Field Guide to Seasonal Pool Fauna

The Field Guide is provided to help interested people identify members of the seasonal pool biological community. Pictorial field guides are included to aid the identification of adults, larvae, and eggs. For those who wish to learn more about the natural history (physical characteristics, behavior, phenology, and reproductive biology) of these indicator species, in-depth information is also provided. Before exploring seasonal pools, please refer to Appendix B for practices to prevent negative impacts to pool animals (p. 74).

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Field Guide 1: Salamanders of seasonal pools in the mid-Atlantic region.*

SPOTTED SALAMANDER
(Ambystoma maculatum)
Indicator Species

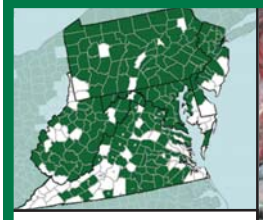



Photo: USGS PWRC

4.4 – 7.8 inches
(11 – 20 cm)

Bright yellow to orange spots on black to bluish-black body

Habitat includes deciduous, mixed deciduous-coniferous, and coniferous forests; breeds in seasonal pools

Protected: Del., N.J., Va.

Description: p. 49

MARBLED SALAMANDER
(Ambystoma opacum)
Indicator Species

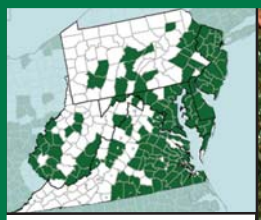



Photo: USGS PWRC

3.5 – 4.3 inches
(9 – 11 cm)

Silvery-white or gray markings or bands on black body

Habitat includes deciduous, mixed deciduous-coniferous, and coniferous forests; breeds in seasonal pool beds

Note: Unlike the other *Ambystoma spp.* that breed during spring, *A. opacum* breeds during fall

Protected: Del., N.J., Va.

Description: p. 50

EASTERN TIGER SALAMANDER
(Ambystoma tigrinum tigrinum)
Indicator Species


Photo: John F. Bunnell

7 – 8.3 inches
(17 – 21 cm)

Yellowish markings on dark brown or black body

Habitat includes moist deciduous, mixed deciduous-coniferous, and coniferous forests; breeds in seasonal pools or fishless permanent pools; favors sandy soils

Endangered: Del., N.J., Va.
Threatened: Md.
Extirpated: Pa.

Description: p. 51

JEFFERSON SALAMANDER
(Ambystoma jeffersonianum)
Indicator Species

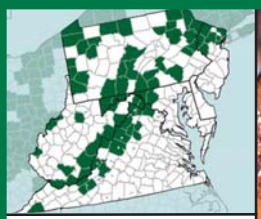



Photo: Steven M. Roble

4.3 – 7.5 inches
(11 – 19 cm)

Light blue-gray flecks on brown or gray body

Habitat includes deciduous forests; breeds in seasonal pools or fishless permanent pools

Protected: N.J., Va.
Watch list: Md., W. Va.

Description: p. 53

** General information is derived from Bishop (1941) and Petranka (1998). Salamander lengths represent total length of the body and tail. Lengths are primarily from Conant and Collins (1998) and represent the range of average total lengths of these salamanders; where mid-Atlantic literature provided dissimilar total lengths, the widest range of lengths was selected. Distribution maps are adapted from the ARMI National Atlas for Amphibian Distributions (http://www.pwrc.usgs.gov/armiatlas/). Maps may not accurately reflect the current presence of species in counties (see website for more information).*

Field Guide 1: Salamanders of seasonal pools in the mid-Atlantic region.

BLUE-SPOTTED SALAMANDER
(Ambystoma laterale)
Indicator Species


Photo: Solon Morse, RTPI

3 – 5.5 inches
(7.5 – 14 cm)

Bluish-white spots on gray, brown or black body

Habitat includes deciduous and mixed deciduous-coniferous forests with rotting logs and deep humus; also inhabits forests surrounding wetlands; breeds in seasonal pools and fish-free ponds

Endangered: N.J.

Description: p. 54

MABEE'S SALAMANDER
(Ambystoma mabeei)
Indicator Species


Photo: Steven M. Roble

3 – 4.8 inches
(7.5 – 12 cm)

White or gray flecks on sides of gray or black body

Habitat includes pine savanna, wet wood, and swamp habitats; breeds in seasonal pools

Threatened: Va.

Description: p. 55

MOLE SALAMANDER
(Ambystoma talpoideum)
Indicator Species


Photo: Jason D. Gibson

3 – 4.7 inches
(7.5 – 12 cm)

Bluish-white or gray flecks on light brown to black body

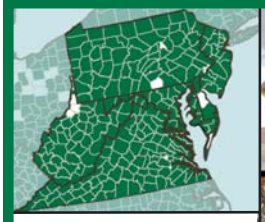
Habitat includes hardwood forests or mixed pine-hardwood forests; breeds in seasonal pools and fish-free ponds

Special Concern: Va.

Description: p. 56

Field Guide 1: Salamanders of seasonal pools in the mid-Atlantic region.

RED-SPOTTED NEWT
(Notophthalmus viridescens viridescens)
Facultative Species



Adult (above): 2.3 – 5 inches (7 – 13 cm); olive to brown with distinctive black-bordered red spots

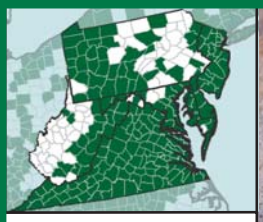
Eft (below): 1.5 – 3.5 inches (4 – 9 cm); bright orange to dull red with spots

Adult habitat includes wide-range of semi-permanent and permanent waters

Efts (juveniles) are terrestrial

Protected: Del., N.J., Va.

FOUR-TOED SALAMANDER
(Hemidactylium scutatum)
Facultative Species



2 – 4 inches (5 – 10 cm)

Rusty brown body with gray sides; four toes on hind feet; white underside with black spots

Habitat includes mature hardwood forests and oak-pine forests; breeds in seasonal pools or other wetlands; lays eggs above the water line; often nests in sphagnum and other mosses

Protected: Del., N.J., Va.

Field Guide 2: Frogs and toads of seasonal pools in the mid-Atlantic region.*

WOOD FROG
(Rana sylvatica)
Indicator Species

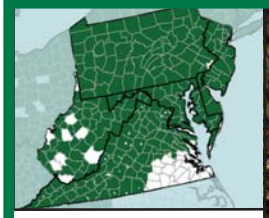



Photo: Steven M. Roble

1.4 – 2.8 inches
(3.5 – 7 cm)

Brown or red-brown with characteristic chocolate mask; white underbelly; two ridges extend along sides of back

Habitat includes moist or lowland deciduous woods; breeds in fish-free seasonal and sometimes permanent pools

Protected: Del., N.J., Va.

Description: p. 57

EASTERN SPADEFOOT
(Scaphiopus holbrookii)
Indicator Species


Photo: John F. Bunnell

1.8 – 3 inches
(4.4 – 7.3 cm)

Smooth skin with scattered warts; sharp black spades on hind feet; vertical pupils and yellow eyes

Habitat includes floodplains of streams and rivers, woods, meadows, or fields with loose, sandy soils; breeds in seasonal pools

Note: Eastern spadefoots primarily breed in seasonal pools with short hydroperiods, including ephemeral pools.

Protected: Del., N.J., Va.
Watch List: W. Va.

Description: p. 59

BARKING TREEFROG
(Hyla gratiosa)
Facultative Species

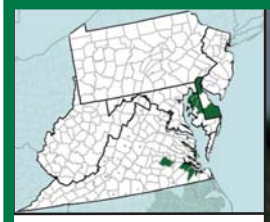



Photo: Alvin Braswell

2 – 2.6 inches
(5 – 6.6 cm)

Color changes from light green to brown; white stripe on upper lip extends down body sides; usually has dorsal spots; large toe disks

Habitat includes coastal plain woodlands; breeds in seasonal pools

Note: In parts of its range, *H. gratiosa* may be an indicator species.

Endangered: Del., Md.
Threatened: Va.

GRAY TREEFROG
(Hyla versicolor/Hyla chrysoscelis)
Facultative Species


Photo: Farmscape Ecology Program, Hawthorne Valley Farm, NY

1.3 – 2.4 inches
(3.2 – 6 cm)

Highly variable body color changing from gray/green/brown; white spot under eye; large toe disks

Habitat includes forest and seasonal pools, permanent water, and swamps; breeds in seasonal pools

Note: In the southern part of its range, *H. versicolor/chrysoscelis* may be an indicator species.

Protected: Del., N.J., Va.

** General information on the frogs and toads is derived from Tyning (1990), Green and Pauley (1987), Hulse et al. (2001), Schwartz and Golden (2002), and White and White (2002). All sizes given for frogs and toads represent 'snout to vent' lengths (SVL) and do not include the legs. Lengths are primarily from Conant and Collins (1998) and represent the range of average SVL of these species; where the literature of the mid-Atlantic region gave different figures, the widest range of lengths was selected. Distribution maps are adapted from the ARMI National Atlas for Amphibian Distributions (http://www.pwrc.usgs.gov/armiatlas/). Maps may not accurately reflect the current presence of species in counties (see website for more information).*

Field Guide 2: Frogs and toads of seasonal pools in the mid-Atlantic region.

PINE BARRENS TREEFROG
(Hyla andersonii)
Facultative Species


Photo: John F. Bunnell

1.1 – 2 inches
(2.8 – 5 cm)

Bright green body with purple stripes down sides; white belly; large toe disks

Found in New Jersey Pine Barrens; breeds in seasonal pools to permanent impoundments

Endangered: N.J.

PINE WOODS TREEFROG
(Hyla femoralis)
Facultative Species


Photo: Steven M. Roble

1 – 1.5 inches
(2.5 – 3.8 cm)

Highly variable body color ranging from reddish-brown to green-gray; row of very small orange, yellow, or white spots on rear of thighs; large toe disks

Habitat includes pine flatwoods and cypress swamps on coastal plain; breeds in seasonal pools

Protected: Va.

UPLAND CHORUS FROG/ NEW JERSEY CHORUS FROG
(Pseudacris feriarum feriarum/ Pseudacris feriarum kalmi)
Facultative Species

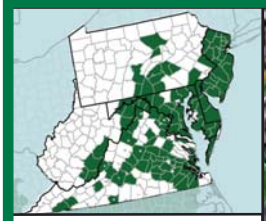



Photo: John F. Bunnell

0.8 – 1.4 inches
(2 – 3.6 cm)

Brown or gray with 3 dark stripes or broken markings down back; dark stripes from snout to groin, passing through the eye; small toe disks

Habitat includes grassy floodplains and wet woodlands; breeds in shallow annual and semi-permanent pools/ wetlands

(*P. f. f.*) Protected: N.J., Va.
Watch list: W. Va.

(*P. f. k.*) Protected: Del., N.J., Va.
Endangered: Pa.

BRIMLEY'S CHORUS FROG
(Pseudacris brimleyi)
Facultative Species

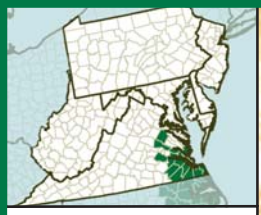



Photo: Joseph Mitchell

1 – 1.3 inches
(2.5 – 3.3 cm)

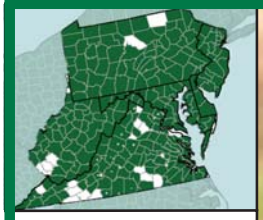
Variable color with bold black stripes down sides from snout to groin, passing through eye; 3 brown or gray stripes down back; small toe disks

Habitat includes wet woods and swamps of coastal plain; breeds in shallow annual and semi-permanent pools/wetlands

Protected: Va.

Field Guide 2: Frogs and toads of seasonal pools in the mid-Atlantic region.

SPRING PEEPER
(Pseudacris crucifer crucifer)
Facultative Species



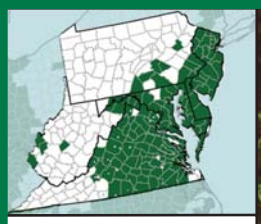
0.7 – 1.3 inches
(1.9 – 3.3 cm)

Variable body color with brown imperfect 'x'-shaped mark on back; small toe disks

Habitat includes forest or field; breeds in shallow seasonal or permanent pools and wetlands

Protected: Del., N.J., Va.

NORTHERN CRICKET FROG
(Acris crepitans)
Facultative Species



0.6 – 1.4 inches
(1.6 – 3.5 cm)

Variable body color; triangular-shaped dark mark between eyes; fully-webbed feet

Habitat includes moist areas near seasonal pools, permanent water and streams; avoids dense vegetation

Protected: Del., N.J., Va.

EASTERN NARROW-MOUTHED TOAD
(Gastrophryne carolinensis)
Facultative Species

0.9 – 1.3 inches
(2.5 – 3.3 cm)

Variable color; fold of skin across back of head; pointed snout

Habitat includes open and forested land; breeds in shallow wetlands, seasonal pools, flooded fields, and ditches

Protected: Va.

Endangered: Md.

NORTHERN/SOUTHERN LEOPARD FROG
(Rana pipiens/Rana sphenocephala)
Facultative Species

2 – 3.5 inches
(5 – 9 cm)

Green and brown with irregular dark spots on back; cream dorsolateral ridges

Habitat includes grassy meadows and fields; breeds in a variety of shallow wetland habitats

(Photograph is of Southern Leopard Frog)

(*R. p.*) Protected: Va.
Watch list: W. Va.

(*R. s.*) Protected: Del., N.J., Va.
Endangered: Pa.

Field Guide 2: Frogs and toads of seasonal pools in the mid-Atlantic region.

CARPENTER FROG
(Rana virgatipes)
Facultative Species


Photo: Steven M. Roble

1.6 – 2.6 inches
(4 – 6.6 cm)

Brown with four coppery stripes running lengthwise on backs and sides

Habitat includes sphagnum bogs, Delmarva bays, some beaver ponds, and swamps

Protected: Del., N.J., Va.

Special Concern: Md., Va.

PICKEREL FROG
(Rana palustris)
Facultative Species

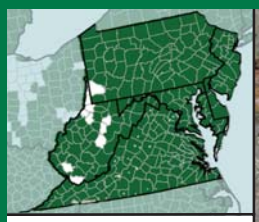



Photo: John F. Bunnell

1.8 – 3 inches
(4.4 – 7.6 cm)

Tan or brown with dark brown square blotches; light-colored dorsolateral ridges

Habitat includes streams, marshes, meadows, and ponds with thick marginal vegetation; breeds in a variety of wetlands

Protected: Del., N.J., Va.

GREEN FROG
(Rana clamitans)
Facultative Species

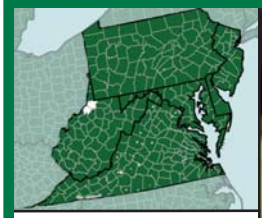



Photo: John F. Bunnell

2 – 4 inches
(5 – 10.2 cm)

Green to brown; two dorsolateral ridges extending two-thirds of the way down the back; white underside

Habitat and breeding grounds include ephemeral to permanent wetlands and other bodies of water including streams

Protected: Del., N.J., Va.

AMERICAN BULLFROG
(Rana catesbeiana)
Facultative Species

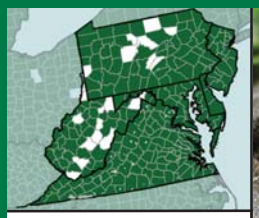



Photo: John F. Bunnell

3.5 – 6 inches
(9 – 15.2 cm); largest frog in mid-Atlantic

Green to brown; no dorsolateral ridges; two ridges extend on sides of face from eye around eardrum to shoulder

Habitat and breeding grounds include mostly deep, sometimes shallow, semi-permanent to permanent bodies of water

Can be a predator of seasonal pool amphibian eggs, larvae and adults

Protected: Del., N.J., Va.

Field Guide 2: Frogs and toads of seasonal pools in the mid-Atlantic region.

AMERICAN TOAD
(Bufo americanus)
Facultative Species

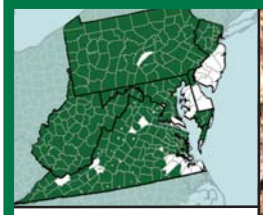



Photo: Steven M. Roble

2 – 3.5 inches
(5 – 9 cm)

Brown with dark brown spots containing 1 to 2 warts; light mid-dorsal stripe may be present; parotoid gland separated from ridge behind eye; often has a spotted underside

Habitat includes woodlands, fields, and human-dominated landscapes; breeds in permanent ponds, seasonal pools, streams, ditches, and road ruts

Protected: Del., N.J., Va.

FOWLER'S TOAD
(Bufo fowleri)
Facultative Species

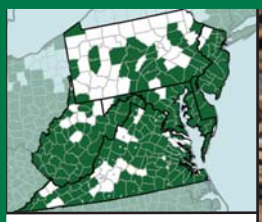



Photo: John F. Bunnell

2 – 3 inches
(5 – 7.5 cm)

Brown with dark brown spots containing 3 - 7 warts; light mid-dorsal stripe often present; parotoid gland in contact with ridge behind eye; unspotted underside

Especially common on Coastal Plain and in sandy areas; breeds in seasonal pools and shallow edges of lakes and streams

Protected: Del., N.J., Va.

Field Guide 3. Invertebrates of seasonal pools in the mid-Atlantic region.*

FAIRY SHRIMP

Crustacea C: Branchiopoda O:Anostraca

Indicator Species

Colorful bodies

0.5 – 2 inches (12 – 51 mm)

Swim upside down with their 11 pairs of legs in the water column

Filter microbes and detritus

Resting eggs overwinter and aestivate

Description: p. 60

Photo: Lesley J. Brown

CLAM SHRIMP

Crustacea *C: Branchiopoda O: Laevicaudata/Spinicaudata*

Facultative Species

Transparent to brown carapace

0.1 – 0.6 inches (2 – 16 mm)

Resemble lentils

Swim slowly with their legs down or forward; associated with aquatic vegetation and the pool bottom; burrow in sediments

Consume detritus or collect plankton

Resting eggs overwinter and aestivate

Photo: Leo Kenney

Note: Clam shrimp inhabit seasonal pools with short hydroperiods, including ephemeral pools. Some species of clam shrimp may be indicator species for ephemeral pools.

SEED SHRIMP

Crustacea C: Ostracoda O: Podocopa

Facultative Species

Variable color

Usually less than 0.04 inches (1 mm)

Resemble miniature mussels or seeds

Filter feeds detritus; may scavenge dead or living animals

Found in sediments

Resting eggs can overwinter and aestivate

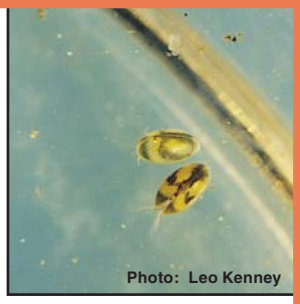


Photo: Leo Kenney

CLADOCERA

Crustacea C: Branchiopoda

Facultative Species

"Water fleas" or "Daphnia"

Clear or transparent

Less than 0.2 inches (5 mm); folded carapace

Use antennae strokes for movement; jerky locomotion

Filter feeds detritus, algae, and bacteria

Parthenogenic eggs; also produces resting eggs that can overwinter and aestivate

Photo: Leo Kenney

ISOPOD

Crustacea C: Malacostraca O: Isopoda

Facultative Species

Brown to light gray

Less than 0.7 inches (18 mm)

Flattened and broad-bodied; 7 pairs of legs

Crawl along pool bottoms

Consume detritus; scavenge on dead organisms

Do not have physiological adaptations to withstand drying

Photo: Solon Morse, RTPI

AMPHIPOD

Crustacea C: Malacostraca O: Amphipoda

Facultative Species

"Scuds"

Variable color: pink, gray, or light green

0.2 – 0.4 inches (5 – 10 mm); narrow-bodied

Swim in quick bursts

Consume detritus; found among detritus on pool bottom or buried in soft-bottom

May survive short dry periods by burrowing in bottom

Photo: Solon Morse, RTPI

P = Phylum C = Class O = Order F = Family

** Invertebrates were selected for Field Guide 3 based on the results of fieldwork conducted in seasonal pools by Mahoney et al. (1990), Leeper and Taylor (1998), and Brooks (2000). Descriptions of these invertebrates were based on Wiggins et al. (1980), Kenney and Burne (2001), Smith (2001), Colburn (2004), and several chapters from the edited volume of Thorp and Covich (1991): Dodson and Frey, Hilsenhoff, and Smith and Cook.*

Field Guide 3: Invertebrates of seasonal pools in the mid-Atlantic region.

COPEPOD

Crustacea C: Copepoda

Facultative Species

Up to 0.1 inches (2.5 mm)

Different species are filter feeders or predators

Adults of some species may form cocoons to survive droughts; many species produce eggs that may enter diapause

AMPHIBIOUS SNAIL

P: Mollusca C: Gastropoda

Facultative Species

Photos: Wayne Davis

Shells are dull brown or light gray; pink bodies

Feeds on detritus and algae

Some species are annual; other species may overwinter by burrowing in frozen mud; also may burrow in leaf litter or sediments to survive dry season

Shells can be found in dry pool beds

FINGERNAIL CLAM

P: Mollusca C: Pelecypoda

Facultative Species

Cream to light brown

Less than 0.5 inches (13 mm)

Filters detritus, algae, and bacteria

Some species burrow in sediments to survive dry periods

Shells can be found in dry seasonal pool beds

PREDACEOUS DIVING BEETLE

P: Arthropoda C: Insecta O: Coleoptera F: Dytiscidae

Facultative Species

Oval body shape; long linear antennae

0.1 – 1.75 inches (2 – 45 mm)

Hind swimming legs are fringed with hairs and kick simultaneously

Feed on invertebrates and amphibian larvae

Some species survive dry periods by burrowing in pool sediments, others by migrating to permanent waters; some species lay diapausing eggs

CADDISFLY LARVA

P: Arthropoda C: Insecta O: Trichoptera

Facultative Species

Sheltered in self-constructed cases

Two seasonal pool families:

1) Limnephilidae: "log cabin" cases (above)
2) Phryganeidae: grass and leaf cases (below)

Shred decaying leaves and detritus; some species also feed on mosquito larvae and amphibian egg masses

Live in seasonal pools and other aquatic habitats; adults emerge before pools dry out; cases found in dry pool beds

Eggs may overwinter

PHANTOM MIDGE LARVA

P: Arthropoda C: Insecta O: Diptera F: Chaoboridae

Facultative Species

Almost transparent; have distinct heads

Less than 1 inch (25 mm)

Predators of insect larvae and small crustaceans

Live in seasonal pools and permanent waters; adults emerge

Abundant in early spring

Field Guide 3: Invertebrates of seasonal pools in the mid-Atlantic region.

CHIRONOMID MIDGE LARVA

P: Arthropoda C: Insecta O: Diptera F: Chironomidae

Facultative Species

0.1 – 0.8 inches (2 – 20 mm)

Often red due to hemoglobin-like pigment

Worm-shaped and cylindrical

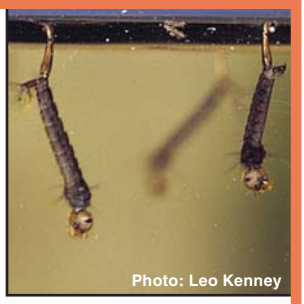
Can survive in low oxygen levels as found in drying seasonal pools

Found in pool bottoms and open water; adults emerge

MOSQUITO LARVA

P: Arthropoda C: Insecta O: Diptera F: Culicidae

Facultative Species



0.3 – 0.5 inches (8 – 13 mm)

Have characteristic flip-flop swimming motion; called "wrigglers"

Feed on detritus and micro-organisms

Live in seasonal pools and other shallow waters; adults emerge

WATER MITE

P: Arthropoda C: Hydrachnidia O: Acariformes

Facultative Species

Brilliant red or green, or brown, tan, brown, yellow or blue

Less than 0.2 inches (5 mm)

Spherical and resembles tiny spiders

Carnivorous or parasitic

Complex life cycle

PLANARIA

P: Platyhelminthes C: Turbellaria

Facultative Species

Flat and unsegmented

0.2 – 1.2 inches (5 – 30 mm)

Live for a year or less; some species encyst themselves to survive dry period

LEECH

P: Annelida C: Hirundinae

Facultative Species

Flattened and elongated; has oral sucker and larger caudal sucker

Parasites, scavengers, or predators (of aquatic invertebrate larvae and amphibian eggs)

Some species can burrow into pool bottom to survive short dry seasons; some species produce drought-resistant eggs

AQUATIC OLIGOCHAETE WORM

P: Annelida C: Oligochaeta

Facultative Species

Elongated; up to 1.5 inches (38 mm)

Feed on leaf litter, detritus and soil

Found among detritus and mud in seasonal pools

Produce cocoons that protect them from short periods of drought

Mole Salamanders

For the salamander species detailed below, please refer to Field Guide 1 for photographs of adults (p. 38), Field Guide 4 for photographs of eggs (p. 63), and Field Guide 5 for photographs of larvae (p. 66). General information on the salamanders' physical appearance, habitat, and behavior is primarily derived from Petranka (1998), Bishop (1941), and Tyning (1990). Species information was tailored to the mid-Atlantic region by using Green and Pauley (1987), Hulse et al. (2001), Schwartz and Golden (2002), and White and White (2002). When there was a range of figures reported for certain parameters (such as egg clutch size), the figures from fieldwork in the mid-Atlantic region were selected when possible, as is the case for this entire section. Salamander lengths represent total length of the body and tail. The lengths are primarily from Conant and Collins (1998) and represent the range of average total lengths of these salamanders; where mid-Atlantic literature provided dissimilar total lengths, the widest range of lengths was selected.

Spotted Salamander (*Ambystoma maculatum*)

Indicator Species

Adult Description: Spotted salamanders are 4.4 to 7.8 inches (11 – 20 cm) total length. These salamanders have bright yellow or yellow-orange spots in two rows from head to tail on black, bluish-black, brownish-black, or steel gray bodies (Field Guide 1). Their undersides are gray.

Habitat Requirements: As adults, spotted salamanders live primarily below ground, residing in small mammal burrows and beneath logs and leaf litter. They feed on invertebrates (such as earthworms, centipedes, spiders, and insects). Spotted salamanders inhabit moist, mature deciduous forests as well as younger deciduous and mixed deciduous-coniferous forests. Breeding occurs primarily in seasonal forest pools, seasonal forested wetland pools, and fish-free ponds.

Reproduction: On moderate rainy or humid nights from mid-February through April, spotted salamanders emerge from their terrestrial burrows and migrate to pools to breed (Green, 1956; Nyman, 1991). At the pools, salamanders may gather in large congresses. The breeding season may be several days to two months long, with one to three major breeding events per season (Stenhouse, 1985; Harris, 1980; Petranka, 1998). Spotted salamander breeding phenology (time frame in months when eggs, larvae, and metamorphs are present at pools) for the mid-Atlantic region is shown in Fig. 3-2.

Eggs: Within hours to a few days following mating, females lay one to four egg masses on submerged vegetation or debris about 8 – 10 inches (20 – 25 cm) below the water surface (Field Guide 4; Bishop, 1941). Freshly laid egg masses are less than 1 inch diameter but expand within hours as they absorb water (Bishop, 1941). Individual egg masses contain an average of 75 – 110 eggs per mass (range of 15 – 250 eggs) (Bishop, 1941; Wood and Wilkinson, 1952; Shoop, 1974; Harris, 1980). Female spotted salamanders have total clutch sizes (total number of eggs laid per breeding effort) of around 200 eggs (Woodward, 1982; Shoop, 1974; Ireland, 1989). An egg mass is surrounded by a stiff gelatinous matrix, which is either clear or opaque white (the latter is due to the presence of a crystalline protein). This gelatinous matrix decreases predation, although adult red-spotted newts, predatory wood frog tadpoles, and caddisfly and midge larvae may still eat the embryos (Rowe et al., 1994; Stout et al., 1992). A

week after being laid, spotted and other mole salamander egg masses may begin to take on a greenish hue caused by the growth of a symbiotic alga, *Oophila amblystomatis*, within the jelly matrix. This alga derives nutrients from the jelly matrix and in turn provides oxygen to the developing embryos (Bachmann et al., 1986; Pinder and Friet, 1994).

Larvae: Spotted salamander larvae hatch from the eggs after about three to seven weeks, depending upon water temperature. Larvae are only 0.5 inch (1 cm) in length at hatching and grow quickly on a diet of zooplankton and other invertebrates to reach about 2 inches (5 cm) at metamorphosis. Larvae are greenish with light-colored underbellies and large feathery gills (Field Guide 5). Spotted salamander larvae are preyed upon by predatory insects and salamander larvae (e.g., marbled and eastern tiger) (Hairston, 1987).

Juveniles: Between six weeks and four months after hatching, mid-June through August, larvae metamorphose into juveniles. Slowly growing larvae in some populations may overwinter and transform the next spring (if the pool remains flooded) (Wilbur, 1977; Phillips, 1992) though this has not been recorded for the mid-Atlantic region. Juveniles are similar to adults but have lighter undersides and less prominent spotting on their backs. Sexual maturity occurs after two to five years, with males typically maturing earlier than females.

Range: Spotted salamanders are found throughout the mid-Atlantic region, although they tend to be absent from coastal areas.

Regional Notes: In Delaware, New Jersey, and Virginia, spotted salamanders are protected (with limits set on take and collection). Major pressures on spotted salamander populations, as with the other species of mole salamanders, come largely from habitat loss and deforestation. Spotted salamander populations appear to have declined in eastern Virginia, which may be related to acidic deposition and concomitant increases in concentrations of various metals (aluminum, copper, silicon, and zinc) (Blem and Blem, 1989, 1991; see Section 4.3).

Marbled Salamander (*Ambystoma opacum*)

Indicator Species

Adult Description: Marbled salamanders are 3.5 to 4.3 inches (9 – 11 cm) total length and thick-bodied with short tails. These salamanders are shiny black to purplish-black with silvery-white or gray markings usually in crossbands, or as stripes in some individuals (Field Guide 1). Males have larger, more distinct silver-white markings compared with females whose markings are more blotchy and gray in coloration.

Habitat Requirements: Marbled salamanders spend most of their adult lives beneath leaf litter, debris, stones, or below ground (up to 1 m in depth) in natural crevices and mammal burrows. In summer and fall after rains, marbled salamanders can be found on the surface of the forest floor. They inhabit deciduous forests as well as mixed deciduous-coniferous and coniferous forests. Marbled salamanders depend upon seasonal pools for breeding; only very rarely will they breed in pools with fish.

Reproduction: Marbled salamanders exhibit a very different breeding behavior than the other mole salamander indicator species. Breeding takes place during a different season and on land rather than in the water. On rainy nights in fall (September to November) courtship and mating begins en route to and in or along the margins of dry seasonal pool beds. In these dry pools, females either find a naturally-occurring depression (e.g., rodent burrow immediately below leaf litter) or scour out their own that will serve as a nest for their eggs. The nest is an

oval-shaped depression about 3 inches (7 cm) long, 2 inches (5 cm) wide, and 1 inch (2 cm) deep (Tyning, 1990; Petranka, 1998). Nests are also created beneath logs and stones and at the bases of grass clumps and trees (Bishop, 1941; Petranka, 1998). Marbled salamander breeding phenology for the mid-Atlantic region is shown in Fig. 3-2. In an opposite pattern compared to the other species of mole salamanders, marbled salamander adults breed earlier in their northern range as compared to their southern range and earlier at higher altitudes as compared to lower altitudes.

Eggs: Females lay 37 – 130 eggs in their nests (Green, 1956). Although nests are usually individual, communal nests holding two to seven clutches have also been found (Petranka, 1998). Females often stay with their eggs, curling their bodies around them until the pool is filled – which may be weeks or even months later. This behavior is thought to protect the eggs from desiccation and predation by insects or small mammals. Females deposit eggs singly and they often appear black due to clinging soil and detritus (Field Guide 4; Bishop, 1941; Petranka, 1998).

Larvae: Marbled salamander larvae hatch from eggs within a few days of being submerged by pool flooding. If they hatch in the fall, the larvae will overwinter. During the cold months they undergo only slow growth (Bishop, 1941), but during warm weather larvae grow quickly, first eating zooplankton and later becoming voracious predators of invertebrates and amphibian larvae including sibling marbled salamander larvae (Walls and Blaustein, 1995). In early spring, marbled salamander larvae are likely to be larger in size than other amphibian larvae in seasonal pools due to earlier hatching. Larvae are brown to blackish with a row of light spots on their sides; older larvae develop mottling on a light yellowish-green body (Field Guide 5). Their throats are darkly pigmented, which may distinguish them from lighter-throated spotted salamander larvae.

Juveniles: The larvae begin transforming in the early spring and most leave the pool by May or June. Recent metamorphs have purplish-black or brown bodies with a light-colored spotted or speckled pattern; by one to two months after transformation, the adult pattern begins to appear (Bishop, 1941). Sexual maturation occurs after one to five years.

Range: Marbled salamanders occur throughout the mid-Atlantic region, but appear to be absent from northern and western Pennsylvania, eastern West Virginia, and western Virginia (with the exception of a few scattered records).

Regional Notes: Like the spotted salamander, marbled salamanders are protected (with limits set on take and collection) in Delaware and Virginia and are listed as special concern in New Jersey. Loss of habitat – particularly bottomland deciduous forests and associated seasonal pool habitats – poses the greatest threat to existing populations of marbled salamanders (Petranka, 1998).

Eastern Tiger Salamander (*Ambystoma tigrinum tigrinum*)

Indicator Species

Adult Description: Tiger salamanders are among the largest pool-breeding or terrestrial salamanders in North America. One of the approximately seven recognized subspecies, eastern tiger salamanders are 7.0 to 8.3 inches (17 – 21 cm) total length with a thick body and broad head. Eastern tiger salamanders are dark brown or dull black with a cream, greenish-yellow or brownish-yellow pattern of irregular blotches or spots, sometimes forming tiger-like stripes around their sides (Field Guide 1). They have yellowish undersides with dark marbling.

Habitat Requirements: Adult eastern tiger salamanders are fossorial, spending most of their terrestrial lives in self-dug tunnels or in mammal burrows. They inhabit areas with suitable conditions for burrowing (e.g., woodlands, open areas with sandy soils). Eastern tiger salamanders breed in seasonal pools and fishless permanent ponds (Bishop, 1941; Wilbur and Collins, 1973).

Reproduction: Tiger salamanders migrate to breeding pools from their underground hideaways earlier than spotted salamanders on rainy or damp nights. Their breeding season occurs from December to March across the mid-Atlantic region (Fig. 3-2; Cooper, 1955; Anderson et al., 1971). The breeding season in New Jersey lasts about two months, which may be longer than other mole salamanders in the area (Hassinger et al., 1970). They congress in smaller groups compared to spotted salamanders (White and White 2002). Males produce larger spermatophores than other ambystomatids.

Eggs: Females lay their eggs in globular or oblong gelatinous masses on twigs, weed stems, and other structures in ponds at depths greater than 20 cm (Field Guide 4; Hassinger et al., 1970). Egg masses measure 2.0 by 2.75 inches (5.5 by 7.0 cm) and swell in size and lose their turgidity as they absorb water. Individual egg masses typically contain 30 – 60 eggs (Hassinger et al., 1970; Stine et al., 1954; Bishop, 1941). Females have an average clutch size of 344 – 421 eggs (Wilbur, 1977; Stine et al., 1954).

Larvae: Eastern tiger salamander eggs hatch after four to seven weeks, depending upon water temperature (Stine et al., 1954; Hassinger et al., 1970). Hatchlings have gray bodies with dark bands across or blotches along their backs and whitish bellies; older larvae have olive green bodies with markings (Field Guide 5). Eastern tiger salamander larvae are larger than other *Ambystoma spp.* larvae in the region. Some larvae develop a cannibalistic morphology, typified by larger size and enlarged teeth (though this has not been observed in the mid-Atlantic region) (J.C. Mitchell, pers. comm.).

Juveniles: Larvae transform after two and a half to four months in late spring and summer. Juveniles are initially dark gray or dark brown, and begin to attain adult coloration within one month of transformation. Sexual maturation occurs generally when two to three years old (Semlitsch, 1983).

Range: Eastern tiger salamanders are found mainly in eastern coastal areas of Delaware, Maryland, southern New Jersey, and southeastern Virginia; they are not found in Pennsylvania and West Virginia. There is also one relict population in the Shenandoah Valley (Blue Ridge Mountains) of Virginia disjunct from other populations (Buhlmann and Hoffman, 1990; Church et al., 2003).

Regional Notes: Tiger salamanders are listed as 'Endangered' in Delaware, Maryland, New Jersey, and Virginia. They are considered extirpated from Pennsylvania as a result of habitat alteration and loss (Hulse et al., 2001). The loss of vernal pools, Delmarva bays, and upland forests is threatening these salamanders on the Delmarva Peninsula (Sipple, 1999; White and White, 2002). Fish stocking and acid deposition also have contributed to declines of tiger salamander populations in Virginia (Buhlmann et al., 1999).

Jefferson Salamander (*Ambystoma jeffersonianum*)

Indicator Species

Adult Description: Jefferson salamanders are 4.3 to 7.5 inches (11 – 19 cm) total length and are slender with long tails and elongated limbs and triangular-shaped toes. They are chocolate brown to dark gray and have light blue or gray speckles on their limbs, lower sides and tail (Field Guide 1). Flecks are bright on young adults, but may fade with age. Their undersides are lighter than their sides and are also speckled. Jefferson salamanders are physically distinguished from blue-spotted salamanders by their slightly larger size, smaller markings, gray area around the vent (as compared to black area in the blue-spotted salamander), and broader head.

Habitat Requirements: Juvenile and adult Jefferson salamanders spend a majority of their lifetimes below ground, feeding on earthworms and other invertebrates. They reside in deciduous forests, and are more likely than the other mole salamander species to live in upland forests. In West Virginia, Jefferson salamanders have been found in caves (Green and Brant, 1966). Seasonal forest pools are the usual breeding location, but semipermanent pools, farm ponds, and floodplain pools may also be used (Petranka, 1998).

Reproduction: In the mid-Atlantic region, Jefferson salamanders breed early in the spring, beginning in February or March when evening rains coincide with temperatures of 40° F or more (Fig. 3-2; Petranka, 1998; Hulse et al., 2001). Males often mount the female (dorsally with forelimbs grasped behind the female's) for a time before more courtship occurs and spermatophores are deposited. Jefferson salamander spermatophores are about twice the size of those deposited by blue-spotted salamanders.

Eggs: One or two days after mating, female Jefferson salamanders deposit their eggs as masses attached to submerged vegetation or unattached in the seasonal pool water. When attached to solid structures such as twigs and branches, egg masses tend to be cylindrical and clumped in groups; when attached to more vegetative substrates, such as grass, the egg masses are more irregular in shape and laid further apart from each other (Field Guide 4; Petranka, 1998). Each female lays up to 300 eggs in separate egg masses of 10 – 75 eggs (Martof et al., 1980, Hulse et al., 2001).

Larvae: The eggs usually hatch after four to six weeks, but the embryonic period may last as long as 14 weeks depending upon water temperature (Martof et al., 1980, Petranka, 1998). Hatchlings are olive green to brown with hints of yellow on the sides of the neck, head and dorsal fin (Field Guide 5). Mature larvae have grayish bodies with heavily mottled broad dorsal fins, broad heads, elongated and tapered toes, and a silvery or white belly. Larvae are voracious feeders, eating small zooplankton at first, then progressing to larger invertebrates, including snails and insects. They are also known to eat spotted salamander larvae and other Jefferson salamander larvae (Petranka, 1998).

Juveniles: The larval period lasts two to five months (J.C. Mitchell, pers. comm.). Metamorphs are uniformly gray or brownish above with muted brownish yellow specks on the sides. Jefferson salamanders become sexually mature after two to three years.

Range: Jefferson salamanders are patchily distributed in the mid-Atlantic states. They are found in northern New Jersey, most of Pennsylvania, western Maryland, and along the Blue Ridge and Allegheny Mountains of Virginia and the Allegheny Plateau of West Virginia. They are absent from Delaware.

Regional Notes: Jefferson salamanders are on the watch list (special concern but without legal protection) in Maryland and West Virginia, are of special concern in New Jersey, and are protected (have limits set on take or collecting) in Virginia. Jefferson salamanders appear to be more vulnerable to acidic conditions than other amphibians (Petranka, 1998). Jefferson salamanders were designated by the Northeast Endangered Species Technical Committee as a species of regional conservation concern due to their risk of extirpation (Therres, 1999). Jefferson and blue-spotted salamanders often hybridize in areas where their ranges overlap, resulting primarily in female polyploids, which could lead to a reduction in pure Jefferson salamander populations (Bogart and Klemens, 1997). In the mid-Atlantic states, triploid hybrids known as *Ambystoma platineum* (having two sets of Jefferson salamander chromosomes and one set of blue-spotted salamander chromosomes) have been confirmed genetically in New Jersey (Schwartz and Golden, 2002) and may exist but are not confirmed in eastern Pennsylvania (Hulse et al., 2001).

Blue-spotted Salamander (*Ambystoma laterale*)

Indicator Species

Adult Description: Blue-spotted salamanders are 3 to 5.5 inches (7.5 – 14 cm) total length with bluish white spots and flecks on a purplish-brown, dark gray or black body (Field Guide 1). Blue spots may stand in sharp contrast against the body color or appear rather muted. Compared to the Jefferson salamander, blue-spotted salamanders are generally smaller, have larger bluish spots distributed on the sides as well as the back, and have darker pigmentation around the vent.

Habitat Requirements: Blue-spotted salamanders are fossorial, spending a majority of their time in deciduous or mixed deciduous-coniferous forests with rotting logs and deep humus. They also inhabit forested areas above the water level in swamps and marshlands. However, compared to other ambystomatids, blue-spotted salamanders are more likely to be found active on the surface during warmer months. They feed primarily at night on earthworms, slugs, isopods and other arthropods. Breeding occurs in fish-free pools, including seasonal forest pools, seasonal open-canopy pools, semipermanent pools, wetlands, and ditches.

Reproduction: Mating occurs in water in late winter or early spring, and generally consists of one to three explosive breeding occasions per year, which are triggered by warm, rainy nights. Courtship behavior resembles that of the Jefferson salamander and is described in detail by Storez (1969). Spermatophores of blue-spotted salamanders are about half the size of those of Jefferson salamanders. Blue-spotted salamander breeding phenology for the mid-Atlantic region is shown in Fig. 3-2.

Eggs: Females lay eggs singly, in strings of two to four eggs, or, less frequently, as poorly-defined masses of 2 – 30 eggs, on the pool floor or attached to leaf litter, vegetation, sticks, or rocks (Field Guide 4). The total number of eggs that a female deposits in a breeding season ranges from 100 – 500.

Larvae: Eggs typically hatch about a month after deposition. Larvae are dark brown with yellow blotches and paired black spots on either side of the tail fin on the back. Each side has a light elongated stripe, the undersides are unpigmented, and the tail fins are broad and mottled with black (Field Guide 5). Larvae most likely feed on zooplankton and dipteran larvae (Petranka 1998). The larval period typically lasts two to three months.

Juveniles: Just after metamorphosis, juveniles have yellowish spotting on both their backs and underbellies. Juvenile blue-spotted salamanders become mature in about two years.

Range: In the mid-Atlantic states, blue-spotted salamanders are confirmed only in northern New Jersey (Anderson and Giacosie, 1967).

Regional Notes: This species is listed as Endangered in New Jersey. Blue-spotted salamanders may have a greater tolerance for disturbed areas than Jefferson salamanders, but this tolerance may make them more susceptible to other threats associated with human development (Klemens, 1993). In New Jersey, blue-spotted salamanders have experienced high road mortality and have had lowered reproductive success in degraded pools with poor water quality (Schwartz and Golden, 2002). Blue-spotted salamanders have declined with the conversion of hardwood forests to urban and agricultural areas. Jefferson and blue-spotted salamanders often hybridize when their ranges overlap, which may reduce the population size of pure diploid blue-spotted salamander populations (Bogart and Klemens, 1997).

Mabee's Salamander (*Ambystoma mabeei*)

Indicator Species

Adult Description: Mabee's salamanders are 3 to 4.8 inches (8 – 12 cm) total length and are dark brownish gray to black with silvery white or gray flecks mostly on the sides with a few on the back (Field Guide 1). Mabee's salamanders have a relatively small head and long slender toes. Their undersides are light gray to grayish brown with scattered light-colored flecks.

Habitat Requirements: Mabee's salamanders are found in pine savanna, wet woods, and swamp habitats in southeastern Virginia. In the pine savanna, they inhabit burrows at the edges of bogs and ponds and migrate long distances to forested areas in the non-breeding season (J.C. Mitchell, pers. comm.). Mabee's salamanders breed in fish-free seasonal pools, including seasonal forest pools, sinkhole ponds, Carolina bays, semipermanent farm ponds, and cypress-tupelo ponds in pinewoods (Hardy and Anderson, 1970).

Reproduction: The breeding biology of Mabee's salamanders is not well-studied (Petranka 1998). According to Hardy (1969) breeding occurs from winter to early spring, but according to Martof et al. (1980) breeding starts as early as late fall; it is also reported to occur between December and March in Virginia (Fig. 3-2; J.C. Mitchell, pers. comm.).

Eggs: Females attach eggs singly or in loose chains of two to six eggs to leaves, twigs, and debris on the bottom of shallow pools (Field Guide 4).

Larvae: Hatchlings are 1/3 inch (0.85 cm) total length and have a single yellow stripe on either side of the body, bushy gills, and a broad dorsal fin that extends onto the back (Field Guide 5). Older larvae are brown to blackish with two cream stripes along the sides of the body that are often broken; dorsal and ventral fins are heavily mottled. Mabee's salamander larvae from Virginian populations feed heavily on isopods and amphipods (McCoy and Savitsky, 2004). Larvae transform in late spring at sizes of about 2 inches (5 – 6 cm) total length.

Juveniles: Juveniles are initially black or dark gray above with little or no light flecking. Time to sexual maturation is unknown.

Range: In the mid-Atlantic region, Mabee's salamanders are only found in southeastern Virginia.

Regional Notes: Mabee's salamanders are listed as threatened in Virginia. The range of the Mabee's salamander was not discovered to extend into Virginia until 1979 (Mitchell and Hedges, 1980). The Mabee's salamander is one of the least-studied species of mole salamanders, with many aspects of their biology and natural history unknown (McCoy and Savitsky, 2004). Larval Mabee's salamanders from Virginian populations were found to have significantly higher gastric parasitic nematode loads as compared to those from North and South Carolinian populations (McCoy and Savitsky, 2004). Habitat loss from ditching and draining of breeding sites and conversion of forests to agricultural lands has presumably impacted this species (Petranka, 1998).

Mole Salamander (*Ambystoma talpoideum*)

Indicator Species

Adult Description: Mole salamanders are 3 to 4.7 inches (7.5 – 12 cm) total length, and are stocky with large limbs, short tails, and large heads. Their backs and sides range in color from light brown to light bluish gray to dark brown or blackish and are speckled with small bluish white or grayish flecks (Field Guide 1). Their undersides are bluish gray with light flecks.

Habitat Requirements: Mole salamanders live in underground burrows or tunnels in pine savannas, hardwood forests, floodplain forests, and swamps. In Virginia, mole salamanders are primarily found in upland and lowland deciduous forests or mixed deciduous-coniferous forests. Mole salamanders breed in fish-free pools, including seasonal forest pools, seasonal forested wetland pools, Carolina Bays, and roadside ditches. They are more successful in pools that do not also support populations of spotted salamanders (Hayslett, 2003).

Reproduction: Breeding typically occurs after long sustained rains and cooler temperatures of 40 – 45° F (Hayslett, 2003). Mole salamanders exhibit a range of migration dates to breeding pools and breeding season durations that are dependent upon environmental conditions (Semlitsch, 1985a; Hayslett, 2003). In Virginia, the time spent at breeding pools was found to extend from mid-October to early May during a wet year and from late-January to early-April in a dry year (Hayslett, 2003). Males arrive earlier and stay longer at the pools compared to females (Semlitsch, 1981). Mole salamander breeding phenology for the mid-Atlantic region is shown in Fig. 3-2.

Eggs: Females lay eggs singly along the pool bottom on leaves, grass, and twigs (Semlitsch 1985a) at depths of 2 – 12 inches (A. Braswell, pers. comm.). Total clutch sizes for a single female are approximately 200 – 700 eggs, with clutch size and egg size increasing with female age (Field Guide 4; Semlitsch, 1985a; Hayslett, 2003).

Larvae: Eggs hatch after 30 – 40 days (Semlitsch et al., 1988). Hatchlings have alternating black and yellow blotches along the midline of the back and on the tail fin. Older larvae develop two cream or dull yellow stripes on each side that break up toward the tail, as well as a characteristic dark band that extends along the midline of the belly, which is retained in juveniles and gilled adults (Field Guide 5).

Juveniles: Larvae may start metamorphosing by mid-June (North Carolina, A. Braswell, pers. comm.). If larvae have not metamorphosed by mid-July, they may overwinter, become sexually mature and reproduce as paedomorphs the following spring and then metamorphose to terrestrial form (Hayslett, 2003; A. Braswell, pers. comm.). This reproductive strategy of

paedomophosis primarily occurs in pools that do not dry annually (Semlitsch, 1985b). A paedomorph, or gilled adult, is darker than an immature larva and may be lacking the midline dark stripe on its belly. Newly transformed juvenile mole salamanders are brownish green in color. About 2 – 4 weeks after transformation, adult patterns (gray flecking) begin to appear. In South Carolina, the majority of mole salamanders become sexually mature in the first year, within a few months of transformation (Semlitsch et al., 1988).

Range: In the mid-Atlantic region, mole salamanders only occur in south central Virginia in an area geographically disjunct from the rest of the species' range (Bader and Mitchell, 1982).

Regional Notes: The mole salamander is a species of special concern in Virginia. Loss of upland forests as well as seasonal and semipermanent pools impacts populations of this species.

Frogs

For the frog species detailed below, please refer to Field Guide 2 for photographs of adults (p. 41), Field Guide 4 for photographs of eggs (p. 65), and Field Guide 5 for photographs of larvae (p. 68). General information on the frogs' physical appearance, habitat, and behavior were compiled from Tyning (1990), Green and Pauley (1987), Hulse et al. (2001), Schwartz and Golden (2002), and White and White (2002). All sizes given for frogs represent 'snout to vent' lengths (SVL) and do not include the legs. Lengths are primarily from Conant and Collins (1998) and represent the range of average SVL of these species; where the literature of the mid-Atlantic region gave different figures, the widest range of lengths was selected.

Wood Frog (*Rana sylvatica*)

Indicator Species

Adult Description: Wood frogs are 1.4 to 2.8 inches (3.5 – 7 cm) SVL and vary in color from gray brown to dark brown or reddish-brown with a pale white or cream-colored underbelly and dark crossbars on the hind legs (Field Guide 2). Two dorsolateral ridges extend along the sides of the back. Wood frogs have a characteristic dark chocolate brown mask that extends from the snout across the eyes to a point behind the eardrum (tympanic membrane). Males are usually darker and smaller than females. Males are dark gray brown and have enlarged thumbs during the breeding season, while females are usually reddish-brown.

Habitat Requirements: As its common name implies, wood frogs inhabit primarily moist or lowland deciduous woods. In northern Pennsylvania, wood frogs are also found in hemlock-northern hardwood-white pine communities (Hulse et al., 2001). Outside of hibernation and breeding times, wood frogs are active on the forest floor during the day and night if temperatures exceed 53° F and if humidity is high or it has rained. In winter, wood frogs hibernate in deciduous forests underneath leaf litter or cover objects or in shallow burrows rarely below the frostline of the soil, making wood frogs susceptible to freezing conditions. However, wood frogs can withstand temperatures as low as 20° F before freezing because they release high levels of glucose into their body fluids from liver glycogen stores, which acts as an antifreeze agent (cryoprotectant). Wood frogs can also survive up to two weeks of extracellular freezing at moderate subzero temperatures (Storey and Storey, 1986). Wood frogs breed in fish-free seasonal and sometimes permanent pools in or adjacent to forests, including vernal pools, beaver ponds, roadside ditches, canals, and borrow/gravel pits.

Reproduction: Wood frogs are the first anurans to breed in the calendar year in most of the mid-Atlantic region. On a warm, wet evening in late winter or early spring, wood frogs migrate from their woodland habitats to breeding ponds for an explosive two to seven days of mating. Males may vocalize in pools for up to three to four weeks, but females are typically in pools for only one to a few days. Freezing weather may interrupt breeding for a period of time. At the Patuxent Research Refuge, a 13,000 acre refuge in Maryland, wood frogs may breed at some seasonal pool sites a week or more before breeding commences at other sites, most likely a result of variation in temperature and microhabitat. Wood frog breeding phenology for the mid-Atlantic region is shown in Fig. 3-2.

Eggs: Females deposit one egg mass containing approximately 500 – 1000 eggs on vegetation or sticks beneath the surface of the water that the male quickly fertilizes (Field Guide 4). At deposition, wood frog eggs are tightly packed together with no outer surrounding jelly matrix unifying the mass, giving the mass a bumpy appearance on the water surface. Egg masses have a diameter of about 2.5 to 4 inches (6.3 – 10 cm). After a week or more, egg masses become amorphous and harder to count individually and may turn green due to algal growth. Females usually deposit egg masses in the same general area of a pool every year. In a woodland setting, this is often on the north side of the pool where the ice melts first; this area receives the most solar exposure. Eggs are most often laid in large communal oviposition sites or rafts that help to trap heat and accelerate development. Seale (1982) reported one raft of 963 wood frog egg masses at a pool in Pennsylvania.

Larvae: Wood frog eggs hatch after two or three weeks. Tadpoles are medium-sized, up to 2 inches (5 cm) in length and are dark brown to blackish with gold flecking (Field Guide 5). Their underbellies are pale iridescent. Eyes are dorsally located just above the sides, not bulging out on sides laterally like tadpoles in the treefrog (Hylidae) family. Initially, they attach themselves to their disintegrating egg mass with their sucker-like mouths and graze the algae growing on its surface. For the remainder of the larval stage, they feed primarily on algae and detritus (although they may also eat smaller siblings or cohorts) and find refuge in the leaf litter at the bottom of the pool and in large schools in shallow areas of the pool.

Juveniles: Tadpoles metamorphose into their terrestrial form 60 – 113 days later, usually sometime in June and July (Berven, 1988; Tyning, 1990). At metamorphosis, froglets look like miniature adults. Sexual maturation occurs after one to two years for males and after two to three years for females (Berven, 1990).

Vocalizations: Male wood frog advertisement calls during the breeding season sound like duck quacks, repeated one to five times. Males call day and night.

Range: Found throughout the mid-Atlantic region except for southeastern Virginia.

Regional Notes: Wood frogs are protected with limits set on take and collection in Delaware, New Jersey, and Virginia.

Eastern Spadefoot (*Scaphiopus holbrookii*)

Indicator Species

Adult Description: Eastern spadefoots are 1.8 – 3 inches (4.4 – 7.6 cm) SVL, short-legged, and stout. They have bulging eyes, rounded heads and snouts, and smooth skin with scattered small tubercles (warts). Their backs are olive or brown or gray to black with two irregular yellow lines running from behind their eyes down the length of their backs meeting at a midline near the rump (Field Guide 2). Sometimes they have an additional yellowish line on the side of the body. Their throat and chest are white, except during the breeding season when males' throats darken. The spadefoot's common name is derived from the dark, horny growth on the inner sides of each hind foot, which facilitates digging. Unlike almost all North American frogs, spadefoots have vertical pupils; they also have greenish-yellow irises.

Habitat Requirements: Eastern spadefoots live below ground, burrowing in loose, sandy soils in river floodplains, woods, meadows, or fields. Breeding occurs in short-hydroperiod seasonal or ephemeral pools. They are adapted to dry conditions and can survive prolonged droughts, sometimes for years, lying dormant below the surface. During these dry periods they excrete a fluid that hardens around their curled-up bodies to prevent desiccation (Tyning, 1990).

Reproduction: On mild afternoons and evenings in the spring (starting as early as February), summer, or fall, during or just after periods of very heavy rains and low barometric pressure, spadefoots dig out from their burrows to breed in recently filled seasonal pools or ditches. They are explosive and unpredictable breeders and may appear by the dozens or even hundreds to breed following a heavy storm. The male grasps the female in an inguinal amplexus, just above her hind legs; other species of male frogs in the region grasp females behind the front legs. During the breeding season, males develop black cornifications on the first three fingers of the front feet. Eastern spadefoot breeding phenology for the mid-Atlantic region is shown in Fig. 3-2.

Eggs: Eggs are laid and fertilized externally on underwater vegetation. Each female may deposit up to 2500 eggs in strands or bands that are 1 – 2 inches wide (2.5 – 5 cm) and up to 12 inches long (30 cm); as the eggs swell with water, they clump into more irregular bunches (Field Guide 4).

Larvae: Spadefoot eggs hatch very rapidly, after 1 day to one week, depending on water temperature (Richmond, 1947). Tadpoles are dark bronze to dark brown and have close-set eyes near the top of their head (Field Guide 5). The tail fins are translucent and are unmarked. Spadefoot tadpoles spend the first one to four days relatively inactive, attached to their egg mass or other objects. Then, tadpoles swim throughout the pool (near the water surface if the pool is deep) feeding on plankton. Between one and two weeks after they hatch, tadpoles form dense schools, feeding continuously on algae and carrion (Richmond, 1947).

Juveniles: Typically, spadefoots transform into juveniles after about a month (range of two to ten weeks) of larval development, depending upon water temperature and larval density (Richmond, 1947; Semlitsch and Caldwell, 1982; Tyning, 1990). Newly transformed eastern spadefoot juveniles congregate in large numbers around the pool for several days after metamorphosis (Richmond, 1947). They are active during the day foraging near their natal ponds. Juveniles reach maturity at about 2 inches (5 cm) at two years of age (Pearson, 1955).

Vocalizations: The advertisement calls of male spadefoots are loud, abrupt grunts or squawks that sound like a downward-slurred "errrrrrgh," often repeated in rapid succession.

Range: Eastern spadefoots are found in lowland areas of the Coastal Plain and some of the adjacent Piedmont areas, with very scattered distributions in mountainous areas (Martof et al., 1980; Mitchell and Reay, 1999). They are absent from northwestern Maryland, northwestern Pennsylvania, northern Virginia and are known from only a few places in West Virginia.

Regional Notes: Eastern spadefoots are on the watch list (special concern without legal protection) in West Virginia and are protected (with limits set on take and collection) in Delaware, New Jersey, and Virginia. Eastern spadefoots are rarely seen or heard except after heavy rain events, undergo rapid development, and spend much of their lifetime underground. For these reasons, the distribution of this species has not been thoroughly elucidated.

Fairy Shrimp

Crustaceans in the class Branchiopoda include fairy shrimps, tadpole shrimps, clam shrimps, and water fleas. With the exception of water fleas, which occur ubiquitously in many freshwater habitats, the Branchiopods are among the most distinctive inhabitants of seasonal pools (Smith, 2001). The primarily freshwater order Anostraca, the fairy shrimp, has 50 documented species in the United States (Belk, 1975; Smith, 2001). Fairy shrimp in particular have become emblematic of seasonal pools, and are considered an indicator species group of mid-Atlantic seasonal pools.

Fairy shrimp: Order Anostraca

Indicator Species

Adult Description: Fairy shrimp adults range in total length from 0.5 to almost 2 inches (1.2 – 5 cm). Their coloration is variable, and may be partially dictated by the food they eat; they occur in colors of gray, blue, green, orange, and red (Field Guide 3; Smith, 2001). These crustaceans glide gracefully about the pool swimming upside down with 11 pairs of swimming legs waving above, filtering their food.

Habitat Requirements: Fairy shrimp feed on microbes and detritus in the water column or substrate (Smith, 2001). Fairy shrimp tend to do better in seasonal pools with short hydroperiods (Mahoney et al., 1990). They appear in seasonal pools in late winter or early spring, completing their life cycle in a short period before predatory insects reach maximum densities (Wiggins et al., 1980).

Reproduction: Detailed species-specific reproductive biology of most fairy shrimps is not well known. The following is a general account; there are likely differences among species. During courtship, male fairy shrimp clasp the female with antennae and they swim together around the pool for days at a time. After copulation, which only lasts several seconds, eggs are carried externally in the female's brood sac for one to several days. During this time the eggs undergo early development. Females lay one to six clutches of eggs per season at two to six day intervals. Clutch size is 10 – 250 eggs (Smith, 2001). Some fairy shrimp may produce two types of eggs – thin-shelled eggs that hatch quickly and thick-shelled eggs that are more hardy. The latter of these two types, the resting (dormant) eggs, allow fairy shrimp to exploit seasonal pools and to maintain their populations through the dry season of the pools and through freezing winter conditions. Fairy shrimp eggs are dormant from 6 to 10 months per year in the mid-Atlantic region before hatching during pool flooding. Not every egg will hatch – eggs may stay viable buried in the seasonal pool bed sediments for many years. Resting eggs may be transported in the wind or by birds, insects, or salamanders (Lowcock and Murphy, 1990; Bohonak and

Whiteman, 1999; Smith, 2001). Metamorphic *Ambystoma* salamanders may ingest female fairy shrimp and defecate in another pool, thereby transporting their eggs (Bohonak and Whiteman, 1999).

Range: Four species from two families have been recorded for the mid-Atlantic region: three species of *Eubranchipus* in the family Chirocephalidae and one species of *Streptocephalus* in the family Streptocephalidae. In addition, another species (*Eubranchipus neglectus*) may be found in the mid-Atlantic region, though this is not confirmed (Belk, 1975, Belk et al., 1998).

Regional Notes: There is very little published research on Anostraca of seasonal pools in the mid-Atlantic region. Additionally, there has been confusion surrounding the records of species distributions due to mistakes in identifying two species (Belk et al., 1998). Adult fairy shrimp tend to be unpredictable in occurrence and abundance and exhibit a patchy distribution across the landscape. They may be sporadic in appearance from one year to the next, or may be abundant for many successive years, then suddenly disappear. Eggs may remain viable in the pool bottom for years until hatching. Pools in close proximity to a pool with a particular species of fairy shrimp may have different species of fairy shrimp or none at all (Smith, 2001).

Family	Scientific Name	States in the Mid-Atlantic Region
Chirocephalidae	*Eubranchipus holmanii*	Md., N.J., Pa., Va.
Chirocephalidae	*Eubranchipus neglectus*	W. Va.* and southwestern Va.*
Chirocephalidae	*Eubranchipus serratus*	Md., Va.
Chirocephalidae	*Eubranchipus vernalis*	Del., Md., N.J., Pa., Va., W. Va.*
Streptocephalidae	*Streptocephalus sealii*	Md., N.J., Va.

Species of fairy shrimp in the mid-Atlantic region. These species distributions are based on Belk (1975) and Belk et al. (1998). Belk (1975) created distributions using published records and specimens from the National Museum of Natural History, Washington, D.C.

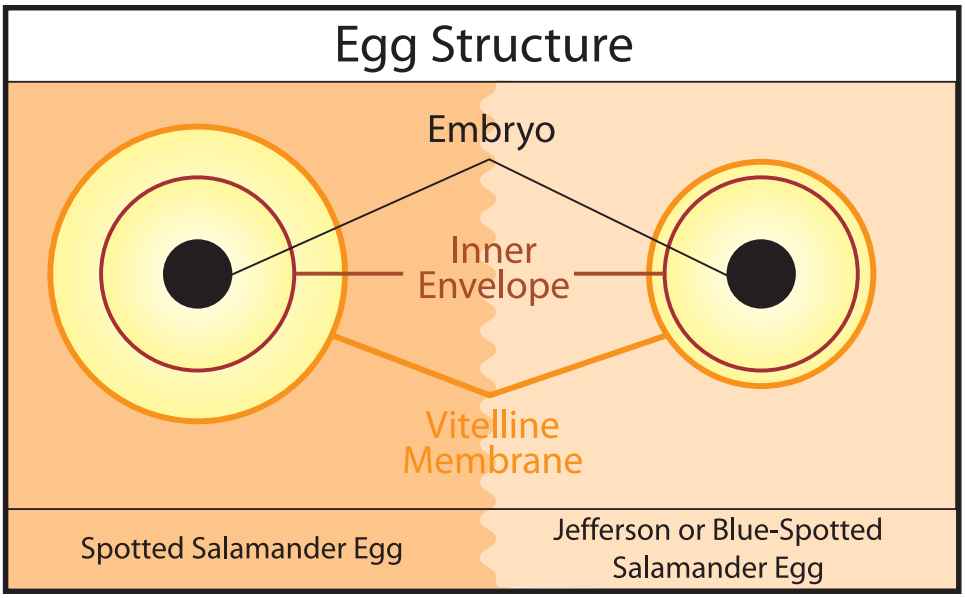
** These species have not been recorded from these states, but according to range maps, they may occur there (see Belk et al., 1998).*

Comparison of Eggs and Larvae of Amphibian Indicator Species

The presence of egg masses and larvae provides evidence of use of the pools by amphibians for breeding. Depending on the species, eggs may be laid singly, in strings, in sheets, or as discrete masses. Females may lay eggs individually or in communal areas of pools. Eggs and egg masses of seasonal pool breeders are usually attached to vegetation or woody debris below the water surface (with the notable exception of the marbled salamander). Egg masses of species of mole salamanders are encapsulated by a jelly matrix that ranges in consistency from very firm (spotted salamanders) to medium-firm (Jefferson salamanders) to soft (blue-spotted salamanders). The jelly matrix is usually clear, although spotted salamander egg masses may be opaque white due to the presence of a crystalline protein. Frog egg masses, in contrast, lack this outer jelly matrix and are less cohesive than mole salamander egg masses. Amphibian egg masses change in appearance over time in the seasonal pools. They swell in size and become more amorphous as they absorb water. Also, egg masses may begin to take on a greenish hue caused by the growth of a symbiotic alga, *Oophila amblystomatis*, within the jelly matrix. This alga derives nutrients from the jelly matrix and in turn provides oxygen to the developing embryos (Pinder and Friet, 1994).

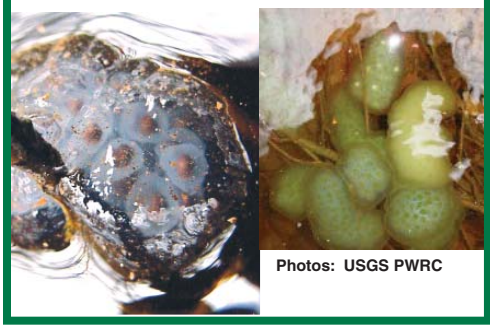
Mole salamander egg masses can also be distinguished from one another based on characteristics of the eggs. Spotted salamander eggs exhibit a large distance between the inner envelope and vitelline membrane, such that the vitelline membrane is much farther from the embryo compared to those of blue-spotted and Jefferson salamanders (Kenney and Burne, 2001). Photographs and descriptions are provided to aid in the identification of eggs of indicator species by highlighting distinctive characteristics (Field Guide 4).

Amphibian larvae are often more difficult to identify to species than the egg masses. Several mole salamander larvae in particular are difficult to distinguish from one another. Photographs and descriptions are provided to aid in the identification of larvae of indicator species by highlighting distinctive characteristics (Field Guide 5).



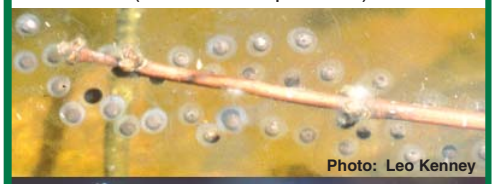
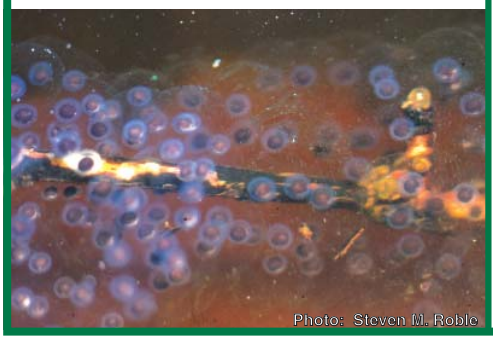
Comparison of relative dimensions of eggs. Spotted salamander eggs (left) exhibit a larger distance between the inner envelope and the vitelline membrane as compared to blue-spotted and Jefferson salamander eggs (right). This characteristic aids in field identification of eggs to the correct species of mole salamander.

Field Guide 4. Amphibian eggs in mid-Atlantic seasonal pools.*

SPECIES	DESCRIPTION	LOCATION
Spotted Salamander # of Eggs per Mass: Average of 75 – 110 (total clutch up to 250)  Photos: USGS PWRC	Clear or opaque white Globular to oval; very firm jelly-like matrix Large distance between inner envelope and vitelline membrane	Attached to sticks, stems, aquatic vegetation; up to 8 – 10 inches or more below water surface
Marbled Salamander # of Eggs per Mass: Laid singly (total clutch 37 – 130)  Photo: USGS PWRC	Eggs often appear black due to clinging dirt Eggs laid singly in nest depression; no cohesive outer envelope, but eggs are grouped Eggs have a firm, sticky outer membrane	Nests located in dried seasonal pool beds; scoured in pool bottom or located in rodent burrows, beneath cover objects, or at water's edge
Eastern Tiger Salamander # of Eggs per Mass: Average of 30 – 60 (total clutch up to 421)  Photo: James W. Petranka	Masses 2 – 2.8 inches diameter Globular or oblong; matrix initially very firm but becomes very loose	Attached to twigs, stems, and vegetation; in water greater than 8 inches deep

** Information on amphibian eggs was primarily derived from Bishop (1941), Tyning (1990), Petranka (1998), and Kenney and Burne (2001).*

Field Guide 4. Amphibian eggs in mid-Atlantic seasonal pools.

SPECIES	DESCRIPTION	LOCATION
Jefferson Salamander # of Eggs per Mass: 10 – 75 (total clutch up to 300)  Photo: Leo Kenney  Photo: Steven M. Roble	Masses clear and cryptic Cylindrical on branches and irregular on grasses; intermediate firm matrix	Attached to submerged branches or grasses
Blue-Spotted Salamander # of Eggs per Mass: 1 – 30 (total clutch 100 – 500 eggs)  Photo: Steven M. Roble	Masses clear Eggs laid singly, in strings of 2 – 4, or in poorly-defined masses of 2 – 30	Attached to submerged branches, stems, and leaves; 8 – 10 inches below surface or on pool floor
Mabee's Salamander # of Eggs per Mass: 2 – 6 (total clutch size unknown)  Photo: Karen Sheffield	Eggs laid singly or in strings of 2 – 6	Attached to leaves, twigs, and debris in shallow pools

Field Guide 4. Amphibian eggs in mid-Atlantic seasonal pools.

SPECIES	DESCRIPTION	LOCATION
Mole Salamander # of Eggs per Mass: Laid singly (total clutch approx. 200 – 700)  Photo: Alvin Braswell	Eggs are darkly pigmented on top and white below Eggs laid singly or in small loose clusters	Attached to submerged twigs and stems in shallow pools
Wood Frog # of Eggs per Mass: 500 – 1000  Photo: USGS PWRC	Masses clear Globular; no outer jelly matrix; grape cluster appearance	Often attached to twigs and stems; often deposited communally; look like lumpy sheets just below water surface
Eastern Spadefoot # of Eggs per Mass: Up to 2500  Photo: John F. Bunnell	Strands or bands 1 – 2 inches wide and up to 12 inches long	Attached to underwater or floating vegetation in shallow pools

Field Guide 5. Amphibian larvae in mid-Atlantic seasonal pools.*

SPECIES	DESCRIPTION	NOTES
Spotted Salamander		
 Photos: Solon Morse, RTPI	Hatchlings dull olive; no markings Older larvae greenish-yellow with light ventral surface; no markings on chin and throat; tail fin mottled with black	More slender than blue-spotted larvae; bushier gills
Marbled Salamander		
 Photo: John F. Bunnell Photo: Leo Kenney	Hatchlings light gray, becoming brown; row of light spots on sides below limbs Older larvae light olive to brown to almost black; pale spots on head and light yellow-green blotches on back and tail; throat and underside pigmented; row of light spots on sides below limbs	Throats darker than spotted larvae; largest mole salamander larvae in early spring due to earlier hatching
Eastern Tiger Salamander		
 Photo: Steven M. Roble	Hatchlings gray or yellowish green; dark bands along backs; white undersides Older larvae olive-green or dark brown with black markings; light underside; throats generally lack pigment	Flattened spade- or triangular- shaped toes; all other mole salamanders have rounded toes; larger-sized than other species of mole salamander larvae

** Information on amphibian larvae was primarily derived from Bishop (1941), Tyning (1990), Petranka (1998), and Kenney and Burne (2001).*

Field Guide 5. Amphibian larvae in mid-Atlantic seasonal pools.

SPECIES	DESCRIPTION	NOTES
Jefferson Salamander		
 Photo: Leo Kenney	Larvae olive green to brown; hints of yellow on sides of neck, head, dorsal fin Older larvae grayish with heavily mottled dorsal fins; broad heads; long toes; silvery or white belly	Difficult to distinguish from other mole salamander larvae
Blue-Spotted Salamander		
 Photo: Steven M. Roble  Photo: Solon Morse, RTPI	Hatchlings dark brown with a yellow stripe on each side Older larvae dark brown with yellow blotches; paired black spots on either side of tail fin on backs; light lateral bands on sides; unpigmented undersides; broad black-mottled tail fins	Difficult to distinguish from other mole salamander larvae
Mabee's Salamander		
 Photo: Steven M. Roble	Hatchlings brown with single yellow stripe on each side of body Older larvae brown to blackish with two cream stripes along sides; fins heavily mottled	Only occur in southeast Va. in the mid-Atlantic region

Field Guide 5. Amphibian larvae in mid-Atlantic seasonal pools.

SPECIES	DESCRIPTION	NOTES
Mole Salamander		
 Photos: Alvin Braswell	Hatchlings have black and yellow blotches on back midline and tail fin (above) Older larvae have two cream stripes on each side; on undersides there are single black lines (below)	Only occur in south-central Va. in the mid-Atlantic region The alternative adult form (paedomorph) is darker than the immature larva
Wood Frog		
 Photo: Solon Morse, RTPI	Hatchlings black Older larvae dark brown to blackish with gold flecking; pale underbellies; light line along side of snout where mouth will later form; side of snout darker than rest of body	May form large schools in shallows
Eastern Spadefoot		
 Photo: John F. Bunnell	Dark brown to bronze; close-set eyes near top of head; tail fins translucent	Form dense schools