

**U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM**

SCIENTIFIC NAME: *Stygobromus indentatus*

COMMON NAME: Tidewater amphipod

LEAD REGION: DOI Region 1, Legacy FWS Region 5

DATE INFORMATION CURRENT AS OF: 03/23/2020

STATUS/ACTION

- Species assessment - determined either we do not have sufficient information on threats or the information on the threats does not support a proposal to list the species and, therefore, it was not elevated to Candidate status
- Listed species petitioned for uplisting for which we have made a warranted-but-precluded finding for uplisting (this is part of the annual resubmitted petition finding)
- Candidate that received funding for a proposed listing determination; assessment not updated
- New candidate
- Continuing candidate
- Listing priority number change
Former LPN: ____
New LPN: ____
- Candidate removal: Former LPN: ____
____ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
____ U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.
____ F – Range is no longer a U.S. territory.
____ I – Insufficient information exists on taxonomy, or biological vulnerability and threats, to support listing.
____ M – Taxon mistakenly included in past notice of review.

- N – Taxon does not meet the Act’s definition of “species.”
 X – Taxon believed to be extinct.

Date when the species first became a Candidate (as currently defined): N/A

Petition Information:

Nonpetitioned

Petitioned; Date petition received: 4/20/2010

90-day substantial finding FR publication date: 9/27/2011

12-month warranted but precluded finding FR publication date: N/A

FOR PETITIONED CANDIDATE SPECIES:

- a. Is listing warranted (if yes, see summary of threats below)? N/A
- b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? N/A
- c. Why is listing precluded? N/A

PREVIOUS FEDERAL ACTION

We identified the tidewater amphipod as a Category 2 candidate species for listing in the May 22, 1984, Notice of Review of Invertebrate Wildlife for Listing as Endangered or Threatened Species (49 FR 21664). The tidewater amphipod remained so designated in our subsequent annual Candidate Notices of Review (54 FR 554, January 6, 1989; 56 FR 58804, November 21, 1991; and 59 FR 58982, November 15, 1994). In the February 28, 1996, Notice (61 FR 7596), we discontinued the designation of Category 2 species as candidates, which removed the species from the candidate list.

On April 20, 2010, we received a petition from the Center for Biological Diversity, Alabama Rivers Alliance, Clinch Coalition, Dogwood Alliance, Gulf Restoration Network, Tennessee Forests Council, and West Virginia Highlands Conservancy to list 404 aquatic, riparian, and wetland species, including the tidewater amphipod, as endangered or threatened species under the Act. On September 27, 2011, we published a 90-day finding in the Federal Register (76 FR 59836) concluding that the petition presented substantial scientific or commercial information indicating that listing may be warranted.

For more information see: <https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=K007>.

ANIMAL GROUP AND FAMILY: Amphipoda, Crangonyctidae

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Maryland, North

Carolina, Virginia

CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE:

Maryland, Virginia

LAND OWNERSHIP: The majority of sites occupied by the tidewater amphipod are on properties owned and managed by Federal, state, or county agencies, or by nonprofit organizations (e.g., The Nature Conservancy). A few sites are privately owned.

LEAD REGION CONTACT: Martin Miller, Chief, Division of Endangered Species 413-253-8615, martin_miller@fws.gov

LEAD BIOLOGIST CONTACT: Julie Slacum, Division Chief, (410) 573-4595, julie_thompson@fws.gov

BIOLOGICAL INFORMATION

The *Species Status Assessment Report for the Tidewater Amphipod—April 2020, Version 1.1* (SSA Report) is a summary of the information assembled and reviewed by the Service and incorporates the best scientific and commercial information available for this species. Excerpts of the SSA Report are provided in the sections below. For more detailed information, please refer to the SSA Report (Service 2020, entire).

Species' Description

The tidewater amphipod is a small, subterranean, shallow ground water crustacean. Species in the genus *Stygobromus* show some modification for subterranean life, in terms of reduction of eyes and pigment (Culver *et al.* 2012, p. 11). The tidewater amphipod is a relatively large species among *Stygobromus* amphipods, with males reaching lengths of 9.7 millimeters (mm) (0.38 inches (in)) and females reaching 8.2 mm (0.32 in) (Culver *et al.* 2012, p. 22, Holsinger 1967, p. 53). Holsinger (1967, p. 53) distinguished the tidewater amphipod from what he described as the closely related *S. pizzinii* by a less elongate gnathopod (appendages) and telson (last segment in abdomen) and by having fewer lateral spines on the telson in both sexes.

Taxonomy

The tidewater amphipod (*Stygobromus indentatus*) was first described by Holsinger (1967, p. 55) from collections made by L. Hubricht (1944 and 1945) in southeastern Virginia. These locations occur in a 150-mile (193-km) expanse of coastal plain that lies between the Washington, D.C., area to the north and Hampton Roads, Virginia, to the south. The tidewater amphipod is one of 209 described subterranean crustaceans belonging to the family Crangonyctidae. These taxa are found in freshwater caves, seeps, wells, and other ground-water-related habitat types. Aquatic species that are limited to subterranean habitats are referred to as “stygebionts” (Culver and

Pipan 2014, p. 1); hence the genus name *Stygobromus*.

The currently accepted taxonomic classification is as follows:

Class: Malacostraca

Order: Amphipoda

Family: Crangonyctidae

Species: *Stygobromus indentatus*

Holsinger (1967, p. 53) described the tidewater amphipod as being closely allied with Pizzini's amphipod (*Stygobromus pizzinii*) but distinguished differences between the species through several morphological features, and the two species are found in different physiographic provinces. Niemiller *et al.* (2017, entire) constructed a gene tree from mitochondrial DNA and sequenced two individuals of the tidewater amphipod, both collected from Fort A.P. Hill in Virginia. The gene tree indicates that the tidewater amphipod is most closely related to the spring cave amphipod (*S. spinatus*) and the Alleghany County cave amphipod (*S. hoffmani*); however, these specific relationships will likely change with additional sequence data.

The Service accepts the above taxonomy as the best available information and considers the tidewater amphipod to be a valid species.

Life History/Habitat

Information about the life history of the tidewater amphipod is limited. Breeding likely occurs in early winter-early spring (pers. comm., Chris Hobson 2017). Holsinger (1967, p.55) reported brood plates on females, indicating that reproduction occurs via eggs and the female provides limited care and protection via the brood pouch, which in amphipods is comprised of a brood plate (Dick *et al.* 1998, p. 666). Juveniles may remain in the brood pouch until early spring. Young of the Potomac groundwater amphipod (*Stygobromus tenuis potomacus*), a closely related species, are known to hatch from the egg and actively swim from the brood pouch, with days or even weeks passing between the hatching of the first and last young of a brood (Williams 2013, p. 10), and we assume tidewater amphipods do the same. The immature stages resemble the adults, and individuals undergo successive molts (usually between eight and nine) until maturity. Parthenogenesis, a form of asexual reproduction in which embryos develop without fertilization, also has been reported to be a possible life history strategy in *Stygobromus* species (Culver and Holsinger 1969, p. 631; Holsinger 1978, pp. 38, 59; Taylor and Holsinger 2011, p. 42). Males and females have been found in different collections, but it remains unknown whether reproduction in the tidewater amphipod is entirely sexual or whether asexual reproduction occurs as well. We do not know at what age or size class individuals become sexually mature. Most surface amphipod species from the family Talitridae complete their life cycle (egg to adult) in 1 year or less, but subterranean species like the tidewater amphipod have a longer lifespan and may live for 4 to 6 years (Foltz and Jepson 2009, p. 2).

The food requirements of the tidewater amphipod are currently unknown. However, attempts to capture tidewater amphipods using a jar trap baited with shrimp have been successful (pers. comm., D. Feller 2017). Captive specimens of other amphipods in the genus *Stygobromus* have been observed feeding on protozoans, flatworms, organic debris, and plant material (Denton and Scott 2013, p. 42).

It is unknown whether the tidewater amphipod uses a “swimmer” or “crawler” form of locomotion, which would likely affect its abilities to reside in certain sediments or respond to changing water levels (Stump and Hose 2013, p. 7). Both swimming and “walking” have been observed in the Potomac ground water amphipod, which also burrowed in clay when water was removed during an experiment (Gilbert *et al.* 2018, p. 22). The behavioral response of the tidewater amphipod to elevated flows, as might happen following a significant precipitation event, or to reduced flows, as might happen during a drought or other drop in water level, is likewise unknown.

Interspecific behaviors, such as predator-prey or competitive interactions, have not been observed. The tidewater amphipod has been known to be associated with other amphipods. It is found with the *Stygobromus tenuis* group and *Crangonyx* spp., which were more commonly found in springs and seeps surveyed in the Piedmont and Coastal Plain physiographic provinces in Maryland, Virginia, and Washington, D.C. (pers. comm., C. Hobson and D. Feller 2017). It has also been found with other amphipod species, Kenk’s amphipod (*S. kenki*), Rappahannock spring amphipod (*S. foliatus*), and Tidewater interstitial amphipod (*S. araeus*) in Virginia (pers. comm., C. Hobson 2020).

The tidewater amphipod inhabits interstitial ground water habitats associated with unconsolidated Cenozoic sediments of the eastern Coastal Plain (Holsinger 1967, p. 55). It is found in habitats that are described as hyporheic (interface between a streambed and an aquifer) or hypotelminorheic (wet patches of forest floor characterized by a perched aquifer underlain by a clay layer and covered with abundant leafy organic matter). Precipitation and runoff filter into these unconfined aquifers in catchment (e.g., recharge or drainage) areas and the water exits these habitats at seepage springs (Culver *et al.* 2012, pp. 4-5). Tidewater amphipods have been found to occupy both the catchment areas and seepage springs. They have also been discovered in tile drain outlets and shallow water wells (Culver *et al.* 2012, p. 22).

Based on surveys and the available literature, we assume that individual tidewater amphipods require these shallow water habitats, which provide space for feeding, breeding, and sheltering, and they require sufficient water quality to support breeding and sheltering. Springs or seeps that support *Stygobromus* spp. have water quality parameters that differ from those parameters of small surface waters by having higher conductivity and dissolved oxygen, and lower pH and temperature (Culver *et al.* 2012, pp. 5-6). An unpublished study (Culver and Chestnut 2006, pp.

1-3) found that sites supporting the genus *Stygobromus* had lower temperatures during spring and summer, higher dissolved oxygen, lower pH, and lower nitrate levels than other seepage springs along the George Washington Memorial Parkway in Virginia. Ground water pools in Virginia with high organic input and connectivity with deeper ground water have also been found to support *Stygobromus* amphipods (pers. comm., C. Hobson 2020). We believe that forest cover provides shade and contributes to maintaining water quality and water quantity by buffering non-point source pollutants from stormwater runoff, maintaining lower temperatures and higher dissolved oxygen, and helping to infiltrate precipitation. Forest cover also provides food through decaying leaves and organic matter that individuals need to grow. The shallow ground water that occurs below springs and seeps is underlain by a clay layer, which we believe is used by individuals for food and sheltering at times when water quantity is limited (Gilbert *et al.* 2018, p. 22). Concrete at the bottom of a shallow well and pipes in which individuals have been found could also retain some water.

Historical and Current Range/Distribution/Abundance

The first two historical localities of the tidewater amphipod were discovered in Nansemonde, Virginia, in 1944 and 1945. Additional sites were discovered in a seep in the adjoining Isle of Wight County, Virginia, and in a shallow well in Nash County, North Carolina (Holsinger 1967, p. 61; Holsinger 1978, p. 103), which expanded the linear distance of the species to 120 miles (193 km). Because the exact locations of all four original sites are unknown and habitat and land use changes have occurred in these areas that could have caused the species to become locally extirpated, the current condition of these sites is unknown.

The current known range of the tidewater amphipod is based on survey data collected between 1982 to 2017. Individuals have been collected from sites located predominantly on publicly owned lands (state, county, Federal) with large, intact forest blocks with moderate to steep slopes, and adjacent to streams. Adjacent land use throughout the range includes agriculture, forest, low density development and secondary roads.

The tidewater amphipod is often found incidentally during surveys focused on other amphipod species. When the Service was being petitioned to list the tidewater amphipod, surveyors began noting occurrences when surveying sites located in the Coastal Plain. The Service also conducted surveys while searching for suitable habitat for the Kenk's amphipod in 2017, which was undergoing a status review at the time. Based on locations identified in Culver *et al.* (2012, pp. 20-22) and surveys conducted by the states and the Service, the current distribution is thought to occur in five counties in Maryland and seven counties in Virginia (see figure 1).

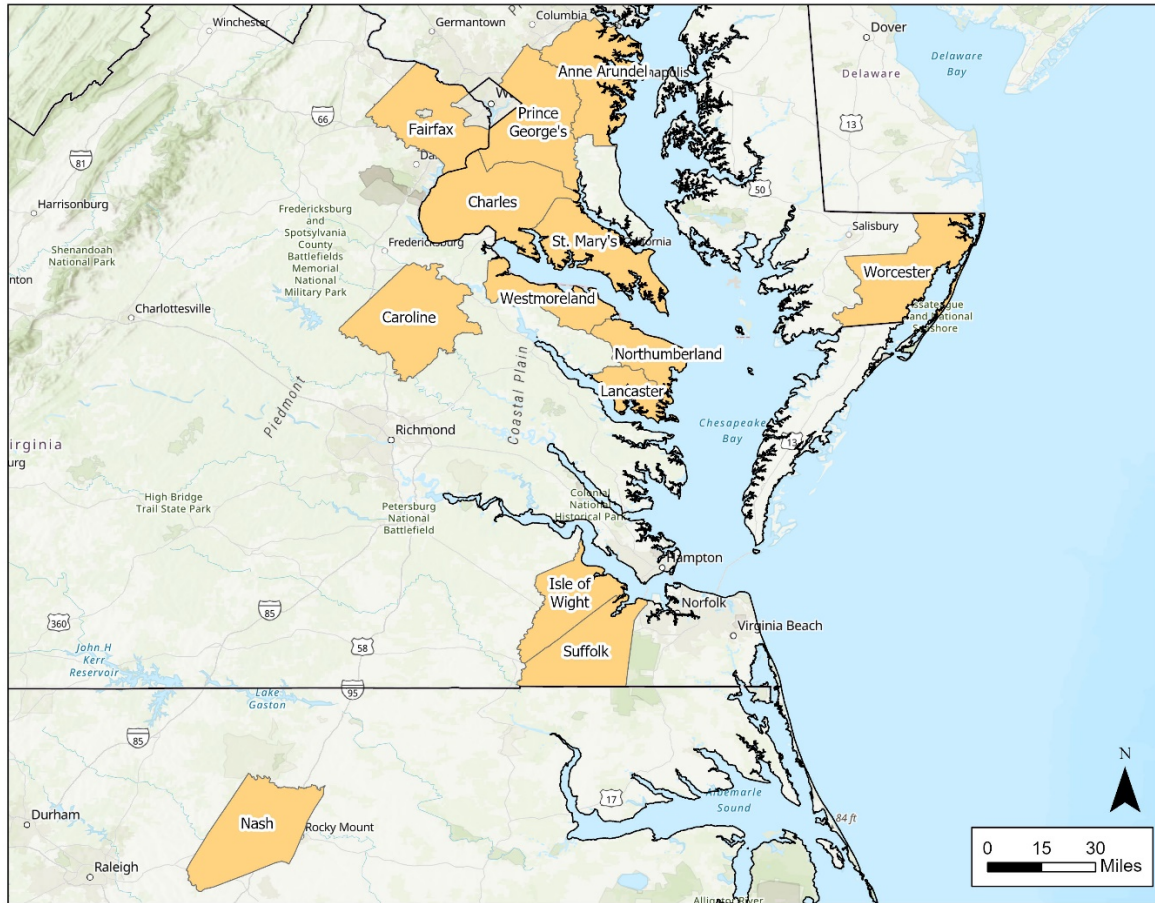


Figure 1. Historical and current range of the tidewater amphipod in counties of Maryland, North Carolina, and Virginia.

Surveys for the tidewater amphipod can confirm presence of the species but are not an indicator of abundance. Therefore, it is not possible to estimate the population size. Comparing the number of occupied sites and documented individuals with surveys from other *Stygobromus* species, we know that the tidewater amphipod is not as common as the Potomac ground water amphipod and is much more abundant and easier to find than the Kenk's amphipod. At the two historical sites in Virginia, 200 and 82 tidewater amphipods were observed in 1944 and 1945, respectively. In more recent surveys for the tidewater amphipod, counts have consisted of fewer than 24 individuals at each site.

All collections of the tidewater amphipod have been reported from the Coastal Plain physiographic province that falls within Maryland, Virginia, and North Carolina (historical collections). The Coastal Plain is divided into two distinct subprovinces based on topography and location and the tidewater amphipod is found in both. The western Upper Coastal Plain is higher in elevation, up to 105 meters (m) (344.5 feet (ft)) above sea level, and often has rolling hills and incised stream valleys. The Lower Coastal Plain lies east, bordering the Atlantic Ocean, has flat, low-lying (less than 20 m [65.6 ft] above sea level) landscape that is dissected by

many tidal tributaries that drain into the Chesapeake Bay and coastal bays on the Atlantic Coast.

Population Estimate/Analysis Units

There are no population estimates for the tidewater amphipod. However, we assume that individuals collected from a seep, spring, shallow well, or pipe are representative of a larger population found in the shallow ground water. We also assume that in places where multiple seeps occur within a 5-acre (2-hectare) drainage area (that is not dissected by a waterbody or topography) with occurrences of the tidewater amphipod, those seeps make up one population. Given these assumptions, there are 38 extant populations and 4 historical populations (sites) for which the presence of the tidewater amphipod is unknown.

SUMMARY OF THE ABOVE BIOLOGICAL INFORMATION

The tidewater amphipod was taxonomically described in 1967, but little is known definitively about its habitat needs and general biology. Since its original discovery in 1944, the species has been found in seven counties in Virginia and five counties in Maryland. We assume that there are 38 extant populations and that there are 4 historical populations without current presence information. Repeated surveys of 4 (Fort A.P. Hill, Fort Belvoir, and Voorhees Nature Preserve in Virginia and Smithsonian Environmental Research Center and Nanjemoy Nature Preserve in Maryland) of the 38 extant populations have shown continued persistence on these properties over decades.

We infer, based on the general principles of conservation biology, general information about other ground water species, and local information from where tidewater amphipods have been observed, that individuals need shallow water habitats with sufficient space to breed and shelter; sufficient water quality for breeding and sheltering; forest cover, which helps support sufficient water quality and quantity and provides food; and a clay or confining layer to help support feeding and sheltering when water quantities are low. Abundance must be large enough within populations and distributed in such a way that local stochastic events do not eliminate all individuals, allowing the overall population to recover from any one event. A larger number of individuals provides a greater chance that a portion of the population will survive. The health of “populations” is generally contingent upon reproduction and recruitment (an increase in a natural population as progeny grow and immigrants arrive). We presume that the viability of the tidewater amphipod would be best supported by multiple (redundancy), self-sustaining (resiliency) populations distributed throughout the geographical extent of its range (representation).

THREATS

We define “threat” as any action or condition that is known to, or is reasonably likely to, negatively affect individuals of a species. This includes those actions or conditions that have a direct impact on individuals, as well as those that affect individuals through alteration of their habitat or required resources. The mere identification of “threats” is not sufficient to compel a finding that listing is warranted. Describing the negative effects of the action or condition (i.e., “threats”) in light of the exposure, timing, and scale at the individual, population, and species levels provides a clear basis upon which to make our determination. In determining whether a species meets the definition of an “endangered species” or a “threatened species,” we considered the factors under section 4(a)(1) and assessed the cumulative effect that the threats identified within the factors—as ameliorated or exacerbated by any existing regulatory mechanisms or conservation efforts—will have on the species now and in the foreseeable future.

The primary factors influencing the viability of the tidewater amphipod are those related to water quality and quantity. We evaluated development (i.e., impervious surfaces) as a primary source of changes in water quantity and water quality and described the effect of these factors on the tidewater amphipod. We also evaluated the influences of climate change, especially changes in water quantity, and concluded it would likely not have an impact during the timeframe analyzed (see Service 2020, appendices A and D). We explored numerous other factors (e.g., effects of small population size, collection, predation, disease, recreation, forest management, and other conservation efforts) and determined that they have little to no measurable impact on the species. Therefore, we did not include these factors in our analysis of the current and future condition of the species. For a detailed discussion of the influences on viability and current and future conditions of the tidewater amphipod, see the SSA Report (Service 2020, chapters 3 to 5). The following is a summary of that information.

Water Quality

The water quality of these habitats is influenced by the combination of pollution and development, which provides the opportunity for contaminants to collect in the unconfined aquifers where the tidewater amphipod occurs. Pollutants can enter ground water or surface water from point sources such as single source industrial discharges or wastewater treatment plants; however, most pollutants are introduced through non-point source pollution from stormwater runoff from impervious surface, agriculture, and failing septic systems. Non-point source pollutants include heavy metals, residues of petroleum products, pesticides, salts, sediments, nutrients, and microorganisms such as bacteria and viruses.

It is well documented that impervious cover from development can negatively impact aquatic organisms such as the tidewater amphipod. Development can also result in leakage of septic systems and runoff of fertilizers and pesticides used on lawns. Such organic inputs may increase the food base and attract surface dwelling (epigeal) species, which may invade these eutrophied

habitats and prey upon or compete with ground-water-limited fauna. The widespread use of salt to deice roadways that ends up in stormwater runoff has led to regionally elevated chloride levels that persist for months and have resulted in changes in mortality of aquatic plants and animals (James *et al.* 2003, pp. 703-713, Eaton *et al.* 1999, pp. 125-128). The chloride levels could inhibit denitrification, a process critical for maintaining water quality in the tidewater amphipod's habitats (Groffman *et al.* 1995, pp. 478-481).

Runoff from impervious surfaces after heavy rain events can also result in flooding (Frazer 2005, p. 4, Arnold and Gibbons 1996, p. 245), which can result in erosion and sedimentation (Center for Watershed Protection 2003, pp. 30–33). Erosion and sedimentation could degrade or influence where the spring or seep exits and could decrease the individuals' ability to feed if the spring exit becomes clogged. Sediment transported by storm runoff results in clogging the interstices of gravels in the spring seep, thereby preventing ground water amphipods from using those interstitial spaces for shelter (Culver and Sereg 2004, p. 69).

Forest cover positively impacts growth and abundance of the tidewater amphipod by decreasing stormwater runoff. May *et al.* (1997, pp. 7-8) reported that riparian conditions (such as buffer width, vegetative condition, and longitudinal connectedness of buffer vegetation) were influenced by level of development. Wide buffers (greater than 30 m (98 ft)) were found to decrease as impervious cover increased. Fragmentation of the riparian corridor was related to the increased development as defined by increased impervious cover. Forest land cover reduces the runoff of water, sedimentation, nutrients, and toxicants to maintain more stable flow, water temperature, and to supply organic material to provide food and habitat for aquatic life (Wang *et al.* 1997, p.11).

While we do not know the specific tolerances of the tidewater amphipod to different non-point source pollutants, we believe that increases in nutrients and contaminants from higher levels of impervious surface and agriculture could result in an overall decline in the abundance of tidewater amphipod populations. Increased organic inputs and erosion and sedimentation from stormwater runoff could negatively impact the species as well. Therefore, we find that water quality degradation historically and currently reduces the fitness of individual tidewater amphipods and the overall resiliency of populations. There are instances of landfills located near several occupied sites (i.e., two at Fort Belvoir sites and one at the Smithsonian property); however, we are unaware whether these activities are resulting in measurable contamination of the species' habitat at these three sites. Although the larger watersheds where the tidewater amphipod occurs contain impervious surfaces and agriculture that could lead to increased organic inputs and erosion and sedimentation, an analysis of the land use within 5 miles of each site found that forest was the most common land use. A buffer of 5 miles was used to account for the potential area of influence to the shallow groundwater (see Service 2020, appendix B for further discussion of the land use analysis). The extensive forest buffers that surround most of

the sites help to reduce inputs that could negatively affect water quality. Therefore, we do not believe water quality degradation is occurring to such an extent that populations are at risk of extirpation. Regulatory and conservation programs (e.g., the Chesapeake Bay Total Maximum Daily Load limit, which ensures water quality standards, and state programs that minimize losses of forest resources), while not eliminating water quality degradation, do help address nutrient and sediment pollution throughout the species' range.

Water Quantity

Sufficient water quantity is the most important factor affecting viability of the tidewater amphipod. The habitat provided by the unconfined aquifers must have adequate space for feeding, breeding, and sheltering. It is also important due to its influence on water flow patterns, temperature, oxygen, and nutrient content (Mosslacher 1998, p. 349).

The recharge zone(s) for the tidewater amphipod could be directly affected by construction of additional impervious cover, such as roadways, parking lots or buildings, and houses. Impervious surfaces from development can affect water quantity; decreased infiltration can result in depletion of ground water reserves, and ultimately cause springs to dry up over time (Frazer 2005, p. 3). As impervious surface increases, surface water increases in volume and velocity while infiltration and soil percolation decreases. The recharge zones of the unconfined aquifers can also be affected by ground water withdrawal from agriculture, golf courses, and shallow wells at residential houses (pers. comm., A. Staley 2019).

Most drinking water in the Coastal Plain is obtained from confined aquifers. However, there is a connection between the shallow ground water and the deeper confined aquifers. The reduction of volume of ground water in the subsurface can lead to subsidence and reduction in surface-water and spring flows (Bartolino and Cunningham 2003, entire). Increased development can reduce water quantity through an increased demand for water and more ground water pumping. Increased development also increases the risk of springs being filled or forest removed on private lands. Removal of forest in recharge areas can further decrease infiltration and increase erosion and sedimentation, thus contributing to the degradation of water quality as described above.

We assume that the tidewater amphipod can adapt to low water levels by residing in pore space of sediments or burrowing in the underlying clay layer of a spring or seep. Reduced flows or no visible flow is often observed in the summer and fall months at springs and seeps in Maryland and Virginia (pers. comm., D. Feller and C. Hobson 2017). However, long-term reductions of water quantity could result in a decrease of unconfined aquifer habitat and decreased oxygen conditions, which could decrease abundance of the tidewater amphipod (Mosslacher 1998, pp. 356 and 360). Currently, state ground water management laws offer some protection to these habitats by limiting water withdrawals via permitting systems where proposals are subject to review.

Summary of Factors Influencing the Species

Water quantity and water quality are the primary factors influencing the species rangewide. While we do not believe that decreased conditions in either of these factors would result in extirpation of sites, there could be decreased fitness and declines in resiliency due to potential for changes in species composition due to degraded water quality. Water quantity is likely a more important factor than water quality in that adequate space and water chemistry (oxygen) is needed for feeding, breeding, and sheltering for population growth to occur.

CURRENT CONDITION

For this assessment, we considered what the species needs to maintain viability by characterizing the biological status of the species in terms of its resiliency, redundancy, and representation. For additional information, see chapter 1 of the SSA Report (Service 2020, pp. 2-3). To assess the resiliency of the tidewater amphipod, we identified nine analytical units and assigned condition categories to each analytical unit using one demographic and two habitat factors: occurrences per survey effort, water quantity, and water quality. The analytical units selected were 8-digit HUC watersheds where surveys were conducted. We considered each survey point to be a distinct population, except in cases where we could assume sites were connected (sites found within the same 5-acre (2-hectare) drainage area with no barriers in between). The 8-digit HUC watershed was chosen as the analysis unit because looking at this geographic scale provided a meaningful way to group populations, analyze habitat factors, and determine threats. Water quantity was evaluated using mean annual ground water recharge, and water quality was evaluated by looking at percent development. Twice as much weight was given to the water quantity ranking, due to its importance to population resiliency.

Survey data ranging from 1984 to 2017 suggest that current distribution for the tidewater amphipod is within the Coastal Plain physiographic province, starting north in Anne Arundel County, Maryland, and ranging south through Suffolk County, Virginia, with 38 extant populations (redundancy) and 4 populations where the status is unknown. The species has been collected from four habitat types (representation). The number of occurrences per survey effort, sufficient mean annual ground water recharge, and low levels of development contribute to six of the nine analytical units being in high to moderate condition. These high-moderate condition ratings indicate that the species likely has some resiliency to withstand stochastic events. Despite uncertainty in our knowledge of the historical condition of the species, we assume that current resiliency, redundancy, and representation have all decreased slightly from the historical condition.

FUTURE CONDITION

For the purposes of this assessment, we defined viability as the ability of the species to sustain itself in the wild over a biologically meaningful timeframe. For this assessment, we evaluate the tidewater amphipod's future condition for a range of plausible future scenarios. We first identified the primary factors likely to influence the species in the future (i.e., water quality and water quantity) and developed plausible scenarios to explore how these factors are likely to change in the future. Multiple scenarios and time steps were used to account for uncertainty related to the magnitude and timing of changes in these factors. We then assessed the likely species response to these changes in water quality and quantity. The result of the analysis is a description of future resiliency, redundancy, and representation under two scenarios and three time steps (2030, 2060, and 2090). The scenarios are based on the Intergovernmental Panel on Climate Change (IPCC) Emissions Scenarios (A2, B1). They were developed without any assigned probabilities or likelihood, so both are equally possible (Nakicenovic *et al.* 2000, p. 11).

Scenarios¹:

- **Scenario 1:** The IPCC A2 scenario is economically focused, with extremely high population growth, predicting the global population will reach 15 billion by 2100. Under this scenario there are high energy demands and slow improvements to energy efficiency. There is greater conversion of resource lands (forests, wetlands) to anthropogenic uses (urban, agricultural) (Sohl *et al.* 2014, p. 1017).
- **Scenario 2:** The IPCC B1 scenario is environmentally focused, with more moderate population growth, expected to reach 8.7 billion globally by 2050, and then declining to 7 billion by 2100. There is a focus on smart urban growth and innovations in energy use and efficiency. Under this scenario there is less urban growth, and only a moderate increase in agricultural lands (Sohl *et al.* 2014, p.1022).

A recent dataset from the U.S. Geological Survey (USGS) was used to assess future development up to 2090 in the tidewater amphipod analysis units. Land use assumptions were downscaled from global scale to national (U.S.) scale to ecoregions, to make sure magnitude of changes were realistic and consistent with the storylines of the emissions scenarios (Sohl *et al.* 2014, p. 1018-1019). These future projections of land use were used to create a spatially referenced dataset for the Chesapeake Bay watershed (Krause and Maloney 2019, entire).

To evaluate how water quality and water quantity could change throughout the analysis units in the future, the development scenarios above were used to estimate how much increase might occur over time. The condition category values used to determine the current condition of water quality in each analysis unit remained the same for the future conditions (0- to 10-percent developed- high future condition, 11- to 39-percent developed- moderate future condition, greater than 40-percent developed- low future condition). For water quantity, the amount of

¹ Please refer to the SSA Report (Service 2020, pp. 30-36) for complete descriptions of these scenarios.

development was used to infer future recharge rates. The condition category values used to determine the future condition in each analysis unit were slightly different from water quality, due to the uncertainties when dealing with ground water. The future condition categories for water quantity were: 0- to 25-percent developed-high future condition (stable recharge rates from current condition, sufficient flow); 26- to 49-percent developed-moderate future condition (reduced recharge rates); greater than 50-percent developed-low future condition (insufficient recharge rate).

In watersheds where the amount of development is currently high (low condition), we assumed that the future condition would not change because it is not likely that there would be removal of existing development. In watersheds where development is currently low or moderate (high or moderate condition), we analyzed the future condition using the USGS dataset (Krause and Maloney 2019, entire) to determine whether there were changes in condition.

We have high confidence that development and associated impervious surface can increase pollutant loads, and high confidence that increases in population growth can lead to increased impervious surface. We expect the amount of development and impervious surface within the tidewater amphipod range to increase in the future but have only moderate confidence in the amount of increase due to uncertainty in how population increases will translate to resource use and land development. Future land use is dependent on population growth as well as local and national policies. Although there is uncertainty on the specific water quality tolerances of the species, we have moderate confidence that increases in nutrients, sediments, and other pollutants can result in the decline in abundance of populations, due to more pollutant-tolerant species being favored.

Future Resiliency

The tables below summarize the results of the future condition analysis and how resiliency changes from the current condition. To analyze the future demographic condition, we assume occurrence will decrease if both habitat factors move to low. We are somewhat confident that declines in both habitat factors will need to occur before populations will be affected. When the amount of development in a watershed increases above 40 or 50 percent, we would expect that water quality and quantity would be affected, respectively, leading to decreases in species abundance within each population. Based on our future analysis, the resiliency of tidewater amphipod populations within some analytical units begins to decrease by 2030 under both scenarios (see tables 1 and 2). By 2030, for both scenarios, only one analytical unit has a high rating, five have a moderate rating, and three have a low rating. These rankings remain the same through 2060 under both scenarios, and to 2090 under Scenario 2. Resiliency is decreased further by 2090 in Scenario 1, with one analytical unit rating high, three rating moderate, and five rating low.

Table 1. Comparison of current condition overall rating to Scenario 1 overall ratings.

Scenario 1				
Analysis Unit	Current Overall Rating	Future Overall Rating (2030)	Future Overall Rating (2060)	Future Overall Rating (2090)
Great Wicomico-Piankatank	moderate	Moderate	Moderate	moderate
Pocomoke-Western Lower Delmarva	high	High	High	high
Severn	high	Moderate	Moderate	low
Patuxent	high	Moderate	Moderate	moderate
Lower Potomac	low	Low	Low	low
Lower Rappahannock	moderate	Moderate	Moderate	moderate
Lower James	moderate	Moderate	Moderate	low
Middle Potomac-Anacostia-Occoquan	low	Low	Low	low
Hampton Roads	low	Low	Low	low

Table 2. Comparison of current condition overall rating to Scenario 2 overall ratings.

Scenario 2				
Analysis Unit	Current Overall Rating	Future Overall Rating (2030)	Future Overall Rating (2060)	Future Overall Rating (2090)
Great Wicomico-Piankatank	moderate	Moderate	Moderate	moderate
Pocomoke-Western Lower Delmarva	high	High	High	high
Severn	high	Moderate	Moderate	moderate
Patuxent	high	Moderate	Moderate	moderate
Lower Potomac	low	Low	Low	low
Lower Rappahannock	moderate	Moderate	Moderate	moderate
Lower James	moderate	Moderate	Moderate	moderate
Middle Potomac-Anacostia-Occoquan	low	Low	Low	low
Hampton Roads	low	Low	Low	low

Future Redundancy

While we have a high level of uncertainty for what level of water quality and water quantity is needed to sustain populations over time, we can assume that the risk of sites being extirpated is higher for the analytical units that are projected to have an overall low condition, and we could expect to lose some sites in those units, which would decrease redundancy.

Future Representation

Very little is known about the species' genetic diversity and future research may inform us about potential genetic variation within the species. In terms of environmental diversity, the species is able to use various habitat types and likely has the ability to disperse to interstitial spaces in the sediment pore space or the underlying clay layer of the spring and seep when their habitat dries. In the future, it is likely that the species will continue to rely on these adaptive capacities in response to changes in habitat conditions. However, the potential loss of sites could result in reduced genetic diversity and a reduction in representation.

Key Uncertainties

Given the limited information about the tidewater amphipod's biology and needs, we made a number of assumptions to complete the SSA analysis. Our assumptions were informed by information from similar species, best professional judgement, and other surrogate data (e.g., surface habitat quality parameters), but may have resulted in us overestimating or underestimating the species' viability. The key uncertainties associated with our assumptions include the following (see also Service 2020, chapter 6):

1. We state that the statuses of the four historical sites are unknown. If they are still occupied, we underestimate current resiliency, representation, and redundancy.
2. There is no population abundance data available for the species, and we assume that individuals observed are part of a population.
3. We assume that the species is represented in the unconfined aquifer habitats as robust, stable population analysis units. If we are wrong, our analysis overestimates viability.
4. We assume that water quantity has more of an impact on population resiliency than water quality.
5. We assume that the species total range is represented by the current 38 populations. If there are other populations that have not been discovered (such as on private lands), we underestimate resiliency, representation and redundancy.
6. We have no information on how stressors directly impact the tidewater amphipod and rely on literature pertaining to other aquatic systems and other fauna to inform our assumptions about how the stressors influence the species' response.

SUMMARY OF THREATS

The primary influencing factors likely to have population- or species-level effects include changes to ground water quality and quantity. We identified development (impervious surface) as a primary source of changes in water quantity and water quality degradation. We explored numerous other factors (e.g., climate change, effects of small population size, collection, predation, disease, recreation, forest management, and other conservation efforts) and determined that they had little to no measurable impact on the species.

The population size of the tidewater amphipod is unknown. The current distribution of the tidewater amphipod is within the Coastal Plain physiographic province, starting north in Anne Arundel County, Maryland, and ranging south through Suffolk County, Virginia, with 38 extant populations (redundancy), and four populations with an unknown condition. The species has been collected from four habitat types (representation). The number of occurrences per survey effort (demographic condition) was evaluated in addition to the habitat condition (mean annual ground water recharge as a measure of water quantity and percent development as a measure of water quality) for nine analytical units. Six of the nine analytical units are currently in high to moderate condition, which aids the species in withstanding stochastic events (resiliency). Despite uncertainty in our knowledge of the historical distribution of the species, we assume that current resiliency, redundancy, and representation have all decreased slightly from the historical condition with some loss of sites due to development or land use change.

Our future analysis focused on the impact of development on water quantity and water quality, two key needs of the tidewater amphipod. Changes in land use were predicted by the IPCC Emissions Scenarios (A2, B1) and their projected impacts on development for three time steps (2030, 2060, and 2090). Based on our future analysis, the resiliency of tidewater amphipod populations begins to decrease by 2030 under both scenarios. Resiliency is decreased further by 2090 in Scenario 1. For watersheds that had an overall low rating, we assume that there is a higher risk of sites within those watersheds being extirpated, resulting in decreases in redundancy and representation of the species. The species displays adaptive capacity through the use of different habitat types and the ability to disperse to wet microclimates under drought conditions. This adaptive capacity is likely to help the species sustain populations into the future. While a catastrophic event could impact populations (e.g., contaminant spill, forest pest) it would likely occur in only one analytical unit at any one time. Therefore, we believe that there is sufficient resiliency, representation, and redundancy for the species to remain viable into the future (up to 2090).

FINDING

Standard for Review

Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species meets the definition of an endangered species or a threatened species. The Act defines “endangered species” as a species “in danger of extinction throughout all or a significant portion of its range,” and “threatened species” as a species “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” The Act requires that we determine whether a species meets the definition of “endangered species” or “threatened species” because of any of the following factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) Overutilization for commercial, recreational, scientific, or educational purposes; (C) Disease or predation; (D) The inadequacy of existing regulatory mechanisms; or (E) Other natural or manmade factors affecting its continued existence.

Summary of Analysis

The biological information that serves as the basis for our finding is presented in detail in our SSA Report for the tidewater amphipod (Service 2020, entire) and is summarized above under the **BIOLOGICAL INFORMATION** section of this Species Assessment Form. In our SSA, we evaluated all threats to the tidewater amphipod, which fall under Factor A of section 4(a)(1) of the Act and include activities that affect water quality and quantity. We also evaluated existing regulatory mechanisms (Factor D) for the tidewater amphipod in the context of relevant threats and determined that regulation and conservation programs, while not eliminating water quality degradation, do help address nutrient and sediment pollution throughout the species’ range. We evaluated the impacts of collection (Factor B), disease and predation (Factor C), forest management (Factor D), recreation (Factor E), and the effects of climate change (Factors A and E), and other conservation efforts on the tidewater amphipod and determined that they had little to no measurable impact on the species over the time period analyzed. Lastly, we were unable to obtain specific information about the tidewater amphipod’s population size and were therefore unable to consider it as part of the species’ current or future condition. We do acknowledge that our assumption that the species exists as a population, based on limited survey data, is a key uncertainty that has implications to our assumptions regarding the effects of small population size, collection, and predation, as well as the species’ current and future conditions.

To make the determination whether the tidewater amphipod warrants protection as an endangered or threatened species under the Act, we evaluated the threats using a future scenario analysis in which we predicted the effects of a range of plausible projected future threat scenarios on the species. As described below, we first evaluated whether the tidewater amphipod is in danger of extinction throughout its range (an endangered species). Second, we evaluated whether the species is likely to become in danger of extinction throughout its range within the foreseeable future (a threatened species). Third and finally, we considered whether the tidewater amphipod is an endangered or threatened species throughout a significant portion of its range.

Status Throughout All of Its Range

After evaluating threats to the species and assessing the cumulative effect of the threats under the section 4(a)(1) factors, we evaluated the tidewater amphipod's current viability to determine if it meets the definition of an endangered species. The tidewater amphipod is found in a variety of habitat types across multiple watersheds and occurs in 38 populations across 180 miles, which is an indication that the species has redundancy. Water quantity and water quality are the primary factors influencing the species rangewide, and six of the nine units analyzed are in high to moderate condition. We believe there could be decreased fitness and declines in resiliency caused by changes in species composition due to reduced water quality. In response to the greater threat of reduced water quantity, there is evidence that the tidewater amphipod can burrow deeper underground for periods of time and reemerge when sufficient water levels return. While representation is assumed to have decreased when compared to historical conditions, this is based on changes in land use over time rather than observed data. Where repeated surveys have been conducted (Fort A.P. Hill in Virginia and the Smithsonian Environmental Center and Nanjemoy Nature Preserve in Maryland), the tidewater amphipod has persisted over decades, which supports the idea that the species can withstand stochastic events and indicates population resiliency. Considering the future scenarios, the majority of populations do not appear to have a high risk of development occurring, and the impact to the species caused by impervious surfaces will not increase substantially in the near-term future. Thus, the threats appear to have low imminence and magnitude such that they are not significantly affecting the species' ability to persist. The SSA Report describes many uncertainties in the species occurrence, populations, and response to threats; but, considering the available data, the risk of extinction is low. Therefore, we conclude that the tidewater amphipod is not in danger of extinction throughout all of its range and does not meet the definition of an endangered species.

Under the Act, a threatened species is any species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The Act does not define the term "foreseeable future," which appears in the statutory definition of "threatened species." Our implementing regulations at 50 CFR 424.11(d) set forth a framework for evaluating the foreseeable future on a case-by-case basis. The term foreseeable future extends only so far into the future as the Services can reasonably determine that both the future threats and the species' responses to those threats are likely. In other words, the foreseeable future is the period of time in which we can make reliable predictions. "Reliable" does not mean "certain;" it means sufficient to provide a reasonable degree of confidence in the prediction. Thus, a prediction is reliable if it is reasonable to depend on it when making decisions. A key statutory difference between a threatened species and an endangered species is the timing of when the relevant threats would begin acting upon a species such that it may be in danger of extinction, either now (endangered species) or in the foreseeable future (threatened species).

In considering the foreseeable future as it relates to the status of the tidewater amphipod, we considered the relevant risk factors (threats/stressors) acting on the species and whether we could draw reliable predictions about the species' response to these factors. We considered whether we could reliably assess the risk posed by the threats to the species, recognizing that our ability to assess risk is limited by the variable quantity and quality of available data about effects to the tidewater amphipod and its response to those effects.

The SSA's analysis of future scenarios over a 70-year timeframe is consistent with and encompasses the best available information for the: (1) tidewater amphipod's past and current persistence (i.e., resiliency); (2) future projections of human populations; and (3) changes in impervious surface cover (i.e., development) data. Considering land use changes caused by development in the future scenarios, both threats of reduced water quality and quantity would not change the conditions of most of the tidewater amphipod populations by the year 2090. There is a low probability of losing populations in parts of its range where development pressure is low, while a small number of sites closer to future development zones could be extirpated. The threat of climate change was analyzed but was determined to have little impact to the tidewater amphipod through the year 2090. As discussed earlier, the potential for the species to burrow underground for periods of time and reemerge when conditions are suitable could mean that it is capable of adapting to the effects of a changing climate that are most likely to impact its habitat. Thus, after assessing the best available information, we determine that the tidewater amphipod is not in danger of extinction now or likely to become so in the foreseeable future throughout all of its range.

Status Throughout a Significant Portion of Its Range

Under the Act and our implementing regulations, a species may warrant listing if it is in danger of extinction or likely to become so in the foreseeable future throughout all or a significant portion of its range. Having determined that the tidewater amphipod is not in danger of extinction or likely to become so in the foreseeable future throughout all of its range, we now consider whether it may be in danger of extinction or likely to become so in the foreseeable future in a significant portion of its range—that is, whether there is any portion of the species' range for which it is true that both (1) the portion is significant; and, (2) the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. Depending on the case, it might be more efficient for us to address the “significance” question or the “status” question first. We can choose to address either question first. Regardless of which question we address first, if we reach a negative answer with respect to the first question that we address, we do not need to evaluate the other question for that portion of the species' range.

In undertaking this analysis for the tidewater amphipod, we choose to address the significance question first—we consider whether any portions of the species' range may be significant based

on their biological importance to the species.

For the tidewater amphipod, we reviewed the nine analytical units we identified in the SSA Report and other geographic regions within the overall range of the species and considered whether any portion may be significant based on their biological importance to the viability of the species. For the purposes of this analysis, when considering whether any of these portions may be biologically significant, we considered whether each portion may (1) occur in a unique habitat or ecoregion for the species, (2) contain high quality or high value habitat relative to the remaining portions of the range for the species' continued viability in light of the existing threats, or (3) contain habitat that is essential to a specific life-history function for the species and that is not found in the other portions (*e.g.*, the principal breeding ground for the species). The tidewater amphipod occurs in a variety of interstitial ground water habitat types distributed across the species' range. There is little evidence to suggest that there is a portion of the range with higher quality or higher value habitat or of special importance to the species' life history. We considered if any portions contribute to the biological significance in any way not listed above and did not find any portion that was more prominent or noteworthy. Collectively, the nine analytical units contribute to the overall viability of the tidewater amphipod in similar ways but no individual unit or geographic region contributes more than any other, nor is any unit or geographic region unique in some way that makes it more important to the viability of the species. Based on the best available scientific information, we find that no portion of the species' range is biologically significant. Therefore, no portion of the species' range can provide a basis for determining that the species is in danger of extinction now or likely to become so in the foreseeable future in a significant portion of its range, and we find the species is not in danger of extinction now or likely to become so in the foreseeable future in any significant portion of its range. This is consistent with the courts' holdings in *Desert Survivors v. Department of the Interior*, No. 16-cv-01165-JCS, 2018 WL 4053447 (N.D. Cal. Aug. 24, 2018), and *Center for Biological Diversity v. Jewell*, 248 F. Supp. 3d, 946, 959 (D. Ariz. 2017).

Determination of Status

Our review of the best available scientific and commercial information indicates that the tidewater amphipod does not meet the definition of an endangered species or a threatened species in accordance with sections 3(6) and 3(20) of the Act. Therefore, we find that listing the tidewater amphipod is not warranted at this time.

RECOMMENDED CONSERVATION MEASURES: Not applicable

We request that you submit any new information concerning the status of, including threats to, the tidewater amphipod to our Chesapeake Bay Field Office (see **ADDRESSES** section of the

Federal Register Notice for the 12-month and discretionary status assessment finding) whenever it becomes available. New information will help us monitor this species and encourage its conservation. If an emergency situation develops for the species, we will act promptly to provide protection.

DESCRIPTION OF MONITORING

Monitoring for the tidewater amphipod is not conducted regularly. The last surveys in habitats where the species was targeted or discovered incidentally to another target species were completed in 2017.

COORDINATION WITH STATES

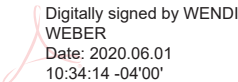
While conducting our SSA for the tidewater amphipod, we closely coordinated with Natural Heritage Programs in the Virginia Department of Conservation and Recreation and in the Maryland Department of Natural Resources.

LITERATURE CITED

See the references cited section of the Species Status Assessment for the tidewater amphipod (*Stygobromus indentatus*), Version 1.1. April 2020. Hadley, MA.

APPROVAL/CONCURRENCE

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: WENDI WEBER  Digitally signed by WENDI WEBER
Date: 2020.06.01 10:34:14 -04'00'

Regional Director, Fish and Wildlife Service _____
Date _____

Concur: _____
Director, Fish and Wildlife Service _____
Date _____

Do not concur: _____
Director, Fish and Wildlife Service _____
Date _____

Director's Remarks:

Date of annual review: June 2020

Conducted by: North Atlantic Appalachian Regional Office