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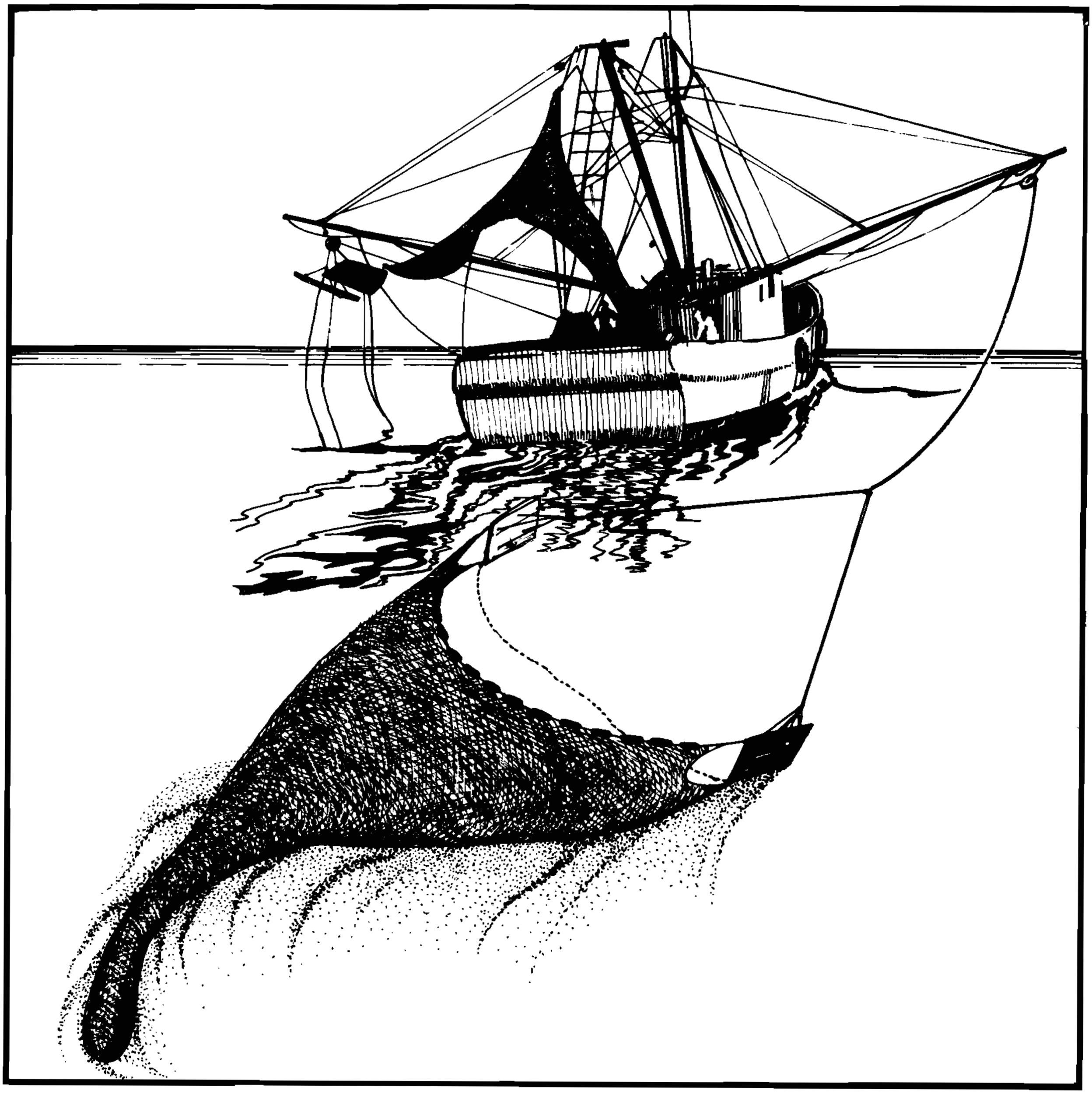

Fish and Wildlife Service
U.S. Department of the Interior

Waterways Experiment Station
Coastal Engineering Research Center
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements (Gulf of Mexico)

BROWN SHRIMP

by

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Performed for
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Fish and Wildlife Service
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PREFACE

This series of profiles about coastal aquatic species of commercial, sport, and/or ecological significance is being jointly developed and funded by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service. It is designed to provide coastal managers, engineers, and field biologists with an introduction to the subject species and a synopsis of the information necessary to relate expected changes (associated with coastal development) in the physicochemical characteristics of estuaries to changes in these selected biological populations. Each profile includes brief sections on taxonomy and identification followed by a narrative of life history, environmental requirements, ecological role, and (where applicable) the fishery of the subject species. A three-ring binder is used for this series to facilitate additions as new profiles are prepared.

Suggestions or questions regarding this report should be directed to:

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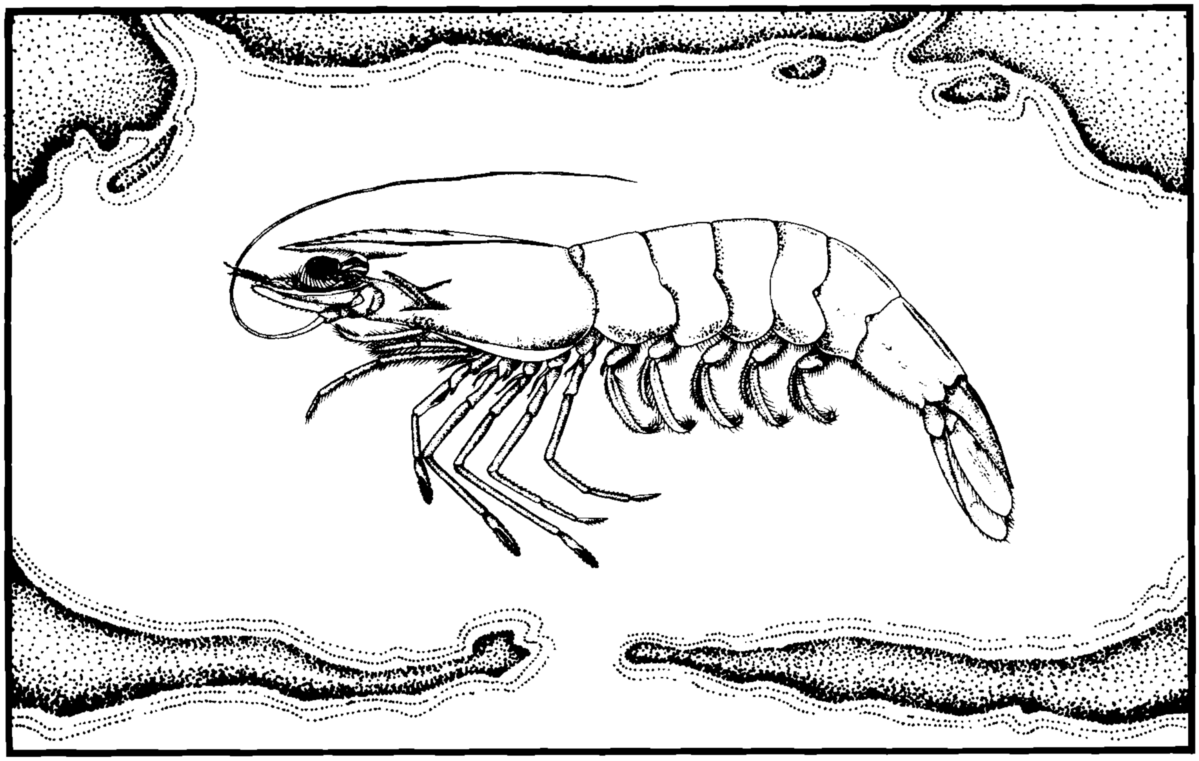

Figure 1. Brown shrimp.

BROWN SHRIMP

NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . . . *Penaeus aztecus* Ives
Common name . . . . Brown shrimp (Figure 1)
Class . . . . Crustacea
Order . . . . Decapoda
Family . . . . Penaeidae

Geographic range: Martha's Vineyard, Massachusetts, through the Gulf of Mexico to the Yucatan Peninsula, Mexico, except absent along the Florida coast between Sanibel and Apalachicola Bay, with maximum density along the Texas-Louisiana coast (Figure 2).

MORPHOLOGY/IDENTIFICATION AIDS

The following list of features which distinguish brown shrimp from white shrimp (*P. setiferus*) and pink shrimp (*P. duorarum*) is adapted from Pérez-Farfante (1977). A more detailed description of the brown shrimp and clarification of terms may be found in that reference or Pérez-Farfante (1969).

Brown: adrostral grooves and crests long, extending almost to hind margin of carapace; postrostral crest well-developed as far back

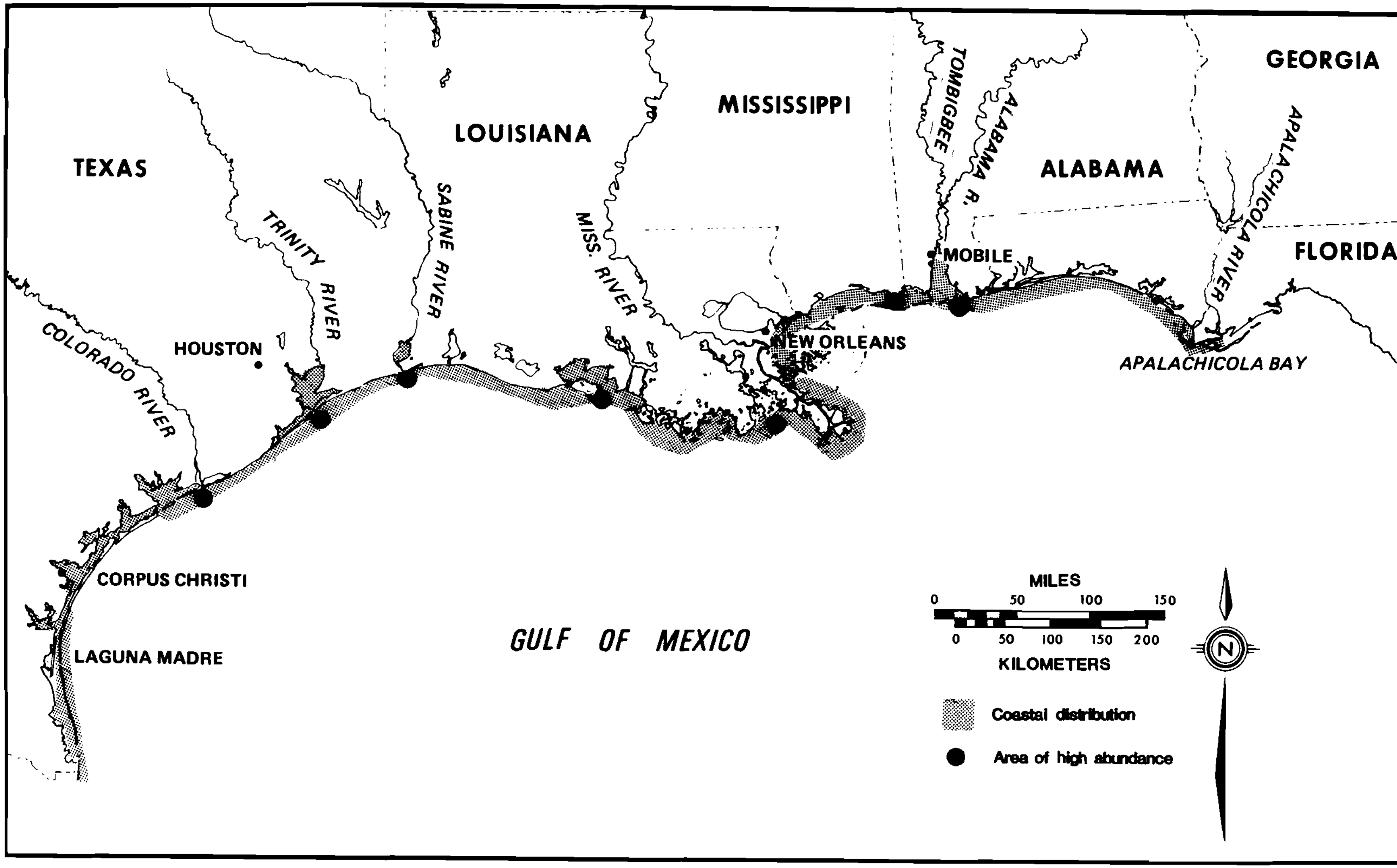

Figure 2. Distribution of brown shrimp along the shore of the Gulf of Mexico.

as adrostral grooves; gastrofrontal crests present; dorso-lateral grooves on last abdominal section well-defined and broad; ratio of height of dorsal keel to width of dorso-lateral groove usually less than 2.25; dark lateral spot at junction of third and fourth abdominal segments usually absent.

White: adrostral grooves and crests short, not exceeding anterior half of carapace; postrostral crest scarcely defined posteriorly; gastrofrontal crests absent.

Pink: dorso-lateral grooves on last abdominal section well-defined and narrow; ratio of height of dorsal keel to width of dorso-lateral groove usually 4.5 or more, and with sharp lips sometimes nearly closed; dark lateral spot at junction of third and fourth abdominal segments usually present.

REASON FOR INCLUSION IN SERIES

The brown shrimp is prey to a host of finfish species and is the major contributor to the Gulf of Mexico shrimp fishery, the most valuable fishery in the United States. Fertile estuarine nursery areas, so susceptible to man's influence, "constitute an irreplaceable factor in the survival strategy of major shrimp resources, and perpetuation of such resources at commercial levels of productivity, apart from their continued existence per se, will be contingent upon our ability to minimize disturbance of the shrimp's estuarine habitat" (Kutkuhn 1966).

LIFE HISTORY

Spawning and Larvae

Since the actual spawning event by brown shrimp has not been observed in situ, statements regarding the site and time of spawning are based upon the capture of eggs, larvae, or spent adults. Spawning is reported to occur primarily in offshore waters deeper than 18 m (60 ft) (Christmas et al. 1966), possibly as deep as 137 m (450 ft) or more (Kutkuhn 1966). The major spawning season extends from September through May, but may occur throughout the year, particularly at depths greater than 46 m (150 ft) (Pearson 1939; Renfro and Brusher 1963). While a single spawning peak, February to March, has been reported along the southeastern Atlantic coast (Williams 1955; Joyce 1965), several studies have suggested two peaks, September through November and April to May, in the northern Gulf of Mexico (Renfro and Brusher 1963; St. Amant et al. 1966). The significance of separate spawning peaks will be discussed in another section (see The Fishery section). Spawning is reported by Cook (1965; cited by Pérez-Farfante 1969) to take place at night.

Externally fertilized, semibuoyant eggs are released into the water column and hatch within 24 hours into the first naupliar stage (Kutkuhn 1966; St. Amant et al. 1966). Brown shrimp larvae, as with other penaeids, pass through five naupliar, three protozoeal, and three mysis stages over a 10- to 25-day period before transforming into postlarvae (Pearson 1939; Anderson et al. 1949; Pérez-Farfante 1969). It has been suggested that these early stages require the more constant environment of the open ocean (Gulf Coast Research Laboratory 1976).

Postlarvae

Peak recruitment of postlarval brown shrimp to the estuaries may occur months after the peak in spawning (Van Lopik et al. 1979). While most authors refer to all stages from hatching to estuarine recruitment as planktonic (pelagic), Temple and Fisher (1967) suggested that overwintering brown shrimp in the Gulf of Mexico may burrow into the bottom and "await the advent of warmer temperatures" before entering the estuaries. There is laboratory evidence of this burrowing behavior in postlarval brown shrimp at temperatures below 18°C (64°F) (Aldrich et al. 1967). St. Amant et al. (1966) stated that brown shrimp postlarvae "winter-over in a state of reduced activity as inshore water temperatures decline," but did not specifically mention burrowing.

Estuarine recruitment of postlarval brown shrimp in the northern Gulf of Mexico apparently spans all months of the year as White and Boudreaux (1977) reported having taken postlarvae from January through June and St. Amant et al. (1966) stated that "ingress" (recruitment) occurred from February through December. February through April is the most commonly cited period of peak recruitment (Baxter and Renfro 1967; Gaidry and White 1973; White and Boudreaux 1977). Peak recruitment to Pamlico Sound, North Carolina, is reported to occur in April to May (Hunt et al. 1980).

Postlarvae are reported to move into the estuaries primarily at night on incoming tides, and to take on a demersal habit as they move to shallow, soft-bottom areas of the estuarine nursery grounds (Christmas et al. 1966; White and Boudreaux 1977). Transformation to the juvenile stage occurs within 4 to 6 weeks after entering the estuary (Pérez-Farfante 1969). Growth and survival during the postlarval and early juvenile stages are thought to be critical factors affecting the harvestable adult population size (see The Fishery section).

Emigration

Young brown shrimp remain in shallow estuarine areas near the marsh-water, mangrove-water interface or in seagrass beds which provide both predator protection and feeding habitat. As they reach 60 to 70 mm[1] they move away from these interface areas into deeper, open water "staging areas" and at 90 to 110 mm begin their gulfward migration (Gaidry and White 1973; Van Lopik et al. 1979). White and Boudreaux (1977) found emigrants as small as 50 mm in western Louisiana that were apparently prompted to leave the estuaries early by a strong freshwater input which had reduced nursery area salinities to 3 to 4 ppt. St. Amant et al. (1966) suggested an inverse relationship between population density on the nursery grounds and the size of migrating adolescent shrimp, possibly as a result of crowding or competition for food.

The period of May through August, particularly June to July, is often cited as peak months of emigration (Copeland 1965; St. Amant et al. 1966; Gaidry and White 1973; White and Boudreaux 1977). The combined effect of increased tidal height and current velocities associated with full moons during these months has been suggested as a stimulus to emigrate (Copeland 1965). While Clark and Caillouet (1975) reported little day/night difference, Blackmon (1974) reported that the highest percentage of emigration occurs at twilight. Blackmon also reported a diel variation in use of the water column during migration, with peak densities near the bottom in daylight hours, midwater at twilight, and near the surface at night. While fishing during emigration is limited in some States, a major portion of the fishery in Louisiana occurs during this period. The minimum size at maturity of 140 mm (Renfro 1964; Van Lopik et al. 1979) is apparently reached during migration to offshore waters.

Adults

After exiting the estuaries, brown shrimp move rapidly to about 18 m

[1] 25.4 mm = 1 inch.

(60 ft) and then slowly make their way to spawning depths of 46 to 91 m (150 to 300 ft) (St. Amant et al. 1966). Van Lopik et al. (1979) reported that the largest catches up to August were from 20 to 37 m (66 to 120 ft) deep at a size of 30 to 40 tails/lb (18 to 24 g whole wet wt/shrimp) and by December from 48 to 55 m (156 to 180 ft) deep at a size of 15 to 20 tails/lb (37 to 49 g whole wet wt/shrimp). Several studies have suggested that offshore adult populations in the northern Gulf of Mexico tend to move westward with the prevailing currents (St. Amant et al. 1966; Gaidry and White 1973; Barrett and Ralph 1977). That the Mississippi River is not an absolute barrier to such westward movement by shrimp migrating from estuaries east of the delta was shown by the tagging studies of Klima and Benigno (1965). Most adults are assumed to spawn a single time (St. Amant et al. 1966), and apparently die soon after spawning, thus ending essentially an annual life cycle. Results of more recent unpublished tagging studies, however, indicate that some may reach an age of 2.5 years or more.

GROWTH

Most published studies of growth in the brown shrimp have addressed the postlarval and juvenile stages. Since it is growth during these stages that has served as a basis for harvest prediction, this emphasis is understandable. These estuarine and nearshore stages are also relatively accessible as study subjects. This section, therefore, also will be limited to the review of postlarval and juvenile growth studies. As in many fisheries, growth is usually reported as change in length (total length in all cases cited here) over time.

Laboratory growth studies of postlarvae and juveniles have generally not been able to achieve the same growth rates as have been observed in situ. These studies have typically shown mean growth rates of less than 1 mm/day regardless of temperature, salinity, or type of food source (Pearson 1939[2]; Ogle and Price 1976), although in one study, Zein-Eldin and Aldrich (1965) were able to attain a 1.4 mm/day growth rate in brown shrimp postlarvae.

Field studies of postlarval and juvenile brown shrimp have usually demonstrated a mean growth rate of 1.0 to 1.5 mm/day during the primary growth season of late spring and early summer (Williams 1955; St. Amant et al. 1966). Maximum growth rate, at least in isolated cases, has been reported to be as high as 3.3 mm/day (Ringo 1965). Growth rates are usually much lower (0 to 0.5 mm/ day) at winter temperatures of less than 16°C or 61°F (Ringo 1965; St. Amant et al. 1966) and can be quite low even during usual peak growth months if temperature and salinity conditions are poor. For example, unusually cool water temperatures and low salinity in western Louisiana nursery areas resulted in an estimated mean growth rate of only 0.7 mm/day from late April through late May (White 1975; White and Boudreaux 1977). A more extensive review of the effects of temperature and salinity on growth will be presented in the Temperature and Salinity sections. An alternative explanation for observed variation in growth rate will also be discussed in The Fishery section.

The following exponential function ($W=aL^b$) describes the length-weight relationship presented by McCoy (1968) for brown shrimp, of 65 to 165 mm, from North Carolina:

$$W = 8.12 \times 10^{-6} L^{3.02}$$

where: W = whole wet wt (g)
L = total length (mm)

[2] Pearson's reference to *Penaeus brasiliensis* was probably *P. aztecus*.

A list of the a and b parameters of other length-weight studies appears in Table 1. As pointed out by McCoy (1968), insignificant difference between his experimentally determined b value (3.02) and the theoretical "cube law" value of 3.0 indicates isometric growth within the range of sizes sampled. Mark-recapture data from this same study yielded the following von Bertalanffy-type growth equation:[3]

$$L = 177.7\ (1-e^{-0.073T})$$

where: L = total length (mm)
T = age (weeks)

Temperature and salinity during the study varied between 23° and 28°C (73° and 82°F) and 17 and 19 ppt, respectively.

THE FISHERY

An extensive review of the Gulf of Mexico shrimp fishery, its biological, socioeconomic and legal basis, and management is provided by Van Lopik et al. (1979). Much of this section has been excerpted from their review. The Gulf of Mexico shrimp fishery is the most valuable commercial fishery in the United States, totaling 129,366,469 lb (58,680 mt)[4] in landings valued at $302,077,000 in 1980 (National Marine Fisheries Service 1981). Brown shrimp are the major contributor to this

Table 1. Literature values for a and b growth parameters for brown shrimp (adapted from Van Lopik et al. 1979).

	Total length (TL) to total weight			Carapace length (CL) to total weight*			
	a	b	Size range (mmTL)	a	b	Size range (mmCL)	Source
Male	11.61	2.91	45-204				Fontaine & Neal (1971)
Female	9.53	2.94	55-240				Fontaine & Neal (1971)
Combined	10.52	2.94	45-240				Fontaine & Neal (1971)
Male				0.00082	2.94	10-42	McCoy (1972)
Female				0.00113	2.84	10-42	McCoy (1972)

*The CL to TL conversion for North Carolina shrimp as derived by McCoy (1972) was:

Male: $TL = 3.50 + 4.16\ CL$
Female: $TL = 10.50 + 3.83\ CL$

[3] 177.7 = L (mean asymptotic length); 0.073 = k (Brody growth coefficient); t (hypothetical age at which length would equal zero had growth always been the same as the data indicate) was assumed to be zero.

[4] Heads-off wet weight (heads-off wt x 1.61 = heads-on wt).

multispecies fishery, having averaged 59% of the total landings by weight and 66% by number from 1963 to 1975 (Van Lopik et al. 1979).

Brown shrimp fishing activities are concentrated within the 55-m (180-ft) contour, but extend to at least 90 m (300 ft). Fishing begins in May, peaks in June and July during their seaward migration, and continues through November in offshore waters. The majority of the harvest is destined for human consumption. There is also a bait-shrimp fishery in some areas of the Gulf of Mexico (Christmas et al. 1976).

Regulation of the shrimp industry is largely carried out by the coastal States and varies from State to State. Several States base their predictions upon a combination of postlarval abundance and environmental conditions (primarily temperature and salinity) in the estuaries during spring recruitment and growth months (Barrett and Gillespie 1973; Van Lopik et al. 1979; Hunt et al. 1980). Such methods have met with some predictive success within a given year, but prediction of year-to-year variation remains unreliable.

Two common assumptions seem to drive all current brown shrimp management in the U.S. Gulf of Mexico. First, since no one has yet demonstrated a good stock-recruitment relationship, recruit overfishing is assumed to be essentially impossible, given present fishing technology. Second, a single, widespread stock throughout the Gulf of Mexico has been assumed. The assumption of stock unity, if untrue, could drastically affect present understanding of the variation in growth and mortality estimates and would require reconsideration of the possible effects of fishing pressure on stock condition.

Recent thought (Gallaway and Gazey, ms.[5] in prep.) is that two temporally segregated stocks, each producing cohorts with different growth characteristics, may exist. The separate spawning peaks mentioned earlier are interpreted to represent two separate spawning stocks. By this scenario, the offspring of the fall spawning stock develop to the postlarval stage, overwinter buried in nearshore sediments, and then emerge and maintain a relatively slow, even growth through the spring and summer. The cohort produced by the spring spawning stock develops and grows rapidly. Recruitment of the two cohorts to the fishery may nearly coincide, with the result that growth sampling might easily be misinterpreted as representative of a single, widely variable stock. The outlined scenario is, as yet, largely speculative but seems a plausible explanation of several areas poorly known in brown shrimp biology.

In light of the above scenario, the relative value of various estimates of mortality will not be discussed beyond the following brief listing:

Weekly Z[6,7]	Source
0.27	Klima (1964)
0.99-1.24	McCoy (1968)
0.57	McCoy (1972)
0.26-0.46	Purvis & McCoy (1974)
0.31-0.76	Laney & Copeland (1981)

[5] LGL Ecological Research Associates, Bryan, Texas.

[6] Adapted from Laney and Copeland (1981).

[7] Z = instantaneous total mortality coefficient.

For discussion of the effects of the brown shrimp fishery on other aquatic resources (e.g., other shrimp, demersal finfish), see Van Lopik et al. (1979) and Gulf of Mexico Fishery Management Council (GMFMC 1981).

ECOLOGICAL ROLE

All actively feeding stages of the brown shrimp are omnivorous. Larvae are reported by Van Lopik et al. (1979) to feed in the water column on both phyto- and zooplankton. After moving into estuarine nursery areas, postlarvae become demersal and feed at the vegetation (marsh grass, mangrove, or seagrass)-water interface. Jones (1973, cited by White and Boudreaux 1977) reported that postlarvae from 25 to 44 mm indiscriminately ingested the top layer of sediment, which contained detritus (comprised primarily of *Spartina*), algae, and microorganisms, and termed them "omivorous encounter feeders."

In this same study, Jones found that 45- to 65-mm juveniles "selected the organic fraction of the sediment" and termed them "opportunistic omnivores." Those over 65 mm began to disperse to deeper waters and became more predaceous, but occasionally ingested both detritus and algae and were termed "omnivorous predators." Prey items included polychaetes, amphipods, nematodes, chironomid larvae, and ostracods. Based on laboratory feeding experiments, Ogle and Price (1976) suggested that mysids may also serve as food for juveniles in northeastern gulf coast estuaries. Darnell (1958) described feeding habits for 91- to 142-mm brown shrimp from Lake Pontchartrain, Louisiana, similar to the findings of Jones (1973) for brown shrimp over 65 mm.

Several species of *Penaeus* are prey to a host of fish species (Gunter 1945; Darnell 1958, 1961) and larger crustaceans (Hunt et al. 1980). Enormous numbers of many of the fish species are captured and discarded as by-catch by commercial shrimp trawlers (GMFMC 1981). No quantitative studies of the role of brown shrimp in estuarine trophic dynamics were found in the literature.

It has been suggested that temporal and spatial shifts which represent the major differences between the three major commercial shrimp species (brown, white, and pink) may have evolved as a mechanism to avoid direct competition (Gunter and McGraw 1973; Van Lopik et al. 1979).

ENVIRONMENTAL REQUIREMENTS

Temperature

Brown shrimp have been collected at water temperatures as low as 2°C (36°F), but few are normally taken below 10°C (50°F), with highest catches taken above 20°C (68°F) (Swingle 1971; Christmas and Langley 1973). Temperatures of 4.4°C (40°F) or less may cause mass narcosis and mortality (Gunter and Hildebrand 1951). Kutkuhn (1966) reported that shrimp taken in waters of greater than 32.2°C (90°F) "are usually flacid and highly sensitive to stresses induced by handling." This is consistent with the observations of Zein-Eldin and Aldrich (1965) that growth and survival were both reduced above 32.2°C (90°F) with a suggested maximum tolerable temperature for postlarvae of just over 35°C (95°F).

Optimum temperature for larval development has been reported as 28° to 30°C (82° to 86°F) (Cook 1965). Estuarine recruitment of postlarval penaeids was recorded by Christmas et al. (1966) only at temperatures of greater than 12°C (54°F). Postlarval growth was reported by Zein-Eldin and Aldrich (1965) to begin between 11° and 18°C

(52° and 64°F), increase rapidly between 18° and 25°C (64° and 77°F), and peak at 32°C (90°F). No growth was seen by St. Amant et al. (1965) when water temperature dropped below 16°C (61°F). Venkataramaiah et al. (1972) found maximum growth, survival, and efficiency of food utilization at 26°C (79°F) (vs. 21° and 31°C [70° and 88°F]). They also found that with a rapid change in temperature (direct transfer from 26° to 21°C [79° to 70°F]), postlarvae and juveniles became inactive, often convulsed, and in some cases developed muscular paralysis. Direct transfers between salinities varying from 8.5 to 34 ppt had no adverse effects.

Salinity

Postlarval brown shrimp have been captured in salinities from essentially fresh (Swingle 1971) to 69 ppt (Simmons 1957), but few have been taken in waters of less than 5 ppt (Loesch 1976; Christmas and Langley 1973). Venkataramaiah et al. (1972) successfully reared brown shrimp at 1.7 ppt, but had no survival at 0.5 ppt. These findings coincide closely with those of Gunter et al. (1964), who suggested a minimum salinity of 0.8 ppt. Tagging studies by White and Boudreaux (1977) indicated that heavy freshwater introduction into marsh nursery areas may cause juveniles to migrate to deeper water or laterally towards offshore shallows (i.e., to higher salinity habitats) earlier than under normal hydrographic conditions. White and Boudreaux also discussed the fishery implications of such early migration. The field observations of Barrett and Gillespie (1973) led them to suggest a salinity optimum of 19 ppt for brown shrimp.

Temperature-Salinity Interaction

A wide range of temperature-salinity combinations seems to be tolerated by brown shrimp, with interactive effects becoming most evident at the extremes of the respective tolerance ranges. Venkataramaiah et al. (1972) observed highest growth rates and survival at temperature-salinity combinations of 26°C or 79°F (vs. 21° and 31°C [70° and 88°F]) and 8.5 or 17 ppt (vs. 25.5 and 34 ppt). A wider range of salinities was tolerated at 26°C (79°F) than at the higher or lower temperatures. An increased range of salinity tolerance at temperatures above 21°C is consistent with the findings of others (Copeland and Bechtel 1974; Loesch 1976). Although inconsistent with the findings of Venkataramaiah et al. (1972), a similar increase in the range of temperature tolerance at higher salinities has also been observed (Zein-Eldin and Aldrich 1965). The combination of low salinity and low temperature has repeatedly been shown to be damaging to brown shrimp (Zein-Eldin and Aldrich 1965; St. Amant et al. 1966; Venkataramaiah et al. 1972).

Van Lopik et al. (1979) summarized the relation of brown shrimp harvest to temperature and salinity by stating that a "good brown shrimp year" can be expected after a warm, relatively high salinity spring in coastal nursery areas. Mean temperature and salinity threshold values (i.e., above which harvest was good and below which harvest was poor) of 20°C (68°F) and 10 ppt during the primary recruitment and growth period were suggested by Hunt et al. (1980) for brown shrimp along the North Carolina coast. These same values appear to be consistent with data from Louisiana presented by Barrett and Ralph (1977) in their figures 5 and 6.

Substrate and System Features

Field observations have repeatedly suggested that postlarval brown shrimp recruit in greatest abundance to soft bottom, shallow areas of estuaries in or near marshes or seagrass beds (Christmas et al. 1966). Williams (1958) experimentally demonstrated a significant preference by settling postlarvae for softer, muddier substrates with decaying vegetation. Apparently, field-observed recruitment patterns, in this case, accurately reflect a specific preference rather than a misinterpretation of the result of several related processes (e.g., random recruitment combined with differential mortality rates between available habitats to give the resultant impression of apparent habitat selection). If this is indeed the case, the maintenance of such interface habitats is critical in the species' life history and to the continuity of normal development. Possible reasons for this association with vegetation-water interfaces have been discussed in previous sections. Adults are taken in greatest abundance on mud or silt bottoms, but are also taken on mud-sand, sand, or shell bottoms (Peréz-Farfante 1969; Van Lopik et al. 1979).

The importance of the surrounding vegetational system has been emphasized by Turner (1977), who found total shrimp yield to be directly proportional to marsh acreage in Louisiana, and to acreage of marsh plus seagrass in the northeastern Gulf of Mexico. He found no significant relationship of shrimp yield with water surface area, mean water depth, or volume of the estuaries investigated. Experimental perturbations (blocking off wetlands with levees and bulkheads) have been shown to decrease postlarval and adult densities (Mock 1967). Van Lopik et al. (1979) provided the following list of "alterations" which remove area suitable as shrimp habitat:

1. Impoundments that prevent influx of shrimp
2. Bulkheading that removes the critical marsh-water or mangrove-water interface
3. Alterations in freshwater discharge that create an unfavorable salinity regime
4. Stimulation of saltwater intrusion
5. Continuing encroachment of polluted waters on the estuarine waters

Other Environmental Requirements

The following quote from Kutkuhn (1966) with regard to turbidity is apparently still applicable today: "No successful studies have been conducted to relate turbidity with shrimp occurrence and density, but gross observation suggests that those bays which are consistently the most roily generally harbor per unit area and, in season, the largest concentrations of young shrimp. Whether this reflects more the nutritive potential of the detrital material in suspension, or protection of transient shrimp from predation by fishes, birds, and other animals remains a moot question." Answers to questions on the effects of increased turbidity may lie largely in understanding its effects upon, and the relative importance of phytoplankton based versus rooted vegetation/detrital based productivity and remineralization. The former would seem to be more directly affected by increased turbidity. For a review of questions relating to estuarine productivity see Nixon (1981).

Trent et al. (1976) attributed decreased brown shrimp abundance at altered marsh sites in West Bay, Texas, to low dissolved oxygen conditions (below 3.0 ml/l, from May 20 to August 12). Detailed laboratory studies of oxygen consumption by brown shrimp and the interaction of oxygen consumption with temperature, salinity, and body size are presented by Bishop et al. (1980).

Couch (1979) reviewed the literature on the effects of various pollutants (petroleum and non-petroleum organic chemicals, heavy metals), biological agents, the interactions both among them and with environmental conditions for several penaeid shrimps. Information on their known diseases and parasites is also reviewed.

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15. Supplementary Notes

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries on the taxonomy, morphology, range, life history, and environmental requirements of coastal aquatic species. They are designed to assist in environmental impact assessment. The brown shrimp, Penaeus aztecus, is the major species in the Gulf of Mexico shrimp fishery, the most valuable ($302 million in 1980) commercial fishery in the United States. It is heavily preyed on by many fishes. Spawning occurs offshore from about September to May and most postlarvae move into estuaries from February through April. Within the estuary they occupy shallow water near marshes with soft substrate. Juveniles emigrate from estuaries to offshore areas from May through August. They grow as fast as 3.3 mm per day in estuaries. Adults concentrate around the 55-m contour offshore. Postlarval and juvenile shrimp are normally taken in water temperatures above 10°C and rapid growth occurs above 18°C. Few shrimp are collected below 5 ppt salinity. Brown shrimp are benthic feeders and prefer soft substrates. High populations are associated with coastal marshes.

17. Document Analysis a. Descriptors

Estuaries
Fishes
Growth
Feeding

b. Identifiers/Open-Ended Terms

Brown Shrimp
Penaeus aztecus
Salinity requirements
Temperature requirements
Habitat requirements
Life history
Spawning

c. COSATI Field/Group

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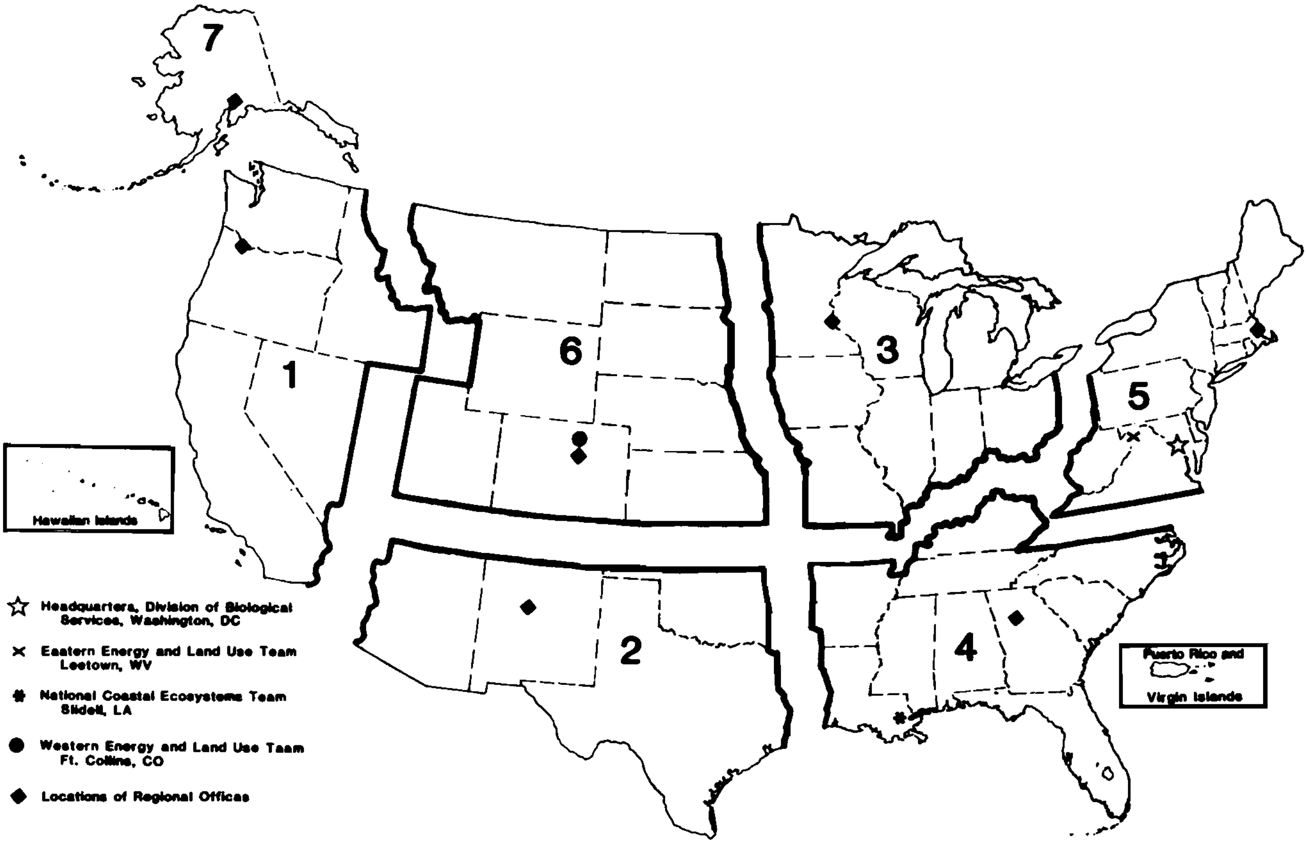

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