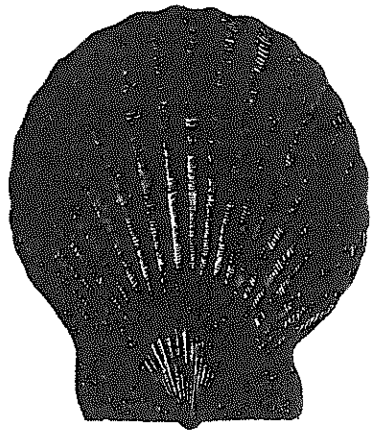
Argopecten irradians
Adult



2 cm

(from Goode 1884)

Common Name: bay scallop
Scientific Name: *Argopecten irradians*
Other Common Names: Atlantic bay scallop, *peigne baie de l'Atlantique* (French), *peine caletero atlántico* (Spanish) (Fischer 1978).
Classification (Turgeon et al. 1988)

Phylum:	Mollusca
Class:	Bivalvia
Order:	Ostreoida
Family:	Pectinidae

Value

Commercial: Bay scallops are harvested commercially by dredging, dip netting, raking, and hand picking (Peters 1978). Reported U.S. 1992 bay scallop landings were161.5 metric tons (mt), with a dollar value of $2.1 million (NMFS 1993). This an important commercial species along the U.S. Atlantic coast, with fisheries in Massachusetts, Rhode Island, New York, North Carolina, and the Gulf coast of Florida (Heffernan et al. 1988, MacKenzie 1989, Rhodes 1991). Landings for 1992 totaled 58.5 mt in the Gulf of Mexico (Newlin 1993). However, the commercial scallop fishery in Florida has been closed since 1995 (Arnold pers. comm.). There is no apparent commercial fishery for this species in the remaining Gulf coastal states because of their relatively low abundance, but their high value and the available market has sparked considerable interest in maricultural production (Hall 1984, Rhodes 1991). There are few commercial scallop mariculture ventures currently in operation, but hatchery technology is well developed and research is in progress (Hall 1984, Crenshaw et al. 1991, Rhodes 1991, Walker et al. 1991).

Recreational: Bay scallops are sometimes collected by hand picking while wading in seagrass beds. In Florida waters of the Gulf of México, recreational harvest is common from Steinhatchee north and west to Panama City (Arnold pers. comm.). However, recreational harvest elsewhere in the Gulf of Mexico is not especially common because of the bay scallop's relatively low abundance. In Florida, the recreational seasons extends from July 1 to September 10, from Suwannee River southward (Arnold pers. comm.). The bag limit is two gallons of whole bay scallops in the shell, or one pint of meat, per day per person, or ten gallons of whole scallops per day per boat (Arnold pers. comm.). In Texas, they may be taken year-round in waters approved by the Texas Department of Health.

Indicator of Environmental Stress: Filter feeders such as bay scallops often ingest and accumulate resuspended detritus and organic matter from polluted areas. This species has been used to test the effects of pollutants from the petroleum industry (Hamilton et al. 1981). Mortality of juvenile bay scallops has been demonstrated in the laboratory in the presence of heavy metals (Nelson et al. 1976).

Ecological: The bay scallop is an important part of the estuarine food web through its conversion of phytoplankton and detritus into available biomass for second order consumers.

Range

Overall: The range of this species extends along the western Atlantic from Cape Cod into the Gulf of Mexico, and down to Colombia (Turner and Hanks 1960, Sastry 1962, Fischer 1978, Peters 1978, Robert 1978, Fay et al. 1983). Areas of abundance as determined from

Table 5.01. Relative abundance of bay scallop in 31 Gulf of Mexico estuaries (from *Volume I*).

Estuary	A	S	J	L	E
Florida Bay	√	√	√	√	√
Ten Thousand Islands	√	√	√	√	√
Caloosahatchee River	√	√	√	√	√
Charlotte Harbor	√	√	√	√	√
Tampa Bay	√	√	√	√	√
Suwannee River					
Apalachee Bay	O	O	O	O	O
Apalachicola Bay	√	√	√	√	√
St. Andrew Bay	O	O	O	O	O
Choctawhatchee Bay					
Pensacola Bay	√	√	√	√	√
Perdido Bay					
Mobile Bay					
Mississippi Sound	O	O	O	O	O
Lake Borgne					
Lake Pontchartrain					
Breton/Chandeleur Sounds	√	√	√	√	√
Mississippi River					
Barataria Bay					
Terrebonne/Timbalier Bays					
Atchafalaya/Vermilion Bays					
Calcasieu Lake					
Sabine Lake					
Galveston Bay	√	√	√	√	√
Brazos River					
Matagorda Bay	√	√	√	√	√
San Antonio Bay	√	√	√	√	√
Aransas Bay	√	√	√	√	√
Corpus Christi Bay	√	√	√	√	√
Laguna Madre	√	√	√	√	√
Baffin Bay					

Life stage: A S J L E

Relative abundance:
- ● Highly abundant
- ◉ Abundant
- O Common
- √ Rare
- blank Not present

Life stage:
- A - Adults
- S - Spawning adults
- J - Juveniles
- L - Larvae
- E - Eggs

commercial landings are coastal areas of Massachusetts, Rhode Island, New York, North Carolina, and the gulf coast of Florida (Heffernan et al. 1988, Rhodes 1991).

In the United States, *Argopecten irradians* is considered to include three subspecies: *A. i. irradians*, ranging from Cape Cod to New Jersey; *A. i. concentricus*, New Jersey to the Chandeleur Islands, east of the Mississippi River; and *A. i. amplicostatus*, Galveston Bay to Tuxapan, Veracruz, Mexico (Andrews 1981, Fay et al. 1983).

Within Study Area: Along the Florida Gulf coast, bay scallops are most abundant from Pepperfish Keys, south of Steinhatchee, north and westward to St. Andrew Bay (Arnold pers. comm.). Populations are scattered in the northwestern Gulf, but become more common in the western Gulf. In Texas, the bay scallop is most abundant in bays of the southern coast where the salinities are generally higher and seagrass meadows are extensive. The subspecies *Argopecten irradians concentricus* ranges from Key West, Florida to the Chandeleur Islands of Louisiana (Broom 1976). *Argopecten irradians amplicostatus* ranges from Galveston, Texas to the Laguna Madre (Broom 1976, Andrews 1981) (Table 5.01).

Life Mode

Fertilized eggs are demersal (Belding 1910). Early larval stages are pelagic and planktonic. Late larval stages are epibenthic. Juveniles up to 20-30 mm in length attach to a surface suspended off the bottom by byssal threads (Sastry 1965). Adults and juveniles >30 mm in length are epibenthic, sometimes motile, and gregarious (Belding 1910, Gutsell 1930, Marshall 1947, Sastry 1962, Robert 1978, Peters 1978, Fonseca et al. 1984).

Habitat

Type: All life stages are estuarine, and marine in nearshore waters, occurring in high salinity (euhaline to polyhaline) waters. Bay scallops are typically subtidal, but may be exposed during especially low tides (Rhodes 1991). Collections have been recorded at depths from 0 to 10 m and a maximum of 18 m. They are most abundant in waters from 0.3 to 0.6 m at low tide (Marshall 1960, Sastry 1962, Thayer and Stuart 1974, Peters 1978, Robert 1978, Fay et al. 1983, Fonseca et al. 1984). Larvae inhabit the water column while searching for a settlement site (Sastry 1965). At settlement the young scallop attaches epifaunally to a surface suspended off the bottom (rock, seagrass, algae, rope) by means of byssal threads (Belding 1910). At 20 to 30 mm in length the juvenile scallop settles to the bottom, beginning a demersal existence that continues through the adult stage (Castagna 1975).

Substrate: Late larval/early juvenile stages use various substrates for attachment, including oyster shells, rope, algae, seagrass, and submerged macrophytes (Gutsell 1930, Marshall 1947, Marshall 1960, Thayer and Stuart 1974, Fay et al. 1983). Seagrasses, such as eel grass (*Zostera marina*) and shoal grass (*Halodule wrightii*), appear to be the preferred settling site given the abundance that is often associated with seagrass habitats (Belding 1910, Gutsell 1930, Sastry 1962, Thayer and Stuart 1974, Castiglione pers. comm.). However, if seagrass density is too great, current velocity is reduced and bay scallop abundance may decline (MacKenzie 1989). Scallops can settle and survive in areas lacking seagrass (Marshall 1947, Marshall 1960), but individuals <10 mm generally cannot tolerate silty substrates (Castagna 1975), and burial can occur in muddy substrates (Tettelbach et al. 1990). Smith et al. (1988) have demonstrated that transplanted seagrass does not serve as a highest quality habitat, due to greater losses from predation and/or transport as compared to a natural seagrass site.

Physical/Chemical Characteristics:
Temperature: Eggs and larvae are stenothermal, with 15 to 20°C required for early development. Optimal embryonic development occurs from 20 to 25° and best larval growth from 25 to 30°C (Tettlebach and Rhodes 1981). Wright et al. (1983, 1984) found larvae subjected to temperatures below the spawning temperature experienced a cold-shock which resulted in higher mortalities. Juveniles and adults are eurythermal, and Connecticut bay scallops are reportedly able to tolerate temperatures as low as -6.6°C for short periods (Marshall 1960). Throughout their range they occur in areas where summer maximum water temperatures do not exceed 32°C (Sastry 1965, Barber and Blake 1983).

Salinity: Eggs and larval stages are generally found in polyhaline salinities (18 to 30‰), and egg and larval development are most successful within that range. In laboratory studies, normal embryo development occurs over a narrow range of salinities. Egg development was successful at 25‰, but no embryo development occurred at 10 or 15‰ (Castagna 1975, Tettlebach and Rhodes 1981). Larvae develop at salinities from 20 to 35‰ with optimal development at 25‰ (Tettlebach and Rhodes 1981), and are not found below 22‰. Although they tend to occur in higher estuarine salinities (15-30‰), juveniles and adults are considered euryhaline and can tolerate moderate salinities. However, symptoms of stress appear when salinities drop below 16‰ (Sastry 1966, Duggan 1973). The minimum salinity determining overall distributions is approximately 14‰ (Belding 1910, Gutsell 1930). Laboratory experiments examining the influence of reduced salinities on scallop behavior indicated that at salinities of 16‰ and temperatures of 10° to 15°C the animals became inactive, and at 20° to 25°C reduced activity occurred at 22‰ and 18‰ (Duggan 1973). Mortality of scallops has been demonstrated in the laboratory at salinities of 10‰ and less over a range of temperatures (Mercaldo and Rhodes 1982).

Dissolved Oxygen: Oxygen resting requirements of 70 ml/kg/hour at 20° have been reported (Van Dam 1954). Critical dissolved oxygen (DO) concentrations for this species may be related to individual size and ambient water temperature (Voyer 1992).

Other: Turbidities greater than 500 ppm may interfere with normal growth and reproduction (Fay et al. 1983). Water currents can displace scallops from their "home" habitat, and current velocity can have effects on growth related to food availability (Moore and Marshall 1967, Kirby-Smith 1972, Rhodes 1991). An optimal amount of current is necessary to maintain high concentrations of suspended food and remove waste materials rapidly (Kirby-Smith 1972).

Movements and Migrations: Egg and early larval stages may be transported by tidal currents. Late larval stages are capable of swimming by use of the ciliated velum and crawling with the foot (Gutsell 1930, Sastry 1965, Hall 1984). Juvenile and adult scallops are capable of swimming via propulsion created by the clapping of the two valves (Belding 1910, Gutsell 1930, Moore and Marshall 1967). This ability apparently serves to maintain position in grassbeds and avoid competitors and predators (Peterson et al. 1982, Winter and Hamilton 1985). The extent of late juvenile and adult movements is unclear. There are, however, some reports of scallops migrating in mass (Roessler and Tabb 1974).

Reproduction

Mode: Bay scallops are hermaphroditic, usually protandrous (Peters 1978), and semelparous (Bricelj et al. 1987). Fertilization is external, in the water column or on the bottom. Male gametes are generally (but not always) released before female gametes, reducing the chance of self-fertilization (Belding 1910, Gutsell 1930, Loosanoff and Davis 1963, Hall 1984).

Spawning: Spawning is influenced by temperature, photoperiod, salinity and food abundance (Sastry 1975). It occurs in estuaries and in nearshore areas at various times throughout the range. In the New England area, spawning is triggered by increasing temperatures (Belding 1910, Cooper and Marshall 1963, Taylor and Capuzzo 1983), while spawning south from North Carolina is triggered by decreasing temperatures (Barber and Blake 1983). In Florida, spawning begins with the decline in summer temperatures, August to October (Sastry 1962, Barber and Blake 1983). Scallops can be conditioned in the laboratory to spawn out of season by raising the temperature to 30°C followed by gradual cooling to 28-26°C (Castagna and Duggan 1971, Castagna 1975). Gametogenesis is triggered by food and temperature (Sastry 1975, Hall 1984). With adequate food supplies, a minimum temperature of 15-20°C is necessary for its initiation (Sastry 1968, Sastry and Blake 1971), with slightly higher temperatures required for complete maturation of gametes and spawning (Sastry 1966, Sastry 1968). As the gonads mature, nutrients stored during the nonreproductive period are diverted to their development (Sastry 1975). Few studies have investigated salinity as a factor in spawning.

<u>Fecundity</u>: Kraeuter et al. (1982) reported a fecundity estimate of 100,000 to 1,000,000 eggs per female. Bricelj et al. (1987) reported fecundities ten to twenty times greater. Some scallops may survive to spawn a second time, but most do not (Robert 1978).

Growth and Development

<u>Egg Size and Embryonic Development</u>: The unfertilized mature oocyte is 62-63 μm in diameter (Sastry 1965, Sastry 1966). After fertilization, the first polar body occurs in 35 minutes with the second cleavage stage occurring in 105 minutes. By 5 hours and 15 minutes the blastula has formed and rapidly develops to the ciliated gastrula stage by 9 to 10 hours and reaches the trochophore stage by about 24 hours (Gutsell 1930, Sastry 1965).

<u>Age and Size of Larvae</u>: Larval development in bay scallops proceeds rapidly. The transition from trochophore to straight-hinged larval stage occurs in about 24 hours (Gutsell 1930, Sastry 1965, Rhodes 1991). In laboratory studies at 24° C the veliger (shelled) larval stage develops within 48 hours at a size of approximately 101 μm (Sastry 1965). By the tenth day of the veliger phase, the pediveliger begins to develop and is complete by day 12, beginning the settlement process at a size of approximately 184 μm (Sastry 1965, Castagna and Duggan 1971, Hall 1984). Attachment with byssal threads occurs between the 10th and 19th day of the veliger stage with the development of the prodissoconch (≈190 μm) and metamorphosis into the juvenile stage commences. The juvenile stage is reached about 29 days from fertilization when larval development is complete (Sastry 1965). Loosanoff and Davis (1963) reported larval growth rate to be greater than 10 μm/day.

<u>Juvenile Size Range</u>: By day 35 the young scallop resembles the adult and is approximately 1.175 mm in length (Sastry 1965). Juveniles remain attached by byssal threads until 20-30 mm in size, but retain the ability to attach throughout their lives (Hall 1984, Garcia-Esquivel and Bricelj 1993). Growth is dependent on temperature and food availability (Sastry 1965). Growth rates are rapid during the warm months, and a marketable size of 50 mm is reportedly reached within 12 to 13 months on the U.S. east coast (Castagna and Duggan 1971, Spitsbergen 1979, Rhodes 1991), or within 6 to 8 months in Florida (Arnold pers. comm.). Little growth occurs during winter, especially in the northern part of the bay scallop's range. When growth resumes in the spring, a raised shell check or color change occurs in the shells of these individuals. Growth rates of 3.8 to 8.0 mm/month (umbo to ventral margin) have been determined. Optimal growth occurs in currents <1cm/s and no growth occurs in currents >12 cm/second (Kirby-Smith 1972).

<u>Age and Size of Adults</u>: Maturity is reached by the end of the first year, and is a function of age and not size (Gutsell 1930, Sastry 1963). Adult sizes range from 60 to 70 mm with a reported maximum of 90 mm. Life expectancy is 12-30 months, and is usually less than two years (Belding 1910, Gutsell 1930, Robert 1978).

Food and Feeding

<u>Trophic Mode</u>: The bay scallop filter feeds at all development stages (Castagna 1975). Veliger feed by means of cilia on their velum (Hall 1984). Chipman (1954) determined that young scallops filter at a rate of 3 l/hour, which increases as they grow reaching an average of 15 l/hour, and a maximum of 25.4 l/hour. Intensity of feeding increases with temperature.

<u>Food Items</u>: The bay scallop feeds primarily on phytoplankton, but it also consumes zooplankton, suspended benthic particles, bacteria, detritus, organic matter, gametes from other species and algae spores. In the laboratory larvae grow and develop well on a diet of unicellular algae and naked dinoflagellates (Castagna 1975), although some algal species have low nutritive value and can result in poor growth and survival (Nelson and Siddall 1988). Juveniles and adults ingest phytoplankton and detritus as well as benthic diatoms (Gutsell 1930, Davis and Marshall 1961, Broom 1976, Fay et al. 1983), but what is actually assimilated has not been determined.

Biological Interactions

<u>Predation</u>: Known and suspected predators of the bay scallop include various gulls and wading birds, starfish, cow-nosed rays, pinfish, boxfish, toadfish, whelks, and various crabs (Thayer and Stuart 1974, Broom 1976, Peterson et al. 1989, Prescott 1990). Scallops in intertidal and/or bare bottom areas appear to be more vulnerable to predation than individuals in seagrass beds or covered by 1-3 cm of water or more (Peterson

et al. 1989, Prescott 1990).

Factors Influencing Populations: A probable limiting factor for distribution in the southern range of the bay scallop is its increased metabolic rate in this area associated with the higher temperatures of this region and a decreased food supply that causes a net loss of available energy for reproduction (Barber and Blake 1983). Excessive turbidities and current velocities can inhibit growth and reproduction (Kirby-Smith 1972, Fay et al 1983). Bay scallops living on soft mud substrate are subject to burial during events that increase current velocity (Tettelbach et al. 1990). Seagrass provides a substrate for attachment by bay scallop larvae, and the abundance of this species is influenced by its presence (Thayer and Stuary 1974, MacKenzie 1989). Destruction of seagrass areas results in decreased abundance of this species. Smith et al. (1988) have demonstrated that transplanted seagrass does not serve as a quality habitat with apparently greater loss due to predation and/or transport in the transplanted seagrass as compared to the natural seagrass. Blooms of red tide algae in sufficient concentrations can result in conditions toxic to adult and larval bay scallops (Summerson and Peterson 1990). Nuisance blooms of algae can affect bay scallops by altering feeding rates. These species are often low in nutritive value causing poor recruitment and settlement of the bay scallop due to the algae's inability to suport adequate larval growth (Nelson and Siddal 1988, Summerson and Peterson 1990). Population sizes are subject to a large degree of variation within the year because of the bay scallop's short life span and semelparous reproductive cycle (Fay et al. 1983, Nelson and Siddall 1988, MacKenzie 1989). Bay scallops generally spawn only once during their lives when they reach the end of their first year. Although two year old animals occur rarely, populations are almost entirely composed of only one year class, upon which the following year class is completely dependent. Unfavorable conditions that result in poor larval recruitment in any given year may therefore lower abundance the following year. Low DO episodes may have long-term population effects due to the bay scallops semelparous reproductive cycle as well as effecting short-term mortality (Voyer 1992). Predation by visually oriented carnivores may be exerting selection pressures on populations of bay scallops resulting in shell color polymorphism (Elek and Adamkewicz 1990). Known parasites include the pea crab, *Pinnotheres maculatus* (Kruczynski 1972). Bay scallops parasitized by this organism display stunted growth rates and reduced weights. Another parasite is the polychaete *Polydora* which can penetrate bay scallop shells and sometimes produce blisters on the interior shell surfaces (Rhodes 1991).

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