**ATTACHMENT 1-12: Biological Information on Listed Species of Aquatic Invertebrates and Model Parameterization for Pesticide Effects Determinations**

1. **Introduction**

The purpose of this document is to summarize available information for currently listed, proposed and candidate aquatic invertebrate species (from the US Fish and Wildlife Service and the National Marine Fisheries Service). The focus of this effort is to capture information that may be used in ecological risk assessments of pesticides to make species-specific effects determinations to be included in biological evaluations submitted for consultation under section 7 of the Endangered Species Act. This report focuses on defining parameters, such as diet and habitat, which may be used to estimate pesticide exposures to listed aquatic invertebrates. This report also focuses on defining species characteristics that may be used to assess potential indirect effects to the species.

A formal quality assurance and quality control plan was implemented in the collection of species-specific data. The instructions for extracting information for aquatic invertebrates are included in **SUPPLEMENTAL INFORMATION 1**. A template for the worksheet used to record relevant biological information for each species is provided in **SUPPLEMENTAL INFORMATION 2**. **SUPPLEMENTAL INFORMATION 3** contains the completed worksheets containing biological information on each listed aquatic invertebrate species.

This document considers 27 crustaceans (amphipods, isopods, crayfish and shrimp), 33 gastropods (snails), and 88 bivalves (mussels and clams) which are federally listed as endangered and threatened (listed) species, subspecies or populations under the Endangered Species Act (ESA) and occur in the United States, its territories and its waters. In addition, there are 17 species (4 insects, 2 crustaceans, 6 bivalves, 6 snails) that are candidates or proposed for listing (**Table A-12.1**). All other invertebrate species classified as proposed have both an aquatic and a terrestrial-phase and are discussed in **ATTACHMENT 1-20: Terrestrial Invertebrate Report**. Of the endangered and threatened species, 36 clams/mussels, 11 crustaceans, and 14 snails have designated critical habitat. These species will be considered in the national level risk assessments for carbaryl, chlorpyrifos, diazinon, malathion and methomyl. A list of species considered is in **Table A-12.2**. This assessment does not consider species listed as “foreign”. This is because they occur outside of the action area for pesticide registrations in the US. This assessment also does not consider species populations designated as experimental non-essential. There may be subsequent listing designations after this report was generated which are not considered.

**Table A-12.1. Number of listed aquatic invertebrates by status.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Number of listings** | | | |
| **Endangered** | **Threatened** | **Candidate** | **Proposed** |
| Clams/Mussels | 75 | 13 | 6 | 0 |
| Crustaceans | 23 | 4 | 1 | 1 |
| Snails | 26 | 7 | 6 | 0 |
| Insects | 3 | 1 | 4 | 0 |
| Total | 124 | 25 | 17 | 1 |

**Table A-12.2. Listed species of aquatic invertebrates included in pesticide effects determinations.**

| **Scientific Name** | **Common Name** | **Group** | **Family** | **Listing Status** | **Critical Habitat?** | **USFWS Species ID EntityID** |
| --- | --- | --- | --- | --- | --- | --- |
| *Alasmidonta atropurpurea* | Cumberland elktoe | Clams/Mussels | Unionidae | E | No | 355 |
| *Alasmidonta heterodon* | Dwarf wedgemussel | Clams/Mussels | Unionidae | E | No | 363 |
| *Alasmidonta raveneliana* | Appalachian elktoe | Clams/Mussels | Unionidae | E | Yes | 354 |
| *Amblema neislerii* | Fat threeridge (mussel) | Clams/Mussels | Unionidae | E | Yes | 375 |
| *Ambrysus amargosus* | Ash Meadows naucorid | Insect | Naucoridae | T | Yes | 439 |
| *Antrobia culveri* | Tumbling Creek cavesnail | Snails | Hydrobiidae | E | Yes | 406 |
| *Antrolana lira* | Madison Cave isopod | Crustaceans | Cirolanidae | T | Yes | 476 |
| *Arkansia wheeleri* | Ouachita rock pocketbook | Clams/Mussels | Unionidae | E | No | 343 |
| *Assiminea pecos* | Pecos assiminea snail | Snails | Assimineidae | E | Yes | 1245 |
| *Athearnia anthonyi* | Anthony's riversnail | Snails | Pleuroceridae | E | No | 396 |
| *Branchinecta conservatio* | Conservancy fairy shrimp | Crustaceans | Branchinectidae | E | Yes | 490 |
| *Branchinecta longiantenna* | Longhorn fairy shrimp | Crustaceans | Branchinectidae | E | Yes | 491 |
| *Branchinecta lynchi* | Vernal pool fairy shrimp | Crustaceans | Branchinectidae | T | Yes | 493 |
| *Branchinecta sandiegonensis* | San Diego fairy shrimp | Crustaceans | Branchinectidae | E | Yes | 495 |
| *Brychius hungerfordi* | Hungerford’s crawling water beetle | Insect | Haliplidae | E | No | 441 |
| *Cambarus aculabrum* | Cave crayfish | Crustaceans | Cambaridae | E | Yes | 489 |
| *Cambarus callainus* | Big Sandy crayfish | Crustaceans | Cambaridae | T | No | 5153 |
| *Cambarus veteranus* | Guyandotte River crayfish | Crustaceans | Cambaridae | E | No | 11201 |
| *Cambarus zophonastes* | Cave crayfish | Crustaceans | Cambaridae | E | Yes | 488 |
| *Campeloma decampi* | Slender campeloma | Snails | Viviparidae | E | No | 417 |
| *Capnia arapahoe* | Arapahoe snowfly | Insects | Capniidae | C | No | 10130 |
| *Cumberlandia monodonta* | Spectaclecase (mussel) | Clams/Mussels | Margaritiferidae | E | No | 4490 |
| *Cyprogenia stegaria* | Fanshell | Clams/Mussels | Unionidae | E | No | 368 |
| *Dromus dromas* | Dromedary pearlymussel | Clams/Mussels | Unionidae | E | No | 334 |
| *Elimia crenatella* | Lacy elimia (snail) | Snails | Pleuroceridae | T | No | 411 |
| *Elimia melanoides* | Black mudalia | Snails | Pleuroceridae | C | No | 8434 |
| *Elliptio chipolaensis* | Chipola slabshell | Clams/Mussels | Unionidae | T | Yes | 386 |
| *Elliptio spinosa* | Altamaha Spinymussel | Clams/Mussels | Unionidae | E | Yes | 4210 |
| *Elliptio steinstansana* | Tar River spinymussel | Clams/Mussels | Unionidae | E | No | 351 |
| *Elliptoideus sloatianus* | Purple bankclimber (mussel) | Clams/Mussels | Unionidae | T | Yes | 366 |
| *Epioblasma brevidens* | Cumberlandian combshell | Clams/Mussels | Unionidae | E | Yes | 353 |
| *Epioblasma capsaeformis* | Oyster mussel | Clams/Mussels | Unionidae | E | Yes | 358 |
| *Epioblasma florentina curtisii* | Curtis pearlymussel | Clams/Mussels | Unionidae | E | No | 333 |
| *Epioblasma florentina florentina* | Yellow blossom (pearlymussel) | Clams/Mussels | Unionidae | E | No | 322 |
| *Epioblasma florentina walkeri (=E. walkeri)* | Tan riffleshell | Clams/Mussels | Unionidae | E | No | 346 |
| *Epioblasma metastriata* | Upland combshell | Clams/Mussels | Unionidae | E | Yes | 367 |
| *Epioblasma obliquata obliquata* | Purple Cat's paw (=Purple Cat's paw pearlymussel) | Clams/Mussels | Unionidae | E | No | 323 |
| *Epioblasma obliquata perobliqua* | White catspaw (pearlymussel) | Clams/Mussels | Unionidae | E | No | 324 |
| *Epioblasma othcaloogensis* | Southern acornshell | Clams/Mussels | Unionidae | E | Yes | 365 |
| *Epioblasma penita* | Southern combshell | Clams/Mussels | Unionidae | E | No | 348 |
| *Epioblasma torulosa gubernaculum* | Green blossom (pearlymussel) | Clams/Mussels | Unionidae | E | No | 319 |
| *Epioblasma torulosa rangiana* | Northern riffleshell | Clams/Mussels | Unionidae | E | No | 374 |
| *Epioblasma torulosa torulosa* | Tubercled blossom (pearlymussel) | Clams/Mussels | Unionidae | E | No | 320 |
| *Epioblasma triquetra* | Snuffbox mussel | Clams/Mussels | Unionidae | E | No | 5281 |
| *Epioblasma turgidula* | Turgid blossom (pearlymussel) | Clams/Mussels | Unionidae | E | No | 321 |
| *Erinna newcombi* | Newcomb's snail | Snails | Lymnaeidae | T | Yes | 418 |
| *Fusconaia burkei* | Tapered pigtoe | Clams/Mussels | Unionidae | T | Yes | 6534 |
| *Fusconaia cor* | Shiny pigtoe | Clams/Mussels | Unionidae | E | No | 339 |
| *Fusconaia cuneolus* | Finerayed pigtoe | Clams/Mussels | Unionidae | E | No | 337 |
| *Fusconaia escambia* | Narrow pigtoe | Clams/Mussels | Unionidae | T | Yes | 7177 |
| *Fusconaia rotulata* | Round Ebonyshell | Clams/Mussels | Unionidae | E | yes | 7363 |
| *Gammarus acherondytes* | Illinois cave amphipod | Crustaceans | Gammaridae | E | Yes | 484 |
| *Gammarus desperatus* | Noel's Amphipod | Crustaceans | Gammaridae | E | Yes | 1261 |
| *Gammarus hyalleloides* | Diminutive Amphipod | Crustaceans | Gammaridae | E | Yes | 8172 |
| *Gammarus pecos* | Pecos amphipod | Crustaceans | Gammaridae | E | Yes | 6596 |
| *Haliotis cracherodii* | Black Abalone | Snails | Haliotidae | E | Yes | 10013 |
| *Haliotis sorenseni* | White Abalone | Snails | Haliotidae | E | No | 8462 |
| *Hamiota australis* | Southern sandshell | Clams/Mussels | Unionidae | T | Yes | 7349 |
| *Heterelmis comalensis* | Comal Springs riffle beetle | Insects | Elmidae | E | Yes | 453 |
| *Heterelmis stephani* | Stephan's Riffle beetle | Insects | Elmidae | C | No | 2767 |
| *Hemistena lata* | Cracking pearlymussel | Clams/Mussels | Unionidae | E | No | 359 |
| *Juturnia kosteri* | Koster's springsnail | Snails | Hydrobiidae | E | Yes | 1247 |
| *Lampsilis abrupta* | Pink mucket (pearlymussel) | Clams/Mussels | Unionidae | E | No | 331 |
| *Lampsilis altilis* | Finelined pocketbook | Clams/Mussels | Unionidae | T | Yes | 372 |
| *Lampsilis bracteata* | Texas fatmucket | Clams/Mussels | Unionidae | C | No | 10038 |
| *Lampsilis higginsii* | Higgins eye (pearlymussel) | Clams/Mussels | Unionidae | E | No | 325 |
| *Lampsilis perovalis* | Orangenacre mucket | Clams/Mussels | Unionidae | T | Yes | 357 |
| *Lampsilis powellii* | Arkansas fatmucket | Clams/Mussels | Unionidae | T | No | 369 |
| *Lampsilis rafinesqueana* | Neosho Mucket | Clams/Mussels | Unionidae | E | Yes | 4086 |
| *Lampsilis streckeri* | Speckled pocketbook | Clams/Mussels | Unionidae | E | No | 360 |
| *Lampsilis subangulata* | Shinyrayed pocketbook | Clams/Mussels | Unionidae | E | Yes | 373 |
| *Lampsilis virescens* | Alabama lampmussel | Clams/Mussels | Unionidae | E | No | 326 |
| *Lanx sp.* | Banbury Springs limpet | Snails | Lymnaeidae | E | No | 409 |
| *Lasmigona decorata* | Carolina heelsplitter | Clams/Mussels | Unionidae | E | Yes | 370 |
| *Lednia tumana* | Meltwater lednian stonefly | Insects | Nemouridae | C | No | 1849 |
| *Lemiox rimosus* | Birdwing pearlymussel | Clams/Mussels | Unionidae | E | No | 332 |
| *Lepidurus packardi* | Vernal pool tadpole shrimp | Crustaceans | Caenestheriidae | E | Yes | 494 |
| *Leptodea leptodon* | Scaleshell mussel | Clams/Mussels | Unionidae | E | No | 345 |
| *Leptoxis ampla* | Round rocksnail | Snails | Pleuroceridae | T | No | 416 |
| *Leptoxis foremani* | Interrupted (=Georgia) Rocksnail | Snails | Pleuroceridae | E | Yes | 2561 |
| *Leptoxis plicata* | Plicate rocksnail | Snails | Pleuroceridae | E | No | 415 |
| *Leptoxis taeniata* | Painted rocksnail | Snails | Pleuroceridae | T | No | 414 |
| *Lepyrium showalteri* | Flat pebblesnail | Snails | Hydrobiidae | E | No | 413 |
| *Lioplax cyclostomaformis* | Cylindrical lioplax (snail) | Snails | Viviparidae | E | No | 412 |
| *Lirceus usdagalun* | Lee County cave isopod | Crustaceans | Asellidae | E | Yes | 486 |
| *Margaritifera hembeli* | Louisiana pearlshell | Clams/Mussels | Unionidae | T | No | 364 |
| *Margaritifera marrianae* | Alabama pearlshell | Clams/Mussels | Margaritiferidae | E | Yes | 4411 |
| *Medionidus acutissimus* | Alabama moccasinshell | Clams/Mussels | Unionidae | T | Yes | 380 |
| *Medionidus parvulus* | Coosa moccasinshell | Clams/Mussels | Unionidae | E | Yes | 381 |
| *Medionidus penicillatus* | Gulf moccasinshell | Clams/Mussels | Unionidae | E | Yes | 384 |
| *Medionidus simpsonianus* | Ochlockonee moccasinshell | Clams/Mussels | Unionidae | E | Yes | 385 |
| *Megalagrion xanthomelas* | Orangeblack Hawaiian damselfly | Insects | Coenagrionidae | C | No | 6867 |
| *Obovaria retusa* | Ring pink (mussel) | Clams/Mussels | Unionidae | E | No | 341 |
| *Orconectes shoupi* | Nashville crayfish | Crustaceans | Cambaridae | E | Yes | 478 |
| *Pacifastacus fortis* | Shasta crayfish | Crustaceans | Cambaridae | E | Yes | 479 |
| *Palaemonetes cummingi* | Squirrel Chimney Cave shrimp | Crustaceans | Palaemonidae | T | Yes | 487 |
| *Palaemonias alabamae* | Alabama cave shrimp | Crustaceans | Atyidae | E | Yes | 480 |
| *Palaemonias ganteri* | Kentucky cave shrimp | Crustaceans | Atyidae | E | Yes | 482 |
| *Pegias fabula* | Littlewing pearlymussel | Clams/Mussels | Unionidae | E | No | 335 |
| *Physa natricina* | Snake River physa snail | Snails | Physidae | E | No | 399 |
| *Planorbella magnifica* | Magnificent ramshorn | Snails | Planorbidae | C | No | 1358 |
| *Plethobasus cicatricosus* | White wartyback (pearlymussel) | Clams/Mussels | Unionidae | E | No | 336 |
| *Plethobasus cooperianus* | Orangefoot pimpleback (pearlymussel) | Clams/Mussels | Unionidae | E | No | 340 |
| *Plethobasus cyphyus* | Sheepnose Mussel | Clams/Mussels | Unionidae | E | No | 7816 |
| *Pleurobema clava* | Clubshell | Clams/Mussels | Unionidae | E | No | 352 |
| *Pleurobema collina* | James spinymussel | Clams/Mussels | Unionidae | E | No | 361 |
| *Pleurobema curtum* | Black clubshell | Clams/Mussels | Unionidae | E | No | 347 |
| *Pleurobema decisum* | Southern clubshell | Clams/Mussels | Unionidae | E | No | 378 |
| *Pleurobema furvum* | Dark pigtoe | Clams/Mussels | Unionidae | E | Yes | 382 |
| *Pleurobema georgianum* | Southern pigtoe | Clams/Mussels | Unionidae | E | Yes | 383 |
| *Pleurobema gibberum* | Cumberland pigtoe | Clams/Mussels | Unionidae | E | No | 376 |
| *Pleurobema hanleyianum* | Georgia pigtoe | Clams/Mussels | Unionidae | E | Yes | 3833 |
| *Pleurobema marshalli* | Flat pigtoe | Clams/Mussels | Unionidae | E | No | 349 |
| *Pleurobema perovatum* | Ovate clubshell | Clams/Mussels | Unionidae | E | No | 377 |
| *Pleurobema plenum* | Rough pigtoe | Clams/Mussels | Unionidae | E | No | 338 |
| *Pleurobema pyriforme* | Oval pigtoe | Clams/Mussels | Unionidae | E | Yes | 371 |
| *Pleurobema strodeanum* | Fuzzy pigtoe | Clams/Mussels | Unionidae | T | Yes | 1369 |
| *Pleurobema taitianum* | Heavy pigtoe | Clams/Mussels | Unionidae | E | No | 350 |
| *Pleurocera foremani* | Rough hornsnail | Snails | Pleuroceridae | E | yes | 3364 |
| *Pleuronaia dolabelloides* | Slabside Pearlymussel | Clams/Mussels | Unionidae | E | Yes | 6841 |
| *Popenaias popei* | Texas Hornshell | Clams/Mussels | Unionidae | C | No | 2917 |
| *Potamilus capax* | Fat pocketbook | Clams/Mussels | Unionidae | E | No | 342 |
| *Potamilus inflatus* | Alabama (=inflated) heelsplitter | Clams/Mussels | Unionidae | T | No | 356 |
| *Procaris hawaiana* | Anchialine pool Shrimp | Crustaceans | Procarididae | P | No | 2929 |
| *Pseudotryonia adamantina* | Diamond Tryonia | Snails | Hydrobiidae | E | Yes | 4437 |
| *Ptychobranchus greenii* | Triangular Kidneyshell | Clams/Mussels | Unionidae | E | Yes | 379 |
| *Ptychobranchus jonesi* | Southern kidneyshell | Clams/Mussels | Unionidae | E | Yes | 7949 |
| *Ptychobranchus subtentum* | Fluted kidneyshell | Clams/Mussels | Unionidae | E | Yes | 1559 |
| *Pyrgulopsis (=Marstonia) pachyta* | Armored snail | Snails | Hydrobiidae | E | No | 402 |
| *Pyrgulopsis bernardina* | San Bernardino springsnail | Snails | Hydrobiidae | T | Yes | 1380 |
| *Pyrgulopsis bruneauensis* | Bruneau Hot springsnail | Snails | Hydrobiidae | E | No | 404 |
| *Pyrgulopsis chupaderae* | Chupadera springsnail | Snails | Hydrobiidae | E | Yes | 4162 |
| *Pyrgulopsis neomexicana* | Socorro springsnail | Snails | Hydrobiidae | E | No | 408 |
| *Pyrgulopsis ogmorhaphe* | Royal marstonia (snail) | Snails | Hydrobiidae | E | No | 401 |
| *Pyrgulopsis roswellensis* | Roswell springsnail | Snails | Hydrobiidae | E | Yes | 1246 |
| *Pyrgulopsis texana* | Phantom Springsnail | Snails | Hydrobiidae | E | Yes | 4479 |
| *Pyrgulopsis thompsoni* | Huachuca springsnail | Snails | Hydrobiidae | C | No | 6739 |
| *Pyrgulopsis trivialis* | Three Forks Springsnail | Snails | Hydrobiidae | E | Yes | 4766 |
| *Quadrula aurea* | Golden orb | Clams/Mussels | Unionidae | C | No | 10039 |
| *Quadrula cylindrica cylindrica* | Rabbitsfoot | Clams/Mussels | Unionidae | T | Yes | 3645 |
| *Quadrula cylindrica strigillata* | Rough rabbitsfoot | Clams/Mussels | Unionidae | E | No | 344 |
| *Quadrula fragosa* | Winged Mapleleaf | Clams/Mussels | Unionidae | E | No | 328 |
| *Quadrula houstonensis* | Smooth pimpleback | Clams/Mussels | Unionidae | C | No | 9969 |
| *Quadrula intermedia* | Cumberland monkeyface (pearlymussel) | Clams/Mussels | Unionidae | E | yes | 330 |
| *Quadrula petrina* | Texas pimpleback | Clams/Mussels | Unionidae | C | No | 9968 |
| *Quadrula sparsa* | Appalachian monkeyface (pearlymussel) | Clams/Mussels | Unionidae | E | No | 329 |
| *Quadrula stapes* | Stirrupshell | Clams/Mussels | Unionidae | E | No | 362 |
| *Spelaeorchestia koloana* | Kauai cave amphipod | Crustaceans | Talitridae | E | Yes | 485 |
| *Streptocephalus woottoni* | Riverside fairy shrimp | Crustaceans | Branchinectidae | E | Yes | 492 |
| *Stygobromus (=Stygonectes) pecki* | Peck's cave amphipod | Crustaceans | Crangonyctidae | E | Yes | 477 |
| *Stygobromus hayi* | Hay's Spring amphipod | Crustaceans | Crangonyctidae | E | Yes | 475 |
| *Stygobromus kenki* | Kenk's amphipod | Crustaceans | Crangonyctidae | C | No | 5714 |
| *Stygoparnus comalensis* | Comal Springs dryopid beetle | Insects | Dryopidae | E | Yes | 454 |
| *Syncaris pacifica* | California freshwater shrimp | Crustaceans | Palaemonidae | E | Yes | 481 |
| *Taylorconcha serpenticola* | Bliss Rapids snail | Snails | Hydrobiidae | T | No | 398 |
| *Thermosphaeroma thermophilus* | Socorro isopod | Crustaceans | Sphaeromatidae | E | Yes | 483 |
| *Toxolasma cylindrellus* | Pale lilliput (pearlymussel) | Clams/Mussels | Unionidae | E | No | 327 |
| *Truncilla macrodon* | Texas fawnsfoot | Clams/Mussels | Unionidae | C | No | 9967 |
| *Tryonia alamosae* | Alamosa springsnail | Snails | Hydrobiidae | E | No | 403 |
| *Tryonia cheatumi* | Phantom Tryonia | Snails | Hydrobiidae | E | Yes | 6138 |
| *Tryonia circumstriata (=stocktonensis)* | Gonzales tryonia | Snails | Hydrobiidae | E | Yes | 5362 |
| *Tulotoma magnifica* | Tulotoma snail | Snails | Viviparidae | T | No | 407 |
| *Vetericaris chaceorum* | Anchialine pool shrimp | Crustaceans | Procaridae | E | Yes | 5449 |
| *Villosa choctawensis* | Choctaw bean | Clams/Mussels | Unionidae | E | Yes | 4042 |
| *Villosa fabalis* | Rayed Bean | Clams/Mussels | Unionidae | E | No | 6062 |
| *Villosa perpurpurea* | Purple bean | Clams/Mussels | Unionidae | E | Yes | 318 |
| *Villosa trabalis* | Cumberland bean (pearlymussel) | Clams/Mussels | Unionidae | E | No | 317 |
| \*E=endangered; T=threatened, C = candidate | | | | | | |

1. **Diets**

Federally listed (threatened or endangered), candidate and proposed species of aquatic invertebrates consume primarily algae, detritus, organic matter attached to surfaces (periphyton), plankton, and other invertebrates. Feeding strategies are generally consistent across groups where feeding morphologies and life-histories are similar (*i.e*. filter feeding bivalves, or benthic aquatic snails) (**Table A 1-12.3**). **Table A 1-12.4** defines the prey consumed by listed aquatic invertebrates. Some invertebrates are cryptic and have little to no information about their life histories available that would indicate food preference. Prey diet items were divided into categories that were used to assess indirect effects of exposure to pesticides due to reductions in dietary items as a result of pesticide exposure. Additional details and source information are provided in **SUPPLEMENTAL INFORMATION 3**.

Where indicated the algae dietary category indicates periphyton. This dietary item would include diatoms and other organic matter on the habitat surfaces. Detritus is a source of food for many filter feeding organisms. Detritus can be a combination of several prey items including plants, invertebrates, fish as well as other organic matter. Given the complexity and uncertainty of its composition, reductions in detritus are not included in modeling indirect effects of exposure to pesticides. For example, for many cave species, the only dietary information available was related to organic matter washed into caves (i.e. detritus). Where life-history information was not identified for the species, feeding habits were filled in based on other members of the order. There was generally little variation in dietary items within invertebrate groups.

**Table A 1-12.3. Number of listed species by taxa with each dietary item categories.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Dietary item** | | **Clams/Mussels\*** | **Crustaceans** | **Insects** | **Snails** |
| Detritus |  | 94 | 25 | 5 | 27 |
| Plant matter | Algae | 94 | 19 | 3 | 33 |
| Aquatic plants | 0 | 9 | 1 | 3 |
| Invertebrates | Freshwater | 94 | 18 | 1 | 4 |
| Seawater | 0 | 2 | 0 | 0 |
| Vertebrates | Freshwater fish and amphibians | 0 | 2 | 0 | 0 |
| Seawater fish | 0 | 0 | 0 | 0 |
| \*All larval mussels are parasitic. As juvenile/adult filter feeding organisms, they obtain nutrients from any particles in the water, which could be from detritus, algae (including diatoms), water column invertebrates, bacteria, fungi, or organic material sorbed to sediment or other surfaces | | | | | |

**Table A 1-12.4. Dietary items of listed aquatic invertebrates**

| **Scientific Name** | **Common Name** | **USFWS ID** | **Detritus** | **Algae** | **Aquatic Plants** | **FW Inverts** | **SW Inverts** | **FW Fish** | **SW Fish** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Alasmidonta atropurpurea* | Cumberland elktoe | 355 | Yes | Yes | No | Yes | No | Yes | No |
| *Alasmidonta heterodon* | Dwarf wedgemussel | 363 | Yes | Yes | No | Yes | No | Yes | No |
| *Alasmidonta raveneliana* | Appalachian elktoe | 354 | Yes | Yes | No | Yes | No | Yes | No |
| *Amblema neislerii* | Fat threeridge (mussel) | 375 | Yes | Yes | No | Yes | No | Yes | No |
| *Ambrysus amargosus* | Ash Meadows naucorid | 439 | No | No | No | Yes | No | No | No |
| *Antrobia culveri* | Tumbling Creek cavesnail | 406 | No | Yes | No | Yes | No | No | No |
| *Antrolana lira* | Madison Cave isopod | 476 | No | No | No | Yes | No | No | No |
| *Arkansia wheeleri* | Ouachita rock pocketbook | 343 | Yes | Yes | No | Yes | No | Yes | No |
| *Assiminea pecos* | Pecos assiminea snail | 1245 | Yes | Yes | No | Yes | No | No | No |
| *Athearnia anthonyi* | Anthony's riversnail | 396 | Yes | Yes1 | No | No | No | No | No |
| *Branchinecta conservatio* | Conservancy fairy shrimp | 490 | Yes | Yes | No | Yes | No | No | No |
| *Branchinecta longiantenna* | Longhorn fairy shrimp | 491 | Yes | Yes | No | Yes | No | No | No |
| *Branchinecta lynchi* | Vernal pool fairy shrimp | 493 | Yes | Yes | No | Yes | No | No | No |
| *Branchinecta sandiegonensis* | San Diego fairy shrimp | 495 | Yes | Yes | No | Yes | No | No | No |
| *Brychius hungerfordi* | Hungerford’s crawling water beetle | 441 | No | Yes | No | No | No | No | No |
| *Cambarus aculabrum* | Cave crayfish | 489 | Yes | No | No | No | No | No | No |
| *Cambarus callainus* | Big Sandy crayfish | 5153 | Yes | Yes | Yes | Yes | No | Yes | No |
| *Cambarus veteranus* | Guyandotte River crayfish | 11201 | Yes | Yes | Yes | Yes | No | Yes | No |
| *Cambarus zophonastes* | Cave crayfish | 488 | Yes | No | No | No | No | No | No |
| *Campeloma decampi* | Slender campeloma | 417 | Yes | No | No | No | No | No | No |
| *Capnia arapahoe* | Arapahoe snowfly | 10130 | Yes | No | No | No | No | No | No |
| *Cumberlandia monodonta* | Spectaclecase (mussel) | 4490 | Yes | Yes | No | Yes | No | Yes | No |
| *Cyprogenia stegaria* | Fanshell | 368 | Yes | Yes | No | Yes | No | Yes | No |
| *Dromus dromas* | Dromedary pearlymussel | 334 | Yes | Yes | No | Yes | No | Yes | No |
| *Elimia crenatella* | Lacy elimia (snail) | 411 | No | Yes1 | No | No | No | No | No |
| *Elimia melanoides* | Black mudalia | 8434 | Yes | Yes1 | No | No | No | No | No |
| *Elliptio chipolaensis* | Chipola slabshell | 386 | Yes | Yes | No | Yes | No | Yes | No |
| *Elliptio spinosa* | Altamaha Spinymussel | 4210 | Yes | Yes | No | Yes | No | Yes | No |
| *Elliptio steinstansana* | Tar River spinymussel | 351 | Yes | Yes | No | Yes | No | Yes | No |
| *Elliptoideus sloatianus* | Purple bankclimber (mussel) | 366 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma brevidens* | Cumberlandian combshell | 353 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma capsaeformis* | Oyster mussel | 358 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma florentina curtisii* | Curtis pearlymussel | 333 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma florentina florentina* | Yellow blossom (pearlymussel) | 322 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma florentina walkeri (=E. walkeri)* | Tan riffleshell | 346 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma metastriata* | Upland combshell | 367 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma obliquata obliquata* | Purple Cat's paw (=Purple Cat's paw pearlymussel) | 323 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma obliquata perobliqua* | White catspaw (pearlymussel) | 324 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma othcaloogensis* | Southern acornshell | 365 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma penita* | Southern combshell | 348 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma torulosa gubernaculum* | Green blossom (pearlymussel) | 319 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma torulosa rangiana* | Northern riffleshell | 374 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma torulosa torulosa* | Tubercled blossom (pearlymussel) | 320 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma triquetra* | Snuffbox mussel | 5281 | Yes | Yes | No | Yes | No | Yes | No |
| *Epioblasma turgidula* | Turgid blossom (pearlymussel) | 321 | Yes | Yes | No | Yes | No | Yes | No |
| *Erinna newcombi* | Newcomb's snail | 418 | No | Yes1 | Yes | No | No | No | No |
| *Fusconaia burkei* | Tapered pigtoe | 6534 | Yes | Yes | No | Yes | No | Yes | No |
| *Fusconaia cor* | Shiny pigtoe | 339 | Yes | Yes | No | Yes | No | Yes | No |
| *Fusconaia cuneolus* | Finerayed pigtoe | 337 | Yes | Yes | No | Yes | No | Yes | No |
| *Fusconaia escambia* | Narrow pigtoe | 7177 | Yes | Yes | No | Yes | No | Yes | No |
| *Fusconaia rotulata* | Round Ebonyshell | 7363 | Yes | Yes | No | Yes | No | Yes | No |
| *Gammarus acherondytes* | Illinois cave amphipod | 484 | Yes | Yes | No | No | No | No | No |
| *Gammarus desperatus* | Noel's Amphipod | 1261 | Yes | Yes | Yes | No | No | No | No |
| *Gammarus hyalleloides* | Diminutive Amphipod | 8172 | Yes | Yes | Yes | Yes | No | No | No |
| *Gammarus pecos* | Pecos amphipod | 6596 | Yes | Yes | Yes | No | No | No | No |
| *Haliotis cracherodii* | Black Abalone | 10013 | No | Yes | No | No | No | No | No |
| *Haliotis sorenseni* | White Abalone | 8462 | No | Yes | No | No | No | No | No |
| *Hamiota australis* | Southern sandshell | 7349 | Yes | Yes | No | Yes | No | Yes | No |
| *Hemistena lata* | Cracking pearlymussel | 359 | Yes | Yes | No | Yes | No | Yes | No |
| *Heterelmis comalensis* | Comal Springs riffle beetle | 453 | Yes | No | No | No | No | No | No |
| *Heterelmis stephani* | Stephan's Riffle beetle | 2767 | Yes | Yes1 | No | No | No | No | No |
| *Juturnia kosteri* | Koster's springsnail | 1247 | Yes | Yes | Yes | Yes | No | No | No |
| *Lampsilis abrupta* | Pink mucket (pearlymussel) | 331 | Yes | Yes | No | Yes | No | Yes | No |
| *Lampsilis altilis* | Finelined pocketbook | 372 | Yes | Yes | No | Yes | No | Yes | No |
| *Lampsilis bracteata* | Texas fatmucket | 10038 | Yes | Yes | No | Yes | No | Yes | No |
| *Lampsilis higginsii* | Higgins eye (pearlymussel) | 325 | Yes | Yes | No | Yes | No | Yes | No |
| *Lampsilis perovalis* | Orangenacre mucket | 357 | Yes | Yes | No | Yes | No | Yes | No |
| *Lampsilis powellii* | Arkansas fatmucket | 369 | Yes | Yes | No | Yes | No | Yes | No |
| *Lampsilis rafinesqueana* | Neosho Mucket | 4086 | Yes | Yes | No | Yes | No | Yes | No |
| *Lampsilis streckeri* | Speckled pocketbook | 360 | Yes | Yes | No | Yes | No | Yes | No |
| *Lampsilis subangulata* | Shinyrayed pocketbook | 373 | Yes | Yes | No | Yes | No | Yes | No |
| *Lampsilis virescens* | Alabama lampmussel | 326 | Yes | Yes | No | Yes | No | Yes | No |
| *Lanx sp.* | Banbury Springs limpet | 409 | No | Yes1 | Yes | No | No | No | No |
| *Lasmigona decorata* | Carolina heelsplitter | 370 | Yes | Yes | No | Yes | No | Yes | No |
| *Lednia tumana* | Meltwater Lednian stonefly | 1849 | Yes | Yes | Yes | No | No | No | No |
| *Lemiox rimosus* | Birdwing pearlymussel | 332 | Yes | Yes | No | Yes | No | Yes | No |
| *Lepidurus packardi* | Vernal pool tadpole shrimp | 494 | Yes | No | No | Yes | No | No | No |
| *Leptodea leptodon* | Scaleshell mussel | 345 | Yes | Yes | No | Yes | No | Yes | No |
| *Leptoxis ampla* | Round rocksnail | 416 | Yes | Yes1 | No | No | No | No | No |
| *Leptoxis foremani* | Interrupted (=Georgia) Rocksnail | 2561 | Yes | Yes1 | No | No | No | No | No |
| *Leptoxis plicata* | Plicate rocksnail | 415 | Yes | Yes1 | No | No | No | No | No |
| *Leptoxis taeniata* | Painted rocksnail | 414 | Yes | Yes1 | No | No | No | No | No |
| *Lepyrium showalteri* | Flat pebblesnail | 413 | Yes | Yes1 | No | No | No | No | No |
| *Lioplax cyclostomaformis* | Cylindrical lioplax (snail) | 412 | Yes | No | No | No | No | No | No |
| *Lirceus usdagalun* | Lee County cave isopod | 486 | Yes | Yes1 | No | No | No | No | No |
| *Margaritifera hembeli* | Louisiana pearlshell | 364 | Yes | Yes | No | Yes | No | Yes | No |
| *Margaritifera marrianae* | Alabama pearlshell | 4411 | Yes | Yes | No | Yes | No | Yes | No |
| *Medionidus acutissimus* | Alabama moccasinshell | 380 | Yes | Yes | No | Yes | No | Yes | No |
| *Medionidus parvulus* | Coosa moccasinshell | 381 | Yes | Yes | No | Yes | No | Yes | No |
| *Medionidus penicillatus* | Gulf moccasinshell | 384 | Yes | Yes | No | Yes | No | Yes | No |
| *Medionidus simpsonianus* | Ochlockonee moccasinshell | 385 | Yes | Yes | No | Yes | No | Yes | No |
| *Megalagrion xanthomelas* | Orangeblack Hawaiian damselfly | 6867 | No | No | No | Yes | Yes | Yes | Yes |
| *Obovaria retusa* | Ring pink (mussel) | 341 | Yes | Yes | No | Yes | No | Yes | No |
| *Orconectes shoupi* | Nashville crayfish | 478 | Yes | No | No | No | No | No | No |
| *Pacifastacus fortis* | Shasta crayfish | 479 | No | Yes1 | No | Yes | No | No | No |
| *Palaemonetes cummingi* | Squirrel Chimney Cave shrimp | 487 | Yes | No | No | No | No | No | No |
| *Palaemonias alabamae* | Alabama cave shrimp | 480 | Yes | No | No | No | No | No | No |
| *Palaemonias ganteri* | Kentucky cave shrimp | 482 | Yes | Yes1 | No | Yes | No | No | No |
| *Pegias fabula* | Littlewing pearlymussel | 335 | Yes | Yes | No | Yes | No | Yes | No |
| *Physa natricina* | Snake River physa snail | 399 | Yes | Yes1 | No | No | No | No | No |
| *Planorbella magnifica* | Magnificent ramshorn | 1358 | Yes | Yes | No | No | No | No | No |
| *Plethobasus cicatricosus* | White wartyback (pearlymussel) | 336 | Yes | Yes | No | Yes | No | Yes | No |
| *Plethobasus cooperianus* | Orangefoot pimpleback (pearlymussel) | 340 | Yes | Yes | No | Yes | No | Yes | No |
| *Plethobasus cyphyus* | Sheepnose Mussel | 7816 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema clava* | Clubshell | 352 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema collina* | James spinymussel | 361 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema curtum* | Black clubshell | 347 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema decisum* | Southern clubshell | 378 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema furvum* | Dark pigtoe | 382 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema georgianum* | Southern pigtoe | 383 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema gibberum* | Cumberland pigtoe | 376 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema hanleyianum* | Georgia pigtoe | 3833 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema marshalli* | Flat pigtoe | 349 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema perovatum* | Ovate clubshell | 377 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema plenum* | Rough pigtoe | 338 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema pyriforme* | Oval pigtoe | 371 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema strodeanum* | Fuzzy pigtoe | 1369 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurobema taitianum* | Heavy pigtoe | 350 | Yes | Yes | No | Yes | No | Yes | No |
| *Pleurocera foremani* | Rough hornsnail | 3364 | Yes | Yes1 | No | No | No | No | No |
| *Pleuronaia dolabelloides* | Slabside Pearlymussel | 6841 | Yes | Yes | No | Yes | No | Yes | No |
| *Popenaias popei* | Texas Hornshell | 2917 | Yes | Yes | No | Yes | No | Yes | No |
| *Potamilus capax* | Fat pocketbook | 342 | Yes | Yes | No | Yes | No | Yes | No |
| *Potamilus inflatus* | Alabama (=inflated) heelsplitter | 356 | Yes | Yes | No | Yes | No | Yes | No |
| *Procaris hawaiana* | Anchialine pool Shrimp | 2929 | No | No | No | No | Yes | No | No |
| *Pseudotryonia adamantina* | Diamond Tryonia | 4437 | Yes | Yes | No | No | No | No | No |
| *Ptychobranchus greenii* | Triangular Kidneyshell | 379 | Yes | Yes | No | Yes | No | Yes | No |
| *Ptychobranchus jonesi* | Southern kidneyshell | 7949 | Yes | Yes | No | Yes | No | Yes | No |
| *Ptychobranchus subtentum* | Fluted kidneyshell | 1559 | Yes | Yes | No | Yes | No | Yes | No |
| *Pyrgulopsis (=Marstonia) pachyta* | Armored snail | 402 | Yes | Yes1 | No | No | No | No | No |
| *Pyrgulopsis bernardina* | San Bernardino springsnail | 1380 | No | Yes1 | No | No | No | No | No |
| *Pyrgulopsis bruneauensis* | Bruneau Hot springsnail | 404 | Yes | Yes1 | No | No | No | No | No |
| *Pyrgulopsis chupaderae* | Chupadera springsnail | 4162 | Yes | Yes1 | No | No | No | No | No |
| *Pyrgulopsis neomexicana* | Socorro springsnail | 408 | Yes | Yes1 | No | No | No | No | No |
| *Pyrgulopsis ogmorhaphe* | Royal marstonia (snail) | 401 | Yes | Yes1 | No | No | No | No | No |
| *Pyrgulopsis roswellensis* | Roswell springsnail | 1246 | Yes | Yes | No | Yes | No | No | No |
| *Pyrgulopsis texana* | Phantom Springsnail | 4479 | Yes | Yes1 | No | No | No | No | No |
| *Pyrgulopsis thompsoni* | Huachuca springsnail | 6739 | Yes | Yes1 | No | No | No | No | No |
| *Pyrgulopsis trivialis* | Three Forks Springsnail | 4766 | No | Yes1 | No | No | No | No | No |
| *Quadrula aurea* | Golden orb | 10039 | Yes | Yes | No | Yes | No | Yes | No |
| *Quadrula cylindrica cylindrica* | Rabbitsfoot | 3645 | Yes | Yes | No | Yes | No | Yes | No |
| *Quadrula cylindrica strigillata* | Rough rabbitsfoot | 344 | Yes | Yes | No | Yes | No | Yes | No |
| *Quadrula fragosa* | Winged Mapleleaf | 328 | Yes | Yes | No | Yes | No | Yes | No |
| *Quadrula houstonensis* | Smooth pimpleback | 9969 | Yes | Yes | No | Yes | No | Yes | No |
| *Quadrula intermedia* | Cumberland monkeyface (pearlymussel) | 330 | Yes | Yes | No | Yes | No | Yes | No |
| *Quadrula petrina* | Texas pimpleback | 9968 | Yes | Yes | No | Yes | No | Yes | No |
| *Quadrula sparsa* | Appalachian monkeyface (pearlymussel) | 329 | Yes | Yes | No | Yes | No | Yes | No |
| *Quadrula stapes* | Stirrupshell | 362 | Yes | Yes | No | Yes | No | Yes | No |
| *Spelaeorchestia koloana* | Kauai cave amphipod | 485 | Yes | No | No | No | No | No | No |
| *Streptocephalus woottoni* | Riverside fairy shrimp | 492 | Yes | Yes | No | Yes | No | No | No |
| *Stygobromus (=Stygonectes) pecki* | Peck's cave amphipod | 477 | Yes | Yes | Yes | Yes | No | No | No |
| *Stygobromus hayi* | Hay's Spring amphipod | 475 | Yes | Yes | Yes | Yes | No | Yes | No |
| *Stygobromus kenki* | Kenk's amphipod | 5714 | Yes | Yes | Yes | Yes | No | No | No |
| *Stygoparnus comalensis* | Comal Springs dryopid beetle | 454 | Yes | No | No | No | No | No | No |
| *Syncaris pacifica* | California freshwater shrimp | 481 | Yes | Yes | Yes | Yes | No | No | No |
| *Taylorconcha serpenticola* | Bliss Rapids snail | 398 | Yes | Yes1 | No | No | No | No | No |
| *Thermosphaeroma thermophilus* | Socorro isopod | 483 | Yes | Yes1 | No | Yes | No | No | No |
| *Toxolasma cylindrellus* | Pale lilliput (pearlymussel) | 327 | Yes | Yes | No | Yes | No | Yes | No |
| *Truncilla macrodon* | Texas fawnsfoot | 9967 | Yes | Yes | No | Yes | No | Yes | No |
| *Tryonia alamosae* | Alamosa springsnail | 403 | No | Yes1 | No | No | No | No | No |
| *Tryonia cheatumi* | Phantom Tryonia | 6138 | Yes | Yes | No | No | No | No | No |
| *Tryonia circumstriata (=stocktonensis)* | Gonzales tryonia | 5362 | Yes | Yes1 | No | No | No | No | No |
| *Tulotoma magnifica* | Tulotoma snail | 407 | Yes | No | No | No | No | No | No |
| *Vetericaris chaceorum* | Anchialine pool shrimp | 5449 | No | No | No | Yes | No | No | No |
| *Villosa choctawensis* | Choctaw bean | 4042 | Yes | Yes | No | Yes | No | Yes | No |
| *Villosa fabalis* | Rayed Bean | 6062 | Yes | Yes | No | Yes | No | Yes | No |
| *Villosa perpurpurea* | Purple bean | 318 | Yes | Yes | No | Yes | No | Yes | No |
| *Villosa trabalis* | Cumberland bean (pearlymussel) | 317 | Yes | Yes | No | Yes | No | Yes | No |

1. **Exposure models**

For direct effects to aquatic invertebrate species and indirect effects to their dietary items, exposure to pesticides is assessed primarily using the Pesticide Root Zone Model (PRZM5) and the Variable Volume Water Model (VVWM) and Downstream Dilution tools. These tools generate exposure estimates based on the location within the United States (by HUC 2 region) and the type of aquatic habitat (e.g. slow-flowing, shallow freshwater). To apply these tools, detailed range information is used to determine which HUC 2 regions a species occupies, and detailed habitat information is used to assign the species to relevant aquatic habitats. Details of this procedure can be found in **ATTACHMENT 1-6** and **1-10**.

1. **Habitat**

Aquatic invertebrate species occupy saline and freshwater aquatic habitats. Some listed aquatic invertebrate species also spend part of their life stage in a terrestrial environment. For each invertebrate species, the habitat is further defined with species-specific aquatic habitat bins or terrestrial habitats used in exposure models (*e.g*., PRZM5/VVWM, T-Rex, *etc*.). **ATTACHMENT 1-10** includes a description of the procedure for assigning species to aquatic habitat bins and a list of the aquatic bin assignments and terrestrial habitats. More details on habitat, including source information are provided in **SUPPLEMENTAL INFORMATION 3.**

1. **Obligate Relationships**

Listed, proposed, and candidate mussels have a parasitic larval life stage. The mussel larva require a fish host to complete their life cycle and for dispersion. If the larval stage (glochidium) comes into contact with an appropriate fish host, it attaches to the fish's skin, fins, or gills and begins its parasitic stage. Glochidia can neither swim nor crawl, and if a glochidium does not come into contact with a proper fish host, it falls to the bottom and dies. Some species can successfully parasitize only certain species of fish. For these species, when a glochidium attaches to the wrong host, it will eventually be sloughed off and die. Glochidia that successfully attach to a host live on the fish host for a week to several months, depending on the species, water temperature, and other factors. While attached, they receive nutrients from the fish. Eventually, glochidia develop into juvenile naiades and drop from the fish to begin life on the stream bottom.

No other obligate relationships were identified between aquatic invertebrates and other taxonomic groups. In addition to obligate relationships, important ecological relationships between an aquatic invertebrate species and other species may need to be considered. For example, juvenile abalone larvae rely on grazers such as sea urchins to prevent the substrate that they settle upon from becoming overgrown and unsuitable. In cases like this, the species involved are from the same taxonomic group and assessing potential direct effects on one species (abalone) will also address impacts on the grazers (sea urchins) that may then affect the first species. In other cases, the relationship may be treated as an indirect effect (i.e. with the second species identified as a ‘prey’ item). Finally, these relationships may also be considered as potential adverse modifications to habitat.

Tables 7 and 8 identify host fish species for the mussel species considered in this assessment. Species accounts, NatureServe, recent FWS Recovery Plans and 5-Year Reviews, the open literature, and consultation with species experts were used to update and expand the list of known hosts for these species.

Two of the listed mussels, the fat pocketbook (*Potamilus capax)* and the scaleshell mussel (*Leptodea leptodon)*, have an identified obligate relationship with a single host, the freshwater drum (*Aplodinotus grunniens)*. The remaining listed mussels either lack a known obligate relationship with one or more host fish or host fish relationships are unknown. Of the 300 identified North American mussel species, there have been no host fish species identified for a significant percentage, and it is likely that the complement of host fish remains incomplete for many other species. Individual mussel species have been found to have up to 25 fish species known to serve as suitable hosts, though host fish specificity to one species or a group of species related by taxonomy or food guild can be common in mussels.

Mussel species were grouped into categories based upon the number and diversity of known hosts:

1. Known obligates – mussel species of this group are believed to use only a single species of fish as a host

2. Specialists – mussel species of this group either have only 1 or 2 known hosts identified (with no evidence of an obligate relationship) or have only host fish from a single family. These species may be specialists, or generalists for which additional host fish species may exist that have not yet been identified.

3. Generalists – mussel species of this group have 3 or more fish hosts identified from at least 2 different families. Additional host fish species may exist that have not yet been identified.

4. Unknown - no hosts have been identified for these species and may belong in categories 1, 2, or 3

For this assessment, the effects of pesticide exposure on fish species are treated as an indirect effect for listed mussel species identified as Generalist in **Table A 1-12.7** and as a direct effect for all other listed mussel species.

**Table A 1-12.7. Host fish species of mussels.**

|  |  |  |
| --- | --- | --- |
| **Listed Mussel** | **Host Fish** | **Category** |
| **MUSSELS WITH OBLIGATE HOST FISH** | |  |
| Fat Pocketbook  *Potamilus capax* | Freshwater drum | Obligate |
| Scaleshell Mussel  *Leptodea leptodon* | Freshwater drum | Obligate |
| **MUSSELS WITH NO KNOWN OBLIGATE HOST FISH** | |  |
| Cumberland Elktoe  *Alasmidonta atropurpurea* | Rainbow darter  Redline darter  Fantail darter | Generalist |
| Banded sculpin |
| Rock bass |
| Northern hogsucker |
| Longear sunfish |
| Whitetail shiner |
| Dwarf Wedgemussel *Alasmidonta heterodon* | Tesselated darter  Johnny darter | Generalist |
| Roanoke darter |
| Mottled sculpin  Slimy sculpin |
| Atlantic salmon |
| Appalachian Elktoe  *Alasmidonta raveneliana* | Banded sculpin  Mottled sculpin | Specialist |
| Fat Threeridge  *Amblema neislerii* | Blackbanded darter | Generalist |
| Redear sunfish |
| Largemouth bass |
| Weed shiner |
| Bluegill |
| Ouachita Rock Pocketbook *Arkansia wheeleri* | White crappie | Generalist |
| Warmouth  Smallmouth bass |
| Black crappie |
| River carpsucker |
| Longear sunfish  Orangespotted sunfish |
| Freshwater drum |
| Largemouth bass |
| Dusky shiner  Bleeding shiner  Golden shiner  Emerald shiner |
| Green sunfish |
| Bluegill |
| Birdwing Pearlymussel *Conradilla caelata* | Greenside darter  Tennessee snubnose darter  Banded darter | Specialist |
| Fanshell  *Cyprogenia stegaria* | Banded darter  Greenside darter  Tennessee snubnose darter | Generalist |
| Blotchside logperch Logperch  Tangerine darter |
| Mottled sculpin  Banded sculpin |
| Dromedary pearlymussel  *Dromus dromas* | Fantail darter  Banded darter  Tangerine darter  Greenside darter  Tennessee snubnose darter | Generalist |
| Gilt darter  Channel darter  Logperch  Blotchside logperch |
| Black sculpin |
| Chipola Slabshell  *Elliptio chipolaensis* | Bluegill | Specialist |
| Tar River Spinymussel  *Elliptio steinstansana* | Bluehead chub  Satinfin shiner  White shiner  Pinewoods shiner | Specialist |
| Purple Bankclimber  *Elliptoideus sloatianus* | Blackbanded darter | Generalist |
| Eastern mosquitofish |
| Greater Jumprock |
| Guppy |
| Cumberlandian Combshell  *Epioblasma brevidens* | Wounded darter  Redline darter  Bluebreast darter  Snubnose darter  Greenside darter | Generalist |
| Logperch |
| Banded sculpin  Mottled sculpin  Black sculpin |
| Oyster Mussel  *Epioblasma capsaeformis* | Wounded darter  Redline darter  Bluebreast darter  Greenside darter  Fantail darter | Generalist |
| Dusky darter |
| Banded sculpin  Black sculpin  Mottled sculpin |
| Curtis Pearly Mussel *Epioblasma florentina curtisii* | Rainbow darter | Generalist |
| Banded sculpin  Mottled sculpin |
| Yellow Blossom (Pearlymussel)  *Epioblasma florentina florentina* | Not known | Unknown |
| Tan Riffleshell  *Epioblasma florentina walkeri* | Fantail darter  Greenside darter  Redline darter  Snubnose darter | Generalist |
| Banded sculpin  Mottled sculpin |  |
| Upland Combshell  *Epioblasma metastriata* | Not known | Unknown |
| Catspaw (Purple Cat’s Paw Pearlymussel)  *Epioblasma obliquata obliquata* | Blackside darter  Logperch | Generalist |
| Mottled sculpin |
| Rock bass |
| Stonecat |
| White Catspaw Pearlymussel  *Epioblasma obliquata perobliqua* | Not known | Unknown |
| Southern Acornshell  *Epioblasma othcaloogensis* | Not known | Unknown |
| Southern Combshell  *Epioblasma penita* | Not known | Unknown |
| Tubercled Blossom  *Epioblasma torulosa torulosa* | Not known | Unknown |
| Turgid Blossom  *Epioblasma turgidula* | Not known | Unknown |
| Green Blossom  *Epioblasma torulosa gubernaculums* | Not known | Unknown |
| Northern Riffleshell  *Epioblasma turulosa rangiana* | Banded darter  Bluebreast darter  Johhny darter  Iowa darter | Generalist |
| Brown trout |
| Banded sculpin  Mottled sculpin |
| Shiny Pigtoe  *Fusconaia cor* | Whitetail shiner  Common shiner  Warpaint shiner  Telescope shiner | Generalist |
| Fine-rayed Pigtoe  *Fusconaia cuneolus* | Mottled sculpin | Generalist |
| River chub  Central stoneroller Telescope shiner Tennessee shiner  Whitetail shiner |
| Fathead minnow |
| Cracking Pearlymussel *Hemistena lata* | Not known | Unknown |
| Pink Mucket  *Lampsilis abrupta* | Walleye  Sauger | Generalist |
| Spotted bass  Smallmouth bass |
| Freshwater drum |
| Largemouth bass |
| Fine-lined Pocketbook  *Lampsilis altilis* | Redeye bass  Spotted bass | Generalist |
| Largemouth bass |
| Green sunfish |
| Higgins Eye  *Lampsilis higginsii* | Sauger  Walleye | Generalist |
| Smallmouth bass |
| Black crappie |
| Freshwater drum |
| Largemouth bass |
| Yellow perch |
| Orangenacre Mucket  *Lampsilis perovalis* | Chain pickerel | Generalist |
| Redeye bass  Spotted bass |
| Largemouth bass |
| Arkansas Fatmucket  *Lampsilis powelli* | Spotted bass | Specialist |
| Largemouth bass |
| Speckled Pocketbook  *Lampsilis streckeri* | Warmouth  Spotted bass  Smallmouth bass  Shadow bass | Generalist |
| Longear sunfish |
| Green sunfish |
| Bluegill |
| Shinyrayed pocketbook  *Lampsilis subangulata* | Eastern mosquitofish | Generalist |
| Spotted bass |
| Largemouth bass |
| Bluegill |
| Guppy |
| Alabama Lampmussel  *Lampsilis virescens* | Not known | Unknown |
| Carolina Heelsplitter  *Lasmigon decorate* | Not known | Unknown |
| Louisiana Pearlshell *Margaritifera hembeli* | Brown madtom | Generalist |
| Blackspotted topminnow |
| Striped shiner  Redfin shiner  Golden shiner |
| Alabama Moccasinshell  *Medionidus acutissimus* | Tuskaloosa darter  Redfin darter  Blackbanded darter  Southern sand darter Johnny darter  Speckled darter | Generalist |
| Saddleback darter  Naked sand darter  Logperch |
| Blackspotted topminnow |
| Coosa Moccasinshell *Medionidus parvulus* | Blackbanded darter | Specialist |
| Gulf Moccasinshell  *Medionidus penicillatus* | Blackbanded darter  Brown darter | Generalist |
| Eastern mosquitofish |
| Guppy |
| Ochlockonee Moccasinshell *Medionidus simpsonianus* | Not known | Unknown |
| Ring Pink  *Obovaria retusa* | Not known | Unknown |
| Littlewing Pearlymussel  *Pegis fibula* | Redline darter  Greenside darter  Emerald darter | Generlist |
| Banded sculpin |
| White Wartyback  *Plethobasus cicatricosus* | Not known | Unknown |
| Orangefoot Pimpleback *Plethobasus cooperianus* | Not known | Unknown |
| Clubshell  *Pleurobema clava* | Blackside darter  Logperch | Generalist |
| Striped shiner  Central stoneroller |
| James Spinymussel  *Pleurobema collina* | Fantail darter | Generalist |
| Pumpkinseed |
| Bluehead chub  Rosyside dace  Satinfin shiner  Rosefin shiner  Blacknose dace  Central stoneroller Mountain redbelly dace Swallowtail shiner  Common shiner |
| Black Clubshell  *Pleurobema curtum* | Not known | Unknown |
| Southern Clubshell  *Pleurobema decisum* | Blacktail shiner  Alabama shiner  Tricolor shiner | Specialist |
| Dark Pigtoe  *Pleurobema furvum* | Blackspotted topminnow | Generalist |
| Largescale stoneroller  Alabama shiner  Blacktail shiner  Creek chub |
| Southern Pigtoe  *Pleurobema georgianum* | Alabama shiner  Blacktail shiner  Tricolor shiner | Specialist |
| Cumberland Pigtoe  *Pleurobema gibberum* | Telescope shiner  Striped shiner | Specialist |
| Flat Pigtoe  *Pleurobema marshalli* | Not known | Unknown |
| Ovate Clubshell  *Pleurobema perovatum* | Not known | Unknown |
| Rough Pigtoe  *Pleurobema plenum* | Not known | Unknown |
| Oval pigtoe  *Pleurobema pyriforme* | Eastern mosquitofish | Generalist |
| Sailfin shiner |
| Guppy |
| Heavy Pigtoe  *Pleurobema taitianum* | Not known | Unknown |
| Alabama Heelsplitter  *Potamilus inflatus* | Freshwater drum | Specialist |
| Triangular Kidneyshell *Ptychobranchus greeni* | Warrior darter  Tuskaloosa darter Blackbanded darter | Generalist |
| Logperch |
| Rough rabbitsfoot  *Quadrula cylindrical strigillata* | Whitetail shiner  Spotfin shiner  Bigeye chub | Specialist |
| Winged Mapleleaf  *Quadrula fragosa* | Blue catfish | Specialist |
| Channel catfish |
| Cumberland Monkeyface *Quadrula intermedia* | Streamline chub  Blotched chub | Specialist |
| Appalachian Monkeyface  *Quadrula sparsa* | Not known | Unknown |
| Stirrupshell  *Quadrula stapes* | Not known | Unknown |
| Pale Lilliput  *Toxolasma cylindrellus* | Not known | Unknown |
| Purple Bean  *Villosa perpurpurea* | Fantail darter  Greenside darter | Generalist |
| Black sculpin  Mottled sculpin  Banded sculpin |
| Cumberland Bean  *Villosa trabalis* | Fantail darter  Striped darter | Specialist |
| Texas fawnsfoot *Truncilla macrodon* | Freshwater drum | Specialist |
| Fuzzy pigtoe  *Pleurobema strodeanum* | Blacktail shiner | Specialist |
| Tapered pigtoe *Fusconaia burkei* | Blacktail shiner | Specialist |
| Texas fatmucket *Lampsilis bracteata* | Bluehead chub  Flathead catfish | Specialist |
| Texas pimpleback *Quadrula petrina* | Bluehead chub  Flathead catfish  Yellow bullhead | Generalists |
| Neosho Mucket *Lampsilis rafinesqueana* | Largemouth bass  Smallmouth bass  Spotted bass | Generalists |
| Spectaclecase (mussel) *Cumberlandia monodonta* | Bigeye chub  Pealip redhorse  Shorthead redhorse | Generalists |
| Rayed Bean  *Villosa fabalis* | Greenside darter  Largemouth bass  Mottled sculpin  Rainbow darter  Tippecanoe darter | Generalists |
| Rabbitsfoot  *Quadrula cylindrica cylindrica* | Black crappie  Blacktail shiner  Bluntface shiner  Cardinal shiner  Emerald darter  Red shiner  Rosyface shiner  Spotfin shiner  Striped shiner  Banded darter  Banded sculpin  Barcheek darter  Blue catfish  Common logperch  Dusky darter  Fantail darter  Rainbow darter  Redline darter  Stripetail darter | Generalists |
| Fluted kidneyshell *Ptychobranchus subtentum* | Banded darter  Banded sculpin  Barcheek darter  Blue catfish  Common logperch  Dusky darter  Fantail darter  Rainbow darter  Redline darter  Stripetail darter | Generalists |
| Snuffbox mussel *Epioblasma triquetra* | Banded sculpin  Black crappie  Blackside darter  Blackspotted Topminnow  Brook stickleback  Common logperch  Iowa darter  Largemouth bass  Mottled Sculpin  Ozark sculpin  Rainbow darter | Generalists |
| Slabside Pearlymussel *Pleuronaia dolabelloides* | Eastern blacknose dace  Popeye shiner  Rosyface shiner  Saffron shiner  Silver shiner  Striped shiner  Telescope shiner  Tennessee shiner  Warpaint shiner  White shiner  Whitetail shiner | Generalists |
| Sheepnose Mussel *Plethobasus cyphyus* | Many > 20 | Generalists |
| Texas Hornshell *Popenaias popei* | Many > 20 | Generalists |
| Golden orb  *Quadrula aurea* | Not known | Unknown |
| Smooth pimpleback *Quadrula houstonensis* | Not known | Unknown |
| Georgia pigtoe *Pleurobema hanleyianum* | Not known | Unknown |
| Choctaw bean  *Villosa choctawensis* | Not known | Unknown |
| Altamaha Spinymussel Elliptio spinosa | Not known | Unknown |
| Alabama pearlshell *Margaritifera marrianae* | Not known | Unknown |
| Round Ebonyshell *Fusconaia rotulata* | Not known | Unknown |
| Southern kidneyshell *Ptychobranchus jonesi* | Not known | Unknown |
| Narrow pigtoe  *Fusconaia escambia* | Not known | Unknown |

**Table A 1-12.8. Fish species identified as hosts of listed mussels.**

|  |  |  |
| --- | --- | --- |
| **Family** | **Common Name** | **Genus species** |
| Catostomidae |  |  |
|  | Northern hogsucker | *Hypentelium nigricans* |
|  | Greater jumprock | *Moxostoma lachneri* |
| Centrarchidae |  |  |
|  | Shadow bass | *Ambloplites ariommus* |
|  | Rock bass | *Ambloplites rupestris* |
|  | Warmouth | *Chaenobryttus gulosus* |
|  | Green sunfish | *Lepomis cyanellus* |
|  | Bluegill | *Lepomis macrochirus* |
|  | Longear sunfish | *Lepomis megalotis* |
|  | Redear sunfish | *Lepomis microlophus* |
|  | Redeye bass | *Micropterus coosae* |
|  | Smallmouth bass | *Micropterus dolomieu* |
|  | Spotted bass | *Micropterus punctulatus* |
|  | Largemouth bass | *Micropterus salmoides* |
|  | Black crappie | *Pomoxis nigromaculatus* |
| Cottidae |  |  |
|  | Black sculpin | *Cottus baileyi* |
|  | Mottled sculpin | *Cottus bairdii* |
|  | Banded sculpin | *Cottus carolinae* |
|  | Slimy sculpin | *Cottus cognatus* |
| Cyprinidae |  |  |
|  | Central stoneroller | *Campostoma anomalum* |
|  | Largescale stoneroller | *Campostoma oligolepis* |
|  | Rosyside dace | *Clinostomus funduloides* |
|  | Satinfin shiner | *Cyprinella analostana* |
|  | Alabama shiner | *Cyprinella callistia* |
|  | Whitetail shiner | *Cyprinella galactura* |
|  | Spotfin shiner | *Cyprinella spiloptera* |
|  | Tricolor shiner | *Cyprinella trichroistia* |
|  | Blacktail shiner | *Cyprinella venusta* |
|  | Streamline chub | *Erimystax dissimilis* |
|  | Blotched chub | *Erimystax insignis* |
|  | Bigeye chub | *Hybopsis amblops* |
|  | Striped shiner | *Luxilus chrysocephalus* |
|  | Common shiner | *Luxilus cornutus* |
|  | Rosefin shiner | *Lythrurus ardens* |
|  | Pinewoods shiner | *Lythrurus matutinus* |
|  | Redfin shiner | *Lythrurus umbratilis* |
|  | Bluehead chub | *Nocomis leptocephalus* |
|  | River chub | *Nocomis micropogon* |
|  | Golden shiner | *Notemigonus crysoleucas* |
|  | White shiner | *Notropis albeolus* |
|  | Warpaint shiner | *Notropis coccogenis* |
|  | Tennessee shiner | *Notropis leuciodus* |
|  | Swallowtail shiner | *Notropis procne* |
|  | Telescope shiner | *Notropis telescopus* |
|  | Weed shiner | *Notropis texanus* |
|  | Mountain redbelly | *Phoxinus oreas* |
|  | Sailfin shiner | *Pteronotropis hypselopterus* |
|  | Blacknose dace | *Rhinichthys atratulus* |
|  | Creek chub | *Semotilus atromaculatus* |
| Esocidae |  |  |
|  | Chain pickerel | *Esox niger* |
| Fundulidae |  |  |
|  | Blackspotted topminnow | *Fundulus olivaceus* |
| Ictaluridae |  |  |
|  | Blue catfish | *Ictalurus furcatus* |
|  | Channel catfish | *Ictalurus punctatus* |
|  | Stonecat | *Noturus flavus* |
|  | Brown madtom | *Noturus phaeus* |
| Percidae |  |  |
|  | Naked sand darter | *Ammocrypta beanii* |
|  | Emerald darter | *Etheostoma baileyi* |
|  | Warrior darter | *Etheostoma bellator* |
|  | Greenside darter | *Etheostoma blennioides* |
|  | Rainbow darter | *Etheostoma caeruleum* |
|  | Bluebreast darter | *Etheostoma camurum* |
|  | Tuskaloosa darter | *Etheostoma douglasi* |
|  | Brown darter | *Etheostoma edwini* |
|  | Fantail darter | *Etheostoma flabellare* |
|  | Southern sand darter | *Etheostoma meridianum* |
|  | Johnny darter | *Etheostoma nigrum* |
|  | Tesselated darter | *Etheostoma olmstedi* |
|  | Redline darter | *Etheostoma rufilineatum* |
|  | Tennessee snubnose darter | *Etheostoma simoterum* |
|  | Snubnose darter | *Etheostoma simoterum* |
|  | Speckled darter | *Etheostoma stigmaeum* |
|  | Striped darter | *Etheostoma virgatum* |
|  | Wounded darter | *Etheostoma vulneratum* |
|  | Redfin darter | *Etheostoma whipplei* |
|  | Banded darter | *Etheostoma zonale* |
|  | Yellow perch | *Perca flavescens* |
|  | Tangerine darter | *Percina aurantiaca* |
|  | Blotchside logperch | *Percina burtoni* |
|  | Logperch | *Percina caprodes* |
|  | Channel darter | *Percina copelandi* |
|  | Gilt dater | *Percina evides* |
|  | Blackside darter | *Percina maculata* |
|  | Blackbanded darter | *Percina nigrofasciata* |
|  | Roanoke darter | *Percina roanoka* |
|  | Dusky darter | *Percina sciera* |
|  | Saddleback darter | *Percina vigil* |
|  | Fathead minnow | *Pimephales promelas* |
|  | Sauger | *Sander canadensis* |
|  | Walleye | *Sander vitreus* |
| Poecilidae |  |  |
|  | Eastern mosquitofish | *Gambusia holbrooki* |
|  | Guppy | *Poecilia reticulata* |
| Salmonidae |  |  |
|  | Atlantic salmon | *Salmo salar* |
|  | Brown trout | *Salmo trutta* |
| Sciaenidae |  |  |
|  | Freshwater drum | *Aplodinotus grunniens* |

1. **Geographic Ranges of Listed Species**

Listed aquatic invertebrates occur throughout the Unites States. County specific location information for each listed species or subspecies is provided in **SUPPLEMENTAL INFORMATION 3**. More detailed range information from the US Fish and Wildlife Service and National Marine Fisheries Service (e.g. range maps when available) is used to identify which HUC 2 region(s) to use in exposure models and to identify overlap between exposure and species (see **ATTACHMENT 1-6**).

1. **Strategy for grouping species**

In order to efficiently assess the risks of a pesticide to listed aquatic invertebrate species, it is necessary to group them by their defining features that are relevant in the context of the risk assessment framework. There are two major factors that impact the risk of a pesticide to a species: exposure and effects. In terms of effects, relevance of surrogate test species for a listed species may alter the confidence associated with the risk call. Surrogacy is determined by taxonomy, specifically whether toxicity data are available for species within the same order as the listed species. Therefore, species may be grouped according to their order. In terms of exposure, species are also potentially grouped according to similarity of their habitats (**Table A 1-12.2**). A final consideration in this strategy is whether or not a species has an obligate relationship. If a species has an obligate relationship, it may be treated separately from other species. Each group of species will share risk hypotheses and lines of evidence.

**SUPPLEMENTAL INFORMATION 1. Instructions for extracting biological information for listed aquatic invertebrates**

The purpose of this project is to compile biological information on federally listed endangered and threatened, proposed or candidate aquatic invertebrate species. This document contains instructions for extracting relevant biological information on each of these species and a form for entering this information.

**Instructions:**

Step 1. Each individual species and/or subspecies will have information collected and entered on the template (**SUPPLEMENTAL INFORMATION 2**) which will create the species profile. This worksheet will be used to record relevant biological information for one of the listed aquatic invertebrate species or subspecies listed in the table above.

Step 2. Go to the species profile for the species of interest. This can be accessed by searching for the species on the US Fish and Wildlife Service (USFWS), or the National Marine Fisheries Service (NMFS) websites.

USFWS: http://www.fws.gov/endangered

NMFS: http://www.nmfs.noaa.gov/pr/species/esa

Step 3. Biological information is collected from documents hyperlinked on the USFWS or NMFS species profile pages. Information is collected only from service documents and service websites. Some examples of relevant documents include recovery plans, federal register rules designating critical habitat, and completed 5-year reviews. Information from the most recent documents will be given preference, unless there is specific information to indicate that older information is more accurate. All reference resources should be separately saved as pdf files.

Step 4. Extract the following biological information and record in the species spreadsheet (**SUPPLEMENTAL INFORMATION 2**):

Basic Information

* Species common name
* Species scientific name
* DPS or ESU
* Listed status (Endangered/Threatened)
* Designated critical habitat (Yes/No)
* Primary Constituent Elements (PCEs)
* Federal lands and Indian Reservations where species is known to occur
* Locations known to occur (states, county, or region)
* Water body names

Life History

* Population Size
* Does Population Growth or Modeling Information Exist? (Yes/No)
* Does Survival Rate Information Exist? (Yes/No)
* Lifespan (years)
* Type of Reproduction (Sexual/Asexual)
* Reproduction Period (Range in day/month)
* Age of First Reproduction/Maturation (in years)
* Reproduction Frequency
* Reproductive Output Rate Available (Yes/No)
* Sex Ratio Data Provided (Yes/No)
* Egg Fertility Rates Available? (Yes/No)
* Egg Hatching Rates Available? (Yes/No)
* Does Body Growth Information Exist? (Yes/No)
* Larval Body Length (cm)
* Juvenile Body Length (cm)

Biological information is recorded as attributes values and comments on those attributes. An attempt to keep attribute values as clear and concise as possible with further explanation in comments should be made. If information is not available for a particular attribute it is left.

Step 5 For each attribute value or comment, a reference should be placed in the spreadsheet which includes page numbers and a URL link to the PDF. All information that appears in the species worksheet must have a source and must be highlighted in the original document. This is a critical component of the Quality Control (QC) for this project.

Step 6: Quality control (QC) of completed spreadsheets for listed species will involve confirmation all data entered into the spreadsheet accurately reflect the data contained in the original sources, and that all sources are cited.

*Note: Some qualities of life history (e.g. sexual v. asexual reproduction), habitat (e.g benthic, water-column life stages), and/or obligate relationships of a listed species may or may not be explicitly stated in the references documents. These attributes may be inferred from the description of the diet or habitat of the listed species. If during review of the documents and attribute spreadsheet it is determined that the listed species attribute while not explicitly stated but is implied based on the available scientific information the data collection/review scientists may determine these values are appropriate to populate.*

**SUPPLEMENTAL INFORMATION 2: Template for worksheet used to collect biological information on listed aquatic species**

See attached Excel file **Aquatic\_KB\_Worksheet\_Template.xlsx**.

**SUPPLEMENTAL INFORMATION 3. Species and subspecies information for aquatic invertebrates**

This attachment contains a summary of the biological and geographical information available (from the US Fish and Wildlife Service) for aquatic invertebrates species and subspecies.

See **SUPPLEMENTAL INFORMATION 3** Excel file **Compiled Aquatic Invertebrates.xlsx**.