, as well as the use of outside fishing vessels and non-traditional crews. In a letter dated November 13, 1957, W.J. Higginbotham, Secretary of the defendant union, addressed the Union's concerns to Mr. Leonard Davis, Manager of the Quaker Oats Company (originally named Coast Fisheries):

"Mr. Leonard Davis, Manager
Coast Fisheries
Pascagoula, Miss.

Dear Sir:

The Fishermen and Allied Workers Union, an Autonomous Union within the National Maritime Union are the successors of the Old Gulf Coast Shrimper's and Oysterman's Association. As you probably know, all of the Fishermen who fished for you when you first started operations in Pascagoula in 1952 were members of this Union. You also know that the Business Agent, Mr. Walter McVey, scheduled the boats for your Agent. That when your production was limited, the

Union, with the consent of your Agent, restricted each boat to five tons per boat per trip, etc. and relations between your company, your agent, and the Union were very cordial and we all prospered and grew larger. It has now been brought to our attention that an ever increasing number of outside boats have been brought in, thereby crowding out some of our local boats. Also that these outside boats are selling from three to five times more fish than the local boats. That our local fishermen are being replaced by Negro Fishermen from other states. It is this discrimination by your agent that the Union is gravely concerned. Your agent has used and abused our local fishermen to the point that the Union must take immediate action, we therefore ask that you meet with us November 15, 1957 in your office to discuss the necessary steps to eliminate these unjust conditions and to draw up an agreement whereby the fishermen of Pascagoula may claim their seniority rights, working conditions, and other benefits to which they are entitled.

Sincerely yours,
W.J. Higginbotham, Secretary"

In testimony following the presentation of the letter to Quaker Oats, Union Secretary Higginbotham highlighted additional complaints from the fishermen related to inequality in working hours, safety for crew during unloading, accuracy questions regarding the fish scales, and deductions made to the fishermen's pay, to cover the cost of insurance and radio facilities (SCM 1959). Quaker Oats filed their own complaint contending that the picketing fishermen were blocking transportation from entering and exiting the plant and 'intimidating' employees, and that the dispute had nothing to do with interstate commerce. The chancellor issued a temporary, and eventually permanent, injunction against the union picketers. There is no further record of the eventual outcome of the strike against Quaker Oats (VanderKooy personal observation).

The Mavar family entered early into the seafood industry in Mississippi. In testimony provided to the U.S. House Small Business Committee in 2009, Victor Mavar of the Mavar Shrimp and Oyster Company in Biloxi, Mississippi provided an overview of his family's role in the Gulf seafood industry (Mavar 2009). Victor reported that his parents came to the U.S. from Croatia in 1898 and settled in Biloxi. His father, John Mavar, fished, while his mother, Olivia, worked in a processing plant and, in 1920, they purchased their own fishing boat. Mavar quickly began to sell his and others' catches both retail and wholesale and his four sons (John, Victor, Sam, and Nick) finished school and joined the business. While shrimping remained profitable, the oyster industry began to decline and in the 1950s, the family began looking at alternative sources of income from their fleet of fishing vessels. They began to evaluate the waste products and discards from shrimping and determined that there may be a way to generate some profit (Dement 2014). The whole family was employed in their various fishing businesses which included fishing, shrimping, canning, and fresh seafood sales. They had a large plant on the beach in Biloxi where they canned shrimp and oysters and tested ways to begin to process and can fish typically culled from their shrimp boats. As a result, the *Kozy Kitten* brand was created. In 1961, the canned cat food was sold locally and sales quickly grew as other companies supplying the pet food market nationally found it harder to get product which had primarily originated from the Great Lakes (Smith 1970).

At the peak of the fishery, 300 people were employed by the Mavar family and they owned a number of the vessels that supplied them with fish (Mavar 2009). Initially, the fleet consisted of shrimp trawlers who retained their bycatch but, eventually, a number of the boats were retooled and became 'croaker boats' which pulled a variation of the traditional shrimp trawl designed to handle the tougher Groundfish of which croaker was a major portion of the catch (Roithmayr 1965). Others began to harvest and process Groundfish as well and additional plants were built along the northern Gulf (Chapter 6 Pet Food Plants). Eventually, the Mavars sold the *Kozy Kitten* brand and the Biloxi plant to the H.J. Heinz Company but, after only a few years, Heinz relocated their operations north and the Biloxi plant was closed (Mavar 2009). Other companies that owned pet food plants in the Gulf included Purina and Quaker Oats, based out of Pascagoula. By the late 1980s, virtually all of the pet food plants on the Gulf Coast had closed. The

Pascagoula plant changed hands a few more times but stopped landing fish to produce pet food around 1994 (Table 6.1).

The DeJean Packing Company (DeJeans) was the other Biloxi-based cannery which produced pet food starting in the late-1950s. The Mavers produced pet food exclusively while the DeJean plant produced a variety of canned seafood such as shrimp, oysters, and crabmeat (depending on the market) in addition to their pet food production (Thiroux personal communication). The DeJean plant, owned by the Williams family, canned for two different companies before developing their own pet food line. The Carnation Company was one of the early cat food lines that DeJeans canned for, producing *Friskies* wet cat food in the mid-1950s.

The DeJean family began working in the seafood industry in the 1920s and focused on fresh shrimp and oysters, shipping the cans in iced barrels to the midwest (Harvey 1980). By the 1930s, the plant began to use machinery to assist with the processing of oysters, shrimp, and some crabmeat, and DeJeans' canned seafood became more widely distributed. Harvey (1980) reported that by the early 1940s, the DeJean fleet had expanded to three individual fleets of ten boats each, Biloxi luggers that would provide shrimp on a steadier basis during the year. Three larger support vessels were built to service the three smaller groups of luggers by providing ice and supplies to allow fishermen to stay out fishing longer and transport their catches back to the plant. DeJeans attempted to can tuna for a California-based tuna fishing company but the Gulf availability of tuna was inconsistent. Mr. Glenn Williams, a former owner and son of founder Peck Williams, indicated that Hilife, a Chicago-based firm, canned *Catlife* pet food in a small plant in Gulfport, Mississippi with fish supplied by a single vessel (Williams personal communication). The DeJeans converted some of their shrimp processing equipment to begin to handle Groundfish and DeJeans began packing pet food for Hilife around 1958 (Williams personal communication). In 1963, DeJeans entered into a contract to can for Purina under the *Friskies* label (Williams personal communication) which was a subsidiary of the Carnation Company.

In late 1957, the Fishermen and Allied Workers Union, to which most of the croaker crews belonged, went on strike against the DeJean plant because they "paid considerably lower for Groundfish by the ton than did the Mavers" according to Thiroux (personal communication) who started his commercial fishing career as a deckhand on one of the DeJean croaker boats. Most of the captains and crews that worked for the DeJean plant walked out but, since DeJeans still owned several of the vessels in its fleet, the plant simply hired new crews, leaving many of the captains out of work (Thiroux personal communication). The Union was unable to help get the increase so many of the fishermen turned to fishing alternate species. Captain Thiroux became one of Mississippi's largest commercial harvesters of blue crabs and he still operates today. As a result of the labor dispute, Purina eventually ceased production at the DeJean plant by about 1970 (Williams personal communication).

In 1969, Hurricane Camille struck the Mississippi Coast and both the DeJean and Mavar plants suffered substantial damages as a result of the category five hurricane. The DeJean plant was quickly rebuilt and added four additional shrimp picking lines to their existing canned shrimp production. Williams indicated that DeJeans continued canning pet food once they rebuilt their facility and actually increased their pet food production (Williams personal communication). Pet food made up about 60-70% of DeJeans' total production at that time. Williams further explained that, after the loss of the Purina contract, the DeJeans developed their own line of pet food around 1971 under the name *Happy Cat* and continued production until about 1975 at which time they stopped all pet food production to focus on the shrimp market. The Mavars continued to produce *Kozy Kitten* after Hurricane Camille until they were bought out by Heinz in 1988 (Table 6.1).

At its peak, after Hurricane Camille, the DeJean plant employed approximately 40 people between the shrimp picking lines, the warehouse, and other canning operations (Williams personal communication). DeJeans relied on the three vessels they owned as well as three additional contract vessels, two from Louisiana and one from Alabama. While the plant owned their vessels, the three-man crews operated

the boats as they saw fit, determining when and where they would fish. Fish that were too valuable to process for pet food (flounder, trout, large shrimp, etc.) were removed from the conveyor during the pump-out and were returned to the captain and crew for their personal consumption or sale (Williams personal communication). Despite the strike in 1967, the plant had continuity of employees and often hired entire families according to Williams. Several teenage children were hired for odd jobs around the plant in the early 1950s and remained with the company until the plant was sold in the 1980s. Some of those employees continued to work for the new owners until the plant was finally closed in the early 1990s (Williams personal communication). Most of the families were 'old Biloxi' families who had worked in the fishing industry dating back to the early 1900s. There were a number of Slavic families, but a great percentage originated from Louisiana and were French Creole according to Williams. Mr. Williams' mother was from Louisiana as well as her three brothers who ran several of the DeJean boats over a period of time. Williams described one of the Louisiana vessels that was contracted to trawl for both shrimp and Groundfish as the "yap yap" boat because the crew only spoke in a French dialect and no one at the plant could understand them.

Two additional Mississippi based pet food plants were mentioned in a local newspaper from the time period. A single plant (Hilife Packing who canned for Fairhaven Fisheries) operated in Gulfport, Mississippi until the DeJeans took over canning of *Cat Life* cat food in 1959, after which there is no further mention of the Hilife plant (Mississippi Magic March 1959a). The only other Mississippi pet food plant was the Bluff Creek Canning Company which produced *Red Heart* pet food in Vancleave, Mississippi from 1953-1961 (Table 6.1). While photos exist of the plant, there are very few descriptions of the company itself and its role in the pet food industry (VanderKooy personal observation). The Mississippi Magic (1953) reported that the Vancleave plant was planning to hire 40 workers and utilizing six boats to harvest Groundfish beginning in 1954. In 1961, the Mississippi Magic (1961) reported that coast-wide, the total production of pet food at the five plants operating between Gulfport and Pascagoula utilized 300 tons of Groundfish per day. It is not clear why the Vancleave plant ceased pet food production after 1961 but there are some anecdotal accounts regarding a switch to canning bonito (*Euthynnus alletteratus*) as a potential substitute for canned tuna instead of pet food (Overstreet personal communication).

In Louisiana, the *Tabby Cat* plant owned by Unen Products operated from 1967-1978; however, there is little information on the facility itself. Local newspaper articles mention that the plant was built in late 1966 along the western shore of Bayou Lafourche. When it opened in 1967, about 30 people were hired to operate the factory, and crew eight vessels (Times-Picayune 1967). The vessels were contracted from the Gulf Coast Boat Company and were built specifically to fish for croaker. The new vessels could transport 100 tons of fish and offered mechanical refrigeration which "insured protection of the catch at a quality that makes it fit for human consumption" (Times-Picayune 1967). The plant processed fish and added chicken and beef to their formula for *Tabby Cat*. There is no information available after its grand opening in 1967. Mr. Ernest Voisan eventually purchased the plant intending to produce additional fishery products such as oysters but apparently never utilized the facility. It was sold again in 1997 and converted to Superior Shipyard. The main structure on the site is still referred to as the *Tabby Cat* building (Duet personal communication).

Austin et al. (1978) characterized the croaker fleet as of mid-1970s, shortly after the recovery from Hurricane Camille of 1969. They reported that the croaker fleet was relatively small despite the large volume of landings. Approximately 50 fishermen (captains and crew) on 15 vessels were still involved in croaker fishing at that time. These were fishermen who had a long history in the seafood industry and whose families had originally shrimped. The workshop participants reported that:

> "There is little labor mobility in or out of the fishery, although crew members frequently move among vessels. Entry into the fishery as a crew member is difficult because of the declining number of crew positions. Those seeking employment without close personal connections, either family or friends in the fishery, have little chance of securing work except as a last minute replacement for an absent regular crewman.

> Many crewmen believe they could earn higher incomes fishing shrimp, but are willing to accept lower pay croaker fishing for two reasons. First, it is not necessary to hand sort the catch. Second, croaker boats make shorter trips and return to the same port.
>
> The captain and the crew are paid individually on the basis of tons of fish landed. An additional source of income to the crew is the incidental catch of food fish and shrimp, all of which goes to the crew."
>
> Austin et al. 1978

The "lower pay" for croaker fishing mentioned by Austin et al. (1978) was refuted by the Mavers who indicated that boats in their fleet stayed because the money for croaker was better than for shrimp at that time (Mavar personal communication). When the Biloxi plant was purchased and closed in about 1990, the Mavar fleet continued to fish for Heinz in Pascagoula.

In addition, there were approximately 350 individuals employed in the six processing plants across the Gulf in 1978 (Panko and Ramke 1978). Several operations still processing croaker in 1978: two pet food canneries in Mississippi (Biloxi and Pascagoula), one surimi plant in Louisiana (Golden Meadow), one surimi plant in Alabama (Bayou LaBatre), one processor of fresh croaker in Alabama (Bayou LaBatre), and one freezer operation in Louisiana. These employment estimates took place during the decline of the Groundfish fishery; however, there were no reliable estimates of total employment from the height of the fishery in the 1950s and 1960s.

One other industry note resulting from the development of the pet food industry along the Gulf of Mexico was the addition of a new source of cans to supply the Coast demand. In 1959, a new can producing plant was built in Pascagoula, Mississippi, east of the city, which was capable of making 210M cans per year (Mississippi Magic 1959b). The Continental Can Company began serving the coast's canning industry in late 1959 and employed about 80 people at that time. The Continental facility closed in 1978 when the Quaker Oats plant canceled their contract to supply the pet food plant in Pascagoula. The Quaker Plant made up 80% of Continental's business (Mississippi Press 1978). The National Can Company quickly purchased the property and continued production of cans for the pet food plants until about 1985 in Pascagoula (VanderKooy personal observation).

Commercial Live Bait Fishery

Nance et al. (1991) summarized the inshore/bait shrimpers in two locations from the Gulf of Mexico: Galveston Bay, Texas and Calcasieu Lake, Louisiana. They reported that, through the late 1980s, the bait shrimp fishery was year-round. Participants were long-time residents who represented the community around Galveston Bay. The fishery was dominated by Caucasians but also included Black, Hispanic, and Southeast Asian fishermen. In Calcasieu Lake, the inshore shrimp fishery of the late-1980s lacked diversity with less than 1% of the population represented by non-Caucasian groups.

There was little demand, however, for live shrimp to supply the local recreational fishing community so the majority of the shrimp landings went to the small shrimp canneries (Nance et al. 1991). The majority of croaker bait landings, according to a Texas live croaker dealer, were harvested by only 10 or 15 boats statewide (VanderKooy personal communication). He indicated that two boats currently operate out of Galveston Bay with the rest operating further south towards Brownsville. The dealer indicated that these individuals are basically shrimp fishermen who target live bait during June and July when the croaker are the right size. There are no published works which characterize the live croaker harvesters specifically.

Recreational Anglers

As far as recreational fishermen are concerned, Atlantic croaker no longer have the value that they may have once held (Chapter 6). While there are numerous anecdotal historic reports of annual runs

of large 'bull' croaker occurring throughout the Gulf of Mexico, there is little evidence of those large fish occurring today in the recreational catch. This has generated much discussion, even within the task force developing this profile. Do large croaker still exist in the offshore waters associated with oil and gas structures and are they simply not targeted or have they disappeared?

Anglers today have much more technology at their disposal when it comes to seeking out fish to target. In addition, the increase in the quality and affordability of larger boats makes offshore fishing grounds accessible to many more anglers. However, the popularity and focus on 'reef fish' in the region has likely resulted in fewer people targeting fish like Atlantic croaker offshore. Red snapper (*Lutjanus campechanus*) has literally become the poster fish for criticism of federal fisheries management and the battle cry over the rights of private recreational anglers, the for-hire fishing industry, and commercial fishermen to reef fish. In addition, the number of oil and gas structures in the Gulf has increased significantly since the first platform was installed off Louisiana in 1942 (BOEM unpublished data; Figure 8.1). Angler opportunities have likewise increased with many retired and inactive structures being reefed through programs like Rigs-to-Reefs. The interest in reef associated species such as snapper and grouper has exploded as a result, further reducing interest in species such as croaker.

Although not well documented, as more popular species become more restricted through regulation, anglers often rediscover fish they may have considered 'trash' before. Increasing regulations on most of the reef fish and increased access to many of the nearshore species will likely increase the interest in fish like Atlantic croaker. A good example is black drum (*Pogonias cromis*) which most people considered a poor man's fish and pest to the oyster industry. As anglers encountered tighter restrictions on red drum populations, both recreational and commercial fishermen increased the harvest of black drum which in reality is an excellent fish and today is substituted for red drum in restaurants (Fritchey 1989). As fewer snapper and grouper are available, it is likely that large Atlantic croaker may become more frequent in the harvest.

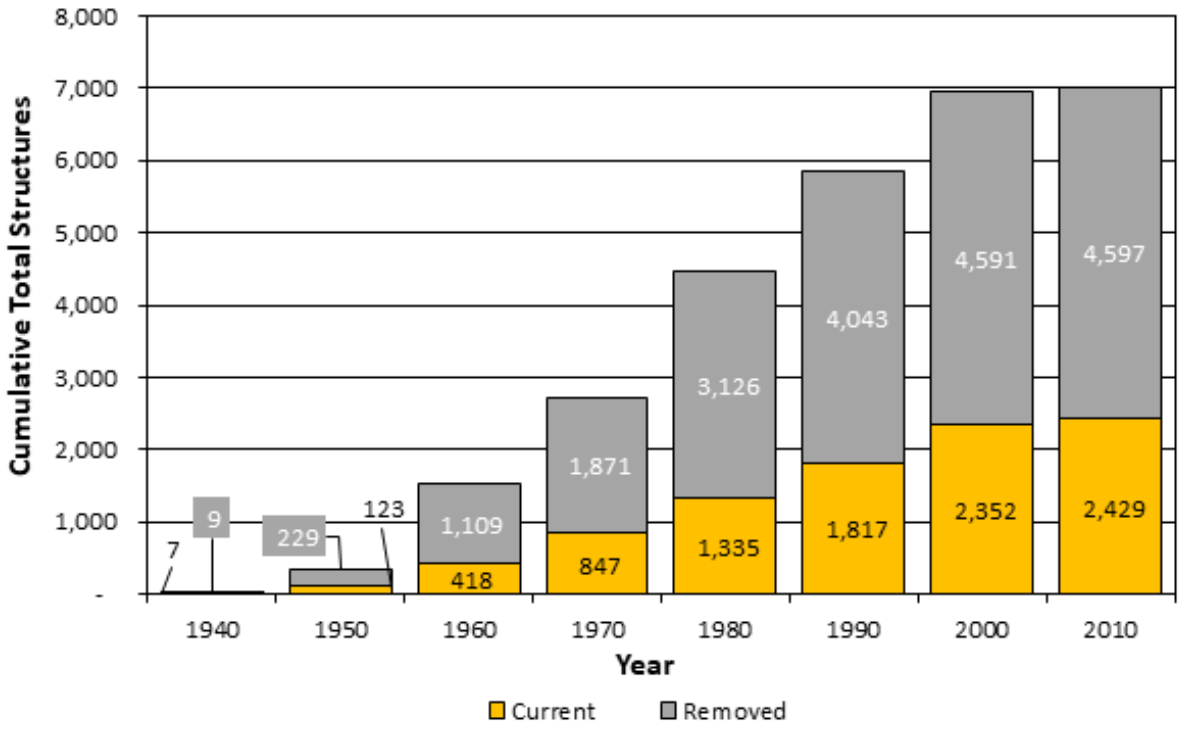

Figure 8.1 Decadal accumulation of active, inactive, and removed oil and gas structures in the U.S. Gulf of Mexico from 1940-present (BOEM unpublished data).

In general, people who fish for any other species than croaker have the potential to land croaker so describing their socio-demographic characteristics is not useful; i.e. considering the high incidental catch rate, every angler could be included as a 'croaker angler'. There are a number of studies which provide historical descriptions of the recreational fishing community in general throughout the Gulf such as USFWS (1996), Ditton and Hunt (1996), LDWF (1997), and Milon (2001).

Recreational Anglers and Live Bait

Declines of gamefish like spotted seatrout in recent years have been theorized to be the result of increased effort by recreational anglers and, in some cases, believed to be caused by unfair targeting with certain baits and techniques. In Texas, many anglers have suggested that the use of live Atlantic croaker gives an unfair advantage over other baits such as shrimp or artificial lures. Some sports writers have suggested that utilizing live croaker is 'a cheat' when fishing for spotted seatrout because of their effectiveness and should be banned as a bait. Tompkins (2014) wrote

> "…some coastal anglers have tried their best to have the use of croaker as bait banned or its use significantly limited. Those efforts have included pushes to have minimum length limits set for croaker or have the fish designated a game fish; either would end its use as bait. In 2003, a Houston state senator introduced a bill that would have prohibited using any croaker less than 10 inches long as bait; the bill went nowhere."
>
> Tompkins 2014

Those who are committed to fishing with live croaker swear that they are 'absolutely irresistible' to big trout. Further perpetuating this belief are the fishing articles, blogs, and web-posts (for example Pustejovsky 2007, Jones 2013, and Kent 2014) proclaiming that Atlantic croaker "are the 'natural enemy' of speckled trout because croaker will eat trout eggs during the spawning season" and a female trout will "kill every croaker it encounters". While there is literally no research or documentation of this, many recreational anglers will pay significantly high prices for live croaker when targeting spotted seatrout, based on this belief.

Smith (2012) described the Texas anglers by characterizing inshore guides and clientele they serviced. He found that a number of inshore guides preferred to use more 'skill-related techniques' such as lures, plugs, and flies and used the derogatory term 'croaker soaker' when referring to anglers who used live croaker to fish for spotted seatrout. Smith (2012) determined that Texas recreational fishing guides could be broken down into four basic specialization groups or 'sub-worlds' based on terminology derived by Ditton et al. (1992): limit guides, all-purpose guides, lure guides, and sight-casting guides. Limit guides represented the part of the fishing population that hired a vessel and captain with the purpose of filling a cooler with a high diversity of fish species. The all-purpose guides catered to anglers who were interested in catching fish but willing to utilize many more techniques and baits to do so. Lure guides were much more specialized and tended to target more high profile species like large spotted seatrout. Finally, sight-casting guides were an angling group who preferred to stalk their prey in shallow waters, typically targeting feeding redfish. The 'croaker soakers' tended to fall into the category of all-purpose guides who specialized in beginner anglers and made up the largest segment of guides along the Texas Coast (Smith 2012).

Chapter 9
RESEARCH NEEDS

Areas of Future Research

Below is a list of research needs based on the current literature in the Gulf of Mexico. Of primary interest to management is an updated understanding of the population dynamics of Atlantic croaker in the Gulf of Mexico across the range of the species. Specifically, improving our understanding of processes like growth, mortality, and maturity and the creation of indices of relative abundance is necessary for assessment and management goals. Such dynamics should then be understood in the context of environmental changes and the effects of alternative management strategies on the population (Diamond et al. 2000). In addition, we include research needs that focus on better understanding the ecology and ecosystem role of Atlantic croaker in the Gulf of Mexico.

Biological

- *Better distribution information for Atlantic croaker is needed for the Gulf of Mexico.*

  Gulf-wide information on the distribution and movement of Atlantic croaker is absent. However, long-term fisheries datasets (e.g. SEAMAP) provide an opportunity to understand the coastal distribution of the species and how it relates to environmental factors, fishing, ontogeny, etc. Such information can also be used for spatially explicit and ecosystem based management objectives.

- *Update with more current croaker age-and-growth studies.*

  The most recent published age-and-growth study for croaker in the Gulf of Mexico was conducted over 30 years ago by Barger (1985). This study took place while the shrimping industry was still very active. Therefore, it would be beneficial to see if the length-at-age and length and age structure of the current stock has differed since the decline of the shrimping industry and introduction of bycatch reduction devices. This would allow fisheries biologists to better understand and manage croaker in the future. Understanding how length-at-age varies spatially will provide information on the spatial stock dynamics. In addition, future studies should attempt to understand the age and growth of samples representative of the entire population in the Gulf of Mexico (Barger 1985).

- *Validate current methods used to derive Atlantic croaker ages.*

  Marginal increment analyses of croaker otoliths have been performed to validate annuli in fish from the Gulf of Mexico (Barger 1985) and Atlantic (Barbieri et al. 1994b). However, the two studies disagree about which mark should be counted as the first annulus. Barger did not count the thin, blurred, opaque band found on 58% of the otoliths, while Barbieri did count these as the first annulus. As a result, it would be beneficial to develop a standardized aging protocol so that future age-and-growth studies are consistent in their methodology.

- *Update fecundity estimate for Atlantic croaker (GSIs of any inshore and offshore populations).*

  Very little is known about croaker fecundity. As noted in Chapter 3, only a few older studies have examined fecundity, with nothing conducted in more recent years. Future studies should aim to understand the reproductive biology of specimens collected using offshore fishery-independent sampling techniques in the Gulf of Mexico (Barbieri et al. 1994a).

- Determine croaker maturity schedules.

  No recent studies have been published on croaker maturity in the Gulf of Mexico. Length- and age-at-maturity are therefore needed for assessment efforts.

- *Estimate natural mortality of Atlantic croaker.*

  Estimates have been conducted on a regular basis for croaker on the U.S. East Coast, but not in the Gulf of Mexico.

- *Determine croaker spawning behavior and location information.*

  It is well documented that croaker migrate offshore to spawn. However, very little is known about their behavior and exact locations where they spawn. It would be beneficial for fisheries managers to know where croaker spawn and whether there are only a few locations or many. Due to their small size and lack of interest from commercial and recreational fishermen, a traditional tagging study may not be feasible. However, examining natural tags using otolith chemistry may provide this information.

- *Explore larval transport mechanisms for croaker.*

  Studies have speculated that larval transport plays a role in how croaker populations are structured. Examining Gulf and coastal currents will likely aid in understanding larval transport, but until their spawning locations are known it will be difficult to fully determine how and where croaker ingress into coastal estuaries. For example, the mechanisms of the transport of larvae from the Mississippi River plume front to inshore estuaries remain to be understood. Loop current dynamics and the timing of spring turnover may also impact larval and adult dynamics of Atlantic croaker populations, but these remain unknown. Given recent advances in statistical modelling and increases in remote-sensing and in-situ data sampling, previous relationships regarding habitat preferences of Atlantic croaker through ontogeny should be evaluated, specifically length or age-structured habitat usage.

- *Determine optimal physiological requirements for Atlantic croaker (temperature, salinity, DO, photoperiod, and the effects on survivorship and recruitment success).*

  While some research has been conducted on physiological preferences of Atlantic croaker, further work is needed to understand how variation in environmental and anthropogenic factors impact recruitment and survivorship. For example, on the Atlantic Coast, temperature has been linked to driving recruitment success, however, such studies are absent in the Gulf.

- *Focus future research on the impacts of river discharge and environmental factors on the population dynamics of Atlantic croaker in the Gulf of Mexico.*

  Previous research has indicated that variation in Mississippi River discharge can alter year-class strength of estuarine dependent fishes in the Gulf of Mexico (Govoni 1997). Variation in river discharge likely impacts processes such as growth, recruitment, and mortality throughout ontogeny of Atlantic croaker in the Gulf of Mexico, similar to populations in the Atlantic (Searcy et al. 2007). In addition, while overwintering temperatures in coastal estuaries is a determinate of year class strength of croaker in the Atlantic (Hare and Able 2007), often the mechanistic processes are unknown. Atlantic croaker (*Micropogonias undulatus*, such research is limited in the Gulf of Mexico.

Variations in river discharge and inter-annual climate regimes such as the El Niño Southern Oscillation and Atlantic Multidecadal Oscillation can alter thermal habitat and primary productivity in the Gulf of Mexico (Sanchez-Rubio et al. 2011) and likely pose consequences for recruitment of Atlantic Croaker. For example, increased nutrient inputs into the Gulf of Mexico are linked to increased biomass of Atlantic croaker (de Mutsert et al. 2016).

- *Determine the impacts of fishing on population dynamics for Atlantic croaker in the Gulf of Mexico.*

  Despite the large scale shrimping effort, impacts of bycatch on the demographics of Atlantic croaker have not been thoroughly investigated in the Gulf of Mexico. Heavy fishing pressure can lead to fisheries-induced evolution leading to decreases in length-at-age and early maturation (Reznick and Ghalambor 2005, Ballón et al. 2008). Comparison of time series of data on fisheries, fishery-independent surveys, winter water temperature, and indices of habitat condition can prove useful to evaluate the impact of environmental conditions and fishing on the production and population dynamics of Atlantic croaker in the Gulf of Mexico, similar to previous work from the Atlantic (Munyandorero 2014).

- *Improve descriptions of Atlantic croaker egg morphology.*

  Information on Atlantic croaker egg morphology is lacking. With better egg morphology descriptions, the eggs from Sciaenids can be more easily distinguished from each another. The identification of Atlantic croaker eggs can also give insight into spawning location, spawning time, and fecundity rates.

- *Expand the current information which would contribute to stock assessment and potential management of Atlantic croaker.*

  Assessment of the Atlantic croaker in the Gulf of Mexico is limited. However, Atlantic croaker represents an important trophic linkage in the ecosystem and supports multiple fisheries. Updated indices of relative abundance, growth, mortality, age- and size-structure, and maturity are needed for such assessment efforts.

Genetic Stock Identification

- *Investigate genetics from the entire Gulf Coast and determine any genetic movement between the East Florida and West Florida Coasts.*

  Attempts to identify Atlantic croaker genetic stocks have mostly focused on the Atlantic Coast rather than the Gulf of Mexico but some of the Atlantic Coast studies that have been done included samples from areas in the Gulf of Mexico. The first study to specifically focus on the Gulf unit was conducted by TPWD (Anderson et al. in prep); other studies focused in the Gulf would be useful for validation purposes. Previous work shows genetic differences between the East Coast and the Gulf of Mexico but a genetic stock assessment attempting to determine genetic movement would be extremely useful (Lankford et al. 1999, Anderson et al. in prep).

- *Examine other genetic techniques beyond the traditional mitochondrial work.*

  Genetic studies to date have used mitochondrial DNA (mtDNA) but other methods beyond the traditional techniques would be beneficial as they provide genetic information that mtDNA cannot always provide.

Inshore/Offshore Movement

- *Determine migration patterns and distribution of Atlantic croaker both regionally and by state and potential ques for migration.*

  Understanding the movement of Atlantic croaker can assist in delineating stock units and help identify ecological and biological processes important to Atlantic croaker in the Gulf of Mexico. In addition, work should explore the foraging behavior of Atlantic croaker and the impacts of hypoxia on such movements (Rahel and Nutzman 1994). Seasonal migration is linked to spawning activity of Atlantic croaker. However, an understanding of such movement is limited in the Gulf.

Feeding and Predator/Prey Relationships

- *Determine the trophic importance of Atlantic croaker in the ecosystem.*

  Croaker diet and the number of species that regularly prey on croaker are well-documented in the Gulf of Mexico. Though many scientists agree that croaker play an important role within the ecosystem, a study quantifying their trophic level and importance has not been conducted. Recent research has also illustrated the role of forage fish in structuring marine ecosystems and supporting fisheries of more valuable upper trophic level species (Pikitch et al. 2014, Geers et al. 2016). Under some classifications, Atlantic croaker are considered a forage fish given its linkage between upper and lower trophic levels (de Mutsert et al. 2016). However, to our knowledge, a holistic understanding of the role of Atlantic croaker in the Gulf ecosystem and consequences for declines in croaker biomass on ecosystem function has yet to be investigated. This can pose interesting questions for management as recent declines in shrimping effort reduce fishing mortality of Atlantic croaker leading to increased biomass. Further research directions on the ecology of the Gulf of Mexico can also be found in Karnauskas et al. (2013).

Habitat

- *Determine habitat usage by age classes and shifts in usage associated with ontogeny.*

  Estuarine and coastal habitat preferences have been documented for Atlantic croaker; however, previous work has often focused on limited geographic ranges and experiments. Therefore, future work should be directed at understanding spatial distribution and habitat use as it relates to the age and length structure of the stock. This includes identifying adult offshore habitat and behaviors related to habitat preferences and identifying larval and juvenile habitat preferences in inshore/estuarine areas.

Socioeconomic

- *Determine information on market channel and consumption estimates.*

  A better understanding of the current market for croaker within the Gulf region is needed. The role that croaker plays in local seafood markets, including the potential to serve as a substitute for more popular species, will provide insight into the current and potential market for croaker. In addition, no current estimates exist as to how important croaker is to regional seafood consumers.

- *Collect information on recreational expenditures and effort related to Atlantic croaker by state, season, fishing mode, etc. (includes use as bait).*

  Given the apparent increasing importance of croaker as a live bait item, additional information is needed regarding angler expenditures, effort, and willingness to pay associated with croaker as a live bait. Such information will provide for more effective management of key species targeted by anglers within the Gulf region. In addition, little information currently exists regarding effort and expenditures associated with anglers who target croaker. Such information would help managers

better understand the role croaker plays within the complement of species that comprise the nearshore marine recreational fishery within the Gulf of Mexico.

- *Improve state-specific sociological data on commercial and recreational sectors.*

  Information on the demographic characteristics of the commercial harvesters and recreational anglers would help managers better understand the role that croaker, as a live bait or targeted food item, plays in the overall sustainability and resiliency of coastal communities.

- *Evaluate the economic contribution from the live bait market.*

  Live bait represents a significant component of the total expenditures by anglers in the Gulf region. However, the contribution of live croaker to the overall expenditures and economic activity associated with live, marine, bait sales in the Gulf region is unknown.

- *Collect general information on live bait harvesters, techniques, and efforts.*

  The popularity of using live croaker as a marine bait has reportedly increased in recent years. However, little is known about how this bait item is harvested, and by whom. In addition, a description of the seasonal, spatial, and other characteristics of the effort, method, and participants associated with this sector needs to be better understood. It is not clear if harvesters are dedicated trawlers or shrimpers looking at alternate targets depending on market.

- *Determine collateral effects of regulations, management, and market shifts in other fisheries on croaker (fishermen and angler behavioral changes and preferences).*

  Little is known regarding the manner in which the bait and food harvest of croaker occurs. In particular, a better understanding of the factors which direct effort toward and away from croaker as a recreationally and commercially targeted species is needed. Such information would help managers better understand and anticipate fishing pressure on the adult and juvenile portions of the croaker stock.

Fishery-Dependent Data Collection

- *Collect data to improve fishing mortality estimates on Atlantic croaker.*

  It will be difficult for scientists to make informed management decisions on croaker until we can quantify fishing mortality for croaker in the Gulf of Mexico.

- *Estimate any directed fishing effort for croaker both commercially and recreationally.*

  Directed effort is difficult to quantify since croaker are often fished for in conjunction with other species. For example, in Texas, croaker caught for the live bait fishery are often caught along with bait shrimp.

- *Collect data on anglers utilizing live croaker as bait in other fisheries.*

  Recreational harvest surveys do not specify whether live croaker were used as bait, only that live fish were used. It would be useful to record live croaker as a separate bait type in order to track estimates of how many anglers are using croaker year in and year out. This would also allow fishery managers to compare catch rates of popular game fish, such as spotted seatrout, between anglers using live croaker with other bait types.

- *Generate landings estimates for live croaker to supply the bait industry (specific codes for trip tickets).*

  The majority of the Gulf states are not separating croaker landings into multiple categories, with Texas being the exception. In order to track whether the popularity of using croaker as bait spreads to other Gulf states, it would be important to separate out croaker sold as live bait versus those sold as food.

Aquaculture

- *Quantify the potential for croaker aquaculture to supply bait and food fish markets (durability and longevity of product, captive breeding, and mortality in live bait holding systems) and optimize the hatchery techniques related to culture of Atlantic croaker.*

  The potential for Atlantic croaker in aquaculture is very high (Creswell et al. 2010, Sink et al. 2010). Although studies have demonstrated the robustness of croaker in tanks and ponds (Leclerq et al. 2014, Saillant unpublished data), more studies focused on croaker as viable candidates to supply live bait and food fish markets would be beneficial. The efficacy of Atlantic croaker as an aquaculture species should be determined by attempting to optimize captive breeding rates, spawning and rearing, and better determining mortality in holding systems.

Chapter 10
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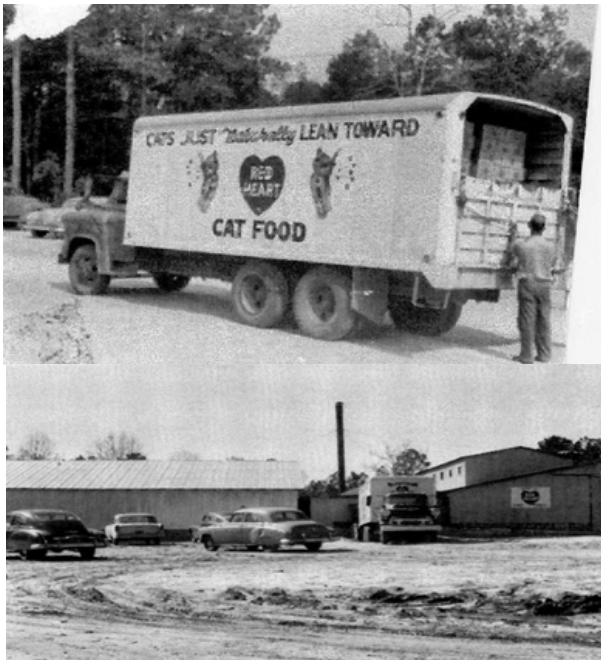
Chapter 11
PHOTO ARCHIVES

During the researching and drafting of the history of the Atlantic croaker fisheries in the Gulf of Mexico (Chapter 6 and 8), a lot of additional photographic material was found related to the Groundfish (pet food) industry in the northern Gulf. Included in this section are some of the items that were located or donated for use here. These materials came from various historic websites, publications, and personal photo collections and will be credited as appropriate.

Bluff Creek Cannery – Vancleave, Mississippi

The Bluff Creek Cannery operated for about ten years in the 1950s and produced Red Heart pet food. The cannery was located along the western shores of the Pascagoula River in Vancleave Mississippi. A recording exists of an interview with a young woman who toured the Coast and spoke on the Tex Hamill radio show which was part of a weekly broadcast of *Down South Magazine*. The original interview was broadcast on Sunday, March 14, 1954. The young woman spoke about the Bluff Creek Cannery specifically and how the operation turned tons of fish into Red Heart cat food for the Morrell Company (MGCCC Archives 1954).



The Bluff Creek Cannery in Vancleave, Mississippi and a Red Heart truck loaded with canned cat food (from Bellande 1999 [Courtesy of Althea "Rete" Murphy Flurry]).

Quaker Oats – Pascagoula, Mississippi

The Quaker Plant in Pascagoula, Mississippi was in operation longer than any of the pet food canneries in the Northern Gulf of Mexico. They were the first plant to begin processing croaker into cat food in 1952 and despite several sales of the company and mergers, continued to process fish along the east Pascagoula River until around 1994. Because they were a large employer in the city of Pascagoula, there are many more images available of the plant and vessels. Their proximity to the Gulf Coast Research Laboratory and the NOAA Fisheries Pascagoula Laboratory yielded much more information on the inner workings of this factory than any other in the Gulf (see Gunter 1956, Roithmayr 1965, Gutherz et al. 1975, Gutherz 1976).

As noted in Chapter 6 (Table 6.1), the Quaker Plant was bought and sold several times through its history but its longest run was producing Puss 'N Boots cat food from 1955-1982. The majority of images we have are from the 25 year celebration hosted by the city of Biloxi (Quaker 1977). However, some other personal images have been found thanks to social media and the internet. Of note are the photos included below from Mr. Jim Page who grew up in Pascagoula in the late 1950s. Of interest in the images included here is the mention of Mr. John Quinn who was one of the founders of the menhaden reduction fishery (Quinn Fisheries) in the Gulf. Mr. Page's father was a spotter pilot for the menhaden fleet and their family moved several times as he was growing up because his father was contracted by multiple plants all along the coast from Port Arthur, Texas to the Florida Panhandle.

The following is the opening speech from the Quaker Plant Manager in the 1977 celebration of 25 years of production in Pascagoula.

The Quaker Oats Company produced Puss'n Boots cat food at this plant in 1957 on Pascagoula's East River. (*Photo from* Anderson 2014).

"In May 1952, The Quaker Oats Company came to Pascagoula, leased a warehouse on the site of the present plant, installed specially-designed operational equipment, and began the production of Puss 'N Boots catfood in the South.

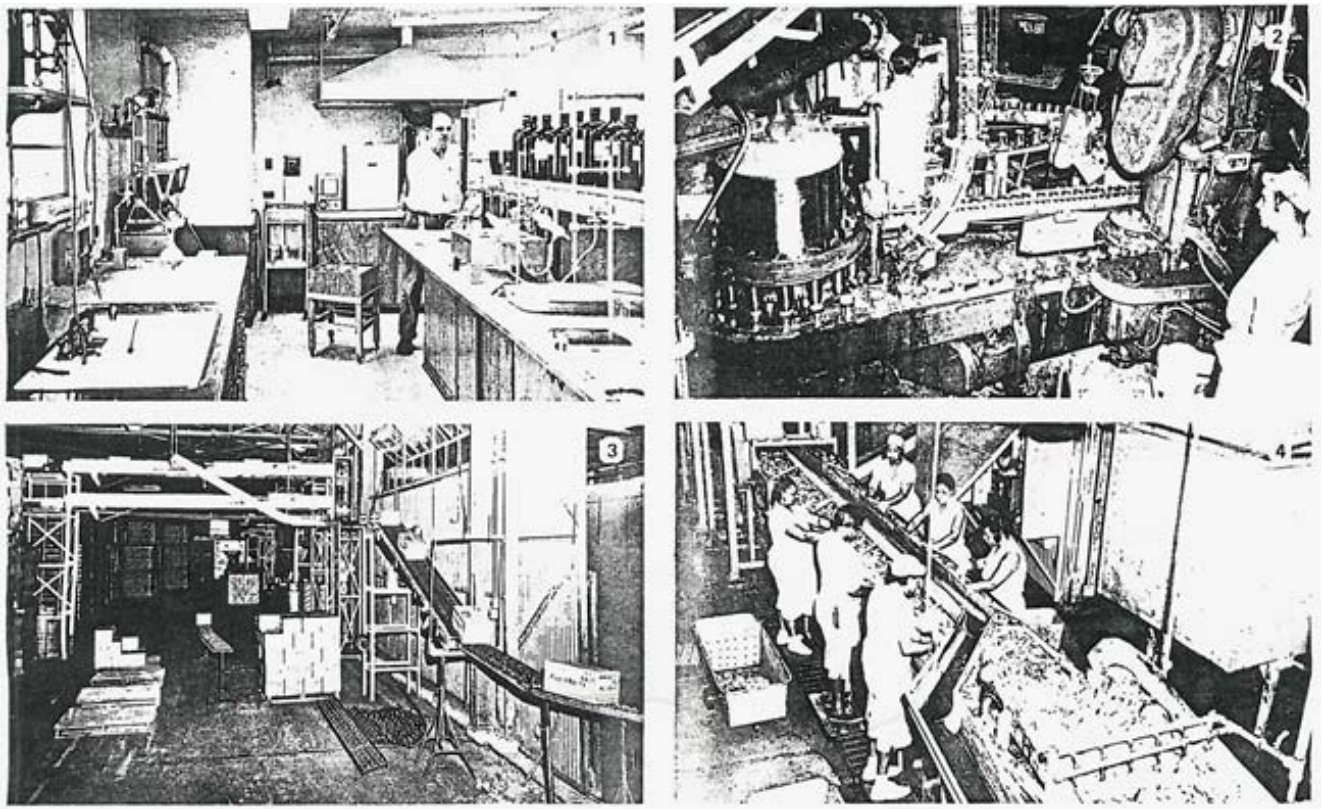
Today The Quaker Oats Company's Pet Foods plant in Pascagoula celebrates its 25th anniversary and honors those employees who have 25 years of service with this plant.

Through these many years, the directing of and the planning for this plant have been based on increasing its productivity, increasing its responsibility to the future importance of the Puss 'N Boots and Ken-L Ration brands, and thus increasing the stability of a pet foods manufacturing facility here on the coast, with its supportive areas of supply and services. In 1952, this plant had 22 employees producing about 700 cases a day. Today, 25 years later, this plant has 170 employees who can produce over 1,000,000 cans a day. In this achievement, the contribution made by innovative, enthusiastic and progress-minded personnel in various departments must be acknowledged. We also acknowledge gratefully the assistance and cooperation extended to The Quaker Oats Company by the City, County and Federal agencies, and by local businesses and services.

In 1952, this plant was one of three Coast Fisheries plants which were subsidiaries of The Quaker Oats Company, and one of the company's six Pet Foods operations in the United States. Today it

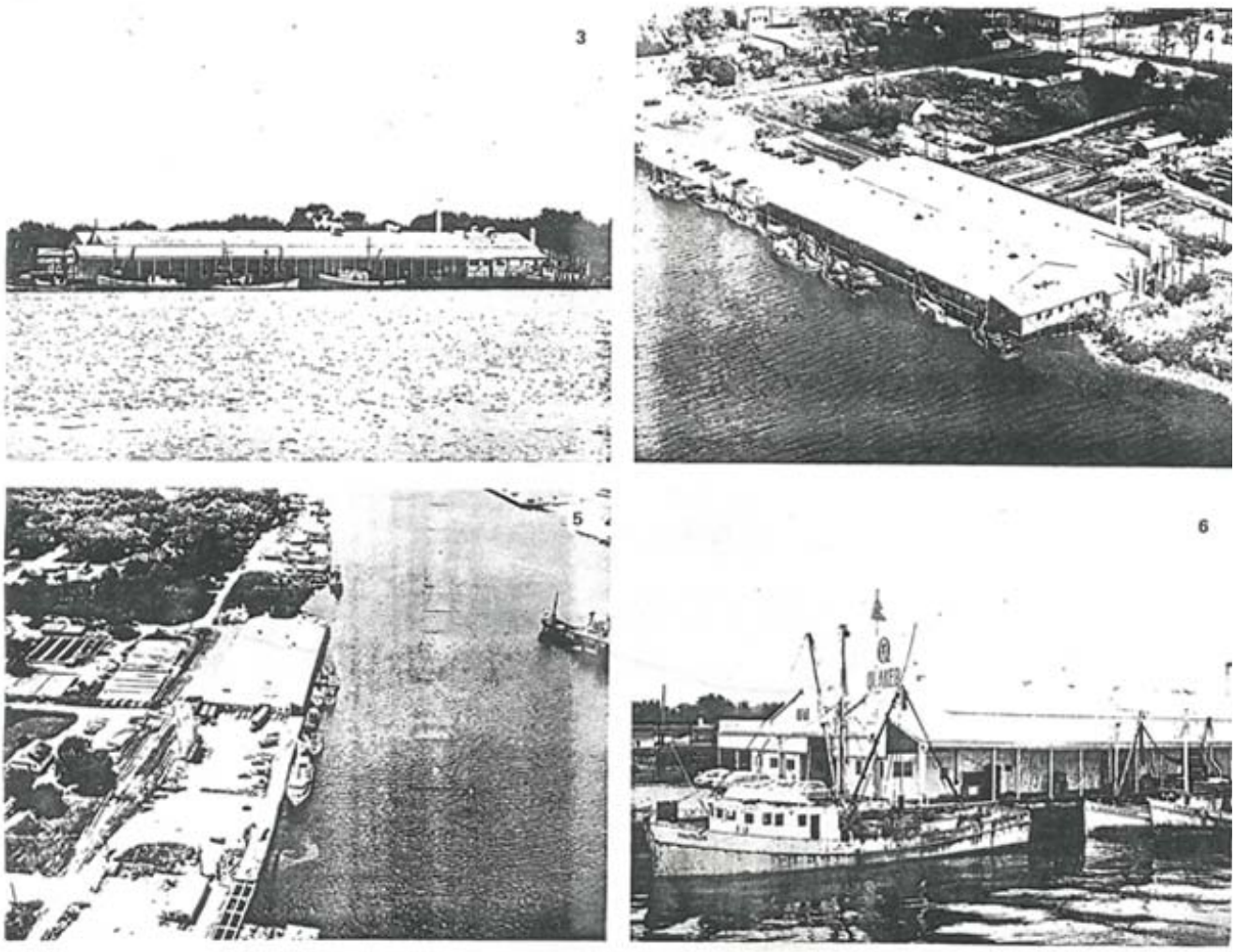
Christmas on the water at the Quaker Oats dock in 1958. "So these were taken in Pascagoula, Mississippi in 1958. I was in the first grade. The Christmas Festival that year was a big deal for me, because my dad flew Santa onto the river with his float plane, and a little boat picked Santa up from my dad's plane and brought him to the docks. Mr. John Quinn, my dad's friend who owned the menhaden plant mentioned earlier, lifted me up onto a 55-gallon drum because I was little. Mr. Quinn is in the dark-blue-black-and-white checked shirt in the second photo, and his wife, Jane, is standing next to him in a red-and-black checked shirt. Here comes Santa on the small boat (Page 2012) *from* https://jimsworldandwelcometoit.com/

Croaker boat tied up at the Quaker Oats plant in Pascagoula, Mississippi in 1960 (Courtesy Mike Frontiero).



1. Don Gibson, QA Supervisor in Quality Assurance Laboratory - November, 1959.
2. Puss 'n Boots - 8 oz. line, 15 oz. line in background - November, 1959.
3. Overhead conveyor system delivered cased Puss 'n Boots from Case Sealer directly to one of five car spots or to palletizing area for warehousing - 1959.
4. Pickers & Graders - 1959 - (left) Amy Moton, Virginia McCollough Green, Sophie Lee, (right) Christina Mack, Fannie Mae Davis, Frankie Johnson.

from Quaker Celebrating 25 Years (Quaker 1977)



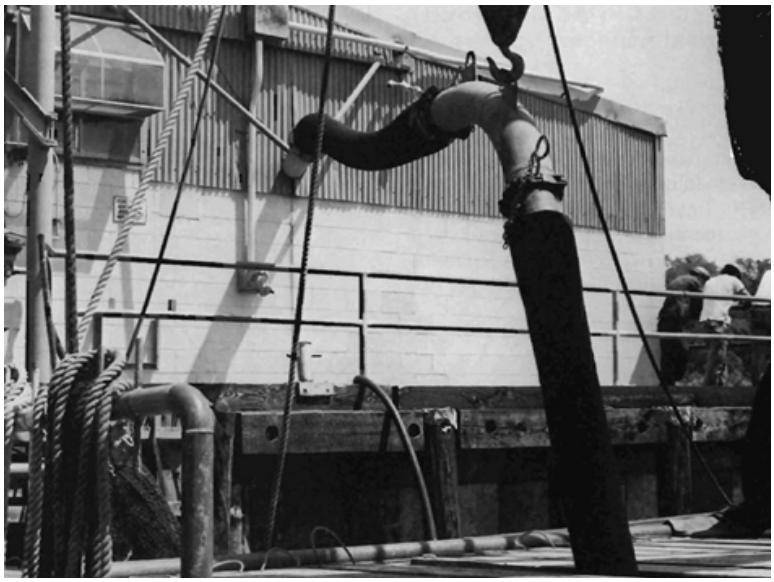
3. This picture gives us a look from the water of how the Quaker Oats plant looked in 1959.
4. This aerial shot gives us a better view of how the plant appeared in March of 1959.
5. In 1962, considerable changes have been made - note addition of grain tanks, paved parking lot, new paint and new sign.
6. Close up of the front of the plant as it appeared in 1962.

from Quaker Celebrating 25 Years (Quaker 1977)

is Quaker's only coastal plant and one of three Pet Foods facilities in the United States. A fourth plant is under construction in Kansas.

Today's uncertainties hand us challenges: challenge to continue to give the consumer top quality products at the lowest possible cost in a highly competitive market; challenge to continue to operate commendably within the guidelines of several governmental agencies; challenge to increase efficiency in fuel usage and the conservation of natural resources. The personnel of this plant and the equipment in it are able to adapt as the challenges and changing conditions may require.

The Pascagoula plant has the special Quaker teamwork which is mandatory for job security and plant expansion. Each member of our "Quaker Team" is known for himself and for his part in the plant's operational records. And each Quaker teammate knows that to work with each other with cooperation and with mutual respect is to bring continued success to the company and recognition to themselves.



The Groundfish fishery utilized the same technology found in the menhaden fishery of the time. Hydraulic fish pumps were used to transfer fish from the holds of the croaker boats to the factory where they were run across sorting belts. In the pet food plants, undesirable fish or those than had high value were removed by workers before processing into pet food (Figure 6 *from* Gutherz et al. 1975).

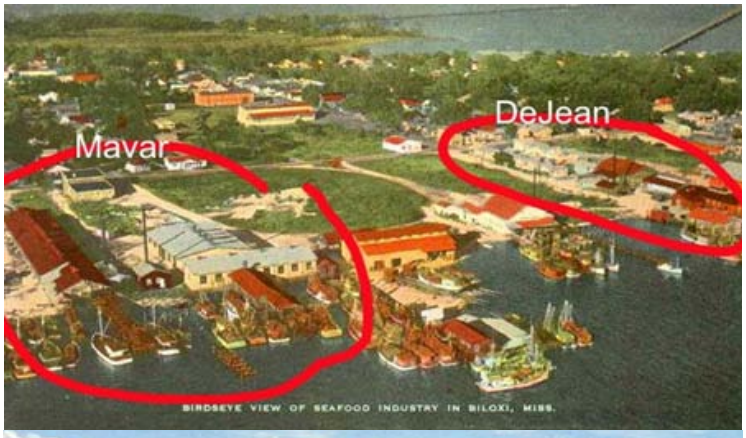
Thus we salute the 25th anniversary of Quaker's Pascagoula Pet Foods plant and all Quakers in its employ. This is a plant to be proud of for itself and for its contribution to The Quaker Oats Company.

John Christensen
Plant Manager"

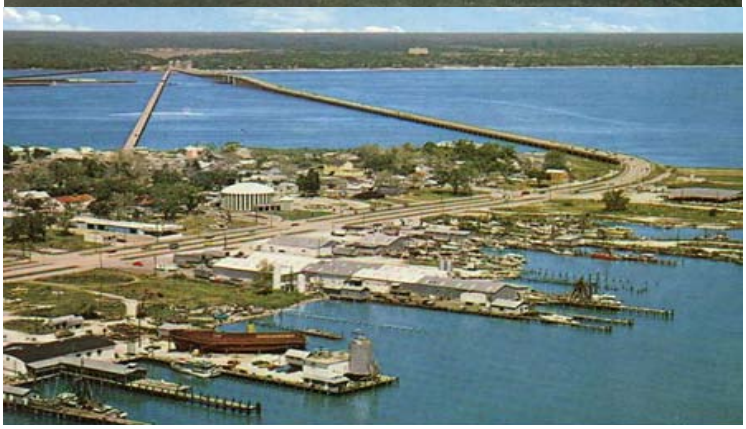
from Quaker Celebrating 25 Years
(Quaker 1977)

DeJean's Packing – Biloxi, Mississippi

Oddly, DeJean's has very little history recorded of their activities either in the shrimp canning business or the pet food industry. One article in *Down South Magazine* by Nedra Harvey (1980) provides some history of the DeJean plant and mentions their cat food production; however, the factory canned shrimp primarily. A number of tropical storms and hurricanes devastated the Mississippi coast over the years and Hurricane Katrina in 2005 eliminated most of the old photographs owned by the Williams family according to Glen Williams. The DeJean factory was just east of the Mavars' Kozy Kitten factory in Biloxi. Two vintage postcards from



Vintage Postcard from 1952 highlighting the Coast's seafood industry which captures both the Mavar Fish Factory and the DeJean Cannery. In 1952, neither plant had begun processing cat food yet.



A postcard from the same area of east Biloxi after completion of the 'new' Highway 90 bridge connecting Ocean Springs with Biloxi. The DeJean factory is in the center and the Mavar Fish Factory is in the lower left.

Can elevator (Depalletizer) for lifting cans into can line for transportation into packing room for filling. • After grading and filling into cans automatically, the cans are automatically weighed by a scale that passes or rejects over or under weights. • After a salt tablet is automatically put in each can, the closing machine seals the can and embosses the can code (includes the date packed and type of product in the can) on the lid.

From Harvey 1980

Present day shrimp boat at dock at the DeJean factory • Picture of Elmer Williams and A.J. Buquet of Buquet Canning Co. of Houma, LA. Buquet had a business as well as friendly relationship with DeJean over a long period of time. DeJean would purchase canned oysters from Buquet sometimes to the tune of over one million dollars per year, around 8.5,000 cases, mostly shrimp and oysters • Leon D. Hall, President of DeJean Packing Company, joined the company in 1948.

From Harvey 1980

Biloxi are the only photographs found that show both facilities. The remaining images below are from *Down South Magazine* (Harvey 1980).

Kozy Kitten (Mavar Fisheries) – Biloxi, Mississippi

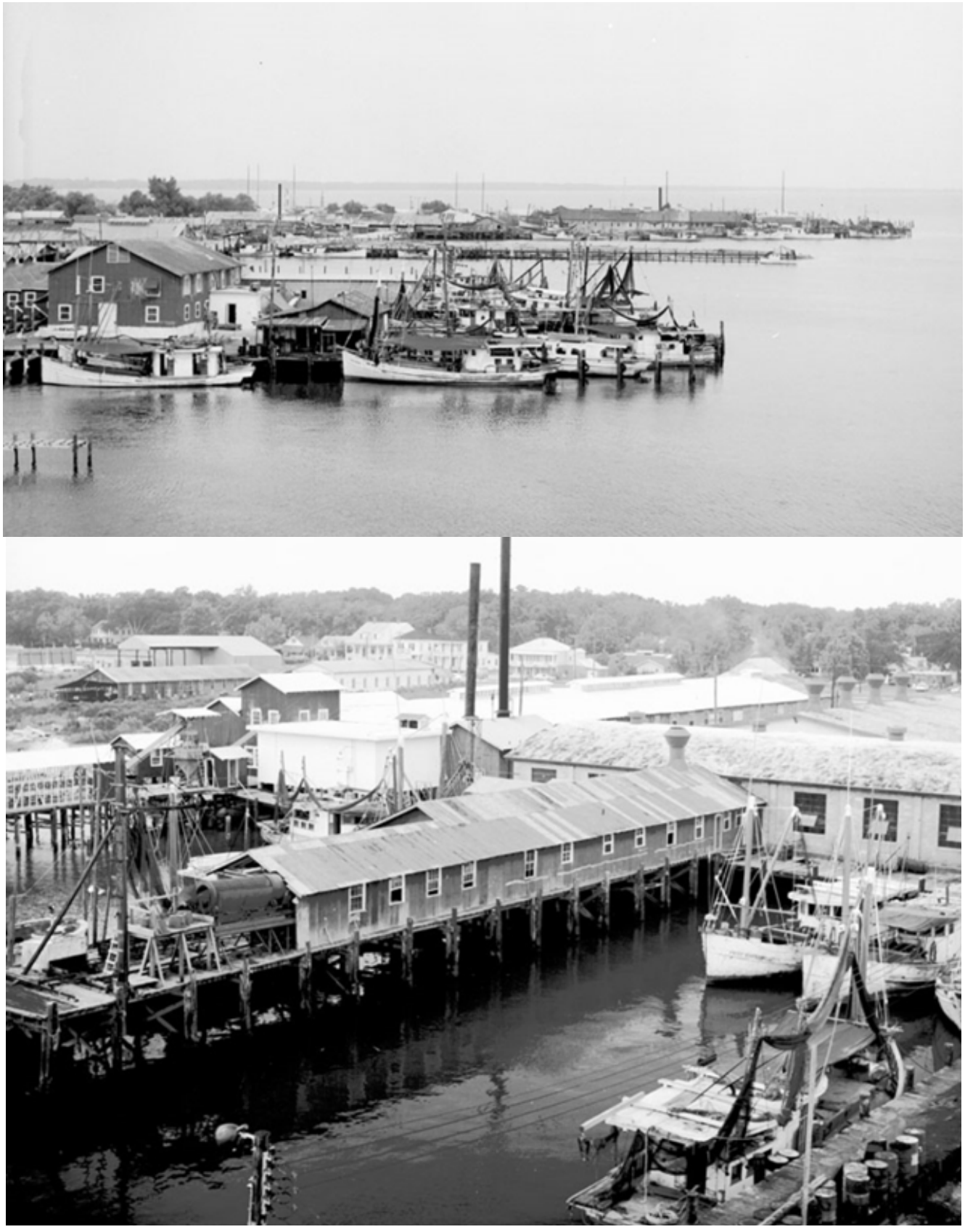
The Mavar factory was the longest operating pet food processor in the Biloxi area, manufacturing their own label of Kozy Kitten from 1957 until the late 1980s. The family is still in the seafood business today with a processing facility along the 'Back Bay' of Biloxi where they still market shrimp and oysters.

The DeJean Packing Company after Hurricane Camille [1969]. 85,000 cases of product were lost • Aerial view of the DeJean Packing Company after rebuilding. Two styles of canned shrimp are produced, regular and deveined, and machinery does it all.

From Harvey 1980

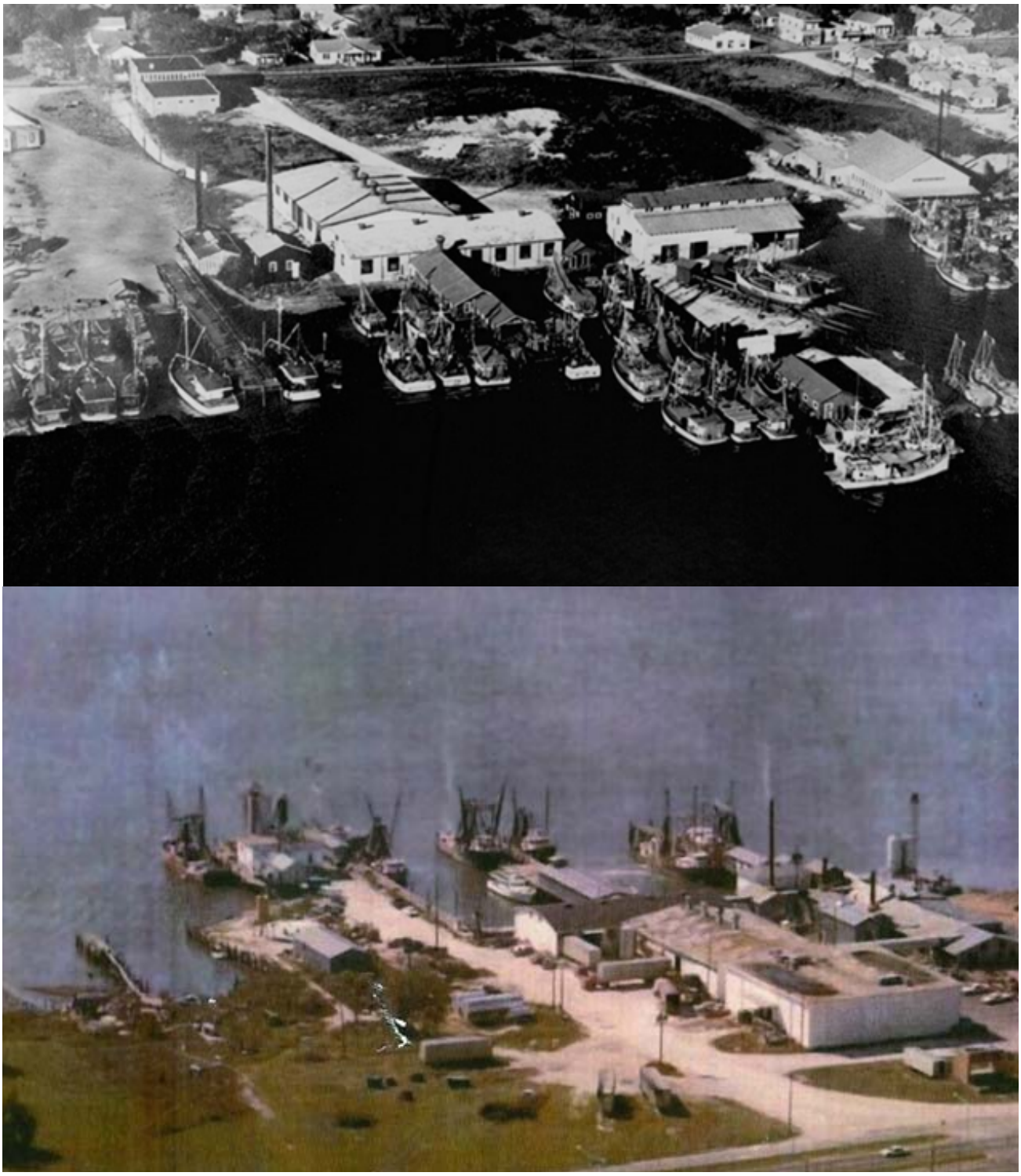
Mavar Shrimp & Oyster Co. Ltd. was a true family operation. Family members involved were Victor Mavar Sr., from left, Nick Mavar Sr., John Steven Mavar, Nick Mavar Jr., Sam Mavar Jr., Geoffrey Mavar, Michael Mavar, Victor Mavar Jr., Marko Butirich. Not pictured is John Butirich.

Courtesy Biloxi Freezing & Processing, Inc. – M & M Processing, LLC



The Mavar fleet and factory in Biloxi, Mississippi around 1950.

Courtesy Biloxi Freezing & Processing, Inc. – M & M Processing, LLC



The Mavar factory in Biloxi, Mississippi prior to the expansion of the pet food processing building (top). The additional building was placed in the large open area in the left (west) of the photo at the head of the last dock. The bottom photo includes the additional processing building in the far right (west) of the photo.

Top photo courtesy Biloxi Freezing & Processing, Inc. – M & M Processing, LLC
Bottom photo courtesy Mr. Nick Mavar

The John Mavar Sr. (a 420 capacity vessel) is the largest vessel built for the Mavar fleet.

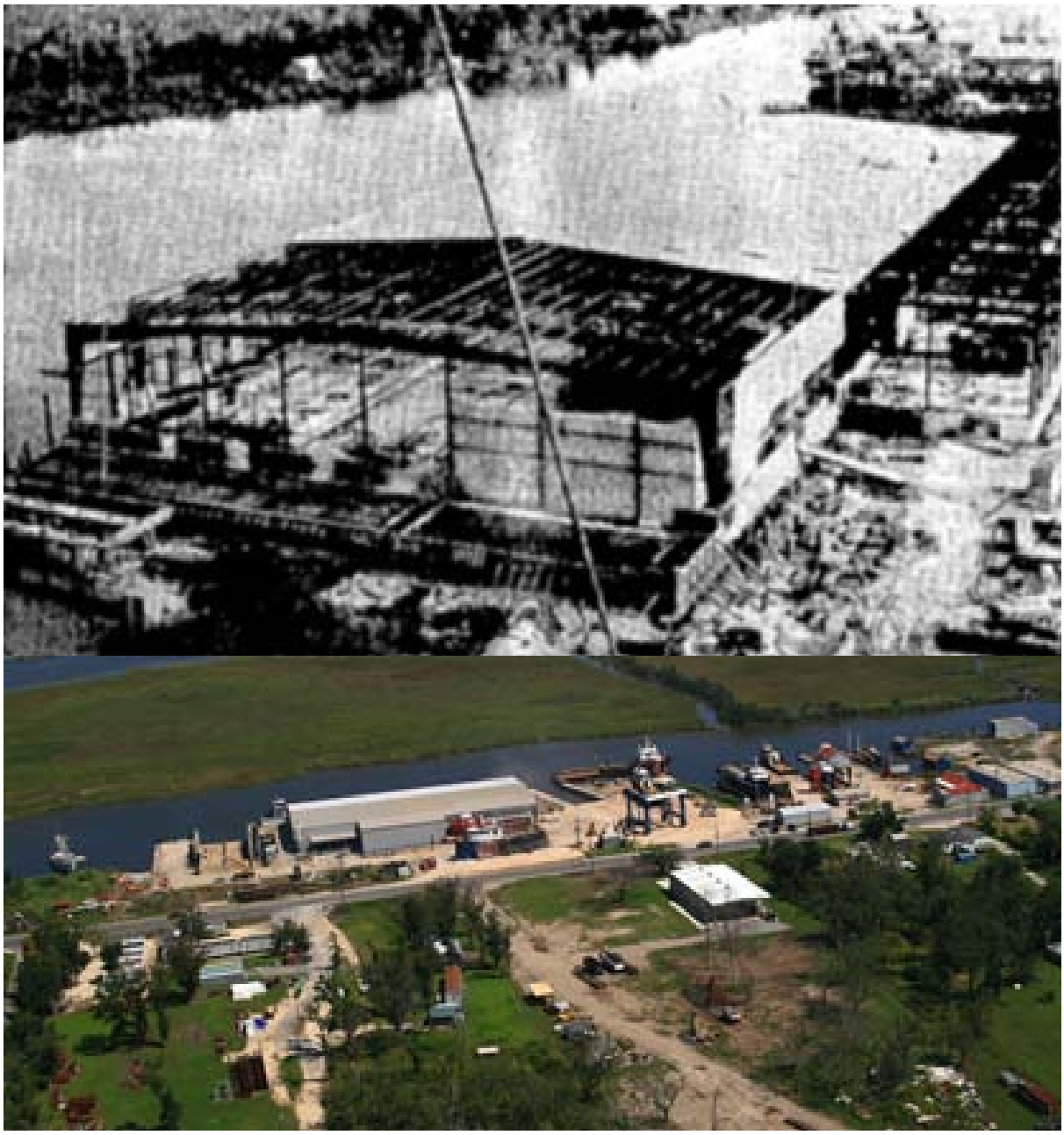
Courtesy Mr. Nick Mavar

The cat food plant was located on the beach along Mississippi Sound and the factory remained despite a number of storms until it was closed in 1992 by the Heinz Company which had previously purchased the plant but only used their operation in Pascagoula (the old Quaker plant) until 1994. The Kozy Kitten factory was torn down in 1993 to build one of Biloxi's largest casinos, the Grand Casino. The property is still leased from the Mavar family today by the casino industry. Today, the Mavars have teamed with the Suarez/McLendon family to form the joint venture of Biloxi Freezing & Processing Inc/M&M Processing. As noted on the members page of the American Shrimp® website:

> "When two well-established seafood families join forces, great things are bound to happen. Biloxi Freezing & Processing Inc/M&M Processing, is guided by a lineage that brings a combined 175 years of experience to the industry through the seafood legacies of the Suarez/McLendon and Mavar families.
>
> Prior to 2006, the two companies were separate. M & M Shrimp Company had grown to become one of Biloxi Freezing & Processing's largest customers. As a great business relationship grew into one of mutual friendship and respect, they decided to merge and become one company, with more capabilities and a stronger competitive advantage in the market."

Tabby Cat – Golden Meadow, Louisiana

Very little was reported on the Tabby Cat Plant in Golden Meadow, Louisiana. As noted in Chapter 8, the plant only operated for about 10 years and is now the home to the Superior Shipyard. The general



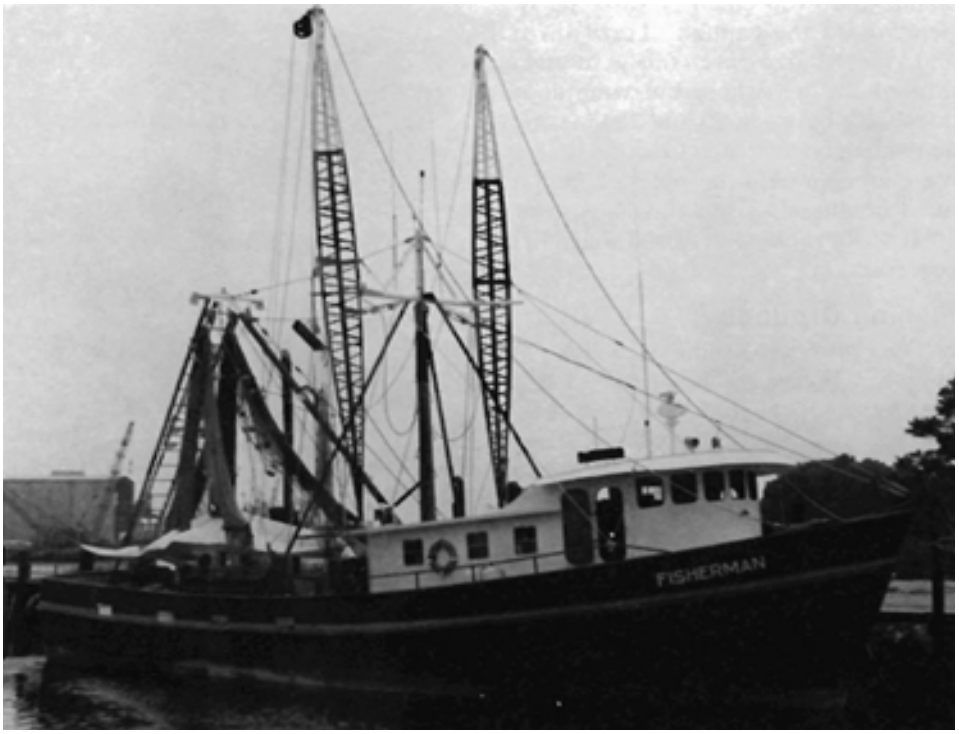
Top Photo: The Tabby Cat plant under construction in November 1966 along the Bayou Lafouche (Morning Advocate 1966). Bottom Photo: Superior Shipyard on the original Tabby Cat location in Golden Meadow, Louisiana (Duet pers comm). The large grey building at the seawall is the original processing plant.

manager of the shipyard indicated that they still refer to one of the buildings on the site as the Tabby building. When the original plant opened in 1967, it was described as the "most modern of its kind in the United States" (Times-Picayune 1967).

Bayou La Batre, Alabama

While a large foodfish industry for Atlantic croaker existed in Alabama starting in the late 1960s to early 1970s, there is not a lot of information available other than a few NOAA reports such as Gutherz et

Traditional 'snapper boat' that targeted a variety of finfish including Atlantic croaker out of Bayou La Batre (Figure 8 *from* Gutherz et al. 1975).



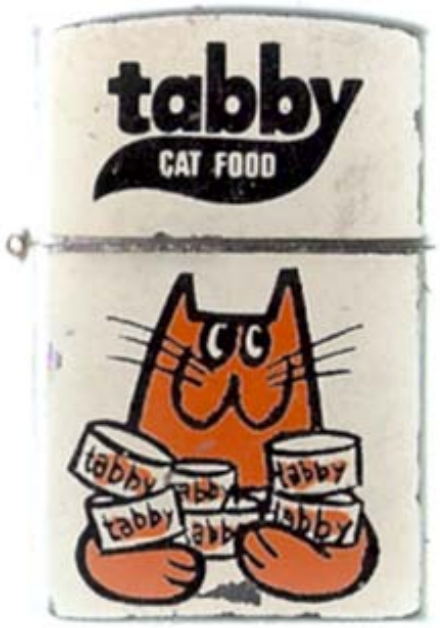
A typical 'northern Gulf foodfish trawler' that regularly landed Atlantic croaker for the fresh fish market in Bayou La Batre (Figure 10 *from* Gutherz et al. 1975).

al. (1975). Elmer Gutherz was part of the seafood innovation program at the NOAA Pascagoula Laboratory at that time and he, along with others at the lab, provided expertise to the seafood industry along the northern Gulf of Mexico. Below are a few of the images included in the synopsis document developed by NOAA on the 'croaker' fishery.

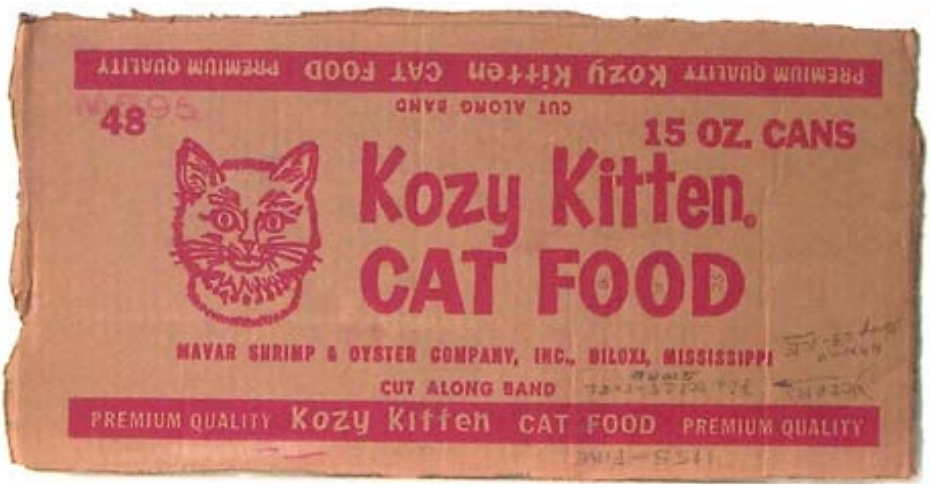
Atlantic croaker being unloaded and sorted at a fish house in Bayou La Batre for processing for the fresh fish market (Figures 12 and 13 *from* Gutherz et al. 1975).

Brands from the Gulf of Mexico Groundfish Fishery

A wide variety of pet foods were processed, canned, and labeled in the Gulf over the duration of the Groundfish fishery (1950-1990). Below are some examples of the lines of pet food collected during the development of the Profile.



Tabby Cat from the Golden Meadow plant.



Kozy Kitten produced by the Mavar factory in Biloxi.

Print ad for the Quaker Oats brand Puss 'N Boots in Pascagoula, Mississippi.

Red Heart Cat Food print ad from 1959. Red Heart was produced in Vancleave, Mississippi by the Bluff Creek Cannery.

About the Artist

Jamie Herring was born and raised on the Mississippi Sound, in the charming city of Ocean Springs, Mississippi. He is a fisheries biologist who works for the Mississippi Department of Marine Resources and blends his love of the sea and his job into his artwork.