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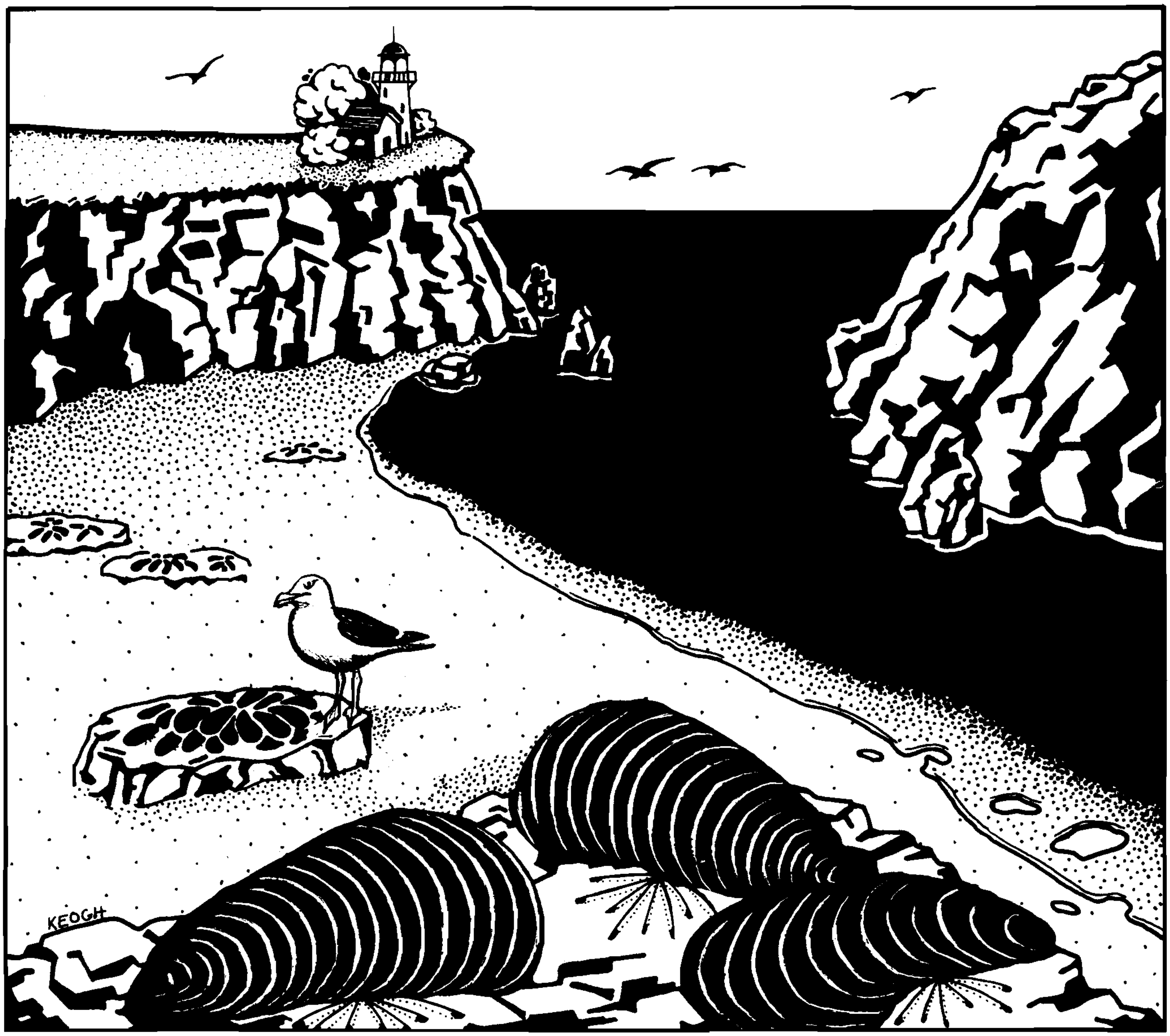

Fish and Wildlife Service
U.S. Department of the Interior

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 (North and Mid-Atlantic)

BLUE MUSSEL

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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 one of the following addresses.

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CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters (m)	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers (km)	0.5396	nautical 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 (m^3)	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons (t)	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (°C)	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
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
pounds (lb)	0.00045	metreic tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (°F)	0.5556 (°F-32)	Celsius degrees

CONTENTS

ACKNOWLEDGMENTS

The blue mussel, *Mytilus edulis*, is often considered to be the "white rat" of the marine invertebrate zoologist, due to its widespread distribution and the ease with which it can be collected and maintained in the laboratory. As a consequence it has been the subject of intense scientific investigation over the last two decades. This wealth of information has made my task of assembling this brief review of the biology of the blue mussel on the Atlantic coast of the United States particularly challenging. Therefore, within the text I have referenced the major reviews of various aspects of the biology of the blue mussel where interested readers can obtain more detailed information. In particular, I draw attention to the book *Marine Mussels*, edited by Bayne (1976a), which provides a comprehensive treatment of many aspects of the biology of *Mytilus edulis*.

I am grateful to Dr. Thomas J. Hilbish, Dr. Victor S. Kennedy, Mr. Carter Newell, and Dr. Ray J. Thompson for reviewing a draft of this manuscript. Debbie Kennedy drew the illustration of the blue mussel shell.

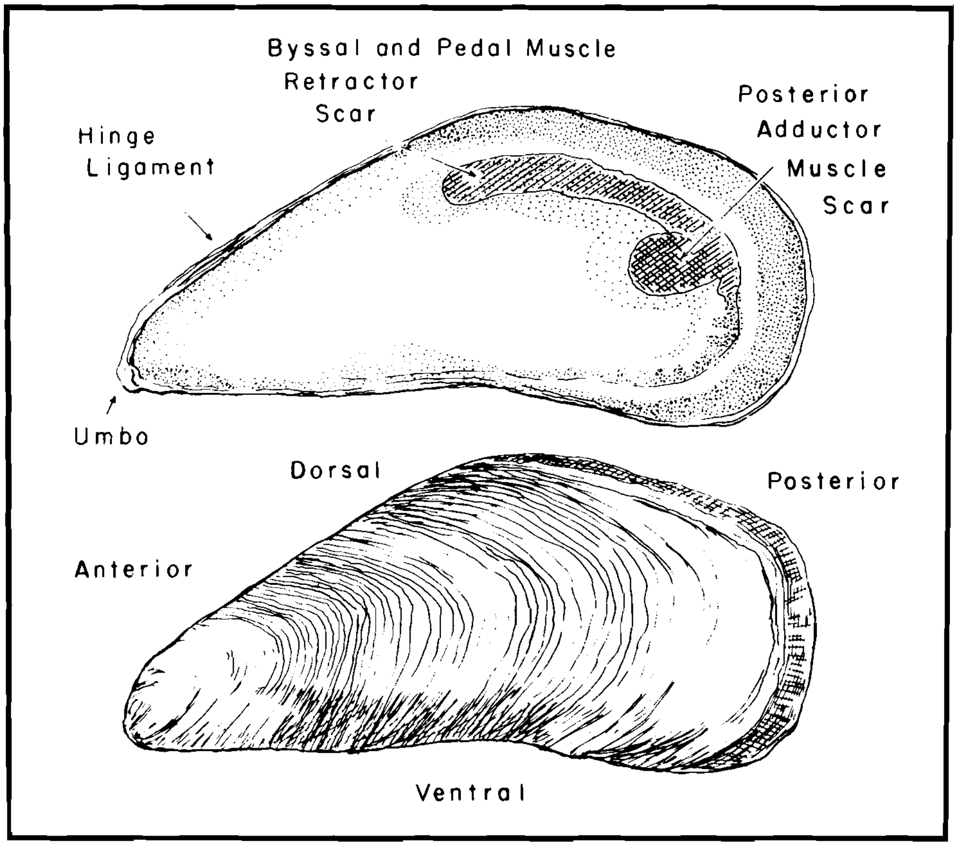

Figure 1. Internal and external characteristics of the blue mussel Mytilus edulis.

BLUE MUSSEL

NOMENCLATURE, TAXONOMY, AND RANGE

Scientific name.....Mytilus edulis Linne 1758 (Abbott 1975)
Preferred common name ....blue mussel (Figure 1)
Other common names...... mussel, sea mussel
Class ....Bivalvia (Pelecypoda)
Order.... .... Mytiloida
Family.................................Mytilidea

Geographic range: The blue mussel is a widely distributed boreo-temperate species occurring in the Arctic, North Pacific, and North Atlantic Oceans (Seed 1976). On the east coast of North America, its range extends from Labrador to Cape Hatteras, North Carolina (Wells and Gray 1960), and it is common throughout the North Atlantic and Mid-Atlantic Regions (Figures 2 and 3). It is most common in the littoral to sublittoral zones (<99 m) of oceanic and polyhaline to mesohaline estuarine environments; however, it has been found in deeper and cooler waters (100 to 499 m) that enable it to penetrate as far south as Charleston, South Carolina (Theroux and Wigley 1983).

MORPHOLOGY AND IDENTIFICATION

The shape of the blue mussel shell is roughly an elongate triangle; the longest dim-

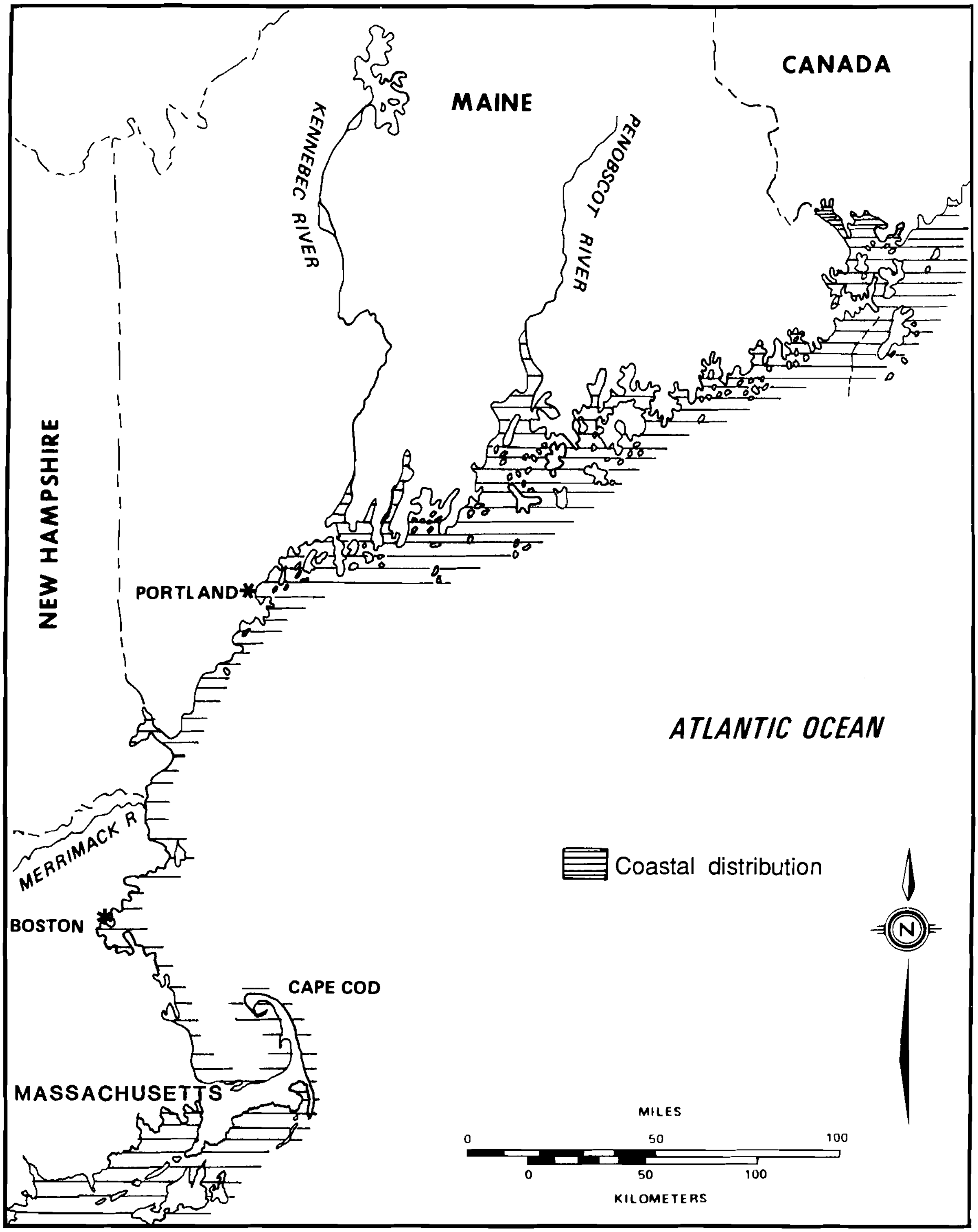

Figure 2. North Atlantic distribution of the blue mussel.

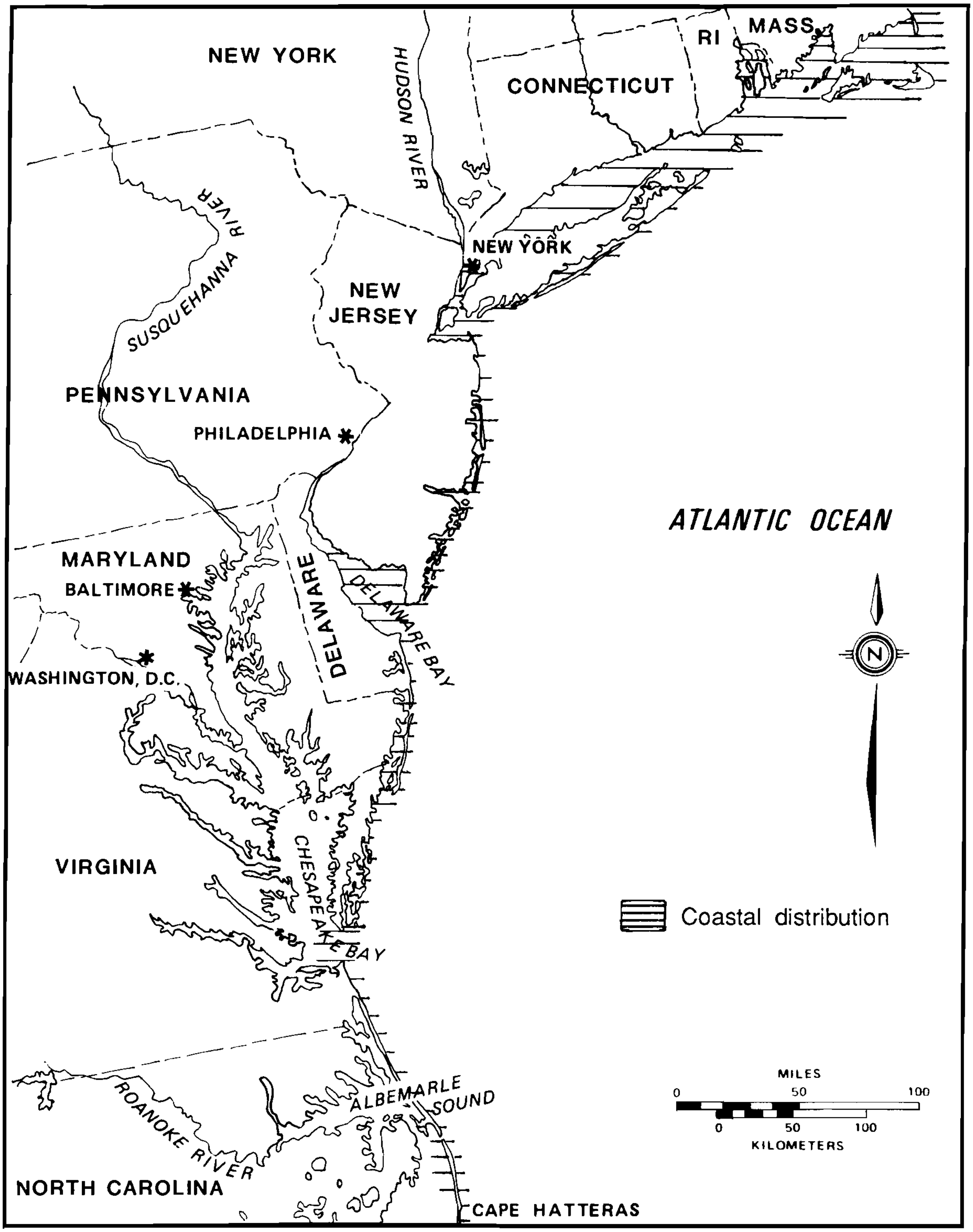

Figure 3. Mid-Atlantic distribution of the blue mussel.

ension (ca. 7-10 cm) is along an anterior-posterior axis from the narrow beaks of the umbo to the broad posterior shell margin (Figure 1). The shell has a sculpture of fine concentric lines and is dark blue to black in color. The entire outer surface of the shell is covered by a shiny proteinaceous membrane, the periostracum. As this protective periostracum becomes abraded, especially toward the umbo, the outer, colored, prismatic calcitic layer sometimes becomes eroded, exposing the white, inner, prismatic, aragonitic layer (Carter 1980). Within any blue mussel population, a few individuals have shells that are light brown or have stripes of different shades of brown. The interior of the shell has a border of dark blue to violet surrounding the pearly white nacreous layer.

Blue mussels are semi-sessile epibenthic bivalves that are anchored to a secure substrate, or attached to other mussels, with byssus threads secreted from glands in the animal's foot. When the valves are closed, the byssus threads pass through a small notch, the pedal gape, in the middle of the ventral junction of the two valves. The blue mussel can achieve a limited degree of movement by secreting new threads and adjusting the lengths of others. This mobility enables the animal to reposition itself in relation to water currents (Yonge 1976), to avoid getting smothered by accreting sediments (Seed 1976), and to move toward the outer edge of mussel clumps (Harger 1968).

The interior anatomy has distinctive characteristics. The posterior adductor muscle is much larger than the anterior adductor muscle. In empty shells, the scars of the posterior adductor muscle and retractor muscles (both posterior pedal and byssal [Yonge 1976]) are clearly visible (Figure 1). In the center of the visceral mass is the darkly pigmented foot, which can be extended to secrete a new byssus thread. The mantle, which extends from either side of the visceral mass, is attached to the entire periphery of both valves of the shell. New shell growth is initiated from the mantle margin (Wilbur and Saleuddin 1983). In two places posteriorly, the mantle is modified to form an inhalant and exhalent siphonal aperture to direct feeding currents into and out from the mantle cavity.

Blue mussel larvae can be identified on the basis of both their shell morphometrics and the position of the ligament (for review and photomicrographs, see Bayne 1976b). More positive larval identification can be obtained by scanning electron microscopic examination of the dentition on the hinge, which is distinctly different from that of other bivalve larvae (Lutz and Hidu 1979).

The only species within the North and Mid-Atlantic Region that can easily be mistaken for the blue mussel is the horse mussel, _Modiolus modiolus_. Unlike the blue mussel, the horse mussel has umbonal beaks, which are not at the apex of the shell but displaced to one side, and by its larger adult size (10-15 cm) and heavier and more eroded shell. Juvenile horse mussels can be distinguished from blue mussels by periostracal "hairs" on the posterior margin of the shell. The horse mussel is usually found in deeper oceanic water than the blue mussel and does not penetrate estuaries. The shells of other species of mussels, such as the ribbed mussel, _Geukensia demissa_, and the hooked mussel, _Brachidontus recurvus_, have numerous ridges radiating from the umbo towards the posterior shell margin that clearly distinguish them from the smooth shell of the blue mussel.

REASON FOR INCLUSION IN SERIES

The blue mussel is a common and often abundant species in the coastal waters of the North and Mid-Atlantic Regions, where it is an important prey item for many animals. Unfortunately, it is precisely these waters that are affected most by the increased urbanization of the Northeastern United States and the disposal of industrial wastes. In addition to its ecological importance, the blue mussel is currently the basis of a resurgent fishery based on wild stocks and a developing aquaculture industry throughout the North Atlantic Region.

LIFE HISTORY

Reproductive Physiology

The blue mussel is diecious, though rare instances of hermaphroditism have been reported (Seed 1976). Mussels generally produce gametes and are ready to spawn by the time they are one year old; however, when adverse environmental conditions (e.g., prolonged periods of exposure to air) cause a slow rate of growth, sexual maturity is sometimes not attained until the second year.

Although the gonad is situated within the visceral mass it extends during the reproductive period into the mantle, which also becomes swollen with gametes. Previtellogenesis (i.e. formation of oogonia and spermatogonia) occurs during the period from winter through early spring when food availability is generally low and feeding activity is further depressed by low water temperatures. Energy for gametogenesis during this period is supplied from nutrient reserves of glycogen, which are sequestered during the post-spawning period and stored in the vesicular cells specialized cells in the connective tissue of the mantle (reviewed by Gabbott 1983). The blue mussel sequesters a separate nutrient reserve in the digestive gland to supply the energy that sustains metabolic energy demands during the period of reduced food intake in the winter. Vitellogenesis, the final stage of gametogenesis when the spermatocytes and oocytes are formed, usually occurs over a comparatively short period of a few weeks in the late spring, during which the nucleus enlarges and lipids are synthesized and stored in the egg yolk (for review see Sastry 1979). Energy for vitellogenesis is supplied from the remaining glycogen reserves, from lipid reserves stored in adipogranular cells in the mantle, and from freshly ingested food material (Gabbott 1983). The ripe gametes are then ready to be spawned; if their release is delayed, they degenerate and are resorbed by hemocytes.

Gametogenesis, spawning, and nutrient storage are linked in an integral process termed the reproductive cycle. This cycle in any blue mussel population is the result of a complex balance between exogenous factors such as food availability, temperature, salinity, and duration of exposure to air and endogenous factors such as nutrient reserves, hormonal cycle, and genotype (Seed 1976; Sastry 1979). Interaction between these factors ensures the synchrony of gamete development within the population. Such synchrony is essential for an oviparous species and ensures that larvae are in the water at the optimum time for their growth and survival (Sastry 1979).

The timing of the various components of the reproductive cycle differs greatly between various blue mussel populations within the North Atlantic and Mid-Atlantic Regions (Figure 4: Newell et al. 1982). Newell et al. (1982) concluded that latitude and water temperature were not as important as food availability in governing the reproductive cycle of the blue mussel along the east coast of the United States. Thus, it is impossible to predict the timing of the reproductive cycle for any particular population. For environments in which variations in physical factors are not large -- especially those that influence patterns of phytoplankton production - it is likely that the reproductive cycle for the blue mussel is probably rather constant from year to year (Newell et al. 1982). In habitats where annual variations in environmental factors are large, such as in estuaries with annually variable freshwater inputs and year to year variations in water temperature, the reproductive cycle of <u>Mytilus edulis</u> can be expected to vary (Thompson 1979,1984a; Lowe et al. 1982).

Spawning

When sperm and eggs are fully ripe they are released from the follicles in each gonad into a series of genital canals that gradually combine into a common gonoduct that opens on the genital papilla (Bayne 1976b). Eggs and sperm are liberated via the exhalent siphon directly into the water column, where fertilization occurs. About 10,000 spermatozoa are shed for each ovum spawned (Thompson 1979).

The exact factors that stimulate the first mussels within a population to spawn are unknown. However, a prerequisite is the presence of fully-ripe gametes that are ready to be liberated. If the gametes are ripe, spawning may be stimulated by a slight increase in water temperature or change in salinity, mechanical disturbance as a result of wave action, desiccation, or even high concentrations of phytoplankton in the water (Seed 1976). Males generally start to spawn

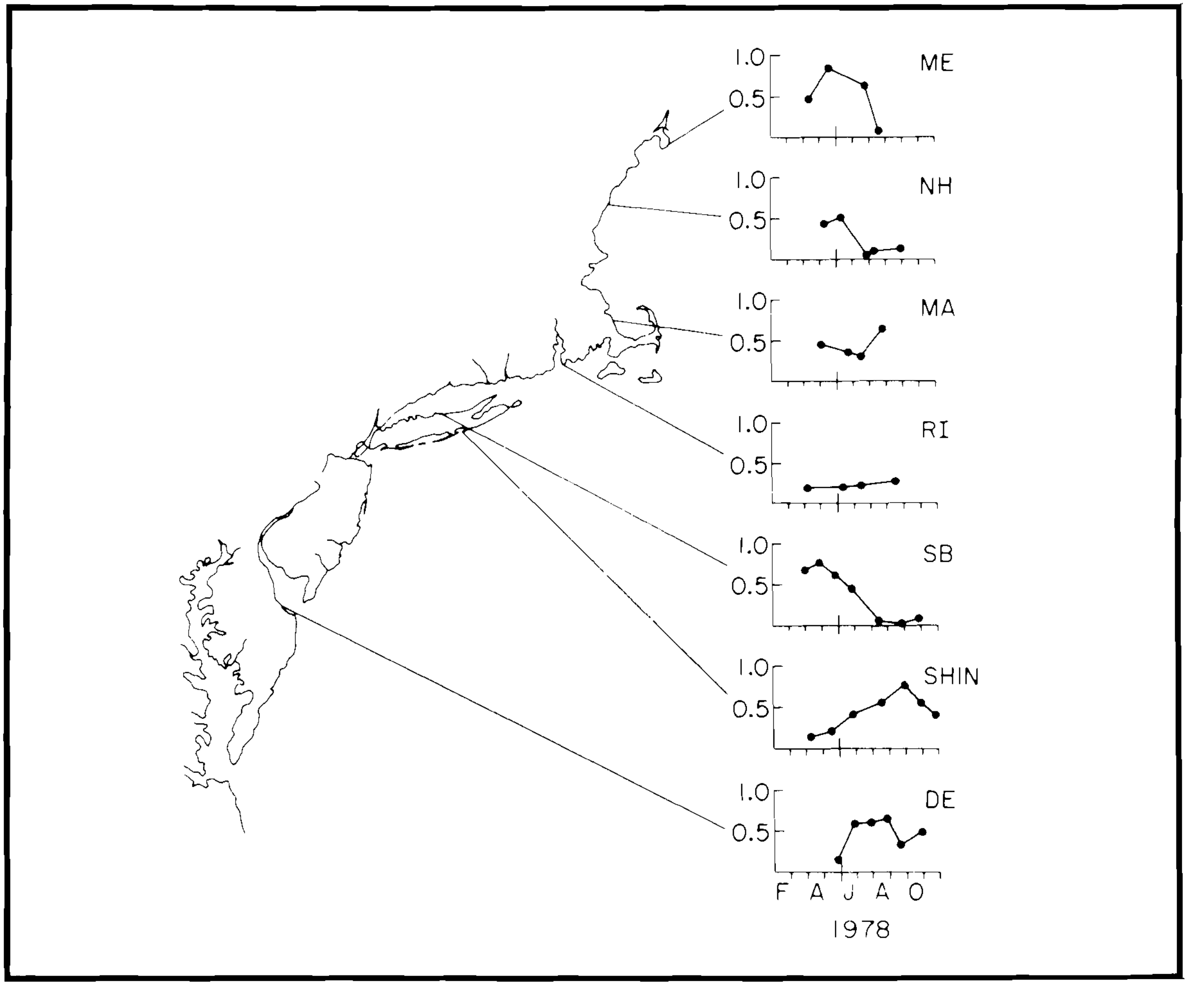

Figure 4. Mean reproductive condition of male and female blue mussels through the breeding season, measured at times designated by solid circles, from seven sites on the east coast of the United States. The reproductive condition varies between 1.0 for a fully ripe mussel and 0.0 for one with no discernible gametes. ME = Damariscotta River, Maine; NH = Newcastle, New Hampshire; MA = Cape Cod Canal, Massachusetts; RI = Narragansett Bay, Rhode Island; SB = Stony Brook, New York; SHIN = Shinnecock, New York; DE = Broadkill Inlet, Delaware (from Newell et al. 1982).

first; the presence of sperm in the water then stimulates the females to cease filtering (Newell and Thompson 1984) and start spawning. This synchronous spawning ensures that the sperm and eggs are in the water column concurrently.

At some localities, a particular set of environmental conditions enables the blue mussel to repeatedly spawn (Lowe et al. 1982; Newell et al. 1982; Rodhouse et al. 1984). Such spawnings may take the form of mass spawnings in which an individual mussel liberates most of its gametes over a short period. Such spawning is followed by a refractory period, during which further oocytes and spermatocytes are developed for the next spawning. In other situations, no large numbers of gametes in any one mussel ripen simultaneously; instead, gametes are continually ripening and are liberated in a "dribble" spawn.