CHAPTER 5: SPOT

Populated with text from the Omnibus Amendment to the ISFMP for Spanish Mackerel, Spot, and Spotted Seatrout (ASFMC 2012)

Section I. General Description of Habitat

Spot are found in estuaries and coastal areas from the Gulf of Maine to the Bay of Campeche, Mexico, and are concentrated between the Chesapeake Bay and South Carolina (Phillips et al. 1989). Juvenile spot prefer shallow water areas, less than 8 m, over fine sediment and in tidal marshes (Phillips et al. 1989; Strickney and Cuenco 1982; Chesapeake Bay Program 1991). Juvenile spot are found in salinities ranging from 0–30 ppt and water temperatures from 5–30°C (Stickney and Cuenco 1982; Phillips et al. 1989, ASMFC 1987), and therefore are found from polyhaline to freshwater nursery areas. Adult spot are more abundant in coastal waters and lower estuaries whereas juveniles are abundant in lower salinity areas.

Part A. Spawning Habitat

Data indicate that spot spawn further offshore and in deeper waters than other sciaenids. Spot typically migrate offshore and spawn in the relatively deep water of the outer continental shelf, though some evidently spawn in both nearshore waters and estuaries (Dawson 1958; Lewis and Judy 1983). Ripe adults aggregate off beaches in the fall and start migrating offshore to more southern waters (Pearson 1932). Spot may spawn repeatedly over several weeks (Hildebrand and Cable 1930), with some individuals remaining offshore after spawning (Pearson 1932; Wenner et al. 1979, 1980). Fall migrations of maturing spot to offshore waters were reported from Chesapeake Bay (Hildebrand and Schroeder 1928), North Carolina (Roelofs 1951), and South Carolina estuaries (Dawson 1958). Ripe spot were collected in depths up to 82 m off South Carolina (Dawson 1958) and 12.8–16.1 km off the Georgia coast (Hoese 1973). Smith (1907) stated that in North Carolina spot spawn in the sounds and inlets and Hildebrand and Cable (1930) suggested that spawning occurred in close proximity to passes off North Carolina; however, no evidence was offered to support these statements. Larval distributions of spot also indicate that spawning occurs more heavily offshore (26–128 m) than inshore (14.6–20.1 m; Lewis and Judy 1983; Warlen and Chester 1985).

Geographic and Temporal Patterns of Migration

By the fall, spot either remain in estuaries another year (after year 1) or migrate offshore. For those that remain nearshore, some adults may spawn on the inner continental shelf during the late fall, if water temperatures remain warm enough. For those that migrate to the outer continental shelf, spawning will occur if temperatures are suitable for spawning and egg development (17.5–25°C) (Hettler and Powell 1981). Compared to other sciaenids, spawning spot are further offshore and in deeper waters. Ripe spot have been collected in depths up to 82 m off South Carolina (Dawson 1958) and shallower waters 8–10 mi off the Georgia coast (Hoese 1973). It is unknown what proportion of spent adults return inshore, or any other habits or behaviors they exhibit (other than the assumption that some proportion return to nearshore or estuarine waters).

Salinity

There is no evidence that spawning individuals experience anything less than full seawater based on their offshore location.

Excerpted from Atlantic Sciaenid Habitats: A Review of Utilization, Threats, and Recommendations for Conservation, Management, and Research

Substrate
While the behaviors of juvenile and adult spot likely center on feeding, and thus substrate, it is unknown to what degree substrate influences spawning individuals. Based on the time of year and the offshore habitats required for spawning, it is unlikely that substrate plays a prominent role in spot behavior. Additionally, spot eggs are pelagic and positively buoyant, so substrates likely does not influence their distribution.

Temperature
Temperature may be the strongest driver of spawning spot behavior. Maturing individuals move offshore in the fall, and if capable (probably based on size) spawn in the late fall if water temperatures are still >17.5°C (Hettler and Powell 1981). If these two conditions are not met, which is likely true for most of the population, mature spot continue their migration offshore to the outer continental shelf habitats where higher winter temperatures can be found.

Dissolved Oxygen
Spawning adults likely experience normoxic conditions (>4.0 mg L^{-1} DO) offshore, and thus DO is not a limiting factor or strong influence on behavior.

Feeding Behavior
Spawning adult feeding behaviors are likely a continuation of adult feeding, which takes place in the substrate feeding on epifauna and benthic infauna (Chao and Musick 1977); however, it is unknown how much time or effort spawning individuals spend on feeding.

Competition and Predation
Because food and space are unlikely limited, environmental constraints (e.g., temperature) are probably greater factors than competition and predation. Offshore predation of spot is not well documented, but thought to be a continuation of the predation seen in lower estuary and nearshore habitats (e.g., sharks, sciaenids, flounders).

Part B. Egg Habitat

Geographic and Temporal Patterns of Migration
Offshore of the U.S. southeast Atlantic coast, spot eggs are spawned during the winter months, but spawning often extends from late fall to early spring (Flores-Coto and Warlen 1993). Exact locations of spawning are not documented, though based on spawning temperature requirements of 17.5–25°C (Hettler and Powell 1981), eggs may be spawned in the inner continental shelf early in the spawning season before temperatures decrease. It is likely, however, that the majority of spot eggs are spawned after the fall on the outer continental shelf as this is the only offshore location supporting temperatures high enough for spawning (Warlen and Chester 1985). Detailed descriptions of the egg (and larval) inshore advection processes remain an active field of study, although the positively buoyant eggs are likely moved toward the coast by a combination of wind and warm water eddies, such as those from the Gulf Stream. For example, Govoni et al. (2013) found that spot larvae in warm water cyclonic eddies that both advance development (with warm water temperatures) and enhanced feeding opportunities for late larvae (supported by increased primary productivity).

Salinity
Because the egg stage of spot occurs entirely offshore, full seawater (approximately 35 ppt) is likely necessary for proper development and transport of eggs, though no studies have explicitly reported any tolerances or thresholds.

Substrate
Because the egg stage of spot occurs entirely offshore and the eggs are positively buoyant, substrate is not considered a critical aspect of spot egg habitat.

Temperature
Spawning adults and larvae (≤15 d old) are have relatively high temperature requirements (17.5–25°C) (Hettler and Powell 1981; Warlen and Chester 1985), which suggests that spot egg temperature requirements are also between 17.5–25°C. Spot eggs hatched within 48 h under laboratory conditions at 20°C, which is likely a realistic temperature based on empirical data (Powell and Gordy 1980).

Dissolved Oxygen
Because the egg stage of spot occurs entirely offshore, eggs are likely only ever exposed to normoxic waters (5–8 mg L^{-1}). It is not currently thought that DO is a limiting factor to survival of spot eggs.

Feeding Behavior
Spot eggs subsist entirely off the yolk sac prior to hatch.

Competition and Predation
Spot eggs likely do not enter into any meaningful ecological competition, as their habitat demands are basic (temperature, salinity, and oxygen requirements largely met by the offshore conditions). Predation of eggs undoubtedly occurs but has not been well studied or reported. Although potentially large numbers of eggs are killed from predation, there is no reason to think that pelagic oceanic predators are targeting spot eggs over other, similar pelagic eggs.

Part C. Larval Habitat

Geographic and Migration Patterns
Powell and Gordy (1980) report that the yolk sac and oil globule were absorbed within 5 d of hatch, in a laboratory setting at 20°C. Newly hatched larvae are likely still close to offshore spawning locations, which have been suggested to be up to or beyond 90 km offshore (Flores-Coto and Warlen 1993). Larvae cover (through a combination of passive and active migration or transport) perhaps the largest geographic distance of any life stage of spot, with the possible exception of adults migrating for spawning. As with the egg stage, larvae depend on wind and currents (e.g., warm water eddies) for transportation and complete their development over the continental shelf waters during the winter (Able and Fahay 2010). In the winter and through early spring, larval spot ingress into estuarine habitats and settle into upper regions of an estuary (Ribeiro et al. 2015).

Salinity
Corresponding with the range of habitats seen by larvae, a range of salinities is also experienced. Beginning offshore, full seawater (approximately 35 ppt) dominates until larvae enter coastal estuaries,

where salinities likely vary considerably. It is unknown what proportion of larvae settles in upper estuarine or oligohaline habitats.

Substrate

For the majority of the larval phase, spot are pelagic and not in contact with or preferring a particular type of substrate. During settlement, they will interact much more with the substrate, though it remains unclear what (if any) substrate preferences exist for post-settlement larvae.

Temperature

Govoni et al. (2013) reported the densest larval spot concentrations were found along the continental shelf, which ranged in temperature from 11–19°C. Temperatures preferences for larvae may not be as high as for spawning adults and egg development since larvae must be transported through waters that are cooler than the offshore waters in which they were spawned. Additionally, spring estuarine water temperatures, particularly in the southeast U.S., may vary substantially based on atmospheric and terrestrial factors, and thus spot toward the end of their larval phase likely experience a wide range of temperatures. Perhaps the greatest temperature threat to larval spot comes from cold temperatures in estuaries. Hoss et al. (1988) reported a stress response to cold temperatures that resulted in an energy deficit at temperatures ≤10°C.

Dissolved Oxygen

DO demands are likely met offshore, as well as inshore after ingress. Both of these habitats typically do not experience hypoxic conditions in the winter and early spring, although no published studies have reported on any limitations.

Feeding Behavior

Larval spot are planktonic feeders. Copepods and ostracods are the primary food up to 25 mm SL (Hildebrand and Cable 1930). Spot larvae are also known to eat tintinnids, pteropods, pelecypods, ostracods, and the egg, naupliar, copepodid, and adult stages of copepods (Govoni et al. 1983). By settlement into nursery habitats (~20 mm SL), sediment is found in the stomachs suggesting that spot are foraging along the bottom (Deary 2015).

Competition and Predation

Spot larvae likely do not enter into any limiting ecological competition, as their habitat demands are basic—it is unknown whether larvae are limited spatially after settlement, and they are largely planktonic feeders. Predation of larvae undoubtedly occurs both offshore and inshore, yet these processes are difficult to quantify in a way meaningful to the overall population or abundance (i.e., at broad scales and not characterized by spatial or temporal effects of a single study). Similar to the early stages of many other pelagic fish larva, the early stages of spot are significantly predated upon by gelatinous zooplankton (Purcell 1985; Olney and Boehlert 1988; Cowan et al. 1992).

Part D. Juvenile Habitat

Tidal salt marshes and larger estuaries are recognized primary nurseries for spot (Weinstein 1979; Currin et al. 1984), although juvenile spot have been frequently collected offshore on the inner continental shelf (Woodland et al. 2012). Due to the generally high productivity of estuaries, this habitat provides ample prey for spot, which feed mostly on small bottom dwelling worms and crustaceans (Chao and Musick 1977). Atlantic coast estuaries are often shallow and structurally complex, providing a physical refuge from predators. In addition, spot are well adapted to live in the physiologically stressful, low DO environment of small tidal creeks (Cochran 1994). Research in Rose Bay, North Carolina suggests that during their first summer, spot grow and disperse from shallow edges of the bay to all depths (Currin 1984). Although exceptions exist, this pattern is the generally observed for many coastal species.

Geographic and Temporal Patterns of Migration

Juveniles occupy a variety of estuarine habitats, although in the early spring they are abundant in seagrass habitats (Olney and Boehlert 1988). Young-of-year juvenile spot are abundant in shallow bay habitats and intertidal and subtidal creeks in the spring (Able et al. 2007; Able and Fahay 2010). By late summer, larger juveniles are common in intertidal and subtidal marsh habitats.

Salinity

Juvenile spot are found in salinities ranging from 0–30 ppt (polyhaline to freshwater) (Phillips et al. 1989; ASMFC 1987) in nursery areas. Ross (2003) noted spot occupy water with a wide salinity range. Even though spot are tolerant to salinity, juveniles are more abundant in less saline estuarine nursery habitats, suggesting these are preferred nurseries (Thomas 1971; Ross 2003; Able and Fahay 2010).

Substrate

Juvenile spot likely have a preference for a substrate type, such as mud (Bozeman and Dean 1980; Strickney and Cuenco 1982). However, a number of studies highlight the opportunistic aspect of spot with regard to habitat. Juvenile spot have been collected over shell, sponge, and peat substrates (Able and Fahay 1998; Able and Fahay 2010). Strickney and Cuenco (1982) report mud being the most suitable, but fine sand and coarse sand. Hettler (1989) concluded that up to 1/3 of juveniles might spend their time in Spartina (*Spartina alterniflora*) vegetation and Weinstein and Brooks (1983) reported spot use seagrass meadows. In many systems across the Atlantic distribution of spot, abundance may vary among substrate type, although spot are ubiquitous and a distribution-wide substrate preference has not been reported.

Temperature

The preferred temperature range of juvenile spot is 6–20°C, with a tolerable temperature range extending from 1.2–35.5°C (Parker 1971). Juvenile spot are susceptible to winter kills when estuarine temperatures drop suddenly; however, there is likely individual variation in the susceptibility to this source of mortality, and those later-spawned spot (which are smaller in size) likely have lower survival to low temperatures.

Dissolved Oxygen

Much work has been done in regard to spot DO tolerances. This work has been done largely in response to the growing number and size of hypoxic events in coastal rivers and estuaries (Breitburg et al. 2009) that spot inhabit. Originally, Ogren and Brusher (1977) reported DO preferences >5.0 mg L^{-1}, although they can tolerate DO as low as 0.8 mg L^{-1} with 95% survival (Burton et al. 1980). Mortality increases to 95% when DO drops below 0.8 mg L^{-1} (Burton et al. 1980). Though recent work has begun to show that spot actively avoid hypoxic areas and even inhabit the margins of these areas (Campbell and Rice 2014).

Feeding Behavior

Juvenile spot feed mostly on small bottom dwelling worms and crustaceans (Chao and Musick 1977; Deary 2015). Hales and Van Den Avyle (1989) noted the flexibility in juvenile diets, including insect larvae, polychaetes, harpacticoid copepods and other crustaceans. Several studies have reported that spot behavior is often driven more by feeding opportunities than by predation risk (Weinstein and Walters 1981; Miltner et al. 1995; Nemerson and Able 2004), which collectively suggests that prey availability and abundance many drive habitat associations to a greater degree than predators.

Competition and Predation

Density-dependence is often cited as the greatest competitive effect on juvenile spot (Craig et al. 2007), particularly as hypoxia limits available habitat and increases fish densities in suitable areas (Campbell and Rice 2014). Predators of spot include common estuarine predatory fish, such as sharks, seatrout (*Cynoscion spp*.), and flounders (*Paralichthys spp*.), among others (Rozas and Hackney 1984).

Part E. Adult Habitat

Adult spot are common in coastal waters during the spawning season and in estuaries and nearshore waters during the other parts of the year. They are typically found over sandy or muddy bottoms in waters up to approximately 60 m deep.

Geographic and Temporal Patterns of Migration

Designation of 'adult' is typically defined by the presence of mature reproductive tissue or after the production of viable gametes (Helfman et al. 2006). Under this designation, it is unknown exactly when spot become adults other than vaguely suggesting around ages-1 or 2 (Hales and Van Den Avyle 1989). Given this transition and the relatively short lifespan of most spot, here we refer to adult spot as those that have lived one year and moved to offshore habitats, which typically takes place around October or November, though in the Chesapeake Bay and estuaries to the south some young-of-year may overwinter in estuaries (Able and Fahay 2010). Adults distribute in the inner continental shelf in the fall, while individuals that are mature begin to move farther offshore to warmer waters.

Salinity

Adult spot are tolerant of salinities up to 60 ppt (ASMFC 1987; Phillips et al. 1989) and are more abundant in coastal waters and lower estuaries and less abundant in lower salinity areas, compared to juveniles.

Substrate

Adult spot are bottom-oriented, and require substrates to forage on epifauna and benthic infauna (Chao and Musick 1977). Adults likely prefer muddy substrates to sand or vegetated substrate, which has been reported for juveniles (see juvenile substrate section), although offshore adults will likely utilize sand substrates, which are more common outside of estuaries.

Temperature

As with other habitat variables, adult spot are likely tolerant to a wide range of temperatures, though specifics have not been reported. Despite any tolerances, however, lower temperatures drive migrations offshore in the fall (Pacheco 1962).

Dissolved Oxygen

As with juveniles, adults are likely tolerant of a wide range of DO, but prefer normoxic conditions (>4.0 mg L^{-1}; Chao and Musick 1977). Hypoxic conditions (<2.0mg L^{-1}) are less common offshore, and thus DO is probably less of a concern for adults than for juveniles.

Feeding Behavior

Adult feeding behaviors are a continuation of juvenile feeding, which takes place in the substrate foraging on epifauna and benthic infauna (Chao and Musick 1977). It is unknown whether adult feeding behaviors change offshore.

Competition and Predation

Density dependence may be less of a factor for adults than was for juvenile spot as there are fewer adults than juveniles because offshore habitats are likely less spatially limiting than smaller and highly-variable upper estuary environments. Holland et al. (1977) did report sharp mid-summer declines of benthic macroinvertebrates in the Chesapeake Bay, although this occurred largely in upper bay habitats where adults are less likely to inhabit. Predation of spot is dominated by sharks and other estuarine and nearshore predatory fishes, such as other sciaenids and flounders (Bowman et al. 2000).

Section II. Essential Fish Habitats and Habitat Areas of Particular Concern

Essential Fish Habitat

The SAFMC's Essential Fish Habitat Plan identifies EFH for coastal migratory pelagic species as including sandy shoals of capes and offshore bars, high profile rocky bottom, and barrier island ocean-side waters, from the surf to the shelf break zone, but from the Gulf Stream shoreward, including Sargassum (SAFMC 1998). It further recognizes all coastal inlets and all state-designated nursery habitats as being of particular importance.

Identification of Habitat Areas of Particular Concern

Spot are strongly associated with the bottom as juveniles and adults and are seasonally dependent on estuaries. From Delaware to Florida, primary nursery habitat includes low salinity bays and tidal marsh creeks with mud and detrital bottoms. Juvenile spot are also found in eelgrass beds in the Chesapeake Bay and North Carolina. By late spring, juveniles are often more abundant in tidal creeks than in seagrass habitats. Estuaries, which are especially susceptible to alterations from human activities, are designated as HAPCs for spot.

Juvenile spot are associated with the estuarine or creek substrates (bottoms, which are often susceptible to degradation from human activities). Additionally, the loss of habitat due to hypoxia is a serious concern across the eastern U.S. (as well as globally), and numerous studies have reported the negative impacts on spot resulting from hypoxic events (Craig et al. 2007; Campbell and Rice 2014).

Present Condition of Habitat Areas of Particular Concern

A number of activities may affect the condition of the habitats utilized by spot. Estuaries are extremely sensitive to dredging, point and nonpoint source pollution, and destructive or unregulated practices in siliviculture, agriculture, or coastal development that contribute to increased turbidity. These activities may reduce the quantity and quality of spot habitat

Section III. Threats and Uncertainties

Significant Environmental, Temporal, and Spatial Factors Affecting Distribution of Spot

For reasons outlined previously in this section, hypoxia is likely the greatest threat to juvenile spot. Spot tend to do well in warm waters, so increased temperatures from climate change are not of immediate concern; however, other impacts of climate change (e.g., changes in precipitation and subsequently salinity) (Schaffler et al. 2013) are not well understood or forecasted.

Unknowns and Uncertainties

The early stages of spot have a ubiquitous distribution throughout estuarine ecosystems using a variety of habitats. However, it is not known if certain nursery habitats contribute more individuals to adult populations. Studies determining preferred nurseries habitats would help managers identify and conserve critical nursery habitats. In addition, spot forage within and along the sediment of the benthos, which concentrates hydrophobic toxicants, potentially increasing their exposure to these contaminants. Previous research has examined the physiological impacts on adult spot (Middaugh et al. 1980; Roberts et al. 1989), however, no known research has examined the impacts of toxicant exposure on early stage spot, which may have developmental or reproductive implications.

Another consideration for spot is the in the early stages, density-dependence is a major competitive force. With the loss of nursery habitats through anthropogenic factors and climate change, competition is expected to increase and the influence of this competitive force on recruitment dynamics is not currently understood.

Section IV. Recommendations for Habitat Management and Research

Habitat Management Recommendations

Spot eggs exist in offshore habitats for a short time in winter and likely have no interactions with other fishery activities. It is not currently thought that any management actions are needed to modify habitat or survival of spot eggs. The following management recommendations were highlighted by the Omnibus Amendment to the ISFMP for Spanish Mackerel, Spot, and Spotted Seatrout (ASFMC 2012):

1. To effectively maintain habitat health, HAPCs should be accompanied by minimization of non-point source and storm water runoff, prevention of significant increases in contaminant loadings, and prevention of the introduction of any new categories of contaminants into the area. Water quality should be monitored to ensure that quality standards are being met.

2. States should minimize loss of wetlands to shoreline stabilization, and monitor navigational dredging, bridge construction, dredged material disposal, and other coastal projects to minimize impact on HAPCs.

3. The use of any fishing gear that is determined by management agencies to have a negative impact on spot habitat should be prohibited within HAPCs.

4. States should identify dams that threaten freshwater flows to nursery and spawning areas, and target them for appropriate recommendations during FERC re-licensing.

5. States should continue support for habitat restoration projects, including oyster shell recycling and oyster hatchery programs as well as seagrass restoration, to provide areas of enhanced or restored bottom habitat.

Habitat Research Recommendations

From the Omnibus Amendment to the ISFMP for Spanish Mackerel, Spot, and Spotted Seatrout (ASMFC 2012). Particular attention should be directed toward what these data may indicate regarding habitat utilization and habitat condition (environmental parameters). A list of existing state and Federal programs generating environmental data such as sediment characterization, contaminant analysis, and habitat coverage (marsh grass, oyster beds, SAV) should also be produced and those programs polled on a similar basis. Habitats utilized by this suite of species range from the fresh water dividing line out to, and likely beyond, the shelf break. Thus, virtually any study generating environmental data from estuarine or coastal ocean systems could be of value.

1. Identify critical habitats at all life stages and assess threats by: habitat alteration, dredging and dredge spoil placement, destructive or unregultated agricultural or coastal development, recreational boating, point and nonpoint source pollution.

2. Egg stage: investigations into cyclonic eddies and other offshore distributional processes is an active area of fisheries research (Govoni and Spach 1999; Govoni et al. 2013). Although threats to spot eggs (and the eggs of other coastal species with offshore, winter-spawned stages) are likely minimal or non-existent, continued efforts into understanding these large-scale processes will likely be informative toward understanding the distribution of subsequent life stages.

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