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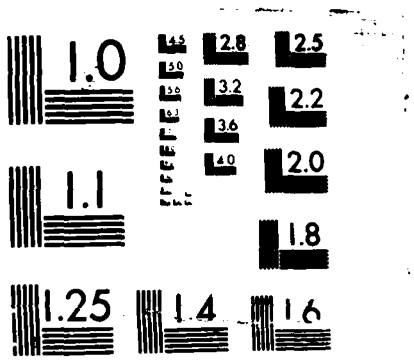

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)

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BLUE CRAB

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Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)

BLUE CRAB

by

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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to:

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Attention: WESER
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Vicksburg, MS 39180

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CONVERSION FACTORS

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (mt)	2205.0	pounds
metric tons	1.102	short tons
kilocalories (kcal)	3.968	BTU
Celsius degrees	1.8(C°) + 32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	By	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
acres	0.4047	hectares
square miles (mi^2)	2.590	square kilometers
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
short tons (ton)	0.9072	metric tons
BTU	0.2520	kilocalories
Fahrenheit degrees	0.5556(F° - 32)	Celsius degrees

ACKNOWLEDGMENTS

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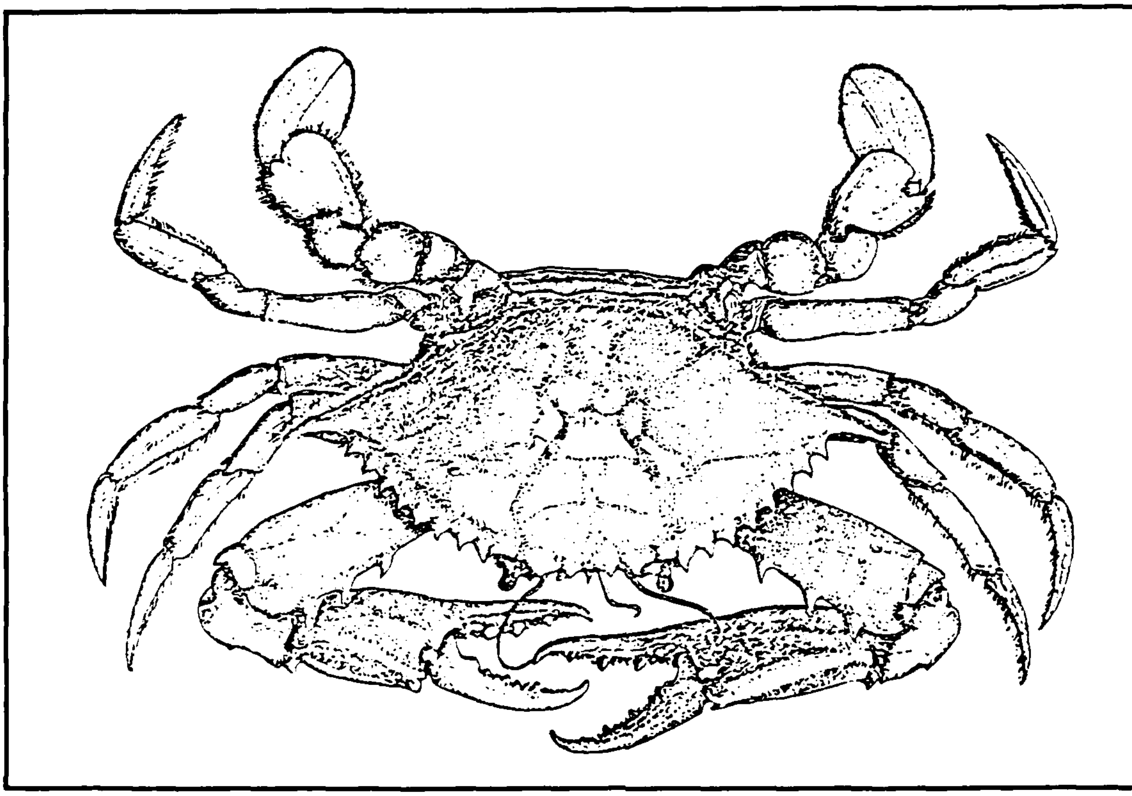

Figure 1. Blue crab.

BLUE CRAB

NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . *Callinectes sapidus* (Rathbun)
Preferred common name . . . . Blue crab (Figure 1)
Other common names. . . . Edible crab, crab; young females are called sally crabs; adult females are called sooks; and males are called jimmies, jimmy-dicks, or channelers (Van Engel 1958)
Class . . . . Crustacea
Order . . . . Decapoda
Family . . . . Portunidae
Geographic range: Coastal waters, primarily bays and brackish estuaries from Massachusetts Bay, southward to the eastern coast of South America, including the Gulf of Mexico. The blue crab occurs in coastal waters throughout the South Atlantic Bight (Figure 2). It has also been reported from France, Holland, Denmark, and the east coast of the Mediterranean Sea (Churchill 1921; Van Engel 1958).

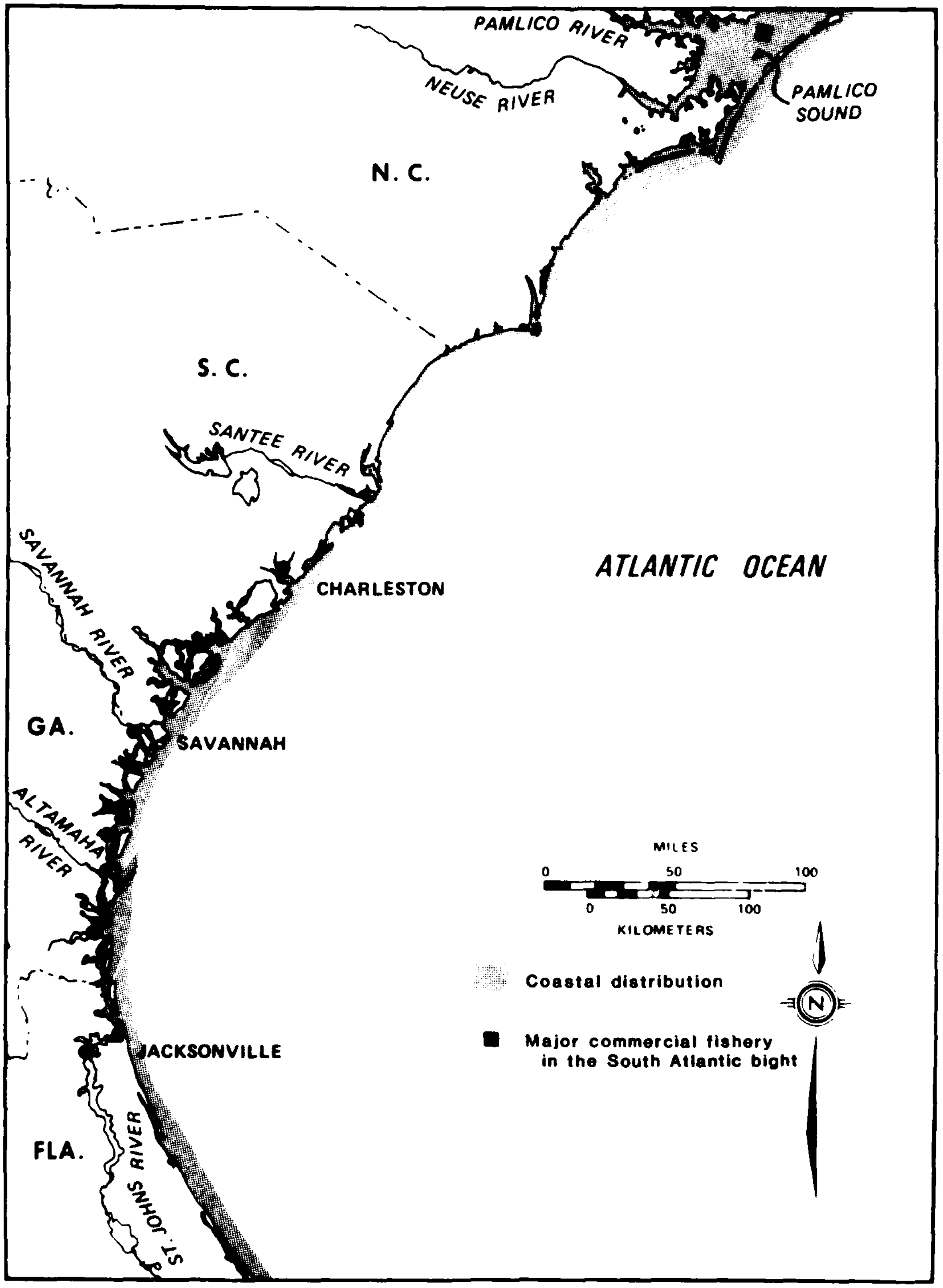

Figure 2. Distribution of the blue crab in the South Atlantic Bight, southeastern United States. The Pamlico Sound area in North Carolina supports the major commercial fishery in the South Atlantic Bight.

MORPHOLOGY/IDENTIFICATION AIDS

The blue crab is grayish or bluish green with red on carapace spines (Pyle and Cronin 1950; Williams 1965). Males have blue pinchers on chelipeds; mature females have red pinchers on chelipeds. Underparts are off-white with tints of yellow and pink (Williams 1965). Young crabs often are brownish with conspicuous white markings (Newcombe 1945).

The carapace, including lateral spines, usually 2.5 times as wide as long, moderately convex, and nearly smooth except for small tubercles that occur on inner branchial and cardiac regions. The anterior margin of the carapace has a median or frontal region that extends between the compound eyes, and two lateral regions. The median region has four serrations and each lateral region has eight (Figure 1); the number of serrations is constant for this species.

The abdomen of the male is shaped like an inverted "T" (Figure 3). The abdomen of immature females is triangular, and the mature female has a broad, rounded abdomen that is folded loosely against the ventral side of the thoracic sterna (Figure 3).

REASON FOR INCLUSION IN SERIES

The blue crab supports a valuable commercial fishery throughout the South Atlantic States and along most of the eastern coast of the United States. Estuaries are essential in the life history of the blue crab; the species' high abundance in estuaries and its omnivorous feeding habits suggest that the blue crab plays an important role in the structure and function of estuarine communities. During pre-adult stages of life, the blue crab is eaten by a large number of estuarine and marine animals.

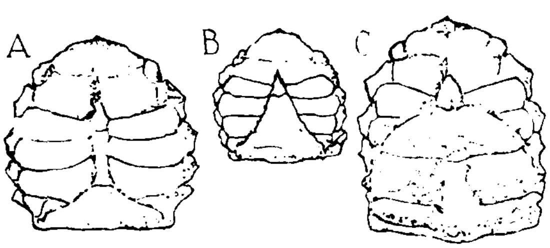

Figure 3. Ventral view of the blue crab male (A), immature female (B), and mature female (C) (Truitt 1939).

LIFE HISTORY

Spawning

Blue crabs mate in Chesapeake Bay from May through October (Van Engel 1958; Williams 1965) and throughout the year in the St. Johns River, Florida (Tagatz 1968). Mating primarily occurs in relatively low-salinity waters in upper areas of estuaries and in lower portions of rivers (Pyle and Cronin 1950; Darnell 1959; Williams 1965; Tagatz 1968).

Williams (1965) described the blue crab's mating behavior. Males may mate during three or four intermolt phases after they mature. Females mate only once in their lives, but the sperm from this mating is stored in seminal receptacles and may be used as often as the female spawns, generally two or more times during a 1- or 2-year period (Pyle and Cronin 1950; Van Engel 1958; Williams 1965).

After mating, females migrate to high-salinity waters in lower estuaries, sounds, and nearshore spawning areas (Churchill 1921; Darnell 1959; Fischler and Walburg 1962). Most females spawn for the first time 2 to 9 months after mating (Churchill 1921; Williams 1965). In Chesapeake Bay, females remain in the lower estuaries and spawn the following spring or summer (Churchill 1921). In Florida, Tagatz (1968) found that females which mated in the spring or summer first spawned 1 or 2 months later in the same year, with peak spawning from

October through December. Steele (1979) reported spawning in Florida from March through December when water temperatures exceeded 22°C. Crabs that mated during the fall or winter in the St. Johns River spawned from March through June of the next year. Some females may spawn twice during a single season (Tagatz 1968).

A comparison of mating and spawning characteristics reported for the St. Johns River and Chesapeake Bay suggests that as temperatures increase in the southerly direction, mating and spawning seasons become longer and less distinct. This fact is probably due to more rapid growth and maturation at warmer temperatures. Daugherty (1952) found that the spawning season was significantly shorter during years in which temperatures were low for extended periods.

The female extrudes fertilized eggs into a mass or "sponge" that remains attached to hairlike branches (setae) of the appendages of the abdomen until larvae emerge (Churchill 1921; Newcombe 1945; Pyle and Cronin 1950). Formation of the sponge, which may contain 700,000 - 2,000,000 eggs, takes about 2 hr (Churchill 1921; Truitt 1939; Williams 1965). The presence of empty egg cases on swimmerets or the occurrence of large, bright-red adult nemertean worms (Carcinonemertes corcinophila) on the gills of a mature female indicate that the individual has spawned at least once (Churchill 1921; Hopkins 1947).

Development

Growth and development of the blue crab, as with other crustaceans, consist of a series of larval, juvenile, and adult stages during which a variety of morphological, behavioral, and physiological changes occur. These changes are most dramatic when the animal molts, or sheds its rigid exoskeleton, permitting growth and changes in body shape. Prior to molting, a new shell is formed beneath the old exoskeleton, which is then loosened and cast off. The new shell is initially soft, but it expands and hardens in a few hours. The stage between molts is termed "intermolt."

The number of molts during certain life stages (e.g., larval and juvenile) is relatively uniform among crabs, but the rate of molting (and hence growth) can vary considerably and is affected by many environmental factors. Much of the information summarized below was obtained from comprehensive studies of blue crab in the Chesapeake Bay area (Churchill 1921; Newcombe 1945; Van Engel 1958) and the St. Johns River Estuary in Florida (Tagatz 1968). Information on the life stages of the crab in these areas should be representative throughout the species' range. Rates of development and timing of certain important events (such as mating, spawning, and migrations) throughout most of the South Atlantic Bight will generally be intermediate between results presented for the two areas. Documented variations are emphasized and cited below.

Eggs

When first deposited, the eggs are bright orange; but they become yellow, brown, and then dark brown before hatching (Van Engel 1958). The color change is caused by absorption of the yellow yolk and development of dark pigment in the eyes. Eggs are about 0.25 mm in diameter (Churchill 1921), and incubation generally requires 1 to 2 weeks. Sandoz and Rogers (1944) reported that hatching of blue crab eggs must occur at salinities of 23 to 33 ppt and temperatures of 19° to 29° C. Mortality of eggs has been attributed to fungus, predation, suffocation in stagnant water, and extreme temperatures (Couch 1942; Humes 1942; Rogers-Tolbert 1948). On the average, only one out of every million eggs survives to become a mature adult (Van Engel 1958).

Larvae

First stage larvae, called zoeae, measure approximately 0.25 mm at hatching. They bear little morphological resemblance to adults (Hopkins 1943), are filter feeders, and live a planktonic existence in the high-salinity surface waters near the spawning grounds (Pyle and Cronin 1950; Darnell 1959). Tagatz (1968) found more zoeae near the water's surface than at the bottom. Churchill (1942) provided illustrated descriptions of zoeae morphology.

The zoeae and all subsequent life stages can increase body size only by molting (Hay 1905; Pyle and Cronin 1950). Zoeal development may require 31 to 49 days, depending on salinity and temperature, but development time has been shown to be variable even in a single salinity-temperature regime (Williams 1965). Zoeae molt four to seven times before entering the next stage of development, and it has been hypothesized that the number of molts required to reach the megalops stage depends on temperature and salinity. The final zoeal stage is about 1.0 mm in width (Hopkins 1943; Sandoz and Rogers 1944).

The final molt of the zoeae is characterized by a conspicuous change to the second larval stage, called a megalops (also termed megalopa [sing.] or megalopae [pl.]). The megalops larva is more crablike in appearance than the zoeae, is broader in relation to its length, and has biting claws and pointed joints at the ends of the legs (see Churchill [1921] and Newcombe [1945] for illustrations). It measures about 1.0 mm in width. The megalops swims freely, but generally stays near the bottom in nearshore or lower-estuarine, high-salinity areas (Tagatz 1968). The megalops stage lasts 6 to 20 days, after which the megalops molts into the "first crab" stage, with proportions and appearance more like those of an adult.

Juveniles

The juvenile "first crab" is typically 2.5 mm wide (from tip to tip of the lateral spines of the carapace). These juveniles gradually migrate into shallower, less-saline waters in upper estuaries and rivers where they grow and mature (Fischler and Walburg 1962). Van Engel (1958) and Tagatz (1968) reported that many juveniles had completed this migration by fall and early winter. Males generally migrate farther upstream, preferring low-salinity waters, whereas females tend to stay in lower rivers and estuaries (Dudley and Judy 1971; Music 1979).

Growth and maturation occur during a series of molts and intermolt phases, each of which is termed a "crab" stage according to the number of molts that have occurred since the megalops stage. Churchill (1921) reported that juveniles reached the 9th or 10th crab stage by October in Chesapeake Bay, but growth varies considerably among years and with latitude along the Atlantic coast. Molting and growth stop during winter (Churchill 1921; Darnell 1959); growth resumes as waters warm, and juveniles generally reach maturity during the spring or summer of the year following their hatching.

Adults

Sexual maturity is reached after 18-20 postlarval molts at 1 to 1.5 years of age in Chesapeake Bay (Williams 1965; Van Engel 1958). Size at maturity is variable; sexually mature females as small as 51 mm (carapace width) have been reported in South Carolina (Fischler and Walburg 1962), but Tagatz (1968) found immature females as large as 177 mm in width in Florida. Males continue to grow and molt after reaching sexual maturity; but after females mature, they mate and do not molt or grow again.

After mature females mate and migrate to spawning areas, they remain there or move only a short distance out to sea during the remainder of their lives (Williams 1965). In warmer months, males generally remain in low-salinity waters such as creeks, rivers, and upper estuaries (Churchill 1921; Van Engel 1958; Dudley and Judy 1971; Music 1979). The maximum age for most blue crabs in Chesapeake Bay (Churchill 1921) and North and South Carolina (Williams 1965) is about 3 years. Tagatz (1968) reported that the maximum age in the St. Johns River was 4 years. Hay (1905) and Truitt (1939) reported that adults lived an average of less than 1 year after reaching maturity.

Migrations

Adult blue crabs are excellent swimmers and also can move quickly on land (Pyle and Cronin 1950). Tagging studies along the South Atlantic have shown that blue crabs rarely move from one estuarine system to another (Porter 1956; Cargo 1958; Fischler and Walburg 1962; Judy and Dudley 1970). These studies also showed that most crabs leaving an estuary generally remain in adjacent coastal areas, but tagged female crabs have occasionally been recovered 100-540 km from their release sites. Such long-range movements generally occur after mating and prior to spawning. Crabs along the Florida gulf coast undergo more extensive migrations between estuaries than do crabs along the South Atlantic Bight (Steele 1979). Males undergo less extensive migrations than females.

Migrations of blue crabs within estuarine systems are related to phases of their life cycle, season, and, to a lesser extent, searches for favorable environmental conditions (Churchill 1921; Fiedler 1930; Truitt 1939; Fischler and Walburg 1962). Most blue crabs move to relatively deeper, warmer waters during winter and return to rivers, tidal creeks, salt marshes, and sounds when conditions become more favorable in the spring (Livingston 1976; Subrahmanyam and Coultas 1980). Livingston (1976) reported that crabs in a Florida estuary moved from inshore areas to deeper, more saline waters when shallow waters cooled.

Migrations associated with reproductive cycles or maturation are described in the Spawning and Development sections.

GROWTH AND MOLTING CHARACTERISTICS

From the first crab stage to the adult, successive intermolt stages of the crab are morphologically similar except for size. Growth rates vary among individuals and are affected by temperature, salinity, and many other factors. Hence, it is generally not possible to determine the stage that a particular crab is in from its size or external characteristics (Churchill 1921). Migrations and movements within estuaries further complicate estimation of growth rates, and repeated sampling at one location can lead to erroneous conclusions (Darnell 1959; Adkins 1972; Palmer 1974). Thus, the growth and molting patterns presented here were derived in part from laboratory studies. This summary should have general applicability throughout the South Atlantic Bight, but rates of growth will vary considerably with temperature, salinity, and other site-specific factors.

Small crabs molt frequently, and the time between molts increases as crabs grow larger (Van Engel 1958). At each normal molt, carapace width typically increases 25%-40% (Churchill 1921; Gray and Newcombe 1939; Van Engel 1958). Results of Churchill's (1921) laboratory studies on growth of Chesapeake Bay blue crabs serve as a general guideline for growth patterns of blue crabs in Virginia and adjacent States (Table 1). The increase in size associated with specific molts may be genetically controlled, but it is believed that environmental conditions have a

Table 1. Growth of blue crabs at temperatures and salinities typical of Chesapeake Bay (Churchill 1921).

Life stage	Carapace width (mm)	Increase in width (mm)	Molt interval (days)	Age (days)
Megalops	1.0			
1st crab	3.2	2.2	1	1
2nd crab	5.0	1.8	8	9
3rd crab	6.6	1.6	4	13
4th crab	8.8	2.2	5	18
5th crab	11.6	2.8	6	24
6th crab	13.1	1.5	13	37
7th crab	20.6	7.5	11	48
8th crab	27.0	6.4	13	61
9th crab	34.9	7.9	10	71
10th crab	42.8	7.9	15	86
11th crab	57.2	14.4	16	102
12th crab	79.4	22.2	20	122
13th crab	109.5	30.1	21	143
14th crab	139.7	30.2	25	168
15th crab	177.8	38.1	35	203

greater influence. Unfavorable water conditions, inadequate food, or injuries such as the loss of one or more legs may cause smaller increases in size or no growth following a molt (Van Engel 1958). Tagatz (1968) found that juvenile crabs in northeastern Florida exhibited more growth per molt in higher salinity waters.

Van Engel (1958) reported that crabs hatched in late May in Chesapeake Bay grew to 64 mm in width by November and to 127 mm by the following August. In the St. Johns River, most blue crabs reach harvestable size (127 mm) 1 year after hatching. Average size at maturity has been reported to be about 178 mm in Chesapeake Bay (Churchill 1921), 203 mm in the Carolinas (Williams 1965), and 102-178 mm in the St. Johns River (Tagatz 1968). The literature indicates considerable variation in the age at which sexual maturity is reached: 12-18 months in Chesapeake Bay (Newcombe 1945; Van Engel 1958), about 22 months in South Carolina (Fischler and Walburg 1962), and less than 12 months in the St. Johns River (*Tagatz* 1968). There is considerable overlap in size ranges of immature and mature crabs (Tagatz 1968).

THE FISHERY

The blue crab supports the largest crab fishery in the United States. Annual commercial landings in the South Atlantic averaged about 48 million lb (valued at $9 million) for 1977-81 (Bell 1978; National Marine Fisheries Service [NMFS] 1981a, 1982). Sholar (1979) summarized most aspects of the Atlantic blue crab fishery, and included landings, by State, for 1950-77. Tagatz and Hall (1971) provided an annotated bibliography on the fishing industry and biology of the blue crab.

Harvest from the South Atlantic Bight during 1977-81 represented 25% - 33% of the total U. S. commercial blue crab harvest. Landings in the South

Atlantic generally consist of about 50% from North Carolina, 20%-25% from Georgia, 20% from South Carolina, and 7%-10% from Florida (NMFS 1979, 1980a, 1980b, 1981b). North Carolina's Pamlico Sound yielded about 10 million lb annually from 1970 to 1978 and is the major production area of the South Atlantic (Sholar 1979). Catches along the east coast of Florida ranged from 4 to 8 million lb annually for 1954-78, and Florida's major production area is from the Indian River northward (Steele 1979).

Blue crabs are exploited throughout the year, but most are taken during the summer and early fall (Music 1979). Hard crabs (crabs with hardened exoskeletons) are primarily taken in shallow water by using trawls, crab pots, or trot lines in the warmer months. Dredges and scrapes are used in deeper offshore waters in the winter (Adkins 1972). Use of crab trawls on the Atlantic coast is limited to the South Atlantic States, particularly North Carolina, where trawls are used during the winter when crabs are relatively inactive (Sholar 1979). From 1950 through 1975, the number of crab fishermen in the South Atlantic remained relatively stable, but there was a trend toward reduced use of trot lines and increased use of pots and trawls to harvest crabs (Table 2). This trend has led to a steady increase in the importance of the trap fishery in overall harvest; since the early 1970's traps have provided 80% or more of the South Atlantic hard crab catch while the contribution from trot lines has decreased to less than 2%.

Blue crabs are commonly caught incidentally to shrimp trawling and other fisheries, but this bycatch often is not kept or represents a small percentage of the marketed harvest.

Peelers or peeler crabs (crabs about to molt) generally constitute a small percentage of South Atlantic landings, but are a significant aspect of the fishery. Peelers are usually taken by dip nets near the shore in shallow waters during the warmer months (Newcombe 1945), or by trawling or pots, and are placed in cages (floats) and allowed to molt prior to marketing. Recently molted "soft shell" crabs are highly sought after by seafood markets and restaurants. Few fishermen engage in the soft shell business because these crabs must be tended constantly (Adkins 1972). Sholar (1979) indicated that North Carolina was the only State that reported a significant peeler and soft crab fishery; annual landings, however, declined from about 100,000 lb prior to 1965 to only about 30,000 lb after 1970.

Management of the commercial blue crab fishery is usually local because most crabs remain within one estuarine system through their lives. Florida uses a permit and license system to identify traps, minimize disruption of navigation, and reduce theft of traps and catch (Willis 1979). Carapace width limits, net mesh sizes, constraints on gear type, closed seasons and areas, prohibition of taking sponge crabs or other females, quotas, and licensing have been used by most States at various times in the management of blue crabs. All South Atlantic States have a 127-mm minimum size (carapace width) for hard crabs, and several States have a 76-mm minimum size for soft or peeler crabs (Sholar 1979). Florida currently allows up to 10% of a fisherman's hard crab catch to be less than 127 mm in size.

The blue crab also supports a recreational fishery and a variety of small-scale commercial harvest and sales operations (sometimes termed "weekend" operators). Methods include handlines, pots, and collapsible traps. Recreational fishermen generally are limited to a maximum of five pots (Sholar 1979). Landings from these activities have rarely been quantified.

More (1969) found that fluctua-

Table 2. Numbers of gear units, fishermen, and boats operating in the blue crab fisheries of the South Atlantic States, 1950-75 (from Sholar 1979).

Year	Pots	Trot lines	Trawls	Fishermen	Boats
1950	11,030	793	184	1,728	1,124
1951	13,175	783	129	1,455	1,137
1952	9,975	631	127	1,268	988
1953	14,565	909	160	1,501	1,003
1954	22,179	905	169	1,380	1,131
1955	28,519	663	143	1,379	1,172
1956	29,030	545	158	1,318	1,123
1957	39,895	561	175	1,477	1,249
1958	37,305	636	218	1,595	1,330
1959	43,856	526	288	1,826	1,415
1960	40,900	528	263	1,762	1,396
1961	46,625	528	264	1,720	1,483
1962	50,545	508	296	1,765	1,495
1963	54,490	510	337	1,895	1,592
1964	63,530	393	432	1,991	1,659
1965	61,842	280	424	1,844	1,528
1966	65,125	168	560	1,762	1,463
1967	59,245	155	538	1,603	1,290
1968	65,315	159	493	1,550	1,192
1969	70,115	160	386	1,482	1,262
1970	70,515	118	449	1,479	1,191
1971	69,426	116	518	1,601	1,248
1972	61,770	112	473	1,608	1,205
1973	76,140	80	508	1,742	1,284
1974	75,697	79	433	1,652	1,176
1975	81,853	75	441	1,837	1,301

tions of blue crab populations were independent of the levels of fishing effort that occurred during his study. Pearson (1948) found that the size of the spawning stock did not determine the size of the population that survived to commercial age at fishing rates that prevailed during the years studied. He noted that fluctuations in abundance were related to rates of survival during the first year of life. Rees (1963) and More (1969) found no direct relationship between commercial catches and recruitment of harvestable crabs in subsequent years. Apparently, no reliable methods of predicting population fluctuations exist. Suggested causes of population fluctuations include extreme cold weather or reduced salinities from heavy rains (Pearson 1948), parasitism (Hutton and Sogandares-Bernal 1959), pesticides (Cottam and Higgins 1946; Mills 1952), and predation (McHugh 1967).

ECOLOGICAL ROLE

Blue crabs perform a variety of ecosystem functions and can play a major role in energy transfer within estuaries. At various stages in its life cycle, the blue crab serves as prey and as a consumer of plankton, small invertebrates, fish, and other crabs. It is an important detritivore and scavenger throughout its range. Much of the information summarized below on trophic relationships was based on work done in the Gulf of Mexico and in Chesapeake Bay, but general aspects of the blue crab's ecological role in those areas should be representative of the South Atlantic Bight.

Zoeae are phytoplanktivorous (Darnell 1959), and Tagatz (1968) reported that zoeae also readily consumed dinoflagellates and copepod nauplii. The megalops is omnivorous and consumes fish larvae, small shellfish, and aquatic plants (Van Engel 1958; Darnell 1959; Tagatz 1968). Cannibalism is common among all life stages of blue crabs (Hay 1905; Churchill 1921; Darnell 1959; Tagatz 1968).

Hay (1905) stated that the post-larval crab is predominately a scavenger and a cannibal. Darnell (1959) and Adkins (1972) described the blue crab as a general scavenger, bottom carnivore, detritivore, and omnivore. Food habit studies have shown that the predominant food items consumed vary greatly among localities. Some common food items are dead and live fish, crabs, organic debris, shrimp, mollusks (including mussels, clams, oysters, and snails), and aquatic plants (Newcombe 1945; Darnell 1959; Williams 1965; Tagatz 1968). Truitt (1939) found that roots, shoots, and leaves of eelgrass (Zostera), ditch grass (Ruppia), sea lettuce (Ulva), and salt marsh grass (Spartina) were commonly consumed by crabs in salt marshes, tidal creeks, and other shallow estuarine areas. Darnell (1958) concluded that mollusks became the dominant food item of crabs larger than 120 mm in width.

Blue crabs are preyed on by a variety of animals. Eggs carried by females are a favorite food of many fishes (Adkins 1972). Larval stages are eaten by fish, shellfish, jellyfish, comb jellies, and various other planktivores (Van Engel 1958). Juvenile blue crabs in Gulf of Mexico areas were important prey of many fishes such as spotted sea trout (Cynoscion nebulosus), red drum (Pogonias cromis), and sheepshead (Archosargus probatocephalus) (Fontenot and Rogillio 1970). Juvenile and adult blue crabs are consumed by mammals and a variety of birds.

The blue crab is the host of several parasites and diseases, but many infections are temporarily eliminated during molting. After their last molt, adult blue crabs can serve as a lodging place for barnacles, bryozoans, and other sessile organisms (Darnell 1959; Williams 1965). The barnacles Balanus amphitrite and Chelonibia patula attach to the carapace, but generally have little effect on the crab (Darnell 1959; Williams 1965). Causey (1961) found that the stalked barnacle Octalasmus lowei may clog a crab's gills and gill chambers. The occurrence of some types of barnacles can prevent molting (Steele 1979). Infections by the amoeba Paramoeba perniciosa have been responsible for massive crab mortalities along the eastern seaboard (Mahood et al. 1970).

Blue crabs have been implicated as carriers of Vibrio cholare strains that are responsible for outbreaks of human cholera in the Gulf States (Moody 1979). Cholera and other food-borne illnesses can be transmitted to humans if crabs are improperly cooked or stored.

ENVIRONMENTAL REQUIREMENTS

Temperature

Water temperature influences survival, molting frequency, and growth of crabs, but optimal temperatures vary with other environmental parameters (Zein-Eldin and Griffith 1966; Hughes et al. 1972; Winget et al. 1976). Williams (1965) found that larval crabs did not develop beyond the first zoeal stage when reared at temperatures less than 21°C and did not progress past the third zoeal stage when reared at 30°C or higher. Development progressed normally at 25°C when salinity was between 20.1 ppt and 31.1 ppt. Costlow (1967) found that survival of megalops larvae exceeded 70% at 20°, 25°, and 30°C when salinity was above 10 ppt, but never exceeded 50% at 15°C. Blue crabs avoided mortality during an extensive fish and shrimp kill on the Georgia coast during January 1977 when water temperatures dipped to 3°C (Music 1979). Their ability to burrow in the substrate apparently enables them to be insulated from cold waters for short periods (Music 1979; Weinstein 1979). Holland et al. (1971) reported that the upper incipient lethal temperature for juvenile blue crabs was 33°C.

Leffler (1972) measured growth of crabs at four temperatures, starting with 22-mm crabs, and found the following mean carapace widths after 70 days:

56 mm at 34°C
48 mm at 27°C
40 mm at 20°C
38 mm at 15°C

Churchill (1921) and Winget et al. (1976) also reported that growth rate was proportional to water temperature. Leffler (1972) noted that growth and molting ceased below 13°C, whereas Churchill (1921) found that they ceased below 15.5°C.

Leffler (1972) found that mortality was directly proportional to temperature within a 15° to 34°C range of experimental conditions. Holland et al.'s (1971) experiments indicated that mortality increased at temperatures above 30°C. Leffler (1972) noted that crabs acclimated to 34°C were hyperactive. Activity and aggression of crabs decreased with temperature until at 13°C almost no movement occurred.

Salinity

Blue crabs occupy waters ranging from 34 ppt to freshwater rivers as far as 195 km upstream from the coast (Tagatz 1968). Newcombe (1945) stated that salinities of 22 to 28 ppt are needed for normal hatching of eggs and for normal development of zoeae, but survival and growth of megalops and small juvenile crabs may be normal at salinities as low as 5 ppt. When salinity is very low, larvae may hatch prematurely and die in the prezoeal stage (Van Engel 1958). Holland et al. (1971) found that salinities within the range of 2-21 ppt had little effect on growth and survival of juveniles.

Gunter (1938) stated that postlarval blue crabs move into freshwater and probably do so throughout the species' range. Palmer (1974) indicated that blue crabs may thrive in highly saline, less saline, and even pure freshwater. Odum (1953) found that oligohaline (100-1000 ppm Cl) and nearly oligohaline (25-100 ppm Cl) waters are invaded to a considerable extent by blue crabs. Specific salinity levels are not critical for postlarval crabs (Odum 1953; Costlow 1967; Adkins 1972; Palmer 1974). The occurrence of mature males generally decreases with increasing salinity over 10 ppt (Music 1979). Males can move distances exceeding 100 km up freshwater coastal rivers (Hay 1905; Pearson 1948; Odum 1953).

Habitat Structure

The blue crab inhabits all areas of estuaries to some extent (Churchill 1921; Newcombe 1945; Palmer 1974; Music 1979). Weinstein (1979) found that shallow salt marsh habitats were important nurseries for juvenile blue crabs. Mature males prefer creeks, rivers, and upper estuaries, but this may be a response to salinity rather than to physical features of the habitat (Churchill 1921; Williams 1965; Music 1979). When not mating, mature females tend to remain in the higher salinity areas of lower estuaries and surrounding waters (Churchill 1921; Van Engel 1958; Palmer 1974; Music 1979).

Adkins (1972) found the optimum habitat for small crabs to be shallow estuarine waters with soft detritus, mud, or mud-shell bottoms. Larger crabs preferred deeper estuarine waters having harder bottom substrates.

Other Environmental Factors

Pesticides, herbicides, domestic and industrial wastes, alteration of currents, and destruction of marshlands are among the many stresses that affect blue crabs while they occupy nursery areas (Adkins 1972). Mahood et al. (1970) found that all 500 South Atlantic blue crabs examined contained chlorinated hydrocarbon pesticides. Toxicity increased with temperature, but decreased with salinity; and they found that 1.0 ppm DDT and 10.0 ppm toxaphene were 100% lethal to adult blue crabs after 24 and 72 hrs, respectively. Pearson (1979) determined that blue crabs could detect napthalene (a toxic constituent of petroleum) at levels encountered after oil spills, but did not specify physiological effects. Bookhout and Costlow (1976) found that 0.01- to 10.0-ppb concentrations of Mirex had no acute effects on mortality of blue crab larvae for 5 days after hatching; they also reported that 1.3 to 1.9 ppb of Methoxychlor were lethal to the blue crab.

Laughlin et al. (1978) indicated that forest clearcutting can increase storm-water runoff, reducing estuarine pH and salinity for short periods. In their study, mature crabs were consistently more abundant in control areas than in areas where acidic runoff had reduced the pH to levels below 6.0. Similar results were observed for acidic pulp mill effluents (Livingston et al. 1976).

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16. Abstract (Limit: 200 words)

Species profiles are summaries of the literature on taxonomy, life history and environmental requirements of coastal fishes and aquatic invertebrates. They are prepared to assist with impact assessment. The blue crab, Callinectes sapidus, occurs in lower reaches of fresh-water rivers, estuaries, and coastal waters along the Atlantic seaboard and Gulf of Mexico, and the species supports the largest crab fishery in the United States. The blue crab's high abundance in estuaries, diverse feeding habits, and importance as prey for other marine animals indicate its important role in the structure and function of estuarine communities. Female blue crabs spawn in high-salinity lower estuaries or coastal areas where the resulting larvae are planktonic and develop into juveniles at 5 to 10 weeks of age. Juveniles gradually migrate into shallower, less-saline upper estuaries and rivers where they grow and mature at 1-2 yr of age. Mating occurs in the upper estuaries after which females migrate to areas having higher salinities. Growth and survival of blue crabs are strongly affected by water temperature and salinity, but tolerances vary with life stage. Larvae require temperatures of 20°-30°C and salinities of 10-30 ppt for proper development, but salinity and temperature tolerances are broad for advanced juveniles and adults. Blue crabs use nearly all areas within estuaries as nursery habitat, and crab populations are sensitive to changes in physical features or contamination of these areas.

17. Document Analysis a. Descriptors

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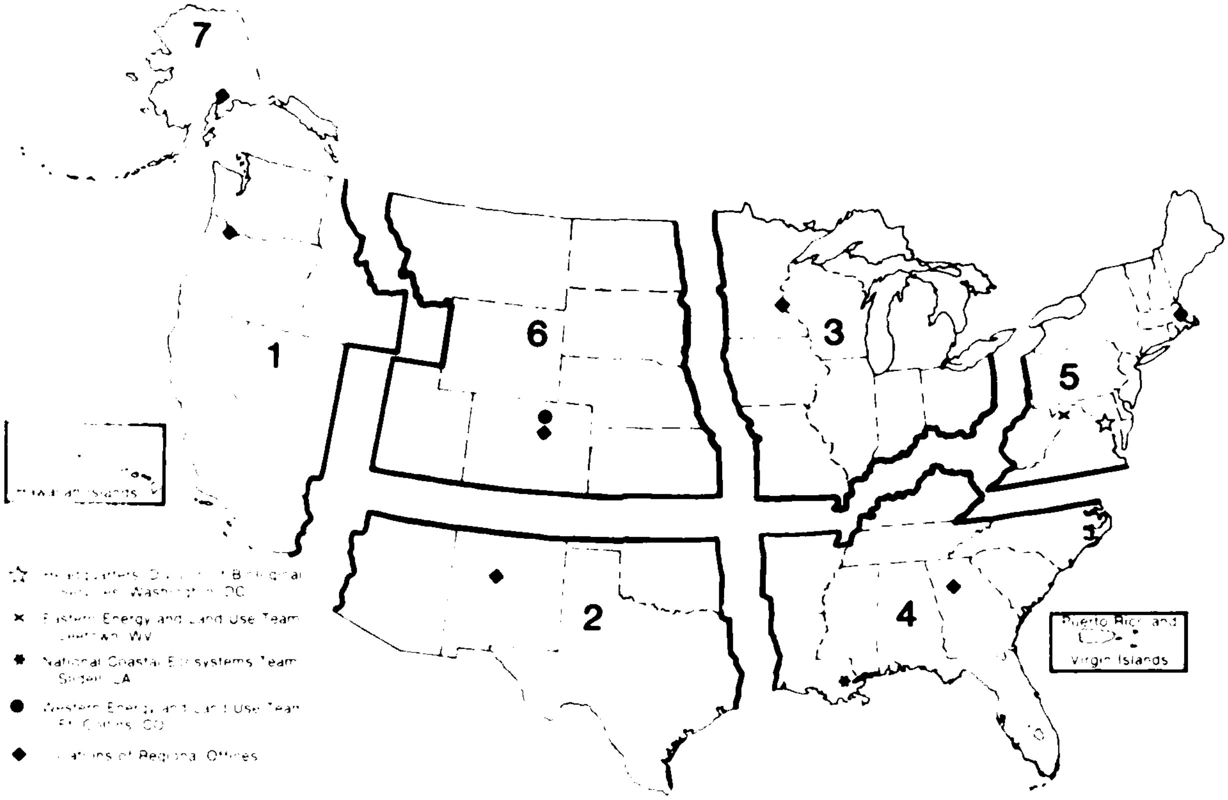

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