



Fish Inventories of Delaware Water Gap National Recreation Area and Upper Delaware Scenic and Recreational River

Natural Resource Report NPS/ERMN/NRR—2014/864

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ON THE COVER

Top: Delaware River in UPDE (R. Horwitz); bottom left: muskellunge (*Esox masquinongy*) caught in DEWA (P. Overbeck); bottom center: ANS and NPS staff electrofishing in the Delaware River in UPDE (A. Fierro); bottom right: brook trout (*Salvelinus fontinalis*) caught in UPDE (P. Overbeck).

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Abstract

From 2003–2008, the Academy of Natural Sciences (ANS) conducted an inventory of fishes in the Delaware Water Gap National Recreation Area (DEWA) and Upper Delaware Scenic and Recreational River (UPDE). The inventory used a stratified random sampling design supplemented by targeted and opportunistic sampling to determine distribution and abundance of all fish species, with an emphasis on 21 priority species. The ANS captured or observed and identified 11,573 individual fish to species in UPDE and 17,222 in DEWA. There are recent records of 52 species in UPDE (48 caught by the ANS) and 53 species in DEWA (52 caught by the ANS). In total, reports of 59 species were found for UPDE; the source of one of these was not located. Reports of 68 species and one hybrid were found for DEWA. However, documentation for eight of those was not found or was erroneous. Fifteen priority species were documented. Many of these are locally common or widespread in low numbers. A few of the other reported species may occur in the parks as strays. Other records probably refer to misidentifications, data errors, or undocumented failed introductions. The bridle shiner (*Notropis bifrenatus*), which is on the Pennsylvania endangered species list, was found at several sites in Pennsylvania and New Jersey. Permanent backwaters and beaver ponds are an important habitat for this and other uncommon species in the park. Presence of small brook trout indicates reproductive populations in three of the sampled streams. Historical changes in the fish fauna of the parks are discussed in the report.

Executive Summary

From 2003–2008, the Academy of Natural Sciences (ANS) conducted an inventory of fishes in the Delaware Water Gap National Recreation Area (DEWA) and Upper Delaware Scenic and Recreational River (UPDE). Objectives of the inventory were to:

- provide information on 21 priority species which were known to be rare or of uncertain status; a candidate list of species was developed by the National Park Service (NPS) and modified in discussions with knowledgeable individuals prior to the start of sampling.
- provide information on frequency of occurrence of all species, based on a probabilistic sampling design.

Following documentation in both parks of the bridle shiner (*Notropis bifrenatus*), a Pennsylvania endangered species, special studies targeting this species were conducted. These studies are not complete and will be documented in a separate report. However, information on species occurrence from those studies and other ongoing ANS studies are included.

A stratified random sampling design was used. Some sites were targeted for sampling (equivalent to a stratum with one member), with other sites randomly selected from a pre-defined list of sites. The Delaware River was divided into four-mile reaches for sample selection in DEWA and UPDE. Eight reaches at UPDE and five reaches at DEWA were randomly selected for sampling. In addition, three additional reaches were purposely targeted for sampling—the most upstream reach at UPDE, the most downstream reach at DEWA, and the Narrowsburg pool reach at UPDE. In DEWA, five sampling strata were defined: (1) lakes on the Kittatinny Ridge, (2) other lakes, (3) valley floor ponds, (4) other ponds, and (5) streams. In addition, one pond and three streams were targeted for sampling. Other water bodies were sampled to target individual species, to sample different habitat types (e.g., coldwater streams and wetlands), or because of convenience. Sites were sampled using a variety of techniques, as appropriate to the sampling site and target species. The primary techniques were boat and walk-along (similar to tow-barge) electrofishing (Delaware River), backpack electrofishing (Delaware River, streams and many ponds), and seining (Delaware River and many ponds). Gill netting, trapping, dip netting, snorkeling and bankside observations, and angling were also used. Attempts were made to capture and identify all species encountered during sampling. Relatively little special effort was expended to determine abundance of sport species, such as trout and American shad (*Alosa sapidissima*), whose status is relatively well-known. Literature and unpublished data were compiled to determine historical occurrence and supplement records by this survey.

ANS captured or observed and identified to species 11,573 individual fish in UPDE and 17,222 in DEWA. Additional specimens were captured near DEWA and UPDE. In total, the ANS recorded 48 species in UPDE, 52 species in DEWA, one other species just outside UPDE, and one other species just outside DEWA. Records of recent capture of three other species in UPDE were found. Recent capture (by the New York State Department of Environmental Conservation) of an estuarine species, the Atlantic needlefish (*Strongylura marina*), in the East Branch Delaware River represents a stray

which almost certainly moved through both parks. As far as could be determined, three species (eastern mudminnow [*Umbra pygmaea*], bluespotted sunfish [*Enneacanthus gloriosus*], and fathead minnow [*Pimephales promelas*]) had not been documented previously in UPDE, and one species, western mosquitofish (*Gambusia affinis*), in DEWA. The mottled sculpin (*Cottus bairdi*), was collected in this survey [and previously by the United States Environmental Protection Agency (USEPA)] just upstream from UPDE. Among the 20 priority species, 15 species were documented in one or both parks. A few of the other species may occur in the park, probably as rare strays. Other species records probably reflect misidentifications, data errors, or failed introductions. There are no valid records of two of the priority species, ironcolor shiner (*Notropis chalybaeus*) and tadpole madtom (*Noturus gyrinus*), but historic occurrence is possible. Detailed accounts of status of priority species are contained in the main text of this report.

High priority species collected in UPDE include the bridle shiner (three reaches), satinfish shiner (*Cyprinella analostana*) (widespread but in small numbers), gizzard shad (*Dorosoma cepedianum*) (five reaches), bluespotted sunfish (captured in backwater pools adjacent to the river in two reaches), northern hog sucker (*Hypentelium nigricans*) (widespread, but collected in small numbers), comely shiner (*Notropis amoenus*) (five reaches), and eastern mudminnow (in a backwater pool in one reach).

Of the 53 species caught by the ANS in or near DEWA, 44 species were recorded in the mainstem Delaware River. Differences in catch rates among samples containing different habitat types were noted. Several high priority species were caught in DEWA, including blueback herring (*Alosa aestivalis*) (juveniles and adults caught near Poxono Island), gizzard shad (caught near Poxono Island), quillback (*Carpoides cyprinus*) (two reaches), northern hog sucker (four reaches and in several streams), goldfish (*Carassius auratus*) and fathead minnow (in Lake Lenape), slimy sculpin (*Cottus cognatus*) (in two streams), bluespotted sunfish (several sites), eastern mudminnow (in four river reaches and in streams), and bridle shiner, creek chubsucker (*Erimyzon oblongus*), redfin pickerel (*Esox americanus*), and western mosquitofish caught in and near Flat Brook. Several of the high priority shiner species (comely shiner, satinfish shiner and swallowtail shiner [*Notropis procne*]) were widespread, though much less common than other minnows, such as spottail shiner (*Notropis hudsonius*) and fallfish (*Semotilus corporalis*).

A total of 21 species were recorded from ponds and lakes in DEWA. Typically, few species were present in each waterbody. A few species were widespread among the sampled sites, but there were some differences in species occurrence among strata. Pond and lake fauna was typical of stocked ponds, although a few species may have been present in local streams and wetlands before impoundment. Flat Brook was extensively sampled, and 34 species were collected in the system, including a number of priority species. Small brook trout (*Salvelinus fontinalis*), indicative of reproduction, were found in three streams in DEWA.

The fish fauna of the area has changed from a variety of causes, including changes in watershed land use and water quality, construction of small dams, construction of large dams with cold releases, overfishing, introduction of nonnative fishes, and climate trends and cycles. Major effects are:

- establishment of brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) in streams and in portions of the upper Delaware cooled by dam releases;
- introduction of other sport fishes, including the most common predatory fish in the areas;
- introduction of other nonnative species;
- warming of streams due to changes in hydrology, riparian cover, and climate changes, decreasing the abundance of brook trout and possibly slimy sculpin;
- changes in the abundance of migratory and lower Delaware River species due to fishing and downstream water quality blocks, followed by recent increases of some species;
- apparent extirpation of a few coldwater or coolwater species due to blockage by dams and fluctuating downstream temperatures;
- increases in pond and lake habitat by construction of small dams, increasing habitat for several introduced and a few native species, at the expense of stream and wetland habitat.

The abundance of various fish species depend on water temperatures and habitat suitability, which are affected by watershed use, riparian cover, water withdrawals, regulation of dam outflows, and trends in climate. Major changes in these factors have occurred at different times, so the integrated effect of various factors on fishes is difficult to reconstruct. An upstream increase of coldwater species (at least to reaches affected by tailwater releases) seems likely.

Establishment of a number of introduced species could have had major effects on native fish fauna. These could include effects of introduced trout on brook trout, channel catfish on white catfish, and effects of the introduced piscivorous species on forage species or native piscivores such as chain pickerel. However, apparent replacements may be due to changes in habitat suitability rather than competition. Since most of the native species are still present in the system, quantitative historical abundance data would be needed to detect such effects. Other biotic changes, such as recent increases of beaver after historic extirpation, may have significant effects, since beaver ponds were important habitats for some species.

Effects of flow management on the fishes of the Delaware River are a major management issue. Ongoing research is investigating effects of flow management on various species or groups of fish. This study found backwaters and floodplain pools to be important habitats for several species of fish, including the bridle shiner. Flow management will have great effects on these habitats via changes in permanence, connections to the main channel, and habitat conditions.

In addition to the short term effects of flow management on temperatures, depths, and velocities, there may be long-term changes in geomorphology and habitat suitability for various species. The overall effect of the variety of changes occurring in the system, including flow management and withdrawals, species introductions, and climate change remain important areas for future research, as are the status and trends of several rare or potentially declining species.

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Introduction

The Upper Delaware Scenic and Recreational River (UPDE) includes 116 km (72.3 mi) of the main river from its formation at the junction of the East and West Branches in Hancock, NY (river-mile 330.7) to the railroad bridge upstream of Sparrowbush, NY (river-mile 258.4). The upper part of the river, downstream to about Milanville, has moderate gradient, while the gradient is higher in the lower section. Both sections have a mix of riffles, runs, and pools. The upper section is more sinuous, has numerous islands, side channels, and backwaters and has rocky bars at the mouths of tributaries and on the inside of bends. The lower section has fewer backwaters and islands and more continuous riffles. There are several deep pools in the upper river, including a 34-m (113-ft) deep pool at Narrowsburg, and an 18-m (60-ft) pool at Pond Eddy. A number of streams enter the Delaware River in UPDE, including the Lackawaxen River, Mongaup River, and Shohola Creek.

Delaware Water Gap National Recreation Area (DEWA) includes 64 km (40.5 mi) of the Delaware River from near Matamoras, PA (river-mile 250.0), to Slateford Creek, PA (river-mile 209.5), as well as areas on both banks of the river. The river in DEWA has lower gradient than in UPDE, and has numerous islands, side channels, and backwaters. From the northern boundary to Bushkill Creek, the river is bordered on the west by the edge (escarpment) of the Pocono Plateau, which is about 240–365 m (787–1,197 ft) in elevation at the edge of the park. The plateau drops steeply down to flats along the river, which are generally about 100–125 m (328–410 ft) in elevation. In some places, such as the northern edge of the park, there is a secondary terrace about 24 m (79 ft) above the main flat land along the river. On the New Jersey (east) side of the river, there are several northeast/southwest trending parallel ridges and valleys. The northernmost ridge (called Godfrey Ridge on the Pennsylvania side) rises steeply along much of its length in the park, but becomes gentler in the northern part of the park. This ridge rises to about 281 m (922 ft) on the New Jersey side and 346 m (1,194 ft) on the Pennsylvania side (at Shawnee). The Delaware River cuts through this ridge at Wallpack Bend. In the vicinity of the park, the second ridge (Kittatinny Ridge or Blue Mountain) rises to 445 m (1,450 ft) on Mt. Minsi in Pennsylvania and 472 m (1,549 ft) on Mt. Tammany in New Jersey. The ridges are formed of resistant quartzite. Flat Brook flows between Kittatinny Ridge and the northern ridge. On the Pennsylvania side, Bushkill Creek and Brodhead Creek lie north and west of the first ridge. These streams drop steeply from the edge of the plateau to terraces along the river at about 100–125 m (328–410 ft) in elevation. Several of the streams, notably Dingmans Creek and Raymondskill, form sheer waterfalls along this drop. DEWA includes the lower parts of Bushkill Creek and Flat Brook. These streams are relatively large, with low floodplains with backwaters and wetlands. Many of the smaller streams have steep sections on the slopes of the plateau and ridges. Some of these, especially those on the Pocono Plateau, have low gradient sections on the top of the slopes. Many of the smaller streams are intermittent in their lower reaches, as surface flows drain into the alluvium along the valley floor. There are a number of impoundments of various sizes. There are no natural lakes, with the exception of some ponds along the floodplain of the river.

Management of the Delaware River requires a balance between water withdrawals in the upper watershed, downstream water use, and maintaining ecological conditions in the river and in Delaware Bay. New York City withdraws water from the drainage and maintains large reservoirs on the West Branch, the East Branch, and the Neversink River. Releases from the reservoirs produce coldwater conditions in the tailwaters, including the West Branch down to its junction with the Delaware, and the Upper Delaware downstream to about Callicoon. Reservoir releases are managed to meet mandated daily flows at Montague, which is located between UPDE and DEWA. These maintain higher summer flows than would occur without regulation. Variations in releases from the upstream reservoirs lead to variations in river discharge and temperature in the upper river.

In 2003, The Academy of Natural Sciences of Philadelphia (ANS) started an inventory of fishes in DEWA and UPDE. Field work for this project was done from 2003–2007, with most sampling done in 2004–2005. Field work in 2006 and 2007 focused on the bridle shiner (*Notropis bifrenatus*), a rare species found in the inventory. In 2007, the ANS started a study on the bridle shiner funded by the State of Pennsylvania Wild Resource Conservation Program. As part of this study, a number of sites in and near DEWA and UPDE were sampled; relevant sampling results of that study are included here. However, information on the status of the bridle shiner will be documented in a subsequent report and is not included in this report.

The study had two primary objectives:

- To develop and implement a probabilistically based sampling design to allow inferences about distribution of species in the parks.
- To document occurrence and status of high priority species (priority categories I and II in Tables 1, 2, and 3) in the park. The designation of high priority species was based on incomplete information (poor documentation, little recent documentation, etc.) of species known from the parks. The base list of species known from the parks was developed by Richard Evans and is hereafter referred to as the NPS base list. The original list of high priority species was modified in discussions with stakeholders knowledgeable about regional fishes. The modifications removed two exotic species and added several minnow species. Based on discovery of populations of bridle shiner in both parks, special studies targeting this species were conducted under a modification of the original agreement.

Table 1. Common and scientific names and status of fishes reported in Upper Delaware Scenic and Recreational River (UPDE).

| Pr | N | Scientific name | Common name | Code | Historical (<1991) | Recent Occurrence (>1990) | Likely Status |
|-------|------|----------------------------------|------------------------|-------|------------------------------|-------------------------------------|----------------------|
| | Nat | <i>Acipenser oxyrhynchus</i> | Atlantic sturgeon | acoxy | | | stray or ext. |
| II | Nat | <i>Alosa aestivalis</i> | blueback herring | alaes | | | rare or abs. |
| II | Nat | <i>Alosa pseudoharengus</i> | alewife | alpse | NYSDEC, PFBC | ANS | rare |
| IV | Nat | <i>Alosa sapidissima</i> | American shad | alsap | Greeley | ANS | common |
| IV | Int | <i>Ambloplites rupestris</i> | rock bass | amrup | Greeley | ANS | common |
| I | Int? | <i>Amia calva</i> | bowfin | amcal | E | Eel weir | rare |
| II | Nat | <i>Amieurus catus</i> | white catfish | amcat | NYSDEC | | stray, rare, or abs. |
| III | Nat | <i>Amieurus natalis</i> | yellow bullhead | amnat | E | ANS | rare |
| IV | Nat | <i>Amieurus nebulosus</i> | brown bullhead | amneb | Greeley | ANS | uncommon |
| IV | Nat | <i>Anguilla rostrata</i> | American eel | anros | Greeley | ANS | common |
| III | Int? | <i>Campostoma anomalum</i> | stoneroller | caano | | ANS | rare |
| II | Nat | <i>Carpoides cyprinus</i> | quillback | cacyp | | | |
| ex II | Int | <i>Carrasius auratus</i> | goldfish | caaur | | | |
| | Nat | <i>Catostomus catostomus</i> | longnose sucker | cacat | NYSDEC | | ext. |
| IV | Nat | <i>Catostomus commersoni</i> | white sucker | cacom | Greeley | ANS | common |
| ω | Int | <i>Cottus bairdi</i> | mottled sculpin | cobai | | <i>tribs (USEPA, ANS)</i> | stray |
| | Nat | <i>Cottus cognatus</i> | slimy sculpin | cocog | <i>tribs (Greeley)</i> | | stray or abs. |
| II* | Nat | <i>Cyprinella analostana</i> | satinfin shiner | cyana | Greeley, NYSDEC | ANS | uncommon |
| II | Nat | <i>Cyprinella spiloptera</i> | spotfin shiner | cyspi | E | creek confluence (Ross) | local |
| IV | Int | <i>Cyprinus carpio</i> | common carp | cycar | Greeley | ANS | uncommon |
| II | Nat | <i>Dorosoa cepedianum</i> | gizzard shad | docep | NYSDEC, PFBC | ANS | common |
| II | Nat | <i>Enneacanthus gloriosus</i> | bluespotted sunfish | englo | <i>tribs (Greeley)</i> | ANS | common |
| III | Nat | <i>Erimyzon oblongus</i> | creek chubsucker | erobl | <i>ponds, etc. (Greeley)</i> | ANS | local |
| II | Nat | <i>Esox americanus</i> | redfin pickerel | esame | <i>Basher Kill (Greeley)</i> | | |
| | Int | <i>Esox lucius</i> | northern pike | esluc | | | |
| IV | Int | <i>Esox masquinongy</i> | muskellunge | emas | PFBC | ANS | uncommon |
| | | <i>Esox masquinongy x lucius</i> | tiger muskie | exhyb | | | |
| IV | Nat | <i>Esox niger</i> | chain pickerel | esmig | Greeley | ANS | common |
| IV | Nat | <i>Etheostoma olmstedi</i> | tesselated darter | etolm | Greeley | ANS | common |
| IV | Nat | <i>Exoglossum maxillingua</i> | cutlip minnow | exmax | Greeley | ANS | common |
| III | Nat | <i>Fundulus diaphanus</i> | banded killifish | fudia | Greeley | ANS | uncommon |
| | Int | <i>Gambusia affinis</i> | western mosquitofish | gaaff | | | |
| | Nat | <i>Hybognathus regius</i> | eastern silvery minnow | hyreg | <i>East Branch (Greeley)</i> | <i>Swinging Bridge Res (NYSDEC)</i> | stray or abs |
| II | Nat | <i>Hypentelium nigricans</i> | northern hog sucker | hynig | PFBC | ANS | uncommon |

| Pr | N | Scientific name | Common name | Code | Historical (<1991) | Recent Occurrence (>1990) | Likely Status |
|-------|-----|--------------------------------|------------------------|-------|------------------------------|---------------------------|---------------------|
| IV | Int | <i>Ictalurus punctatus</i> | channel catfish | icpun | E | Anglers' logs | local |
| I | Nat | <i>Lampetra appendix</i> | American brook lamprey | laapp | | | |
| | Nat | <i>Lepisosteus osseus</i> | longnose gar | leoss | | | |
| III | Nat | <i>Lepomis auritus</i> | redbreast sunfish | leaur | Greeley | ANS | common |
| III | Int | <i>Lepomis cyanellus</i> | green sunfish | lecy | E | ANS | uncommon |
| IV | Nat | <i>Lepomis gibbosus</i> | pumpkinseed | legib | Greeley | ANS | common |
| IV | Int | <i>Lepomis macrochirus</i> | bluegill | lemac | PFBC, NYSDEC | ANS | uncommon |
| IV | Nat | <i>Luxilus cornutus</i> | common shiner | lucor | Greeley | ANS | common |
| IV | Int | <i>Micropterus dolomieu</i> | smallmouth bass | midol | Greeley | ANS | common |
| IV | Int | <i>Micropterus salmoides</i> | largemouth bass | misal | PFBC, NYSDEC | ANS | uncommon |
| | Nat | <i>Morone americana</i> | white perch | moame | E | | stray or abs |
| IV | Nat | <i>Morone saxatilis</i> | striped bass | mosax | E | ANS | uncommon |
| II | Int | <i>Nocomis micropogon</i> | river chub | nomi | | | |
| IV | Nat | <i>Notemigonus crysoleucas</i> | golden shiner | nocry | Greeley | ANS | common |
| II* | Nat | <i>Notropis amoenus</i> | comely shiner | noamo | Greeley | ANS | uncommon |
| | Int | <i>Notropis atherinoides</i> | emerald shiner | noath | NYSDEC (misid?) | | failed intro or abs |
| I | Nat | <i>Notropis bifrenatus</i> | bridle shiner | nobif | Greeley | ANS | local |
| I | Nat | <i>Notropis chalybaeus</i> | ironcolor shiner | nocha | <i>Basher Kill (Greeley)</i> | | ext or abs |
| III | Nat | <i>Notropis hudsonius</i> | spottail shiner | nohud | Greeley | ANS | common |
| II* | Nat | <i>Notropis procne</i> | swallowtail shiner | nopro | Greeley | ANS | uncommon |
| | Int | <i>Notropis rubellus</i> | rosyface shiner | norub | E (misid?) | | failed intro or abs |
| I | Nat | <i>Noturus gyrinus</i> | tadpole madtom | nogy | <i>Basher Kill (Greeley)</i> | | abs or ext |
| III | Nat | <i>Noturus insignis</i> | margined madtom | noins | Greeley | ANS | common |
| IV | Int | <i>Oncorhynchus mykiss</i> | rainbow trout | onmy | Greeley | ANS | local and stray |
| IV | Nat | <i>Perca flavescens</i> | yellow perch | pefla | Greeley | ANS | common |
| IV | Nat | <i>Percina peltata</i> | shield darter | pepel | Greeley | ANS | uncommon |
| IV | Nat | <i>Petromyzon marinus</i> | sea lamprey | pemar | Greeley | ANS | common |
| II | Nat | <i>Pimephales notatus</i> | bluntnose minnow | pinot | Greeley | ANS | common |
| ex II | Int | <i>Pimephales promelas</i> | fathead minnow | pipro | | ANS | uncommon |
| IV | Int | <i>Pomoxis nigromaculatus</i> | black crappie | ponig | PFBC, NYSDEC | ANS | rare |
| IV | Nat | <i>Rhinichthys atratulus</i> | blacknose dace | rhatr | Greeley | ANS | common |
| IV | Nat | <i>Rhinichthys cataractae</i> | longnose dace | rhcat | Greeley | ANS | common |
| | Int | <i>Salmo salar</i> | Atlantic salmon | sasal | PFBC from introductions | | failed intro |
| IV | Int | <i>Salmo trutta</i> | brown trout | satru | Greeley | ANS | local and stray |
| IV | Nat | <i>Salvelinus fontinalis</i> | brook trout | safon | NYSDEC | ANS | stray |

| Pr | N | Scientific name | Common name | Code | Historical (<1991) | Recent Occurrence (>1990) | Likely Status |
|----|-----|--------------------------------|---------------------|-------|--------------------|-----------------------------|---------------|
| IV | Int | <i>Sander vitreum</i> | walleye | savit | Greeley | ANS | uncommon |
| IV | Nat | <i>Semotilus atromaculatus</i> | creek chub | seatr | Greeley | ANS | uncommon |
| IV | Nat | <i>Semotilus corporalis</i> | fallfish | secor | Greeley | ANS | common |
| | Nat | <i>Strongylura marina</i> | Atlantic needlefish | stmar | | <i>East Branch (NYSDEC)</i> | stray |
| I | Nat | <i>Umbra pygmaea</i> | eastern mudminnow | umpyg | | ANS | local |

Pr: Priority of the species for the inventory (see text).

N: Nativity.

Historical: Lists reports prior to 1991.

Recent Occurrence: Lists reports after 1990.

ANS: Indicates that the species was documented by the Academy of Natural Sciences through July 31, 2008; other sources of data are discussed in the text. Records do not list all reports of the species; recent reports from other sources are listed only where there are no ANS records.

Italics indicate that the species was recorded in tributaries or ponds outside the park.

Likely Status: indicates the authors' best judgment on the current status of the species. For UPDE, records refer to the Delaware River unless stated otherwise. See Table 3 for explanation of terms.

Table 2. Common and scientific names and status of fishes reported in Delaware Water Gap National Recreation Area (DEWA).

| Pr | N | Scientific name | Common name | Code | Historical (<1991) | Recent Occurrence (>1990) | Likely Status |
|-------|------|----------------------------------|------------------------|-------|----------------------------|------------------------------|----------------------|
| | Nat | <i>Acipenser oxyrhynchus</i> | Atlantic sturgeon | acoxy | Arndt, Neversink | | stray or ext |
| II | Nat | <i>Alosa aestivalis</i> | blueback herring | alaes | Arndt, NJDEP | Del R (ANS) | uncommon |
| II | Nat | <i>Alosa pseudoharengus</i> | alewife | alpse | E | | uncertain |
| IV | Nat | <i>Alosa sapidissima</i> | American shad | alsap | NYSDEC | Del R (ANS) | common |
| IV | Int | <i>Ambloplites rupestris</i> | rock bass | amrup | NYSDEC | Del R, streams (ANS) | common |
| I | Int? | <i>Amia calva</i> | bowfin | amcal | PFBC | occ. reports (NJDEP) | rare |
| II | Nat | <i>Amieurus catus</i> | white catfish | amcat | NYSDEC, PFBC, Arndt | | stray or rare |
| III | Nat | <i>Amieurus natalis</i> | yellow bullhead | amnat | Arndt | Del R, ponds (ANS) | uncommon |
| IV | Nat | <i>Amieurus nebulosus</i> | brown bullhead | amneb | NYSDEC | Del R, streams, ponds (ANS) | common |
| IV | Nat | <i>Anguilla rostrata</i> | American eel | anros | NYSDEC | Del R, streams (ANS) | common |
| III | Int? | <i>Campostoma anomalum</i> | stoneroller | caano | E | | rare, ext or abs |
| II | Nat | <i>Carpodes cyprinus</i> | quillback | cacyp | PFBC | Del R (ANS) | uncommon |
| ex II | Int | <i>Carrasius auratus</i> | goldfish | caaur | E | Lake Lenape (ANS) | local |
| | Nat | <i>Catostomus catostomus</i> | longnose sucker | cacat | | | abs |
| IV | Nat | <i>Catostomus commersoni</i> | white sucker | cacom | NYSDEC | Del R, streams, ponds (ANS) | common |
| 9 | Int | <i>Cottus bairdi</i> | mottled sculpin | cobai | | | |
| | Nat | <i>Cottus cognatus</i> | slimy sculpin | cocog | Flat Brook (Arndt) | Flat Brook, Vandermark (ANS) | local |
| II* | Nat | <i>Cyprinella analostana</i> | satinfish shiner | cyana | NYSDEC, Stockholm, USEPA | Del R (ANS) | common |
| II | Nat | <i>Cyprinella spiloptera</i> | spotfin shiner | cyspi | Stockholm, Arndt, etc. | Del R (ANS) | common |
| IV | Int | <i>Cyprinus carpio</i> | common carp | cycar | NYSDEC | Del R, ponds (ANS) | uncommon |
| II | Nat | <i>Dorosoma cepedianum</i> | gizzard shad | docep | NYSDEC, PFBC | Del R (ANS) | common |
| II | Nat | <i>Enneacanthus gloriosus</i> | bluespotted sunfish | englo | Arndt | Del R, streams, ponds (ANS) | uncommon |
| III | Nat | <i>Erimyzon oblongus</i> | creek chubsucker | erobl | Arndt | Flat Brook (ANS) | local |
| II | Nat | <i>Esox americanus</i> | redfin pickerel | esame | pond or stream (Arndt) | Flat Brook (ANS) | local |
| | Int | <i>Esox lucius</i> | northern pike | esluc | Del R (PFBC) | | uncertain |
| IV | Int | <i>Esox masquinongy</i> | muskellunge | esmas | Arndt | Del R (ANS) | uncommon |
| | | <i>Esox masquinongy x lucius</i> | tiger muskie | exhyb | Del R (PFBC) | | uncertain |
| IV | Nat | <i>Esox niger</i> | chain pickerel | esmig | NYSDEC | Del R, streams, ponds (ANS) | common |
| IV | Nat | <i>Etheostoma olmstedi</i> | tesselated darter | etolm | NYSDEC | Del R, streams (ANS) | common |
| IV | Nat | <i>Exoglossum maxillingua</i> | cutlip minnow | exmax | NYSDEC | Del R, streams (ANS) | common |
| III | Nat | <i>Fundulus diaphanus</i> | banded killifish | fudia | NYSDEC | Del R, Bushkill (ANS) | uncommon |
| | Int | <i>Gambusia affinis</i> | western mosquitofish | gaaff | | Flat Brook (ANS) | rare or failed intro |
| | Nat | <i>Hybognathus regius</i> | eastern silvery minnow | hyreg | Arndt (probably erroneous) | | stray or abs |
| II | Nat | <i>Hypentelium nigricans</i> | northern hog sucker | hynig | Flat Brook (Arndt) | Del R, streams (ANS) | uncommon |

| Pr | N | Scientific name | Common name | Code | Historical (<1991) | Recent Occurrence (>1990) | Likely Status |
|-------|-----|--------------------------------|------------------------|--------|-------------------------------|--------------------------------|---------------------|
| IV | Int | <i>Ictalurus punctatus</i> | channel catfish | icpun | Arndt | Del R (ANS) | uncommon |
| I | Nat | <i>Lampetra appendix</i> | American brook lamprey | laapp | Flat Brook (Arndt, USEPA) | Flat Brook (tentative id)(ANS) | rare or abs |
| | Nat | <i>Lepisosteus osseus</i> | longnose gar | leoss | Arndt | | ext |
| III | Nat | <i>Lepomis auritus</i> | redbreast sunfish | leaur | NYSDEC | Del R, streams, ponds (ANS) | common |
| III | Int | <i>Lepomis cyanellus</i> | green sunfish | lecy | <i>Big Flat Brook (Arndt)</i> | pond near Del R (ANS) | local |
| IV | Nat | <i>Lepomis gibbosus</i> | pumpkinseed | legib | NYSDEC | Del R, streams, ponds (ANS) | common |
| IV | Int | <i>Lepomis macrochirus</i> | bluegill | lemac | NYSDEC | Del R, streams, ponds (ANS) | common |
| IV | Nat | <i>Luxilus cornutus</i> | common shiner | lucor | NYSDEC | Del R, streams, ponds (ANS) | common |
| IV | Int | <i>Micropterus dolomieu</i> | smallmouth bass | midol | NYSDEC | Del R, streams (ANS) | common |
| IV | Int | <i>Micropterus salmoides</i> | largemouth bass | misal | NYSDEC | Del R (ANS) | common |
| | Nat | <i>Morone americana</i> | white perch | moame | Arndt | | stray |
| IV | Nat | <i>Morone saxatilis</i> | striped bass | mosax | Arndt | Del R (ANS) | uncommon |
| II | Int | <i>Nocomis micropogon</i> | river chub | nomic | E (misid?) | | failed intro or abs |
| IV | Nat | <i>Notemigonus crysoleucas</i> | golden shiner | nocry | NYSDEC | Del R, streams, ponds (ANS) | common |
| II* | Nat | <i>Notropis amoenus</i> | comely shiner | noamo | NYSDEC, Stockholm | Del R (ANS) | uncommon |
| | Int | <i>Notropis atherinoides</i> | emerald shiner | noath | | | |
| I | Nat | <i>Notropis bifrenatus</i> | bridle shiner | nobif | Flat Brook (Arndt) | Flat Brook (ANS) | local |
| I | Nat | <i>Notropis chalybaeus</i> | ironcolor shiner | nocha | <i>Basher Kill (Greeley)</i> | | abs or ext |
| III | Nat | <i>Notropis hudsonius</i> | spottail shiner | nohud | NYSDEC | Del R, streams (ANS) | common |
| II* | Nat | <i>Notropis procne</i> | swallowtail shiner | noopro | NYSDEC, Stockholm | Del R, Flat Brook (ANS) | common |
| | Int | <i>Notropis rubellus</i> | rosyface shiner | norub | | | |
| I | Nat | <i>Noturus gyrinus</i> | tadpole madtom | nogyr | Misid (ANS coll) | | abs or ext |
| III | Nat | <i>Noturus insignis</i> | Margined madtom | noins | NYSDEC | Del R, streams (ANS) | common |
| IV | Int | <i>Oncorhynchus mykiss</i> | Rainbow trout | onmyk | tribs (Arndt) | Streams (ANS) | local |
| IV | Nat | <i>Perca flavescens</i> | Yellow perch | pefla | NYSDEC, PFBC | Del R, ponds (ANS) | common |
| IV | Nat | <i>Percina peltata</i> | Shield darter | pepel | NYSDEC | Del R, streams (ANS) | uncommon |
| IV | Nat | <i>Petromyzon marinus</i> | Sea lamprey | pemar | NYSDEC | Del R, streams (ANS) | common |
| II | Nat | <i>Pimephales notatus</i> | Bluntnose minnow | pinot | | | |
| ex II | Int | <i>Pimephales promelas</i> | Fathead minnow | pipro | E | ponds (ANS) | local |
| IV | Int | <i>Pomoxis nigromaculatus</i> | Black crappie | ponig | NYSDEC | Del R, ponds (ANS) | common |
| IV | Nat | <i>Rhinichthys atratulus</i> | Blacknose dace | rhatr | NYSDEC | Del R, streams (ANS) | common |
| IV | Nat | <i>Rhinichthys cataractae</i> | Longnose dace | rhcat | NYSDEC | Del R, streams (ANS) | common |
| | Int | <i>Salmo salar</i> | Atlantic salmon | sasal | PFBC from introductions | | failed intro |
| IV | Int | <i>Salmo trutta</i> | Brown trout | satru | NYSDEC | Del R, streams (ANS) | local |
| IV | Nat | <i>Salvelinus fontinalis</i> | Brook trout | safon | tribs (Arndt) | Del R, streams, ponds (ANS) | local |

| Pr | N | Scientific name | Common name | Code | Historical (<1991) | Recent Occurrence (>1990) | Likely Status |
|----|-----|--------------------------------|---------------------|-------|--------------------|-----------------------------|---------------|
| IV | Int | <i>Sander vitreum</i> | Walleye | savit | NYSDEC | Del R (ANS) | uncommon |
| IV | Nat | <i>Semotilus atromaculatus</i> | Creek chub | seatr | NYSDEC | Del R, streams (ANS) | uncommon |
| IV | Nat | <i>Semotilus corporalis</i> | Fallfish | secor | NYSDEC | Del R, streams, ponds (ANS) | common |
| | Nat | <i>Strongylura marina</i> | Atlantic needlefish | stmar | | East Branch (NYSDEC) | stray |
| I | Nat | <i>Umbra pygmaea</i> | Eastern mudminnow | umpyg | E | Del R, ponds (ANS) | uncommon |

Pr: Priority of the species for the inventory (see text).

N: Nativity.

Historical: Lists reports prior to 1991.

Recent Occurrence: Lists reports after 1990.

ANS: Indicates that the species was documented by the Academy of Natural Sciences through July 31, 2008; other sources of data are discussed in the text. Records do not list all reports of the species; recent reports from other sources are listed only where there are no ANS records.

Italics indicate that the species was recorded in tributaries or ponds outside the park.

Likely Status: indicates the authors' best judgment on the current status of the species. For UPDE, records refer to the Delaware River unless stated otherwise. See Table 3 for explanation of terms.

Table 3. Explanation of terms used in Tables 1 and 2.

| Term | Explanation |
|--------------|---|
| common | Widespread in park, frequently in large numbers |
| uncommon | Widespread, but generally in low numbers, although the species may be common in some areas |
| local | Present in a few areas, where the species may be common |
| rare | Very low numbers and very local, or very few records widely scattered over time and locations. |
| stray | Individuals may occasionally move into the river from tributaries, reservoirs or the lower river |
| ext | Probably extirpated |
| abs | Probably never present, except possibly as stray |
| failed intro | Species introduced, but not currently established |
| uncertain | Species may occur in low numbers |
| misid | Records probably based on misidentifications |
| | No record of species in park |
| Nat | Native to Delaware River drainage |
| Int | Introduced to Delaware River drainage |
| E | Species recorded in NPS base list (presumably from before 1991), but source of record not found |
| Pr | Priority for determination of status in ANS inventory |
| I | Highest priority; very poorly known |
| II | Secondary priority; status not well known |
| ex II | In priority II at start of inventory, but priority lowered, following discussions with regional experts |
| II* | Priority raised to II following discussions with regional experts |
| III | Occurrence of species well-documented, but range and abundance not well known |
| IV | Species widespread and well-known in park, of lowest priority for inventory |

Sampling Design

A stratified random sampling design was developed, based on different strata for the main river, streams, and lakes and ponds. Additional sites were targeted for sampling, based on the likelihood that these would support uncommon species, position (e.g., most upstream and downstream river reaches), water chemistry (e.g., acidic ponds), etc. These would be treated as distinct strata with one member in any inferences about the entire population of reaches or water bodies.

- 4-mi reaches of the Delaware River in DEWA and UPDE. Three reaches (uppermost, lowermost, and that containing the Narrowsburg Pool) were designated for sampling; remaining reaches were randomly selected.
- Lakes and ponds were divided into five strata, with one site placed in a unique stratum. Lakes and ponds were distinguished on the basis of size, with a threshold of 2 ha (about 5 ac).
 - Lakes and ponds on the Kittatinny Ridge in New Jersey, since the geology of the ridge may lead to differences in fish assemblages.
 - Catfish Pond.
 - Other lakes.
 - Ponds located on the valley floor of the Delaware River; in most cases, these would be on the floodplain of the river, although a few were on terraces between the valley slope and active floodplain.
 - Other ponds.
- Streams were divided into four strata, including three streams placed in unique strata:
 - Bushkill Creek and Flat Brook were targeted for sampling based on their size.
 - Vancampens Brook was targeted for sampling since it is a relatively large, coldwater stream, with known reproduction by several species of trout.
 - Other streams.

Coldwater streams could not be identified *a priori*. Streams arising in mapped springs were assumed to be coldwater streams, and other coldwater streams were identified during field reconnaissance. Three coldwater streams were sampled.

Streams were divided into three physiographic sections, plateau, slope, and flat (traversing the Delaware River floodplain), following Ross et al. (2003). Separate random selections of streams were done for plateau and flat sections.

In addition to the randomly selected sites, some other sites were sampled, e.g., based on reports of target or unusual species, or since they were near sites on the list. These sites would be treated differently in making population-wide inferences.

Some sites were dry on visitation. These were replaced by other randomly selected sites. In one case (inlet stream to Kittatinny Camp Lake), a stream was impounded. In another (Success Lake), the lake had been drained, but a stream and wetland remained. Both sites were sampled since they could have provided habitat for fish. Mis-classification of two sites was noted after development of the classification. Whittakers Pond, originally classified as a lake, should have been classed as a pond, and an unnamed lake south of Bushkill Creek was originally classed as a pond. Both sites were selected for sampling and were sampled. The results of these samples are included under their proper class.

The number of sites designated for sampling within each stratum was defined *a priori*, based on the number of sites in each stratum and estimates of the faunal richness and variability of various strata. After an initial round of sampling, the allocation of sampling among strata was revised. The number of stream sites was reduced, since many stream reaches were intermittent and many reaches had been previously sampled (Ross et al. 2003). More sites were sampled on Flat Brook and more intensive sampling was designated within river reaches.

Methods

Sampling was done with a variety of techniques appropriate to the type of waterbody sampled and sufficient to sample the range of expected species. Techniques included boat electrofishing (Delaware River), walk-along electrofishing (Delaware River), backpack electrofishing (Delaware River, streams and many ponds), seines (Delaware River, lakes and ponds), gill nets (Delaware River), traps (Delaware River), dip nets (Delaware River, ponds, and wetlands), snorkel and bankside observation (Delaware River, Flat Brook, and other streams and ponds), and angling (Delaware River). Data from a variety of other sources have been compiled as well. The sampling methods used at each site are summarized in Tables 4, 5, and 6.

Boat Electrofishing

Boat electrofishing was done in deeper portions of the Delaware River (pools, runs, and bases of riffles) using a 5.2-m (17-ft) Coffelt electrofishing boat. In 2004 and 2005, sampling was done with a Honda 5000 watt generator, a Coffelt Model 15 VVP controller, and a pair of 70-cm (27.6 in) diameter Wisconsin rings with stainless steel droppers attached to long booms spread off the bow of the boat. The voltage produced by this equipment ranged from 300–500 volts with an output current of 3–10 amps (typically 5 amps) depending on water conductivity. One to six samples per reach were taken using this equipment (three reaches in DEWA and four in UPDE in 2004, two reaches in DEWA in 2005).

In the spring of 2006, the electrofishing boat was fitted with a new electronics system. The new system incorporated a Honda 6000 watt generator with a Smith-Root 5.0 GPP control box and two anode array umbrella droppers. Because of the low conductivity in the Delaware River in both parks, the control box was operated at high range power, 50–1000 volts, 20–60 % pulse width range and 60–120 pulses of DC current/second for optimum electrofishing performance. The output current ranged from 2–6 amps (typically 5 amps) depending on water conductivity. Three to five samples per reach were completed using this equipment in 2006 (one reach in DEWA and five reaches in UPDE). One sample in reach U1 was taken in 2006 by placing the 5.0 GPP Control Box and a smaller generator (Honda 2500 watt) in a 4.3-m (14-ft) Jon boat and sampling with hand held pole anodes off the front of the smaller boat.

Samples were taken following Patrick Center Standard Operating Procedure No.P-14-02.

One crew member operated the boat while two additional crew members used long-handled dip nets with 0.32-cm (0.13-in) square mesh to collect fishes. The fish targeted by this collection method tended to be medium to large individuals. However, all fish affected were netted and placed into a tub on the boat for recovery, identification, and measurement before they were released. Some fish (mainly young-of-year fish) were preserved in 10% formalin for laboratory identification and/or use as voucher specimens. Observed fish which could not be netted were identified and recorded if possible.

Boat electrofishing samples were typically 15.0 min in duration (range 3–110 min) and were taken in an upstream direction. The sample distance (in meters) was either measured with a Bushnell optical Rangefinder (when the sample path was straight and continuous) or estimated using

Table 4. List of stations, locations, and number of samples per technique for sites sampled by the Academy of Natural Sciences between 2004 and 2007 in the Delaware River, Flat Brook, and adjacent to the Upper Delaware River as part of the Upper Delaware Scenic and Recreational River and Delaware Water Gap National Recreation Area fish inventory.

| Station | Type | Station name | Station location | Sample technique used | | | | | Fish Table |
|-------------------------------|------------|----------------------------------|----------------------------|-----------------------|----|----|----|------|------------|
| | | | | BP | WS | BS | S | Misc | |
| Delaware River in UPDE | | | | | | | | | |
| U1 | Fixed | Delaware R @ Hancock | Hancock RM 331-327 | | 3 | 1 | 11 | NH | 8, 22 |
| U2 | Random | Delaware R @ Equinunk | Buckingham RM 327-323 | 3 | 4 | | 4 | | 8, 9 |
| U6 | Random | Delaware R @ Hankins | Hankins RM 311-307 | | 2 | 3 | 1 | O | 8, 21, 22 |
| U7 | Random | Delaware R @Callicoon upper | Callicoon Upper RM 307-303 | 2 | | 7 | 1 | O | 8, 21, 22 |
| U8 | Random | Delaware R @Callicoon lower | Callicoon Lower RM 303-299 | 3 | | 1 | 1 | | 8, 22 |
| U11 | Fixed | Delaware R @ Narrowsburg | Narrowsburg RM 291-287 | | | 5 | 1 | G | 8, 21, 22 |
| U13 | Random | Delaware R @ Shohola | Shohola RM 283-279 | | 5 | | | | 8 |
| U14 | Random | Delaware R @ Lackawaxen | Lackawaxen RM 279-275 | | 2 | 7 | | | 8, 21, 22 |
| U15 | Random | Delaware R @ Shohola | Shohola RM 275-271 | | 1 | 3 | 2 | | 8, 21, 22 |
| U16 | Random | Delaware R @ Handsome Eddy | Handsome Eddy RM 271-267 | | 2 | 4 | 1 | AT | 8, 21, 22 |
| Sites adjacent to UPDE | | | | | | | | | |
| WBR1 | Additional | West Branch Delaware R | West Branch Delaware River | | | | 5 | | 9 |
| WBR3 | WRCP | West Branch Delaware R | Upstream Faulkner Brook | | | | | O | |
| WBR4 | WRCP | Upper West Branch Delaware R | Balls Eddy | | | | 3 | N | 9 |
| WBBE | WRCP | Lower West Branch Delaware R | Balls Eddy | | | | 7 | | 9 |
| WBH | NPS-bridle | West Branch Delaware R | Hancock | 4 | | | | | 9 |
| HB | Target | Halfway Brook | Mouth of Halfway Brook | 2 | | | | | 9 |
| SHT1 | Target | Shehawken Creek | Shehawken Creek at mouth | | | | 1 | | 9 |
| CC | WRCP | Cooleys Creek | Beaver ponds at mouth | | | | 3 | | 9 |
| NL | WRCP | Nabbys Lake | | | | | 10 | N | 9 |
| Delaware River in DEWA | | | | | | | | | |
| D2 | Adjacent | Delaware River @ Minisink | Minisink RM 246-242 | | | 1 | 1 | | 10 |
| D3 | Random | Delaware River @ Dingman's Ferry | Dingman's Ferry RM 242-238 | | 2 | 5 | | | 10, 23 |
| D4 | Random | Delaware River @ Shapnack | Shapnack RM 238-234 | | 4 | | | | 10 |
| D6 | Random | Delaware River @ Wallpack | Wallpack RM 230-226 | | 4 | 4 | 1 | OAT | 10, 23 |
| D8 | Random | Delaware River @ Smithfield | Smithfield RM 220-218 | | 2 | 6 | 5 | GT | 10, 23 |
| D9 | Random | Delaware River @ Shawnee | Shawnee RM 218-214 | | 3 | 11 | | G | 10, 23 |
| D10 | Fixed | Delaware River @ Water Gap | DWG RM 214-Boundary | 3 | | 3 | 3 | | 10, 23 |

| Station | Type | Station name | Station location | Sample technique used | | | | | Fish Table |
|-------------------|-------------|-----------------------------|--------------------------------------|-----------------------|----|----|---|------|------------|
| | | | | BP | WS | BS | S | Misc | |
| Flat Brook | | | | | | | | | |
| FB1 | Fixed | Flat Brook near Walpack | Near Walpack Bridge | 2 | | | 1 | ON | |
| FB1.1 | Adjacent | Flat Brook 1.1 | Between FB1 and large pool | | | | 1 | N | |
| N FB1.2 | Adjacent | Flat Brook 1.2 | Large pool @ footbridge ds of FB1.2 | | | | 1 | N | |
| FB2 | Adjacent | Flat Brook, isol pond | Near Walpack Bridge | | | | 1 | | 17 |
| FB3 | Replacement | Flat Brook at Three Bridges | SE of Peters Village | 3 | | | | | 7, 11 |
| FB4 | Replacement | Flat Brook at Haneys Mills | Haneys Mill | 1 | 2 | | | | 11 |
| FB5 | Replacement | Flat Brook N of Walpack | North of Walpack Bridge | | | | 1 | | |
| FB6 | NPS-bridle | Flat Brook 6 | Small pond on RB Flat Brook | | | | 1 | | |
| FB7 | NPS-bridle | Flat Brook 7 | Downstream of right bank tributary | | | | 1 | N | |
| N FB8 | Fixed | Flat Brook 8 | Big Flat Brook in DEWA | 2 | | | | N | |
| N FB9 | NPS-bridle | Flat Brook 9 | Pools and riffles between FB7 and LB | | | | | N | |
| N FB10 | NPS-bridle | Flat Brook 10 | Flat Brook S Walpack WMA | | | | 1 | | |
| FB11 | NPS-bridle | Flat Brook 11 | Flat Brook at closed bridge | | | | 1 | N | |
| HMP | Additional | Haney's Mill Pond | | 1 | | | | H | |

Note: See Table 6 for explanation of “type” and “techniques” columns.

Fish table indicates the table number in which fish catches (if any) are reported.

“RB” refers to right bank and “LB” refers to left bank.

Table 5. List of stations, locations, and number of samples per technique for lakes, streams, and ponds other than Flat Brook sampled by the Academy of Natural Sciences between 2004 and 2007 as part of the Upper Delaware Scenic and Recreational River and Delaware Water Gap National Recreation Area fish inventory.

| Station | Type | Stratum | Station name | Station location | Sample technique used | | | | | Fish Table |
|---------|-------------|------------|------------------|------------------|-----------------------|----|----|---|------|------------|
| | | | | | BP | WS | BS | S | Misc | |
| BK1 | Fixed | Stream | Creek @ 209 | at 209 birdge | 2 | | | | | 11, 18 |
| BH, BR | | | Creek | backwater | 1 | | | 7 | | 19 |
| ANS04 | Random | Stream | Creek | near mouth | 2 | | | | | 18 |
| ANS8.0 | Replacement | Stream | Dingmans | | 1 | | | | | 11, 18 |
| ANS8.1 | Additional | Stream | Dingmans | Silverthread | 1 | | | 1 | | 11, 18 |
| ANS8.2 | Additional | Stream | Dingmans | Outlet of P55 | | | | | H | NF |
| ANS8.3 | Random | Stream | Unt Dingmans | | | | | | | Dry |
| ANS31 | Random | Stream | Harmony Lake | | | | | | | Dry |
| ANS38.1 | Random | Stream | Tributary 38.1 | SW of Catfish | 1 | | | | H | NF |
| ANS39.1 | Random | Stream | Tributary 39.1 | tributary of | | | | | | Dry |
| ANS42 | Fixed | Stream | Pond | | 1 | | | | | 18 |
| VAN | Replacement | Stream | Creek | Milford | 2 | | | | | 19 |
| VC | Fixed | Stream | Brook | Mouth | | | | 3 | N | 18 |
| L01 | Fixed | Kittatinny | Catfish Pond | | 1 | | | 3 | | 13 |
| L02 | Random | Kittatinny | Success Lake | | 1 | | | | | wetland NF |
| L03 | Random | Kittatinny | Crater Lake | | 1 | | | 1 | | 13 |
| L04 | Random | Kittatinny | Lake | | | | | | O | 13 |
| L05 | Replacement | Kittatinny | Lake | | | | | 1 | | 13 |
| L08 | Random | Kittatinny | Lakes | | 2 | | | 2 | G | 13 |
| L11 | Random | Lake | Lake 11 | Flat Brook | | | | 1 | | 14 |
| L13 | Random | Lake | Camp Lake | | 1 | | | 1 | | 14 |
| DWGL14 | Random | Lake | Hainesville | | 1 | | | | | 14 |
| L16 | Random | Lake | Lake | | 2 | | | 2 | | 14 |
| DWGL17 | Random | Lake | Lake 17 | Sunny Hill | | | | 2 | | 14 |
| DWGL19 | Random | Lake | Pond | | | | | 1 | | 16 |
| DWGL20 | Replacement | Lake | Landis Lake | | 1 | | | 1 | | 14 |
| LL | Target | Lake | Lake Lenape | | | | | 1 | | 17 |
| W1 | Target | | Wetland | NPS | | | | 1 | | NF |
| P15 | Additional | Pond | Pond 15 | | | | | | H | 17 |
| P25 | Additional | Pond | Pond 25 | | | | | | H | 17 |
| P31 | Stream* | Pond | Impoundment Camp | | | | | | H | NF |
| P34 | Random | Pond | Pond 34 | about 5 mi W | | | | 1 | | 15 |

| Station | Type | Stratum | Station name | Station location | Sample technique used | | | | | Fish Table |
|---------|------------|------------|--------------|------------------|-----------------------|----|----|---|------|-----------------|
| | | | | | BP | WS | BS | S | Misc | |
| P42 | Additional | Pond | Pond 42 | Corner NW | | | | 1 | | 17 |
| P43 | Random | Pond | Pond 43 | Corner SE | | | | 1 | | 16 |
| P55 | Additional | Pond | Pond 55 | Dingmans | | | | 1 | | 17 |
| P60 | Random | Floodplain | Pond 60 | Conashaugh | | | | 1 | | 15 |
| P71 | Random | Floodplain | Pond 71 | river access | | | | 1 | | 15 |
| P77 | Random | Floodplain | Pond 77 | Creek | | | | | H | 14 |
| P78 | Random | Pond | Pond 78 | Community | | | | | H | 17 |
| P9 | Random | Pond | Pond 9 | Watergate Rec | | | | 1 | | 16 |
| P41 | Random | Pond | Pond 41 | Silver Spring | | | | | | Dry |
| P20 | Random | Pond | Pond 20 | Brook | | | | | | wetland NF |
| P35 | Random | Pond | Pond 35 | Course | 1 | | | | | 16 |
| P36 | Random | Pond | Pond 36 | Course | 2 | | | | | 16 |
| P46 | Random | Pond | Pond 46 | McCarty's | | | | 1 | H | recently dry NF |
| P48 | Additional | Pond | Pond 48 | Dingmans | | | | 1 | | NF |
| P50 | Random | Pond | Pond 50 | Dingmans | | | | 1 | | no pond |
| P51 | Additional | Pond | Pond 51 | Dingmans | | | | 1 | | NF |
| P57 | Random | Pond | Pond 57 | Dingmans | 1 | | | | | 16 |
| P70 | Random | Pond | Pond 70 | Bushkill | 1 | | | | | 16 |
| P86 | Random | Pond | Pond 86 | on Mt. Minsi | | | | | O | no pond |
| P90 | Random | Pond | Pond 90 | near Slateford | | | | 1 | | 16 |

Note: See Table 6 for descriptions of "type" and "techniques" columns

Fish table indicates the table number in which fish catches (if any) were reported.

Table 6. Descriptions of type of sample site selection methods and abbreviated sample techniques listed in Tables 4 and 5.

| Column Heading | Description |
|-----------------------|---|
| Type | |
| Random | Randomly selected |
| Fixed | Defined site (one site in stratum) |
| Replacement | Replacement for other site |
| Adjacent | Target species found in adjacent site |
| Target | Target species found in adjacent site |
| NPS-bridle | Site targeted for bridle shiner under inventory modification |
| WRCF | Site targeted for bridle shiner under PA WRCF bridle shiner study |
| Stream* | Randomly selected as stream site; site impounded |
| Technique | |
| BS | Boat electrofishing |
| WS | Walkalong (tow-barge) electrofishing |
| BP | Backpack electrofishing |
| S | Seine |
| O | Observation |
| G | Gill net |
| A | Angle |
| T | Trap |
| H | Dip net |
| N | Snorkel |
| Fish Table | |
| Dry | Site dry; replaced by another site |

Google Earth and GPS coordinates of the sample path taken in the field. The sample distances covered at each reach varied according to the homogeneity of the area, the number of individuals affected within the sample area (i.e., the time needed to capture fish increases with the number of fish affected), and by variations in lengths of similar habitat types (pool, riffle, run). In general it was attempted at each reach to sample from at least one of the different habitat types present at that station. At some reaches, boat electrofishing was limited either by poor access to the reach or by shallow riffles which prevented boat passage. In some cases (e.g., the Delaware River Hankins reach, station U6), boat electrofishing was completed with two or more upstream and downstream passes made into a moderate-depth riffle covering more area of the riffle. Shallow riffle and backwater depositional areas were typically inaccessible by boat and were sampled with walk-along electrofishing. In some cases only walk-along electrofishing was completed at a reach because of lack of large boat access.

In 2004, limited boat electrofishing was done at Station U8, resulting in low coverage of the station. In 2008, additional boat electrofishing was done at the station, providing a similar level of sampling effort as at the other stations. Fish caught in these samples are included in the tabulations of total numbers and species of fish but are not used in other analyses (e.g., habitat use).

Walk-along Electrofishing

Various shallow water habitats on the main stem Delaware River in both DEWA and UPDE and one site on Flat Brook were sampled using walk-along electrofishing (similar to tow-barge electrofishing) in 2004–2005. The technique was used in shallow side pools adjacent to the main river (e.g., the Dillontown Beaver Ponds at Station U2), mouths of tributaries (e.g., Lacawaxen River and Vancampens Brook), backwaters and depositional areas behind islands (e.g., Poxono Island area D8), and bases and edges of riffles which could not be sampled by boat electrofishing. This technique proved to be efficient at collecting small- to medium-sized target species. Walk-along electrofishing was done using the 17-ft (5.2-m) electrofishing boat with associated electronics and a pair of positive electrodes, or anodes, carried by the operators along with 0.32-cm (0.13-in) mesh dip nets. The anodes were hoops covered with 0.32-cm (0.13-in) mesh (to aid in collecting stunned fish) mounted on fiberglass poles which were connected to a 61-m (200-ft) long cable. The negative electrode, or cathode, was several stainless steel cables that were submerged into the sampling area adjacent to the boat. The field crew carried the anodes with attached cable through shallower areas upstream of the boat to collect, while another crew member maintained the appropriate output current and netted the stunned fish and returned them to a tub of recovery water on the boat. After sampling, most fish were released to the water after identification and measurement. The voltage produced by this equipment ranged from 300–500 volts with an output current between 1–5 amps. Two to five samples per reach were completed with this equipment (one reach in DEWA and two in UPDE in 2004; four reaches in DEWA and one in UPDE and Flat Brook in 2005). More walk-along electrofishing was done at Station U13 (five samples) because the reach was inaccessible for sampling by the larger electrofishing boat. Duration of the sample was typically recorded, providing estimates of catch per unit effort.

Walk-along electrofishing was done using the new electronic system described in the boat electrofishing section after the spring of 2006. This system used a pair of positive electrodes (anodes) attached to a 30.5-m (100-ft) cable for walk-along sampling; this system was used in 2005–2006. In 2006, the reach at U1 was sampled by walk-along electrofishing using a smaller 4.3-m (14-ft) Jon boat (as a tow-barge) and lighter Honda 2500 watt generator with the same Smith-Root 5.0 GPP Control Box and paired anode rods on a cable.

Backpack Electrofishing

Backpack electrofishing was done using Smith Root Model 15-D (gasoline-powered) electrofishers. The units typically were used at the H5 mode setting, at 300–700 volts, which produced an output level between 0.2–0.5 amps. The operator waded while carrying an anode pole with a 0.32-cm (0.13-in) mesh covered hoop (to aid in collecting stunned fish) and a 0.32-cm (0.13-in) mesh dip net. The operator and one to two additional netters collected the stunned fish for processing and identification. Backpack electrofishing with one unit and without net blocking was done at a number of lakes and ponds in DEWA. This method was effective in sampling where snags and tree stumps were present in the ponds, limiting other collection techniques (e.g., Catfish Pond). This technique was also effective in tributary mouths at the main stem Delaware River (e.g., Callicoon Creek). On some wider stream segments (e.g., Bushkill Creek), two electrofishing units with one to two additional netters were used to increase sampling efficiency. Reach-level sampling was done at

Raymondskill Creek, one location on Flat Brook, and one location on Big Flat Brook. Either block seines with mesh size of 0.32-cm (0.13-in) were installed across the stream at the upstream and downstream ends of the sample area, or the sample area was positioned between natural blocks (e.g., shallow riffles) to contain fish movement from the area. Two passes were completed through these sample areas in order to allow depletion estimates of total abundance of fish in that reach segment. Fish were held in tubs and processed after each pass. Fish from the first pass were maintained in the tubs until the second pass was completed. After sampling, most fish were released to the water after identification and measurement. Some individuals of uncertain identity and/or voucher specimens were preserved. Each pass was recorded as a distinct sample. Time and distance of the sample were typically recorded. At each sample reach, notes were taken at intervals on the stream width, substrate, and maximum depths.

Seines

A variety of seines (of different lengths and mesh) were used to collect fish: 1.8 m (5.9 ft) with 0.32-cm (0.13-in) mesh, 4.6 m (15.1 ft) with 0.32-cm mesh, 6.2 m (20.3 ft) with 0.64-cm (0.25-in) mesh, and 6.2-m with 0.32-cm mesh. A majority of the ponds, lakes, several creeks, Flat Brook, and mainstem Delaware River were sampled using seines. When using the shorter seine, kick seining was often used. In kick seining, one person holds the seine open at the downstream side and the substrate or vegetation is kicked (by the same or a different person), which dislodges or scares fish from cover (under rocks, in vegetation, etc.) and causes them to drift or swim downstream with the flow into the open net, which is lifted to collect the fish. At other times, the short seine was pushed upstream into a riffle ledge or into a snag pile to collect the fish. The longer seine nets were typically dragged by two people in an arc from the shoreline into deeper open water or along vegetation beds and dragged back to shore where the net was then lifted onto the shore to capture the fish. If flow was present, the longer seine nets were dragged in the direction of the flow. A site was typically sampled by a combination of several seine hauls. At one location (The Dillontown beaver ponds at Station U2), which had dense submerged vegetation, the seine net was held off the side of a boat and the boat was moved in an arc into deeper water while the other end was held along the shoreline, sweeping the net through the vegetation line.

In 2008, seine sampling was done in backwaters at Station U8 as part of another project. These fish are not included in summaries of numbers of fish caught, etc. However, station records from these samples are noted.

Snorkeling

Many species of fish were observed and documented using this method. This method was used extensively in Flat Brook and in backwater areas along the mainstem Delaware River. Of particular importance was the snorkel observation of bridle shiner (see Tables 1 and 2 for common and scientific names of fishes mentioned in the text) in Flat Brook. In these areas, the bridle shiners were often swimming above and into patches of submerged vegetation. Visual identification of the species was confirmed by seining. After identification and measurements, the captured fish were returned to the water.

Visual Observation

Visual identifications of fish were made at many locations when fish were either evading capture after being shocked, observed swimming in shallow clear water, found dead or dying near the shoreline, or when breaking the surface of the water [e.g., American shad (*Alosa sapidissima*) young dimpling the water while feeding]. These observations were made either from along the bank side, bridge, or off the side of a boat.

Hand/Dip Net

Dip nets (0.32-cm [0.13-in] and finer mesh) were used to collect fish in areas which were difficult to sample by other methods. These areas included wetlands, shallow edges of ponds, root wads, and densely vegetated areas throughout the parks. A number of stations on Flat Brook were collected using this technique. In addition to fish, many aquatic insects, crayfish, and amphibians were collected by this method.

Gill Nets

Gill nets were used at both parks to target mainly bottom-dwelling and nocturnal predatory species (e.g., catfish species and walleye [*Sander vitreum*]) in the deeper pool areas. The gill nets were set in backwater pools behind islands (Poxono Island Station D8) or main stem pools (Narrowsburg Station U11) with little or no flow. Nets were placed adjacent to submerged logs and vegetation or adjacent to boulder piles along shorelines. Nets were set in a “sinking” mode (i.e., with lead line on the bottom) and allowed to fish overnight. Gill nets were typically 18.2-m (59.7-ft) long by 1.8-m (5.9-ft) deep and had three panels of varying mesh (5.1 x 7.6 x 10.1-cm [2 x 3 x 4-in]). One experimental net 30.5-m (100-ft) long and 3.05-m (10-ft) wide (with varying panels of 7.6, 10.1, and 12.7-cm [3 x 4 x 5-in] mesh) was set in a vertical mode from top to bottom of the main stem river at Narrowsburg Pool. This gill net was twisted during deployment and, as a result, no fish were caught in it. Gill nets were also set at Blue Mountain Lake and were successful in collecting several species of fish.

Bazemore Traps

Bazemore traps (modified catfish traps) were used in the mainstem Delaware River at both parks. These are cylindrical traps with an internal set of funnels. They are 1.2 m (4 ft) long with 1.3-cm (0.5-in) mesh and were baited with liver, blood bait, crayfish tails, or a combination of all. As with gill nets, the traps were deployed in areas of deeper water adjacent to large tree/brush snag piles at each station.

Angling

Hook and line fishing was done at several locations on the mainstem Delaware River in both parks, mainly targeting catfish. Several species were captured using this method.

Habitat Assessment

The field crew recorded observations on specific sample area habitats within each reach on the main river after most boat and walk-along electrofishing samples and for many samples taken with the other techniques. Within most boat electrofishing sample areas, notes were taken on the shoreline makeup (e.g., open shoreline vs. island complex), the general topography of the area (steep vs. shallow sample depths), the percentage of different substrates present in the area (e.g., boulder,

cobble, gravel), the submerged woody cover (number and size of snag piles), an estimate of overall flow (slow pool vs. fast run), and the presence/absence of submerged macrophyte vegetation. The overall length of the sample area was measured directly with a Bushnell optical Rangefinder or from subsequent processing of the GPS coordinates that were recorded in the field during the sample run. Water depths were recorded with a Humminbird Piranha Max 10 fish/depth finder or a metal ruler. Latitude and longitude coordinates were recorded with a Garmin GPS MAP76 chartplotting receiver (accuracy level of <15m), Google Earth, or using the TOPO! software on USGS topographic maps. A Yellow Springs Instrument (YSI) Model 556 Multi probe system and Oakton pocket size recorders were used to record the water temperature (°C), pH, conductivity (µmhos) and dissolved oxygen (mg/L) at most sample areas (Table 7).

Fish Handling and Identification

Most fishes collected were identified, measured, and released in the field. Some fish, mainly large individuals (striped bass [*Morone saxatilis*], American shad, and muskellunge [*Esox masquinongy*]) and target species were photographed with a digital camera (usually Pentax Optio) for documentation. Fish that were difficult to identify (mainly young-of-year centrarchids and cyprinids and lamprey ammocoetes) and specimens needed for the DEWA and UPDE teaching collections or voucher collection were preserved in the field with 10% buffered formalin. In the laboratory, preserved fishes were transferred to 50% ethanol after a two-day water rinse and, subsequently, to 70% ethanol for storage. Voucher specimens were accessioned into the ANS Fish collection. Preserved specimens of most species captured were separated into jars (one species of varying numbers per jar) for three separate collections (DEWA and UPDE teaching collections and ANS voucher collection). Too few specimens of a few species were collected to provide specimens for the voucher and both teaching collections. In these cases, preserved specimen(s) of a few species from another study were used for the teaching collections, where all specimens caught in the inventory were needed as vouchers or where only photographic vouchers had been obtained. Similarly, specimens of some species potentially occurring in the park which were not collected in this study were included in the teaching collection. Nomenclature of fishes was consistent with the Sixth (2000) edition of *Common and Scientific Names of Fishes* (Nelson et al. 2004). In addition, amphibians and crayfish that were collected were also identified to the lowest practical level and enumerated.

Almost all captured fishes were identified to species using standard references. A few very small minnow and sunfish young-of-year were not identifiable to species. Some specimens which were observed but not captured (e.g., during snorkeling) could not be identified to species. Two lamprey specimens were tentatively identified. A summary of occurrence of reptiles, amphibians, and crayfish is presented in the Appendix.

Table 7. Minimum and maximum values of five water chemistry measurements* taken at each sampling station by the Academy of Natural Sciences between the years 2004 and 2007 as part of the Upper Delaware Scenic and Recreational River (UPDE) and Delaware Water Gap National Recreation Area (DEWA) fish inventory.

| Station | Location | Water Temperature (°C) | | Conductivity (µmho) | | DO (mg/l) | | DO (%) | | pH | |
|---------|---|------------------------|---------|---------------------|---------|-----------|---------|---------|---------|---------|---------|
| | | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| ANS04 | Raymondskill Creek | | 18.71 | | 121.00 | | 9.40 | | 101.10 | | 8.00 |
| ANS38.1 | Small stream SW of Catfish Pond | | 11.00 | | 30.00 | | - | | - | | 6.00 |
| ANS42 | Outlet stream from Catfish Pond | | 18.00 | | 30.00 | | - | | - | | 6.00 |
| BK1 | Bushkill Creek at Rt. 209 bridge | | 21.50 | | 58.00 | | 7.38 | | 84.90 | | 6.95 |
| D3 | Delaware River @ Dingman's Ferry | 19.52 | 20.35 | 87.0 | 105.00 | 7.55 | 12.38 | 82.60 | 136.00 | 6.36 | 8.04 |
| D4 | Delaware River @ Shapnack | | 26.70 | | 111.00 | | 9.40 | | 118.50 | | 5.50 |
| D6 | Delaware River @ Walpack | 22.95 | 24.00 | | 109.00 | | 9.11 | | 105.80 | | 5.25 |
| D8 | Delaware River @ Smithfield | 17.76 | 27.75 | 84.00 | 113.00 | 6.87 | 11.12 | 72.10 | 133.0 | 7.56 | 9.20 |
| D8.0 | Dingmans Creek 8.0 | | 21.06 | | 109.00 | | 8.43 | | 95.40 | | 6.42 |
| D8.1 | D8.1 Trib Dingmans | - | - | | 224.00 | | 8.85 | | 101.50 | | 6.34 |
| D9 | Delaware River @ Shawnee | 17.91 | 22.29 | 82.00 | 111.00 | 7.86 | 8.81 | 83.20 | 101.70 | 6.95 | 7.25 |
| D10 | Delaware River @ Delaware Water Gap | 14.80 | 14.92 | 82.00 | 84.00 | 9.49 | 10.11 | 94.10 | 99.80 | 7.61 | 7.83 |
| DWGL14 | Lake west of Hainesville | | 24.70 | | 106.00 | | 3.95 | | 48.70 | | 8.14 |
| DWGL17 | Lake south of SunnyHill Lake | | 22.80 | | 32.00 | | 6.86 | | 79.70 | | 7.12 |
| DWGL19 | Whittakers Pond | | 23.84 | | 38.00 | | 9.45 | | 111.70 | | 7.70 |
| DWGL20 | Landis Lake | | 23.14 | | 47.00 | | 6.83 | | 79.50 | | 7.40 |
| FB1 | Flat Brook at Walpack Center Bridge | | 21.00 | | - | | - | | - | | - |
| FB3 | Flat Brook below Three Bridges | 23.82 | 23.97 | 194.00 | 194.00 | 8.06 | 8.73 | 94.80 | 104.00 | 6.14 | 7.08 |
| FB4 | Flat Brook at Haleys Mill | | 22.10 | | 227.00 | | 7.36 | | 84.40 | | 7.50 |
| FB8 | Near confluence of Big and Little FB | | 15.99 | | 112.00 | | 8.80 | | 89.20 | | 7.89 |
| FB9 | Pools and riffles between FB7 and LB trib | | 23.00 | | 195.00 | | - | | - | | 3.90 |
| FB11 | Flat Brook @ closed bridge | | 16.00 | | 195.00 | | - | | - | | 6.60 |
| LB | Halfway Brook | | 30.00 | | - | | - | | - | | - |
| L01 | Catfish Pond, SE end | 16.00 | 25.55 | 30.00 | | | - | | - | | 6.40 |
| L03 | Crater Lake, east side | | 24.44 | | 30.00 | | - | | - | | - |
| L04 | Long Pine Lake | | 25.55 | | 30.00 | | - | | - | | - |
| L05 | Mt. Ridge Lake | | 25.55 | | 40.00 | | - | | - | | - |
| L08 | Blue Mt. Lakes | 16.00 | 29.00 | 30.00 | | | - | | - | | - |
| L13 | Kittatinny Camp Lake | | 30.55 | | 251.00 | | 7.10 | | 97.10 | | 6.15 |
| L16 | Sunny Hill Lake, L16 | | 28.44 | | 38.00 | | 7.34 | | 93.20 | | 7.11 |
| LL | Lake Lenape | | 24.00 | | - | | - | | - | | 7.80 |

| Station | Location | Water Temperature (°C) | | Conductivity (µmho) | | DO (mg/l) | | DO (%) | | pH | |
|---------|--|------------------------|---------|---------------------|---------|-----------|---------|---------|---------|---------|---------|
| | | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| P35 | Smaller pond in Cliff Inn golf course | 15.72 | | 69.00 | | 7.60 | | 77.00 | | 6.62 | |
| P36 | Larger pond in Cliff Inn golf course | 20.73 | | 32.00 | | 8.17 | | 91.00 | | 7.66 | |
| P46 | Pond 46, SE of McCarty's Corner | 17.00 | | 50.00 | | - | | - | | 6.10 | |
| P48 | Pond 48, North of Dingmans Ferry | 17.00 | | 30.00 | | - | | - | | 6.40 | |
| P55 | South of Dingmans Creek | 32.00 | | - | | - | | - | | - | |
| P57 | Dingmans Ferry | 30.86 | | 46.00 | | 8.28 | | - | | 7.29 | |
| P60 | East of 209, South of Conashaugh Creek | 27.50 | | 111.00 | | 7.50 | | 95.00 | | 6.80 | |
| P70 | Downstream of Maple Lake | 29.02 | | 300.00 | | 6.35 | | 83.40 | | 6.72 | |
| P71 | North of Bushkill Creek access | 21.21 | | 89.00 | | 4.10 | | 46.50 | | 8.73 | |
| SHT1 | Shehawkin Creek at mouth | 11.00 | | - | | - | | - | | - | |
| U1 | Delaware River @ Hancock | 16.03 | 19.01 | 58.00 | 79.00 | 9.17 | 11.58 | 93.30 | 119.80 | 6.80 | 7.64 |
| U2 | Delaware River @ Buckingham/Equinunk reach | 14.19 | 19.27 | 51.00 | 86.00 | 7.99 | 9.65 | 86.50 | 96.40 | 7.56 | 8.55 |
| U6 | Delaware River @ Hankins | 21.14 | 22.04 | 69.00 | 72.00 | 8.20 | 8.46 | 93.60 | 95.20 | 7.40 | 7.44 |
| U7 | Delaware River @ Callicoon upper | 11.06 | 23.57 | 71.00 | 130.00 | 8.33 | 11.06 | 98.20 | 129.70 | 7.54 | 8.41 |
| U8 | Delaware River @ Callicoon lower | 24.00 | 25.00 | 80.00 | 85.00 | 8.73 | 105.20 | | | 7.60 | 8.92 |
| U11 | Delaware River @ Narrowsburg | 15.00 | 17.81 | 73.00 | 90.00 | 9.31 | 11.93 | 96.00 | 123.80 | 7.60 | 8.04 |
| U13 | Delaware River above Minisink Ford | 26.18 | 30.82 | 89.00 | 93.00 | 7.72 | 8.70 | 103.00 | 106.00 | 6.36 | 6.57 |
| U14 | Delaware River @ Lackawaxen | 17.55 | 25.78 | 67.00 | 90.00 | 7.09 | 10.06 | 80.50 | 105.30 | 7.47 | 7.97 |
| U15 | Delaware River @ Shohola | 12.91 | 19.00 | 68.00 | 69.00 | 10.01 | 10.80 | 94.80 | 105.20 | 7.39 | 7.43 |
| U16 | Delaware River @ Handsome Eddy | 13.23 | 15.26 | 67.00 | 68.00 | 10.68 | 11.04 | 101.90 | 108.50 | 7.78 | 8.23 |
| VAN | Vandermark Creek | 16.00 | | 100.00 | 110.00 | - | | - | | 8.20 | |
| W1 | W1, by NPS headquarters | 19.00 | | 140.00 | | - | | - | | 6.60 | |
| WBR1 | West Branch Delaware River | 11.00 | | - | | - | | - | | - | |

* If only one water chemistry sample was taken at a particular station, only a single value is listed.

Disposition of Specimens

Wherever practical, fish were identified and returned alive to the capture site. Voucher specimens of most species will be accessioned into the permanent Fish Collection of The Academy of Natural Sciences, which provides expert curation. The Fish Collection can be queried using the Internet (http://data.acnatsci.org/biodiversity_databases/fish.php). Fishes from the NPS inventory are not identified as such but can be identified by location, time of collection (2004-2008), and collectors (e.g., Patrick Center, R. Horwitz, P. Overbeck, D. Keller, S. Moser, A. Kindt, A. Fierro, and J. Collins). Specimens accessioned into the Fish Collection are also designated in the project database developed by the ANS and given to the NPS. A few species (largely sport species) are vouchered by photographs. No photographs or voucher specimens were obtained for gizzard shad (*Dorosomas cepedianum*) or striped bass in UPDE. Teaching collections were made and given to staff at UPDE and DEWA. These collections contain specimens of all species caught in each park, with the exception of muskellunge. Specimens of some other species which are potentially in the park were also included in the teaching collections.

Location Data

Location (latitude and longitude, converted to UTM) was determined for each station. For stream and river sites, locations of individual sampling sites within stations were determined. Determinations were made using a Garmin GPS MAP76 chartplotting receiver (accuracy level of <15 m [49 ft]), and/or from digital maps, locating sample locations from prominent landmarks. GPS readings were taken at single points within sampling locations (smaller sample areas) or from starting and stopping points (longer samples, such as boat electrofishing samples). Digital data were estimated using Topo! software (which displays seamless digital versions of USGS 1:24,000 maps), and/or from Google Earth. The locations of the upper and lower boundaries of the river stations (which were defined relative to mapped river-miles) were determined from digital map data. For pond and lake samples, a single point was used, taken near the center of the waterbody (small sites) or in the area where most samples were taken (larger waterbodies). Location data were sent to Cara Campbell of the USGS for use in modeling of fish habitat. The location data were mapped using ESRI GIS software. In addition, sample points were imported into Google Earth maps. These GIS and Google Earth maps of sampling points were examined to determine accuracy of locations. Where needed, points were relocated to be consistent with these maps. Descriptions of locations of sampling areas were also recorded in field notes.

Data Management

Field and laboratory data were entered into the ANSP Fisheries Section database. The Fisheries Section database is an ACCESS database, which is based on hierarchical tables of project, station, sample, container, and individual fish information, linked to habitat and other data. After data entry, all data were rechecked against original field sheet data. At the end of the project, a project-specific database was made from the Fisheries database, based on specifications provided by the NPS. This project database was given to the NPS as one of the project deliverables.

Data Analysis

Data analyses addressed several questions:

- Occurrence and abundance of species within and among groups of sites (Table 8). Occurrence and total numbers of individuals of each species caught in each waterbody were tabulated within each stratum. The frequency of occurrence of each species was estimated from the proportion of randomly selected sites in which the species was found.
- Patterns of occurrence and relative abundance within strata. Strata may be heterogeneous, with differences in occurrence among different areas. For the Delaware River this could reflect longitudinal patterns, or other patterns related to habitat structure, gradient, temperature, etc. The occurrence of fish by all techniques provides the best basis for comparing species occurrence, but the use of different methods prevents use for comparing abundance of species. Abundances were analyzed by comparison of standardized catch rates (catch per distance of shoreline sampled) for boat electrofishing, the most consistently used technique. Analogously, comparisons among streams were done using presence/absence by all techniques and comparison of catch rate (number per distance of shoreline sampled) for electrofishing samples. For lakes, ponds, and streams strata, comparisons of species occurrence by all techniques was used as the basis of comparing distribution. Relative abundance of different species was examined, but results of these comparisons may be complicated by differences in sampling techniques. Because of the great differences in topography within the lakes and ponds strata and the variety of sampling techniques used, no attempt was made to compare abundance of fish within or among strata.
- The boat electrofishing samples were used to analyze habitat use of various species in the Delaware River. Typically, a single electrofishing sample would contain several microhabitats, because of the small scale of some habitats and since fish from several microhabitats were typically chased into confined areas. Therefore, each sample was rated on the basis of presence or absence of various types of microhabitats. The average catch per length of samples containing each habitat type was calculated and compared.
- The co-occurrence matrix of different habitat types was assessed to indicate associations or dissociations among different habitat characteristics.

Table 8. Total number of each fish species documented between 2004 and 2007 [including one 2008 Upper Delaware Scenic and Recreational River (UPDE) sampling station] by the Academy of Natural Sciences as part of the UPDE and Delaware Water Gap National Recreation Area fish inventory.

| Scientific name | Common name | Rank* | Total | DEWA | DEWA Near | UPDE | UPDE Near |
|--------------------------------------|-------------------------------|------------|------------|-----------|-----------|------------|-----------|
| <i>Alosa aestivalis</i> | blueback herring | 51* | 5 | 5 | - | - | - |
| <i>Alosa pseudoharengus</i> | alewife | 55* | 1 | - | - | 1 | - |
| <i>Alosa sapidissima</i> | American shad | 26 | 261 | 98 | - | 163 | - |
| <i>Ambloplites rupestris</i> | rock bass | 16 | 585 | 256 | 35 | 294 | - |
| <i>Ameiurus natalis</i> | yellow bullhead | 45* | 16 | 14 | - | 2 | - |
| <i>Ameiurus nebulosus</i> | brown bullhead | 12 | 1,005 | 891 | 2 | 111 | 1 |
| <i>Anguilla rostrata</i> | American eel | 8 | 1,466 | 642 | 112 | 707 | 5 |
| <i>Campostoma anomalum</i> | central stoneroller | 55* | 1 | - | - | 1 | - |
| <i>Carassius auratus</i> | goldfish | 51* | 5 | 5 | - | - | - |
| <i>Carpiodes cyprinus</i> | quillback | 51* | 5 | 5 | - | - | - |
| <i>Catostomus commersoni</i> | white sucker | 1 | 6,444 | 3,015 | 313 | 1,709 | 1,407 |
| <i>Cottus cf. bairdi</i> | cf mottled sculpin | 55* | 1 | - | - | - | 1 |
| <i>Cottus cognatus</i> | slimy sculpin | 22 | 287 | 225 | 62 | - | - |
| <i>Cyprinella analostana</i> | satinfish shiner | 33 | 105 | 45 | 4 | 56 | - |
| <i>Cyprinella spiloptera</i> | spotfin shiner | 38 | 63 | 40 | 23 | - | - |
| <i>Cyprinus carpio</i> | common carp | 43 | 27 | 9 | - | 14 | 4 |
| <i>Dorosoma cepedianum</i> | gizzard shad | 40 | 55 | 2 | - | 53 | - |
| <i>Enneacanthus gloriosus</i> | bluespotted sunfish | 23 | 287 | 82 | 31 | 166 | 8 |
| <i>Erimyzon oblongus</i> | creek chubsucker | 47 | 14 | 3 | 10 | 1 | - |
| <i>Esox americanus</i> | redfin pickerel | 35 | 79 | 39 | 40 | - | - |
| <i>Esox masquinongy</i> | muskellunge | 50 | 8 | 7 | - | 1 | - |
| <i>Esox niger</i> | chain pickerel | 28 | 161 | 108 | - | 51 | 2 |
| <i>Etheostoma olmstedii</i> | tesselated darter | 6 | 2,098 | 779 | 180 | 766 | 373 |
| <i>Exoglossum maxillingua</i> | cutlip minnow | 13 | 950 | 175 | 157 | 402 | 216 |
| <i>Fundulus diaphanus</i> | banded killifish | 25 | 191 | 7 | 156 | 19 | 9 |
| <i>Gambusia affinis</i> | western mosquitofish | 54 | 3 | - | 3 | - | - |
| <i>Hypentelium nigricans</i> | northern hog sucker | 42 | 39 | 17 | 4 | 18 | - |
| <i>Ictalurus punctatus</i> | channel catfish | 49 | 11 | 11 | - | - | - |
| <i>Lampetra appendix</i> | American brook lamprey | 55* | 1 | 1 | - | - | - |
| <i>Lepomis auritus</i> | redbreast sunfish | 17 | 533 | 214 | 13 | 300 | 6 |
| <i>Lepomis cyanellus</i> | green sunfish | 31 | 119 | 96 | - | 17 | 6 |
| <i>Lepomis gibbosus</i> | pumpkinseed | 2 | 2,628 | 2,497 | 45 | 86 | - |
| <i>Lepomis macrochirus</i> | bluegill | 11 | 1,042 | 978 | 21 | 42 | 1 |
| <i>Luxilus cornutus</i> | common shiner | 5 | 2,225 | 1,223 | 110 | 816 | 76 |
| <i>Micropterus dolomieu</i> | smallmouth bass | 15 | 796 | 185 | 21 | 579 | 11 |
| <i>Micropterus slamoides</i> | largemouth bass | 18 | 442 | 392 | 10 | 34 | 6 |

| Scientific name | Common name | Rank* | Total | DEWA | DEWA Near | UPDE | UPDE Near |
|-----------------------------------|---------------------------|------------|------------|-----------|-----------|-----------|------------|
| <i>Morone saxatilis</i> | striped bass | 48 | 13 | 3 | - | 10 | - |
| <i>Notemigonus crysoleucas</i> | golden shiner | 4 | 2,261 | 778 | 9 | 1,474 | - |
| <i>Notropis amoenus</i> | comely shiner | 37 | 75 | 30 | - | 45 | - |
| <i>Notropis bifrenatus</i> | bridle shiner | 27 | 173 | 87 | 16 | 70 | - |
| <i>Notropis hudsonius</i> | spottail shiner | 9 | 1,200 | 768 | 9 | 423 | - |
| <i>Notropis procne</i> | swallowtail shiner | 29 | 141 | 93 | 19 | 29 | - |
| <i>Noturus insignis</i> | marginated madtom | 19 | 329 | 76 | - | 249 | 4 |
| <i>Oncorhynchus mykiss</i> | rainbow trout | 44 | 20 | 8 | 1 | 10 | 1 |
| <i>Perca flavescens</i> | yellow perch | 20* | 303 | 192 | - | 109 | 2 |
| <i>Percina peltata</i> | shield darter | 24 | 225 | 133 | 22 | 66 | 4 |
| <i>Petromyzon marinus</i> | sea lamprey | 10 | 1,343 | 262 | 22 | 1,055 | 4 |
| <i>Pimephales notatus</i> | bluntnose minnow | 20* | 311 | - | - | 46 | 265 |
| <i>Pimephales promelas</i> | fathead minnow | 36 | 76 | 63 | - | 13 | - |
| <i>Pomoxis nigromaculatus</i> | black crappie | 45* | 16 | 13 | - | 2 | 1 |
| <i>Rhinichthys atratulus</i> | blacknose dace | 7 | 1,705 | 1,091 | 217 | 134 | 263 |
| <i>Rhinichthys cataractae</i> | longnose dace | 14 | 821 | 278 | 89 | 341 | 113 |
| <i>Salmo trutta</i> | brown trout | 32 | 120 | 72 | 2 | 36 | 10 |
| <i>Salvelinus fontinalis</i> | brook trout | 39 | 56 | 55 | - | 1 | - |
| <i>Sander vitreum</i> | walley | 41 | 53 | 24 | - | 20 | - |
| <i>Semotilus atromaculatus</i> | creek chub | 30 | 123 | 91 | 19 | 1 | 12 |
| <i>Semotilus corporalis</i> | fallfish | 3 | 2,286 | 1,030 | 44 | 938 | 274 |
| <i>Umbra pygmaea</i> | eastern mudminnow | 34 | 92 | 9 | - | 83 | - |
| Subtotal | | | 33,701 | 17,222 | 1,821 | 11,573 | 3,085 |
| <i>Cyprinella</i> species | shiner species | - | 8 | 8 | - | - | - |
| <i>Cyprinidae</i> species | minnow | - | 3,108 | 3,076 | - | 31 | 1 |
| <i>Esox</i> species | pike species | - | 3 | - | - | 3 | - |
| <i>Lepomis</i> species | sunfish species | - | 17 | 16 | - | - | 1 |
| <i>Salmo</i> species | trout species | - | 4 | 3 | 1 | - | - |
| Total of All | | | 36,841 | 20,325 | 1,822 | 11,607 | 3,087 |

* Tie; rank listed is lowest rank.

DEWA includes sites within the Delaware Water Gap National Recreation Area.

DEWA NEAR includes some nearby sites, such as the mouth of Brodhead Creek, and Flat Brook sites in Wallpack and Flatbrook-Roy wildlife management areas.

UPDE includes fishes caught in the Delaware River and adjacent ponds.

UPDE NEAR includes fish from sites on the West Branch Delaware River, Nabbys Lake, and the mouth of Cooleys Creek.

Bold print indicates Priority I or II species.

- Abundance of fish. Most data resulted in estimates of relative abundance (proportions of different species) and/or catch per unit effort (cpue, e.g., number per area, shoreline distance, time sampled, etc.). While cpue is expected to be an index of population abundance, differences in catchability among sites will weaken the relationship between cpue and abundance. In a few cases, estimates of abundance could be made from multiple passes taken in the same site, where site characteristics constrained movement of fish from the site between passes. Only a few such samples were taken, since estimation of abundance was not a primary goal of the study and the technique was infeasible at many sites. Where multi-pass sampling was done for several streams (all in DEWA), multiple passes of the same area were taken. For these streams, the total population of each species was estimated using MicroFish software, which produces maximum-likelihood estimates of population sizes (Table 9) (Van Deventer and Platts 1985; Van Deventer 1989). These data are included, since they provide the only available estimates of real population densities. The accuracy and precision of the depletion technique depends on the degree to which assumptions of the technique are met (individual fish of each taxon equally likely to be captured on each pass) and the catchability of fish. With high catchability, relatively precise estimates can be made from two sample passes, while more passes are necessary with lower catchabilities. In addition, assumptions of the technique can be tested with more than two passes. For this study, two passes were made, producing relatively good estimates of populations of many species.

Project Deliverables

The following deliverables were specified and produced by The Academy of Natural Sciences (ANS) as part of the fish inventories of UPDE and DEWA:

- “A report describing the statistical (and purposive) sampling plan.” The sampling plan was produced in 2004 and distributed to the NPS and others during a project start-up meeting in April 2004. Subsequent modifications to the sampling plan, made with agreement between ANS and NPS personnel, were documented in subsequent progress reports and or emails.
- All voucher specimen data in the Automated National Catalog System (ANGST) database (digital database). The ANS included voucher specimen information in the inventory database.
- Inventory data in an electronic format compatible with the NPS “Database Template” in MS Access. The ANS provided a draft ACCESS database structure to the NPS on June 10, 2008. This database was modified based on comments by Jennifer Keefer (email on June 11, 2008). A final database, that incorporated the desired changes, was delivered to the NPS on July 11, 2008. This database includes all of the fields used specifically in the ANCS+ database. In addition to data tables, the database tables serve as a “data dictionary,” explaining abbreviations and other aspects of the data tables.
- Preserved and labeled specimens of each species collected in each park, with the possible exception of rare, threatened, and endangered species. These specimens were then delivered to each park.

- GIS data layers of all sampling locations at DEWA and UPDE, with fish species present as attributes. There is a table in the database created by the ANS showing station or sample locations in both latitude and longitude and UTM Northing and Easting coordinates. The ANS discussed GIS data requirements with Leslie Morlock of the NPS. Data layers were submitted on August 6, 2008.
- Progress reports every six months from the date of project initiation. These reports should document the Cooperator's accomplishments to date, any difficulties encountered or foreseen, and next tasks to be undertaken. Progress reports were submitted during the primary periods of project planning, implementation, sampling, and data analysis. The ANS was in frequent contact with NPS personnel throughout the project.
- Draft final reports for DEWA and UPDE, submitted electronically and in paper copy, in MSWord. A draft final report was submitted on March 18, 2008.
- Final Reports for DEWA and UPDE, submitted electronically and in paper copy, in MSWord. This document constitutes the final report.

Table 9. Catch rate (# fish/100 m), depletion population estimate, and capture probability data per 100 m backpack shock depletion sampling at two stream sites in 2004 and 2005 collected by the Academy of Natural Sciences as part of the Delaware Water Gap National Recreation Area fish inventory.

| Station/Year: | | ANS-04 | | | FB3-05 | | |
|----------------------------|-----------------|---------------------|---------------------|-----------------|--------------------------------|---------------------|--|
| Station Name: | | Raymondskill Creek | | | Flat Brook below Three Bridges | | |
| Common name | # of fish/100 m | Population estimate | Capture probability | # of fish/100 m | Population estimate | Capture probability | |
| American eel | 168 | 193 | 0.63 | 31 | 45 | 0.42 | |
| Blacknose dace | 128 | 182 | 0.45 | 398 | 597 | ne | |
| Brown trout | 28 | 28 | 0.83 | 3 | 3 | ne | |
| Common shiner | 14 | 14 | 0.71 | 43 | 43 | 0.88 | |
| Creek chub | 3 | 3 | ne | 40 | 40 | 0.82 | |
| Cutlip minnow | 45 | 45 | 0.84 | 34 | 34 | 0.86 | |
| Fallfish | 557 | 835 | ne | 3 | 3 | ne | |
| Largemouth bass | x | x | x | 3 | 3 | ne | |
| Longnose dace | 122 | 213 | 0.34 | 188 | 841 | 0.12 | |
| Margined madtom | 74 | 111 | ne | x | x | ne | |
| Northern hog sucker | 3 | 3 | ne | x | x | x | |
| Pumpkinseed | x | x | x | 17 | 17 | 0.75 | |
| Rainbow trout | x | x | x | 3 | 3 | ne | |
| Redfin pickerel | x | x | x | 3 | 3 | ne | |
| Rock bass | 9 | 9 | 0.6 | x | x | x | |
| Shield darter | 23 | 23 | 0.73 | x | x | x | |
| Slimy sculpin | x | x | x | 176 | 264 | ne | |
| Smallmouth bass | 3 | 3 | ne | 3 | 3 | ne | |
| Tesselated Darter | 131 | 170 | 0.51 | 185 | 278 | ne | |
| White sucker | 88 | 273 | 0.18 | 99 | 151 | ne | |
| Totals/100m | 1,395 | 2,105 | - | 1,227 | 2,327 | - | |

“ne” indicates that no estimate could be made since only one fish was caught or all fish were caught on the first pass.

“x” indicates that a species was not caught at that site.

Bold print indicates Priority I or II species.

Results

UPDE

Sampling was done in the 10 target reaches in the Delaware River in UPDE (Table 4). Extensive boat electrofishing using the electrofishing boat was done at eight of the 10 reaches. In addition, boat electrofishing from a small boat was done in the Hancock reach (U1). Limited boat electrofishing (one sample) was done in the Lower Callicoon reach (U8) in 2004; data from this sample are supplemented by sampling of this reach in 2008. Boat electrofishing was not done in the other two reaches because of poor access. In total, the ANS recorded 48 species in UPDE (Table 10). Within reaches, 20–36 species were recorded. In streams and ponds throughout the Upper Delaware River a 41 total species were recorded (Table 11).

There are recent documented reports of four additional species in the Delaware River in UPDE (Table 1). A bowfin (*Amia calva*) was caught in an eel weir near Smith Switch (in ANS station U10) in September 2006; photographs show it to be about 60 cm (24 in) in total length. Another bowfin was recorded in a log from the same site on August 28, 2002. No channel catfish (*Ictalurus punctatus*) were caught by the ANS, but Richard Evans (NPS) reported a fish from UPDE in September 2005. In addition, channel catfish are recorded in anglers' logs (one caught between Pond Eddy and Millrift in 2002 and two caught between Narrowsburg and Lackawaxen, one in 2002 and the second in 2003) and were locally reported to occur in pools, such as a deep pool at Pond Eddy. No spotfin shiners (*Cyprinella spiloptera*) were caught by the ANS, but Robert Ross (USGS) captured spotfin shiners at the confluences of Callicoon Creek and Tenmile River within the Delaware River. There was a recent (1997) report of an Atlantic needlefish (*Strongylura marina*) caught in an eel weir in the East Branch of the Delaware. Since this is an estuarine fish, it almost certainly moved through UPDE and DEWA to reach the East Branch. There are older reports of eastern silvery minnow (*Hybognathus regius*), white catfish (*Amieurus catus*, collected in the vicinity of the Ten Mile River confluence), and longnose sucker (*Catostomus catostomus*). One other species, mottled sculpin (*Cottus bairdi*), was caught in the mouth of Shehawken Creek, which is not far from the confluence of the East and West Branches.

High priority species collected in UPDE include the satinfin shiner (*Cyprinella analostana*, collected in small numbers in six reaches), gizzard shad (*Dorosoma cepedianum*, five reaches), bluespotted sunfish (*Enneacanthus gloriosus*, in two ponds and backwater pools of three reaches), northern hog sucker (*Hypentelium nigricans*, widespread, but collected in small numbers), comely shiner (*Notropis amoenus*, four reaches), and eastern mudminnow (*Umbra pygmaea*, in a backwater pool in one reach, along with bluespotted sunfish).

Table 10. Records of fishes collected between 2004 and 2007 [including one 2008 Upper Delaware Scenic and Recreational River (UPDE) sampling station] using specific sampling methods at various stations in UPDE by the Academy of Natural Sciences as part of the UPDE fish inventory.

| | | | | Station: | U1 | U2 | U6 | U7 | U8 | U11 | U13 | U14 | U15 | U16 |
|----------------------------|-----------|-----------------|------------------------------|----------------------|-------------|------------------------------------|-----------|----------------|----------------|-------------|---------------------|------------|-----------|---------------|
| | | | | Station name: | Hancock | Buckingham / Equinunk [†] | Hankins | Calicoon Upper | Calicoon Lower | Narrowsburg | above Minisink Ford | Lackawaxen | Shahola | Handsome Eddy |
| | | | | Sample technique(s): | BS WS S H N | WS S | BS WS S | BS BP S O | BS BP S | BS S G | WS | BS WS | BS WS S | BS WS S A T |
| Common name | Total | Frequency of 10 | Frequency of 9 ^{††} | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish |
| Alewife | 1 | 0.10 | 0.11 | 1 | - | - | - | - | - | - | - | - | - | - |
| American eel | 688 | 1.00 | 1.00 | 18 | 40 | 39 | 75 | 178 | 39 | 71 | 160 | 31 | 37 | |
| American shad | 163 | 0.70 | 0.67 | - | - | 10 | 19 | 85 | - | 28 | 15 | 1 | 5 | |
| Banded killifish | 19 | 0.70 | 0.78 | 4 | 2 | 8 | 2 | * | 1 | 1 | - | 1 | - | |
| Black crappie | 2 | 0.20 | 0.22 | - | - | - | 1 | - | - | - | - | 1 | - | |
| Blacknose dace | 132 | 0.70 | 0.78 | 55 | 15 | 38 | 8 | * | 5 | - | - | 5 | 6 | |
| Bluegill | 38 | 0.60 | 0.67 | - | 1 | - | 1 | * | 1 | - | 6 | 21 | 8 | |
| Bluespotted sunfish | 54 | 0.30 | 0.22 | 7 | 25 | - | - | 22 | - | - | - | - | - | |
| Bluntnose minnow | 46 | 0.70 | 0.67 | 9 | - | 10 | - | 8 | 6 | 4 | - | 6 | 3 | |
| Bridle shiner | 2 | 0.10 | 0.11 | 2 | - | - | - | * | - | - | - | - | - | |
| Brook trout | 1 | 0.10 | 0.11 | - | - | - | - | - | - | - | 1 | - | - | |
| Brown bullhead | 109 | 0.70 | 0.67 | 2 | - | - | - | 94 | 3 | 1 | 3 | 5 | 1 | |
| Brown trout | 36 | 0.50 | 0.44 | 29 | - | 1 | 1 | 4 | - | - | 1 | - | - | |
| Central stoneroller | 1 | 0.10 | 0.11 | - | 1 | - | - | - | - | - | - | - | - | |
| Chain pickerel | 34 | 0.50 | 0.44 | 10 | 18 | - | - | 3 | 2 | - | - | 1 | - | |
| Comely shiner | 45 | 0.40 | 0.44 | 6 | - | 2 | 14 | * | 23 | - | - | - | - | |
| Common carp | 14 | 0.60 | 0.56 | 1 | - | 1 | 5 | 1 | - | - | 4 | 2 | - | |
| Common shiner | 815 | 0.90 | 0.89 | 559 | 35 | 57 | 35 | 45 | 17 | - | 4 | 56 | 7 | |
| Creek chub | 1 | 0.10 | 0.11 | - | - | - | - | * | - | - | - | 1 | - | |
| Creek chubsucker | 1 | 0.10 | 0.11 | - | - | - | - | - | - | - | - | - | 1 | |
| Cutlip minnow | 401 | 1.00 | 1.00 | 180 | 75 | 49 | 23 | 10 | 5 | 8 | 22 | 21 | 8 | |
| Eastern mudminnow | 83 | 0.10 | 0.11 | - | - | - | - | - | - | - | - | 83 | - | |
| Fallfish | 890 | 1.00 | 1.00 | 205 | 82 | 65 | 212 | 22 | 53 | 36 | 29 | 141 | 45 | |
| Fathead minnow | 12 | 0.20 | 0.22 | 10 | - | - | 2 | * | - | - | - | - | - | |
| Gizzard shad | 53 | 0.60 | 0.56 | - | - | - | 17 | 7 | 5 | - | 9 | 2 | 13 | |
| Golden shiner | 145 | 0.70 | 0.78 | 26 | - | 1 | 3 | * | 3 | - | 88 | 22 | 2 | |
| Green sunfish | 12 | 0.50 | 0.56 | 6 | 3 | 1 | - | - | - | - | - | 1 | 1 | |
| Largemouth bass | 33 | 0.40 | 0.44 | 1 | - | - | - | * | 5 | 22 | - | 5 | - | |
| Longnose dace | 280 | 0.90 | 0.89 | 135 | 20 | 84 | 4 | 11 | - | 13 | 6 | 3 | 4 | |
| Margined madtom | 249 | 0.90 | 0.89 | 54 | 14 | 18 | - | 23 | 1 | 58 | 37 | 2 | 42 | |

| Station: | | U1 | U2 | U6 | U7 | U8 | U11 | U13 | U14 | U15 | U16 | |
|----------------------------|-----------|-----------------|------------------------------------|-----------|----------------|----------------|-------------|---------------------|------------|-----------|---------------|-----------|
| Station name: | | Hancock | Buckingham / Equinunk [†] | Hankins | Calicoon Upper | Calicoon Lower | Narrowsburg | above Minisink Ford | Lackawaxen | Shahola | Handsome Eddy | |
| Sample technique(s): | | BS WS S H N | WS S | BS WS S | BS BP S O | BS BP S | BS S G | WS | BS WS | BS WS S | BS WS S A T | |
| Common name | Total | Frequency of 10 | Frequency of 9 ^{††} | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish | # Fish |
| Minnow species | [31] | 0.00 | 0.00 | [31] | - | - | - | - | - | - | - | - |
| Muskellunge | 1 | 0.10 | 0.11 | 1 | - | - | - | - | - | - | - | - |
| Northern hog sucker | 18 | 0.60 | 0.56 | 2 | - | - | 3 | 6 | 4 | 1 | - | 2 |
| Pickereel species | [3] | 0.00 | 0.00 | [2] | - | - | [1] | - | - | - | - | - |
| Pumpkinseed | 30 | 0.60 | 0.67 | 7 | 4 | - | 9 | - | 2 | - | 2 | 6 |
| Rainbow trout | 10 | 0.40 | 0.33 | 6 | - | 1 | 2 | 1 | - | - | - | - |
| Redbreast sunfish | 300 | 0.90 | 0.89 | 21 | - | 4 | 26 | 21 | 4 | 10 | 106 | 14 |
| Rock bass | 281 | 1.00 | 1.00 | 28 | 4 | 8 | 36 | 34 | 40 | 4 | 71 | 18 |
| Satinfin shiner | 56 | 0.70 | 0.67 | 18 | 7 | - | 1 | 1 | - | 2 | - | 25 |
| Sea lamprey | 845 | 1.00 | 1.00 | 12 | 10 | 1 | 13 | 254 | 2 | 331 | 9 | 211 |
| Shield darter | 54 | 0.80 | 0.78 | 6 | 11 | 1 | 2 | 1 | - | 17 | 15 | - |
| Smallmouth bass | 573 | 1.00 | 1.00 | 10 | 2 | 75 | 40 | 47 | 28 | 97 | 146 | 50 |
| Spottail shiner | 423 | 0.90 | 1.00 | 355 | 2 | 5 | 1 | * | 46 | 1 | 8 | 3 |
| Swallowtail shiner | 29 | 0.40 | 0.44 | 16 | - | 3 | - | - | 2 | - | - | - |
| Tesselated darter | 732 | 1.00 | 1.00 | 165 | 57 | 172 | 31 | 62 | 2 | 94 | 36 | 15 |
| Walleye | 29 | 0.60 | 0.56 | - | - | 1 | 3 | 13 | 5 | - | 6 | 1 |
| White sucker | 1686 | 1.00 | 1.00 | 838 | 271 | 92 | 60 | 182 | 69 | 40 | 65 | 26 |
| Yellow bullhead | 2 | 0.20 | 0.22 | - | - | 1 | - | - | - | - | - | 1 |
| Yellow perch | 76 | 0.80 | 0.78 | 14 | 31 | 3 | 1 | 2 | 20 | - | 3 | 2 |
| Totals | 9515 | - | - | 2819 | 730 | 751 | 656 | 1137 | 393 | 839 | 856 | 785 |
| Number of species | 48 | - | - | 36 | 23 | 28 | 31 | 26 | 27 | 20 | 26 | 34 |

Note: The frequency columns reflect the occurrence of each species at nine (excluding U8, where relatively few fish were caught) or all ten of the UPDE stations. Refer to Table 6 for descriptions of sampling technique abbreviations.

[] Numbers in brackets indicate specimens not identified to species; these are not included in the station totals.

[†] Values reflect only 2004 samples collected from the main river, excluding subsequent samples from beaver ponds

^{††} Excludes lower Calicoon Reach, which had lower sampling effort.

* Species caught at U8 in samples taken subsequent to completion of the inventory.

Bold print indicates Priority I or II species.

Table 11. Records of fishes collected between 2004 and 2007 by various sampling methods in pond and tributary stations near the Upper Delaware Scenic and Recreational River (UPDE) by the Academy of Natural Sciences as part of the UPDE fish inventory.

| | Upper Delaware River | | | West Branch Delaware River | | | | | | |
|----------------------------|----------------------|---------------|-----------------|----------------------------|---------------------------|------------------|-----------|---------------------------|--------------|--------------|
| | Station: | HB | SHT1 | U2 | WBBE | WBH | WBR1 | WBR4 | CC | NL |
| | Stratum: | UPDE | Special | | | | | | | |
| | Waterbody: | Halfway Brook | Shehawken Creek | Dillontown Beaver ponds | Balls Eddy Lower W Branch | W Branch Hancock | Shehawken | Balls Eddy Upper W Branch | Cooley Creek | Nabby's Lake |
| Common name | | | | | | | | | | |
| American eel | | 4 | - | 15 | - | 5 | - | - | - | - |
| Banded killifish | | - | - | - | - | - | 1 | - | 8 | - |
| Black crappie | | - | - | - | - | - | - | - | - | 1 |
| Blacknose dace | | 2 | - | - | 115 | 42 | 50 | 33 | 23 | - |
| Bluegill | | - | - | 4 | - | - | - | - | 1 | - |
| Bluespotted sunfish | | - | - | 112 | - | - | - | - | - | 8 |
| Bluntnose minnow | | - | - | 1 | - | - | - | - | 265 | - |
| Bridle shiner | | - | - | 68 | - | - | - | - | - | - |
| Brook trout | | - | - | - | - | - | - | - | - | - |
| Brown bullhead | | - | - | 2 | - | 1 | - | - | - | - |
| Brown trout | | - | - | - | 1 | 8 | - | 1 | - | - |
| Cf mottled sculpin | | - | 1 | - | - | - | - | - | - | - |
| Chain pickerel | | - | - | 17 | - | - | - | - | - | 2 |
| Common carp | | - | - | - | 2 | - | - | 2 | - | - |
| Common shiner | | 1 | - | - | - | 9 | 56 | 1 | 10 | - |
| Creek chub | | - | - | - | - | 1 | - | - | 11 | - |
| Creek chubsucker | | - | - | - | - | - | - | - | - | - |
| Cutlip minnow | | 1 | 2 | - | - | 45 | 162 | - | 7 | - |
| Fallfish | | 46 | - | 2 | 1 | 89 | 112 | - | 72 | - |
| Golden shiner | | - | - | 1329 | - | - | - | - | - | - |
| Green sunfish | | - | - | 5 | - | 1 | - | - | 5 | - |
| Largemouth bass | | 1 | - | - | - | - | - | - | 2 | 4 |
| Longnose dace | | 61 | 3 | - | 3 | 63 | 2 | - | 42 | - |
| Margined madtom | | - | - | - | - | 4 | - | - | - | - |
| Minnow | | - | - | - | - | - | 1 | - | - | - |
| Northern hog sucker | | - | - | - | - | - | - | - | - | - |
| Pumpkinseed | | - | - | 56 | - | - | - | - | - | - |
| Rainbow trout | | - | - | - | 1 | - | - | - | - | - |
| Redbreast sunfish | | - | - | - | - | - | - | - | 6 | - |
| Redfin pickerel | | - | - | - | - | - | - | - | - | - |
| Rock bass | | - | - | 13 | - | - | - | - | - | - |
| Sea lamprey | | - | - | 210 | - | 4 | - | - | - | - |

| | Upper Delaware River | | | West Branch Delaware River | | | | | |
|---------------------------|----------------------|-----------------|-------------------------|----------------------------|------------------|------------|---------------------------|--------------|--------------|
| Station: | HB | SHT1 | U2 | WBBE | WBH | WBR1 | WBR4 | CC | NL |
| Stratum: | UPDE | Special | | | | | | | |
| Waterbody: | Halfway Brook | Shehawken Creek | Dillontown Beaver ponds | Balls Eddy Lower W Branch | W Branch Hancock | Shehawken | Balls Eddy Upper W Branch | Cooley Creek | Nabby's Lake |
| Common name | | | | | | | | | |
| Shield darter | 12 | - | - | - | 3 | 1 | - | - | - |
| Smallmouth bass | 5 | - | 1 | - | - | 7 | - | 4 | - |
| Spottail shiner | - | - | - | - | - | - | - | - | - |
| Sunfish species | - | - | - | - | - | - | - | - | 1 |
| Swallowtail shiner | - | - | - | - | - | - | - | - | - |
| Tesselated darter | 34 | 3 | - | 3 | 127 | 172 | 64 | 4 | - |
| Western mosquitofish | - | - | - | - | - | - | - | - | - |
| White sucker | 13 | - | 10 | 238 | 221 | 343 | 572 | 33 | - |
| Yellow perch | - | - | 33 | - | - | - | - | - | 2 |
| Totals | 180 | 9 | 1878 | 364 | 623 | 907 | 673 | 493 | 18 |
| Number of species | 11 | 4 | 16 | 8 | 15 | 11 | 6 | 15 | 6 |

Bold print indicates Priority I or II species.

DEWA

The ANS captured or observed 53 species in DEWA (Table 2), with 44 species recorded in the Delaware River, 21 species in ponds and lakes, and 36 in streams. The recent record of Atlantic needlefish, which presumably moved through DEWA, adds another species. Reports of 64 species in DEWA were found, but two of the reports are erroneous (Table 2). It is likely that several of these (see Table 2 and discussion below) no longer occur in the park. The eastern silvery minnow was recorded in the East Branch of the Delaware in 1935 (Greeley 1936). This fish probably moved upstream through DEWA.

Delaware River

Sampling was completed in five randomly selected reaches and one fixed sample reach. Forty-four species were recorded in the mainstem Delaware River in DEWA by the ANS (Table 12). There were no obvious longitudinal patterns in species occurrence, with differences related mostly to differences in effort and range of techniques used. Catch was standardized to effort (length of shoreline sampled) for most of the boat electrofishing samples (Table 13). There were no clear longitudinal patterns for boat electrofishing catch rates, except for weak trends for higher catch rates of rock bass (*Ambloplites rupestris*) and smallmouth bass (*Micropterus dolomieu*) at downstream stations. Several high priority species were caught, including blueback herring (*Alosa pseudoharengus*, juveniles and adults caught near Poxono Island), gizzard shad (caught near Poxono Island), quillback (*Carpionodes cyprinus*, caught in two reaches), northern hog suckers (caught in four reaches), bluespotted sunfish (caught near the Water Gap), and eastern mudminnow (caught in cover along the banks in four reaches). Several of the high priority shiner species (comely shiner, satinfin shiner, and swallowtail shiner [*Notropis procne*]) were widespread, though much less common than other minnows, such as spottail shiner (*Notropis hudsonius*) and fallfish (*Semotilus corporalis*).

Ponds and Lakes

Twenty-one species were recorded from ponds and lakes in DEWA (Table 14). Typically, few species were present in each waterbody, with a maximum of nine species among the sites sampled (from Blue Mountain Lake). Few species were widespread among the sampled sites. Lakes and ponds were stratified *a priori* into Kittatinny Ridge sites, other lakes, floodplain ponds, and other ponds, and there were some differences in species occurrence among these groups. Pumpkinseeds (*Lepomis gibbosus*) were found in most ponds and lakes. Bluegill (*Lepomis macrochirus*), golden shiner (*Notemigonus crysoleucas*), brown bullhead (*Amieurus nebulosus*), largemouth bass (*Micropterus salmoides*), and chain pickerel (*Esox niger*) were widespread across all types of lakes and ponds, but were found in half or less of all sites. Yellow perch (*Perca flavescens*) was found mainly in lakes. Swallowtail shiner and common shiner (*Luxilus cornutus*) were found in one pond adjacent to Flat Brook. These species are primarily stream dwellers which probably enter ponds during floods and get trapped with receding water levels.

Table 12. Records of fishes collected between 2004 and 2007 by all sampling methods at various stations by the Academy of Natural Sciences in the Delaware River within the Delaware Water Gap National Recreation Area (DEWA) as part of the DEWA fish inventory.

| Station: | | D3 | D4 | D6 | D8 | D9 | D10 | D2 | |
|----------------------------|-----------|-------------------|----------|------------------|----------------|----------|--------------------|----------|-----|
| Station name: | | Dingman's Ferry | Shapnack | Walpack | Smithfield | Shawnee | Delaware Water Gap | Minisink | |
| Sample technique: | | BS WS | A WS | A BS BT O S W | G BS BTS WS | G BS WS | BP BS S | S | |
| Common name | Total | Frequency of 6 | # fish | # fish | # fish | # fish | # fish | # fish | |
| American eel | 434 | 1.00 | 49 | 72 | 88 | 14 | 140 | 71 | - |
| American shad | 98 | 0.67 | - | 1 | 15 | 3 | 79 | - | - |
| Banded killifish | 7 | 0.50 | - | 1 | - | 5 | 1 | - | - |
| Blacknose dace | 2 | 0.17 | - | - | 2 | - | - | - | 10 |
| Blueback herring | 5 | 0.17 | - | - | - | 5 | - | - | - |
| Bluegill | 24 | 0.67 | 9 | - | 1 | 13 | - | 1 | - |
| Bluespotted sunfish | 1 | 0.17 | - | - | - | - | - | 1 | - |
| Brook trout | 1 | 0.17 | - | - | - | - | - | 1 | - |
| Brown bullhead | 644 | 1.00 | 1 | 220 | 1 | 418 | 2 | 2 | - |
| Brown trout | 4 | 0.50 | - | - | 1 | 1 | - | 2 | - |
| Chain pickerel | 1 | 0.17 | - | - | - | 1 | - | - | 2 |
| Channel catfish | 11 | 0.67 | - | 2 | 1 | 7 | 1 | - | - |
| Comely shiner | 30 | 1.00 | 7 | 2 | 5 | 1 | 14 | 1 | - |
| Common carp | 7 | 0.83 | - | 2 | 1 | 1 | 1 | 2 | - |
| Common shiner | 64 | 0.83 | 19 | 37 | 5 | 1 | - | 2 | - |
| Creek chub | 2 | 0.17 | 2 | - | - | - | - | - | - |
| Cutlip minnow | 14 | 0.50 | 5 | 3 | 6 | - | - | - | - |
| Eastern mudminnow | 6 | 0.67 | - | 1 | 1 | 3 | 1 | - | - |
| Fallfish | 257 | 1.00 | 193 | 21 | 19 | 10 | 6 | 8 | 200 |
| Gizzard shad | 2 | 0.17 | - | - | - | 2 | - | - | - |
| Golden shiner | 27 | 0.33 | 2 | - | 25 | - | - | - | - |
| Green sunfish | 96 | 0.17 | - | - | - | - | - | 96 | - |
| Largemouth bass | 11 | 0.50 | 3 | - | - | 7 | - | 1 | 1 |
| Longnose dace | 42 | 0.67 | - | 9 | 8 | 1 | - | 24 | 3 |
| Margined madtom | 34 | 0.83 | 5 | 16 | 5 | - | 2 | 6 | - |
| Minnow | [3001] | 0.00 | - | - | [3000] | [1] | - | - | - |
| Muskelunge | 7 | 0.67 | - | 2 | 3 | 1 | 1 | - | - |
| Northern hog sucker | 14 | 0.83 | 2 | 6 | 1 | - | 2 | 3 | - |
| Pumpkinseed | 41 | 0.83 | 1 | 1 | 2 | 29 | - | 8 | - |
| Quillback | 5 | 0.33 | - | 1 | - | 4 | - | - | - |
| Redbreast sunfish | 184 | 0.83 | 42 | 12 | 29 | - | 45 | 56 | - |

| Station: | | D3 | D4 | D6 | D8 | D9 | D10 | D2 | |
|---------------------------|-----------|-----------------|----------|------------------|----------------|-----------|--------------------|-----------|-----|
| Station name: | | Dingman's Ferry | Shapnack | Walpack | Smithfield | Shawnee | Delaware Water Gap | Minisink | |
| Sample technique: | | BS WS | A WS | A BS BT O S W | G BS BTS WS | G BS WS | BP BS S | S | |
| Common name | Total | Frequency of 6 | # fish | # fish | # fish | # fish | # fish | # fish | |
| Rock bass | 249 | 1.00 | 30 | 17 | 37 | 32 | 82 | 51 | 1 |
| Satinfin shiner | 45 | 0.83 | 6 | - | 1 | 4 | 6 | 28 | - |
| Sea lamprey | 219 | 1.00 | 16 | 69 | 52 | 6 | 16 | 60 | - |
| Shield darter | 101 | 1.00 | 13 | 11 | 29 | 5 | 11 | 32 | - |
| Shiner species | [8] | 0.00 | - | - | - | - | - | [8] | - |
| Smallmouth bass | 163 | 1.00 | 14 | 16 | 24 | 17 | 26 | 66 | - |
| Spotfin shiner | 40 | 0.83 | 8 | 6 | - | 12 | 4 | 10 | - |
| Spottail shiner | 709 | 1.00 | 230 | 108 | 119 | 214 | 10 | 28 | - |
| Striped bass | 3 | 0.17 | - | - | - | - | - | 3 | - |
| Sunfish species | [15] | 0.00 | - | - | - | - | - | [15] | - |
| Swallowtail shiner | 53 | 1.00 | 2 | 23 | 15 | 2 | 6 | 5 | - |
| Tesselated darter | 463 | 1.00 | 85 | 110 | 82 | 96 | 24 | 66 | 50 |
| Walleye | 24 | 0.33 | - | 12 | - | - | - | 12 | - |
| White sucker | 2276 | 1.00 | 29 | 811 | 230 | 1149 | 43 | 14 | 30 |
| Yellow bullhead | 10 | 0.67 | - | 1 | - | 6 | 2 | 1 | 1 |
| Yellow perch | 54 | 0.83 | 1 | - | 2 | 45 | 4 | 2 | - |
| Totals | 6484 | - | 774 | 1593 | 810 | 2115 | 529 | 663 | 298 |
| Number of species | 44 | - | 25 | 29 | 30 | 32 | 25 | 31 | 9 |

Note: Refer to table 6 for descriptions of sampling technique abbreviations.

[]Numbers in brackets indicate specimens not identified to species; these are not included in the station totals.

"Frequency" indicates the proportion of randomly-selected stations (all stations except D2) at which a species was present.

Bold print indicates Priority I or II species.

Table 13. Catch rates of fish caught per 100-m sample lengths taken in 2005 and 2007 by either backpack (BP) or walk-along shock (WS) sampling methods at various stations by the Academy of National Sciences in Delaware Water Gap National Recreation Area (DEWA) streams as part of the DEWA fish inventory.

| Station / Year: | BK1-05 | D8.0-05 | D8.1-05 | FB3-05 | FB4-05 | FB4-05 | FB4-05 | FB8-07 | FB8-07 |
|-------------------------------|----------------|----------------|--------------------|------------------------|-------------------|-------------------|-------------------|-------------------------------|--------------------------------|
| Station name / location: | Bushkill Creek | Dingmans Creek | Tributary Dingmans | FB below Three Bridges | FB at Haleys Mill | FB at Haleys Mill | FB at Haleys Mill | Ups of Big & Little FB Confl. | Ups of Bigs & Little FB Confl. |
| Sample technique: | BP | BP | BP | BP | BP | WS | WS | BP | BP |
| Sample date: | 07/07/08 | 08/04/05 | 08/04/05 | 07/19/05 | 7/21/05 | 7/21/05 | 7/21/05 | 05/17/07 | 05/17/07 |
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| American eel | 41 | 2 | - | - | 22.4 | 48.3 | 147.5 | 6.7 | 12.5 |
| Blacknose dace | 98 | 24 | 63 | 131.0 | 4.7 | 48.3 | 8.8 | 50.0 | 12.5 |
| Bluegill | 1 | 1 | - | - | 1.2 | - | - | - | - |
| Bluespotted sunfish | - | - | - | - | 1.2 | 8.3 | 5.9 | - | - |
| Bridle shiner | - | - | - | - | - | - | - | - | 1.3 |
| Brook trout | 1 | 5 | 36 | - | - | - | - | 6.7 | 2.5 |
| Brown trout | 2 | 7 | - | - | - | - | 2.9 | 3.3 | - |
| Common shiner | 2 | - | - | 31.0 | 1.2 | 33.3 | - | - | 1.3 |
| Creek chub | - | - | - | 10.3 | - | 3.3 | - | - | 1.3 |
| Cutlip minnow | 17 | - | - | 24.1 | 87.1 | 73.3 | 41.3 | 3.3 | 6.3 |
| Creek chubsucker | - | - | - | - | - | 3.3 | - | - | - |
| Fallfish | 15 | - | - | - | - | 6.7 | - | - | - |
| Golden shiner | 1 | - | - | - | - | - | - | - | - |
| American brook lamprey | - | - | - | - | - | - | - | - | 1.3 |
| Largemouth bass | 1 | - | - | - | - | - | - | - | - |
| Longnose dace | 73 | - | - | - | - | 20.0 | 2.9 | 16.7 | 20.0 |
| Margined madtom | 7 | 2 | - | - | - | - | - | - | 1.3 |
| Northern hog sucker | 1 | - | - | - | - | - | 5.9 | - | - |
| Pumpkinseed | - | - | - | - | - | - | 3 | - | - |
| Rainbow trout | - | 7 | - | - | - | - | - | 3.3 | - |
| Redbreast sunfish | - | - | - | - | 1.2 | - | - | - | - |
| Redfin pickerel | - | - | - | - | - | - | - | - | 3.8 |
| Rock bass | 1 | - | - | - | 5.9 | 21.7 | 2.9 | - | - |
| Sea lamprey | 2 | - | - | 48.3 | 3.5 | 8.3 | - | 6.7 | 27.5 |
| Shield darter | 5 | - | - | - | 12.9 | 3.3 | 8.8 | - | - |
| Slimy sculpin | - | - | - | - | - | - | - | 256.7 | 162.5 |

| Station / Year: | BK1-05 | D8.0-05 | D8.1-05 | FB3-05 | FB4-05 | FB4-05 | FB4-05 | FB8-07 | FB8-07 |
|---------------------------|----------------|----------------|--------------------|------------------------|-------------------|-------------------|-------------------|-------------------------------|--------------------------------|
| Station name / location: | Bushkill Creek | Dingmans Creek | Tributary Dingmans | FB below Three Bridges | FB at Haleys Mill | FB at Haleys Mill | FB at Haleys Mill | Ups of Big & Little FB Confl. | Ups of Bigs & Little FB Confl. |
| Sample technique: | BP | BP | BP | BP | BP | WS | WS | BP | BP |
| Sample date: | 07/07/08 | 08/04/05 | 08/04/05 | 07/19/05 | 7/21/05 | 7/21/05 | 7/21/05 | 05/17/07 | 05/17/07 |
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| Smallmouth bass | 10 | - | - | - | 3.5 | 3.3 | 5.9 | - | - |
| Spottail shiner | - | - | - | - | - | 15.0 | - | - | - |
| Swallowtail shiner | - | - | - | - | - | 25.0 | - | - | - |
| Tessellated darter | 30 | - | - | 34.5 | 35.3 | 105.0 | 23.6 | 20.0 | 11.3 |
| White sucker | 82 | 11 | - | 120.7 | 57.6 | 175.0 | 29.5 | - | - |
| Total fish/100m | 385 | 59 | 99 | 400 | 238 | 602 | 289 | 373 | 265 |
| Number of species | 19 | 8 | 2 | 7 | 13 | 17 | 13 | 10 | 14 |
| Total meters sampled | 100 | 100 | 100 | 29 | 85 | 60 | 33.9 | 30 | 80 |
| Average sample width | 70 | 2.5 | 1 | 7 | - | 15 | 28.5 | 9 | 12 |

Note: The Flat Brook samples were extrapolated due to sample length being less than 100 m.

Bold print indicates Priority I or II species.

Table 14. Frequencies of occurrence (Freq.) and relative abundances of fish species (Rel.) caught by the Academy of National Sciences in different groups of lakes and ponds in the Delaware Water Gap National Recreation Area (DEWA) (sorted in descending order based on frequency) as part of the DEWA fish inventory.

| Common name | Frequency (%) | Number of sites | Average relative | Unweighted relative | Lakes on Kittatinny Ridge | | Other lakes | | Floodplain ponds | | Other ponds | | Non-randomly selected lakes & ponds | |
|----------------------------|---------------|-----------------|------------------|---------------------|---------------------------|----------|--------------|-------------|------------------|-------------|-------------|----------|-------------------------------------|-------------|
| | | | | | Freq. (%) | Rel. (%) | Freq. (%) | Rel. (%) | Freq. (%) | Rel. (%) | Freq. (%) | Rel. (%) | Freq. (%) | Rel. (%) |
| Pumpkinseed | 76.7% | 23 | 39.4% | 46.9% | 40.0% | 17.7% | 85.7% | 14.5% | 100.0% | 59.1% | 87.5% | 52.6% | 71.4% | 53.1% |
| Bluegill | 50.0% | 15 | 17.8% | 18.6% | 60.0% | 15.4% | 57.1% | 22.8% | 100.0% | 22.2% | 37.5% | 13.5% | 28.6% | 15.3% |
| Golden shiner | 43.3% | 13 | 14.0% | 14.5% | 60.0% | 23.8% | 28.6% | 5.9% | 33.3% | 17.1% | 50.0% | 16.7% | 42.9% | 6.4% |
| Brown bullhead | 36.7% | 11 | 7.0% | 4.8% | 40.0% | 9.0% | 57.1% | 23.7% | 33.3% | 0.1% | 25.0% | 1.4% | 28.6% | 0.9% |
| Largemouth bass | 36.7% | 11 | 8.5% | 7.2% | 20.0% | 8.1% | 57.1% | 18.4% | 33.3% | 0.2% | 50.0% | 11.4% | 14.3% | 4.2% |
| Chain pickerel | 33.3% | 10 | 2.6% | 1.7% | 40.0% | 7.0% | 42.9% | 2.6% | 33.3% | 0.6% | 37.5% | 1.8% | 14.3% | 1.1% |
| Yellow perch | 20.0% | 6 | 2.7% | 1.4% | 80.0% | 8.4% | 14.3% | 4.9% | - | - | 12.5% | 0.1% | - | - |
| Black crappie | 10.0% | 3 | 0.2% | 0.3% | - | - | 14.3% | 0.5% | 66.7% | 0.5% | - | - | - | - |
| Redbreast sunfish | 10.0% | 3 | 1.7% | 0.6% | 20.0% | 8.1% | - | - | 33.3% | 0.1% | - | - | 14.3% | 0.2% |
| Bluespotted sunfish | 6.7% | 2 | 1.6% | 0.9% | - | - | - | - | 33.3% | 0.1% | - | - | 14.3% | 7.9% |
| Fathead minnow | 6.7% | 2 | 1.5% | 1.2% | - | - | - | - | - | - | 12.5% | 2.5% | 14.3% | 4.8% |
| Redfin pickerel | 6.7% | 2 | 1.9% | 1.2% | - | - | 14.3% | 4.9% | - | - | - | - | 14.3% | 4.4% |
| Bridle shiner | 3.3% | 1 | 0.4% | 0.3% | - | - | 14.3% | 1.9% | - | - | - | - | - | - |
| Brook trout | 3.3% | 1 | 0.3% | 0.1% | 20.0% | 1.7% | - | - | - | - | - | - | - | - |
| Goldfish | 3.3% | 1 | 0.2% | 0.1% | - | - | - | - | - | - | - | - | 14.3% | 0.9% |
| Common carp | 3.3% | 1 | 0.0% | 0.0% | - | - | - | - | - | - | - | - | 14.3% | 0.2% |
| Common shiner | 3.3% | 1 | 0.1% | 0.0% | - | - | - | - | - | - | - | - | 14.3% | 0.4% |
| Creek chubsucker | 3.3% | 1 | 0.0% | 0.0% | - | - | 14.3% | 0.1% | - | - | - | - | - | - |
| Eastern mudminnow | 3.3% | 1 | 0.0% | 0.1% | - | - | - | - | 33.3% | 0.2% | - | - | - | - |
| Swallowtail shiner | 3.3% | 1 | 0.0% | 0.0% | - | - | - | - | - | - | - | - | 14.3% | 0.2% |
| Yellow bullhead | 3.3% | 1 | 0.2% | 0.1% | 20.0% | 0.9% | - | - | - | - | - | - | - | - |
| Totals | - | - | - | 5062 | - | 345 | - | 782 | - | 1932 | - | 1459 | - | 544 |
| Number of sites | - | 30 | - | - | - | 5 | - | 7 | - | 3 | - | 8 | - | 7 |

*Relative abundance is calculated as the total number of individuals of a species in all ponds in a group divided by the total number of individuals caught in those ponds.

Note: The average relative abundance is weighted by the number of sites in each group. Calculations are over sites in which fish were caught. Bold print indicates Priority I or II species.

Some of the lakes and ponds selected for sampling had no fish or were dry. The proportion of these among the original list of randomly selected sites provides an estimate of the frequency of fishless or drained ponds (inclusion of sites subsequently sampled would bias the estimate, since selection stopped when a site with fish was identified) (Tables 15–22). Of the five Kittatinny Ridge lakes and ponds selected, three had fish. Success Lake had been largely drained; the remaining wetland was sampled, but no fish were caught. Dry Pond is either intermittent or dry. All of the seven selected lakes in the other lake stratum had fish. The water control structure at the outlet of L11 (adjacent to Flat Brook) is apparently not maintained, and the area of water was smaller than indicated on topographic maps.

All three of the floodplain ponds selected contained water and fish, although one was drying, with fish concentrated into a small remaining area. Of the 13 other randomly selected ponds, eight contained fish. P51 appeared permanent and P50 was dry. P46 appeared to be a vernal pool; it had water at the time of sampling, but appeared to have been recently dry. The site P20 (adjacent to Flat Brook downstream of Walpack Center Bridge) is no longer a pond; no fish were caught in the remnant wetland and stream. Pond P41 no longer exists; there was no outlet structure and the site of the pond was dry at the time of the site visit. Site P86 is mapped on topographic maps as a small pond near the Mt. Minsi ridge. The site was dry and didn't appear to support wetland vegetation at the time of sampling. Most of the sites which were dry and/or fishless were small, with no mapped inlet or outlet stream on the USGS topographic maps, although several had stream channel-like contours at the inlet or outlet. However, fish were found in some ponds which were small and had no mapped inlet or outlet stream.

In the Kittatinny Ridge sites (Table 15), yellow perch was the most widespread species; chain pickerel, golden shiner, and bluegill were also frequent. One site (Success Lake) was recently drained so that it consists mainly of stream channel and wetland, and no fish were found in this site. Long Pine Pond had few fish (a few yellow perch were seen), apparently due to acidification (USEPA, J. Kurtenbach, pers. comm., 2004). Only 11 species were collected in other lakes (Table 16).

Three valley floor ponds were sampled. Pumpkinseed and bluegill were caught in all three, but there were differences in fish occurrence among the three (Table 17). These differences are likely due to differences in permanence and connection to the river. A pond near the Bushkill access contained eastern mudminnow and bluespotted sunfish. This is the largest of the three ponds, is closest to the river, and is probably most often connected to the river. A pond near the mouth of Hornbecks Creek had high densities of fish and a moderately high diversity of fish. This pond was clearly drying up at the time of sampling, accounting for the high densities of fish. This pond is on the floodplain of the river and is connected to the river or to Hornbecks Creek at high water levels. A third pond (P34) had only a few species. This pond is an artificial pond on the terrace near Milford. This pond is probably flooded by the Delaware River only at extremely high water levels, if at all.

Eight species were collected from other randomly selected ponds (Table 18), with few species (one to five) in each pond. Pumpkinseeds were caught in most of these ponds. Centrarchids (sunfish, largemouth bass and black crappie [*Pomoxis nigromaculatus*]) were most widespread.

Table 15. Records of fishes collected in 2004 and 2006 by the Academy of Natural Sciences via various sampling methods from the Kittatinny stratum (lakes on the Kittatinny Ridge in NJ) and Catfish Pond (placed in its own stratum) as part of the Delaware Water Gap National Recreation Area fish inventory.

| Common name | Station: | | | L02 | L03 | L04 | L05 | L08 | L01 |
|----------------------------|------------|----------------|--------------|-------------|----------------|----------------|---------------|--------------|-----|
| | Total of 5 | Frequency of 5 | Success Lake | Crater Lake | Long Pine Lake | Mt. Ridge Lake | Blue Mt. Lake | Catfish Pond | |
| Bluegill | 53 | 0.60 | - | 38 | - | 8 | 7 | 21 | |
| Bluespotted sunfish | 0 | 0.00 | - | - | - | - | - | 33 | |
| Brook trout | 6 | 0.20 | - | - | - | - | 6 | - | |
| Brown bullhead | 31 | 0.40 | - | 29 | - | 2 | - | 1 | |
| Chain pickerel | 24 | 0.40 | - | - | - | 17 | 7 | 9 | |
| Golden shiner | 82 | 0.60 | - | 45 | - | 36 | 1 | - | |
| Largemouth bass | 28 | 0.20 | - | - | - | - | 28 | 2 | |
| Pumpkinseed | 61 | 0.40 | - | - | - | 9 | 52 | 18 | |
| Redbreast sunfish | 28 | 0.20 | - | - | - | - | 28 | - | |
| Yellow bullhead | 3 | 0.20 | - | - | - | - | 3 | - | |
| Yellow perch | 29 | 0.80 | - | 22 | 2 | 1 | 4 | 69 | |
| Totals | 345 | - | 0 | 134 | 2 | 73 | 136 | 153 | |
| Number of species | 10 | - | 0 | 4 | 1 | 6 | 9 | 7 | |
| Number of sample dates | - | - | 1 | 1 | 1 | 1 | 1 | 2 | |

Note: At the time of sampling, Success Lake had been drained and sampling was done in wetland channels.

Frequency indicates the proportion of Kittatinny stratum stations at which a species was present.

Bold print indicates Priority I or II species.

Table 16. Records of fishes collected in 2004 and 2005 by various sampling methods in the Lakes stratum (lakes, excluding those on the Kittatinny Ridge in NJ) by the Academy of Natural Sciences as part of the Delaware Water Gap National Recreation Area fish inventory.

| Common name | Total | Station: | | | | | | | |
|------------------------|-----------|----------------|-------------------------------|---------------------------------|------------------------------|-----------------------|--------------------------------|-----------------------------|------------------------|
| | | Frequency of 7 | DWGL14 West of Hainesville | DWGL17 SW of Sunny Hill Lake | P77 Plateau S of Bushkill | DWGL20 Landis Lake | L11 Tributary to Flat Brook | L13 Kittatinny Camp Lake | L16 Sunny Hill Lake |
| Black crappie | 4 | 0.14 | - | 4 | - | - | - | - | - |
| Bluegill | 178 | 0.57 | 10 | - | - | 28 | - | 132 | 8 |
| Bridle shiner | 15 | 0.14 | - | - | - | - | 15 | - | - |
| Brown bullhead | 185 | 0.57 | - | 179 | - | 2 | 1 | - | 3 |
| Chain pickerel | 20 | 0.43 | - | 2 | - | 5 | - | - | 13 |
| Creek chubsucker | 1 | 0.14 | - | - | - | - | 1 | - | - |
| Golden shiner | 46 | 0.29 | - | 39 | - | - | 7 | - | - |
| Largemouth bass | 144 | 0.57 | 60 | - | - | 67 | - | 15 | 2 |
| Pumpkinseed | 113 | 0.86 | 8 | 51 | 12 | 27 | 3 | 12 | - |
| Redfin pickerel | 38 | 0.14 | - | - | - | - | 38 | - | - |
| Yellow perch | 38 | 0.14 | - | 38 | - | - | - | - | - |
| Totals | 782 | - | 78 | 313 | 12 | 129 | 65 | 159 | 26 |
| Number of species | 11 | - | 3 | 6 | 1 | 5 | 6 | 3 | 4 |

Note: Frequency indicates the proportion of all seven of the stations at which a species was present. Bold print indicates Priority I or II species.

Table 17. Records of fishes collected in 2004 by seine sampling in the floodplain ponds stratum by the Academy of Natural Sciences as part of the Delaware Water Gap National Recreation Area fish inventory.

| Common name | Total | Station: | | | |
|----------------------------|----------|----------------|--------------------------------|---------------------------------|-------------------------|
| | | Frequency of 3 | P71 North of Bushkill Creek | P60 North of Hornbecks Creek | P34 South of Milford |
| Black crappie | 9 | 0.67 | 6 | - | 3 |
| Bluegill | 429 | 1.00 | 102 | 22 | 305 |
| Bluespotted sunfish | 2 | 0.33 | 2 | - | - |
| Brown bullhead | 1 | 0.33 | - | 1 | - |
| Chain pickerel | 11 | 0.33 | - | 11 | - |
| Eastern mudminnow | 3 | 0.33 | 3 | - | - |
| Golden shiner | 330 | 0.33 | - | 330 | - |
| Largemouth bass | 4 | 0.33 | - | - | 4 |
| Pumpkinseed | 1142 | 1.00 | 8 | 1133 | 1 |
| Redbreast sunfish | 1 | 0.33 | 1 | - | - |
| Totals | 1932 | - | 122 | 1497 | 313 |
| Number of species | 10 | - | 6 | 5 | 4 |

Frequency indicates the proportion of all three of the stations at which a species was present. Bold print indicates Priority I or II species.

Table 18. Records of fishes collected between 2004 and 2006 by various sampling methods in the ponds stratum by the Academy of Natural Sciences as part of the Delaware Water Gap National Recreation Area fish inventory.

| | Station: | | | | | | | | | |
|-----------------------|-----------|----------------|------------------------------|---------------------------|------------------------------------|----------------|----------------|------------------|-----------------|------------------|
| | | P9 | P35 | P36 | P43 | P57 | P70 | DWGL19 | P90 | |
| Common name | Total | Frequency of 8 | Pond 9 in Watergate Rec area | at Cliff park golf course | Big pond at Cliff park golf course | McCarty Corner | Dingmans Ferry | Maple left trib. | Whittakers Pond | Slateford Quarry |
| Bluegill | 197 | 0.38 | 1 | - | 145 | - | - | 51 | - | - |
| Brown bullhead | 21 | 0.25 | - | - | - | 11 | - | - | 10 | - |
| Chain pickerel | 26 | 0.38 | 2 | - | - | - | 5 | - | 19 | - |
| Fathead minnow | 37 | 0.13 | - | - | - | - | - | - | - | 37 |
| Golden shiner | 243 | 0.50 | 2 | - | - | 12 | 1 | - | 228 | - |
| Largemouth bass | 166 | 0.50 | 12 | - | 149 | - | 1 | 4 | - | - |
| Pumpkinseed | 767 | 0.88 | 25 | 4 | 2 | 332 | 43 | 11 | 350 | - |
| Yellow perch | 2 | 0.13 | - | - | - | - | 2 | - | - | - |
| Totals | 1459 | - | 42 | 4 | 296 | 355 | 52 | 66 | 607 | 37 |
| Number of species | 8 | - | 5 | 1 | 3 | 3 | 5 | 3 | 4 | 1 |

Note: See text for information on ponds without fish and dry ponds.

Frequency indicates the proportion of all eight of the stations at which a species was present.

Bold print indicates Priority I or II species.

Table 19. Records of fishes collected in 2004 and 2005 by various sampling methods in non-randomly selected ponds by the Academy of Natural Sciences as part of the Delaware Water Gap National Recreation Area fish inventory.

| | Station: | Target | | | Non-random (arbitrary) | | | | |
|----------------------------|-----------|----------------|-------------|---------------------------|------------------------|--------------------|-----------------------------|---------------------------|-----------------------|
| | | LL | FB2 | P55 | P15 | P42 | P78 | P25 | |
| Common name | Total | Frequency of 7 | Lake Lenape | Flat Brook, isolated pond | Trib. Dingmans | North of Millbrook | Milford Rd McCarty's Corner | Tributary Sand Hill Creek | North of Peters Creek |
| Bluegill | 83 | 0.29 | - | - | 73 | - | - | - | 10 |
| Bluespotted sunfish | 43 | 0.14 | - | 43 | - | - | - | - | - |
| Brown bullhead | 5 | 0.29 | 3 | - | - | - | 2 | - | - |
| Chain pickerel | 6 | 0.14 | - | - | 6 | - | - | - | - |
| Common carp | 1 | 0.14 | - | - | - | 1 | - | - | - |
| Common shiner | 2 | 0.14 | - | 2 | - | - | - | - | - |
| Fathead minnow | 26 | 0.14 | 26 | - | - | - | - | - | - |
| Golden shiner | 35 | 0.43 | 15 | - | - | - | 9 | 11 | - |
| Goldfish | 5 | 0.14 | 5 | - | - | - | - | - | - |
| Largemouth bass | 23 | 0.14 | - | - | 23 | - | - | - | - |
| Pumpkinseed | 289 | 0.71 | 15 | 6 | 2 | - | 248 | - | 18 |
| Redbreast sunfish | 1 | 0.14 | 1 | - | - | - | - | - | - |
| Redfin pickerel | 24 | 0.14 | - | 24 | - | - | - | - | - |
| Swallowtail shiner | 1 | 0.14 | - | 1 | - | - | - | - | - |
| Totals | 544 | - | 65 | 76 | 104 | 1 | 259 | 11 | 28 |
| Number of species | 14 | - | 6 | 5 | 4 | 1 | 3 | 1 | 2 |

Frequency indicates the proportion of all seven of the stations at which a species was present.

Bold print indicates Priority I or II species.

Table 20. Records of fishes collected between 2004 and 2006 by various sampling methods in randomly selected streams by the Academy of Natural Sciences as part of the Delaware Water Gap National Recreation Area fish inventory.

| | Station: | ANS04 | D8.0 | ANS42 | D8.1 |
|----------------------------|-------------------|--|---|-------------------------------------|---|
| | Stratum: | II | II | II | V |
| | Waterbody: | Raymondskill Creek at 209 | Dingmans Creek at Milford Road | Outlet from catfish pond | D8.1 Trib. Dingmans at 739 |
| Common Name | Total | # | # | # | # |
| American eel | 61 | 59 | 2 | - | - |
| Blacknose dace | 157 | 45 | 24 | - | 88 |
| Bluegill | 1 | - | 1 | - | - |
| Bluespotted sunfish | 1 | - | - | 1 | - |
| Brook trout | 46 | - | 5 | - | 41 |
| Brown bullhead | 1 | - | - | 1 | - |
| Brown trout | 17 | 10 | 7 | - | - |
| Chain pickerel | 4 | - | - | 4 | - |
| Common shiner | 5 | 5 | - | - | - |
| Creek chub | 1 | 1 | - | - | - |
| Cutlip minnow | 16 | 16 | - | - | - |
| Fallfish | 196 | 196 | - | - | - |
| Longnose dace | 43 | 43 | - | - | - |
| Margined madtom | 28 | 26 | 2 | - | - |
| Northern hog sucker | 1 | 1 | - | - | - |
| Pumpkinseed | 46 | - | - | 46 | - |
| Rainbow trout | 7 | - | 7 | - | - |
| Rock bass | 3 | 3 | - | - | - |
| Shield darter | 8 | 8 | - | - | - |
| Smallmouth bass | 1 | 1 | - | - | - |
| Tesselated darter | 46 | 46 | - | - | - |
| White sucker | 42 | 31 | 11 | - | - |
| Totals | 731 | 491 | 59 | 52 | 129 |
| Number of species | 22 | 15 | 8 | 4 | 2 |

Bold print indicates Priority I or II species.

Table 21. Records of fishes collected between 2004 and 2006 by various sampling methods in fixed and target streams by the Academy of Natural Sciences as part of the Delaware Water Gap National Recreation Area fish inventory.

| Common Name | Station Name | Fixed | | | | Target | | |
|----------------------------|--------------|-------------|------------|----------------|--------------------|-------------------|------------------|----------------|
| | | FB | BK1 | VCC | VC | VAN | BH, BR | |
| | | Stratum | VIA | VIC | VIC | V | | |
| | | Waterbody | Flat Brook | Bushkill Creek | Van Campens Brook | Van Campens Brook | Vandermark Creek | Brodhead Creek |
| | | 14 stations | BK1 | Confluence | Watergate Rec Area | below 209 | mouth | |
| Total | # | # | # | # | # | # | | |
| American eel | 259 | 167 | 81 | - | - | 8 | 3 | |
| Banded killifish | 156 | - | - | - | - | - | 156 | |
| Blacknose dace | 1164 | 952 | 196 | - | 15 | 1 | - | |
| Bluegill | 14 | 7 | 1 | - | - | - | 6 | |
| Bluespotted sunfish | 76 | 76 | - | - | - | - | - | |
| Bridle shiner | 88 | 88 | - | - | - | - | - | |
| Brook trout | 7 | 4 | 1 | - | - | 2 | - | |
| Brown bullhead | 3 | 1 | - | - | 2 | - | - | |
| Brown trout | 53 | 9 | 3 | - | - | 41 | - | |
| Chain pickerel | 6 | 1 | - | - | 5 | - | - | |
| Common shiner | 1264 | 1260 | 4 | - | - | - | - | |
| Creek chub | 107 | 107 | - | - | - | - | - | |
| Creek chubsucker | 12 | 12 | - | - | - | - | - | |
| Cutlip minnow | 302 | 268 | 34 | - | - | - | - | |
| Fallfish | 412 | 7 | 29 | 346 | - | - | 39 | |
| Golden shiner | 23 | 22 | 1 | - | - | - | - | |
| Lamprey species | 1 | 1 | - | - | - | - | - | |
| Largemouth bass | 22 | 13 | 1 | - | - | - | 8 | |
| Longnose dace | 279 | 124 | 145 | - | - | - | 10 | |
| Margined madtom | 14 | 1 | 13 | - | - | - | - | |
| Minnow species | 75 | 75 | - | - | - | - | - | |
| Northern hog sucker | 6 | 3 | 1 | - | - | - | 2 | |
| Pumpkinseed | 45 | 43 | - | - | 2 | - | - | |
| Rainbow trout | 2 | 2 | - | - | - | - | - | |
| Redbreast sunfish | 14 | 2 | - | - | - | - | 12 | |
| Redfin pickerel | 40 | 40 | - | - | - | - | - | |
| Rock bass | 38 | 32 | 1 | - | - | - | 5 | |

| | Station | Fixed | | | | Target | |
|---------------------------|--------------|-------------|----------------|-------------------|--------------------|------------------|----------------|
| | | FB | BK1 | VCC | VC | VAN | BH, BR |
| | Stratum | | VIA | VIC | VIC | V | |
| | Waterbody | Flat Brook | Bushkill Creek | Van Campens Brook | Van Campens Brook | Vandermark Creek | Brodhead Creek |
| | Station Name | 14 stations | BK1 | Confluence | Watergate Rec Area | below 209 | mouth |
| Common Name | Total | # | # | # | # | # | # |
| Satfin shiner | 4 | - | - | - | - | - | 4 |
| Sea lamprey | 65 | 63 | 2 | - | - | - | - |
| Shield darter | 46 | 28 | 10 | 2 | - | - | 6 |
| Slimy sculpin | 287 | 269 | - | - | - | 18 | - |
| Smallmouth bass | 42 | 8 | 20 | 1 | - | - | 13 |
| Spotfin shiner | 23 | - | - | - | - | - | 23 |
| Spottail shiner | 68 | 9 | - | 59 | - | - | - |
| Sunfish species | 1 | 1 | - | - | - | - | - |
| Swallowtail shiner | 59 | 54 | - | 1 | - | - | 4 |
| Tessellated darter | 400 | 225 | 60 | 112 | - | - | 3 |
| Trout species | 3 | - | - | - | 3 | - | - |
| Western mosquitofish | 3 | 3 | - | - | - | - | - |
| White sucker | 980 | 612 | 164 | 125 | - | - | 79 |
| Totals | 6472 | 4589 | 767 | 646 | 27 | 70 | 373 |
| Number of species | 36 | 33 | 19 | 7 | 5 | 5 | 16 |

Bold print indicates Priority I or II species.

Table 22. Frequency of fishes collected at each group of sampling stations by the Academy of Natural Sciences as part of the Upper Delaware Scenic and Recreational River (UPDE) and Delaware Water Gap National Recreation Area (DEWA) fish inventory.

| Common name | Delaware River | | Kitt. Lakes & Ponds | Other Lakes | Floodplain Ponds | Other Ponds | Streams | Non-random | Coldwater Streams | Fixed | UPDE Adjacent |
|-------------------------------|----------------|-------------|---------------------|-------------|------------------|-------------|-------------|-------------|-------------------|-----------|------------------|
| | UPDE | DEWA | | | | | | | | | |
| Alewife | 0.11 | - | - | - | - | - | - | - | - | - | - |
| American brook lamprey | - | - | - | - | - | - | - | - | 0.06 | - | - |
| American eel | 1.00 | 1.00 | - | - | - | - | 0.43 | - | 0.28 | 0.5 (V) | 0.14 (WBH) |
| American shad | 0.67 | 0.67 | - | - | - | - | - | - | - | - | - |
| Banded killifish | 0.78 | 0.50 | - | - | - | - | - | - | - | - | 0.29 (2) |
| Black crappie | 0.22 | - | - | 0.14 | 0.67 | - | - | - | - | - | 0.14 (NL) |
| Blacknose dace | 0.78 | 0.17 | - | - | - | - | 0.71 | - | 0.61 | 1.0 (D,V) | 0.71 (5) |
| Blueback herring | - | 0.17 | - | - | - | - | - | - | - | - | - |
| Bluegill | 0.67 | 0.67 | 0.60 | 0.57 | 1.00 | 0.38 | 0.29 | 0.29 | 0.33 | - | 0.14 (CC) |
| Bluespotted sunfish | 0.22 | 0.17 | 0.00 | - | 0.33 | - | 0.14 | 0.14 | 0.33 | - | 0.14 (NL) |
| Bluntnose minnow | 0.67 | - | - | - | - | - | - | - | - | - | 0.14 (CC) |
| Bridle shiner | 0.11 | - | - | 0.14 | - | - | - | - | 0.28 | - | - |
| Brook trout | 0.11 | 0.17 | 0.20 | - | - | - | 0.43 | - | 0.11 | 1.0 (D,V) | - |
| Brown bullhead | 0.67 | 1.00 | 0.40 | 0.71 | 0.33 | 0.13 | 0.29 | 0.29 | 0.17 | - | 0.14 (WBH) |
| Brown trout | 0.44 | 0.50 | - | - | - | - | 0.43 | - | 0.33 | 0.5 (V) | 0.43 (3) |
| Central stoneroller | 0.11 | - | - | - | - | - | - | - | - | - | - |
| Chain pickerel | 0.44 | 0.17 | 0.40 | 0.57 | 0.33 | 0.25 | 0.29 | 0.14 | 0.17 | - | 0.14 (NL) |
| Channel catfish | - | 0.67 | - | - | - | - | - | - | - | - | - |
| Comely shiner | 0.44 | 1.00 | - | - | - | - | - | - | - | - | - |
| Common carp | 0.56 | 0.83 | - | - | - | - | - | 0.14 | - | - | 0.29 (2) |
| Common shiner | 0.89 | 0.83 | - | - | - | - | 0.29 | 0.14 | 0.72 | - | 0.57 (4) |
| Creek chubsucker | 0.11 | - | - | 0.14 | - | 0.00 | - | - | 0.22 | - | - |
| Creek chub | 0.11 | 0.17 | - | - | - | - | 0.14 | - | 0.39 | - | 0.29 (2) |
| Cutlip minnow | 1.00 | 0.50 | - | - | - | - | 0.29 | - | 0.56 | - | 0.57 (4) |
| Eastern mudminnow | 0.11 | 0.67 | - | - | 0.33 | - | - | - | - | - | - |
| Fallfish | 1.00 | 1.00 | - | - | - | - | 0.43 | - | 0.28 | - | 0.57 (4) |
| Fathead minnow | 0.22 | - | - | - | - | 0.13 | - | 0.14 | - | - | - |
| Gizzard shad | 0.56 | 0.17 | - | - | - | - | - | - | - | - | - |
| Golden shiner | 0.78 | 0.33 | 0.60 | 0.43 | 0.33 | 0.38 | 0.14 | 0.43 | 0.33 | - | - |
| Goldfish | - | - | - | - | - | - | - | 0.14 | - | - | - |
| Green sunfish | 0.56 | 0.17 | - | - | - | - | - | - | - | - | 0.29 (2) |
| Largemouth bass | 0.44 | 0.50 | 0.20 | 0.57 | 0.33 | 0.50 | 0.14 | 0.14 | 0.61 | - | 0.29 (2) |
| Longnose dace | 0.89 | 0.67 | - | - | - | - | 0.29 | - | 0.28 | - | 0.71 (5) |
| Margined madtom | 0.89 | 0.83 | - | - | - | - | 0.43 | - | 0.11 | - | 0.14 (WBH) |
| Minnow species | 0.00 | - | - | - | - | - | - | - | 0.11 | - | 0.14 (WBR1) |
| Mottled sculpin | - | - | - | - | - | - | - | - | - | - | 0.14 (SHT1) |
| Muskellunge | 0.11 | 0.67 | - | - | - | - | - | - | - | - | - |

| Common name | Delaware River | | Kitt. Lakes & Ponds | Other Lakes | Floodplain Ponds | Other Ponds | Streams | Non-random | Coldwater | | UPDE Adjacent |
|----------------------------|----------------|-------------|------------------------|----------------|---------------------|----------------|-------------|-------------|-------------|---------|------------------|
| | UPDE | DEWA | | | | | | | Streams | Fixed | |
| Northern hog sucker | 0.56 | 0.83 | - | - | - | - | 0.29 | - | 0.17 | - | - |
| Pumpkinseed | 0.67 | 0.83 | 0.40 | 0.86 | 1.00 | 0.88 | 0.29 | 0.71 | 0.56 | - | - |
| Quillback | - | 0.33 | - | - | - | - | - | - | - | - | - |
| Rainbow trout | 0.33 | - | - | - | - | - | 0.14 | - | 0.11 | - | 0.14 (WBBE) |
| Redbreast sunfish | 0.89 | 0.83 | 0.20 | - | 0.33 | - | - | 0.14 | 0.11 | - | 0.14 (CC) |
| Redfin pickerel | - | - | - | 0.14 | - | 0.00 | - | 0.14 | 0.39 | - | - |
| Rock bass | 1.00 | 1.00 | - | - | - | - | 0.29 | - | 0.33 | - | - |
| Satinfin shiner | 0.67 | 0.83 | - | - | - | - | - | - | - | - | - |
| Sea lamprey | 1.00 | 1.00 | - | - | - | - | 0.14 | - | 0.28 | - | 0.14 (WBH) |
| Shield darter | 0.78 | 1.00 | - | - | - | - | 0.43 | - | 0.33 | - | 0.29 (2) |
| Slimy sculpin | - | - | - | - | - | - | - | - | 0.11 | 0.5 (V) | - |
| Smallmouth bass | 1.00 | 1.00 | - | - | - | - | 0.43 | - | 0.22 | - | 0.29 (2) |
| Spotfin shiner | - | 0.83 | - | - | - | - | - | - | - | - | - |
| Spottail shiner | 1.00 | 1.00 | - | - | - | - | 0.14 | - | 0.11 | - | - |
| Striped bass | 0.22 | 0.17 | - | - | - | - | - | - | - | - | - |
| Sunfish species | - | - | - | - | - | - | - | - | 0.06 | - | 0.14 (NL) |
| Swallowtail shiner | 0.44 | 1.00 | - | - | - | - | 0.14 | 0.14 | 0.33 | - | - |
| Tesselated darter | 1.00 | 1.00 | - | - | - | - | 0.43 | - | 0.56 | - | 0.86 (6) |
| Trout species | - | - | - | - | - | - | 0.14 | - | 0.06 | - | - |
| Walleye | 0.56 | 0.33 | - | - | - | - | - | - | - | - | - |
| Western mosquitofish | - | - | - | - | - | - | - | - | 0.06 | - | - |
| White sucker | 1.00 | 1.00 | - | - | - | - | 0.57 | - | 0.61 | - | 0.71 (5) |
| Yellow bullhead | 0.22 | 0.67 | 0.20 | - | - | - | - | - | - | - | - |
| Yellow perch | 0.78 | 0.83 | 0.80 | 0.14 | - | 0.13 | - | - | 0.06 | - | 0.14 (NL) |
| Totals | 27.8 | 28.7 | 4.0 | 4.43 | 5.0 | 2.8 | 8.6 | 3.1 | 10.7 | 3.5 | 9.3 |
| # sites samples | 9 | 6 | 5 | 7.00 | 3 | 8 | 7 | 7 | 18 | 2 | 7 |

Note: The first eight columns of numbers were taken directly from previously constructed tables and the individual sampling sites that make up these frequencies can be seen there.

The coldwater streams column included the catfish pond, Bushkill Creek, all Flat Brook sites, and Van Campens Brook.

The fixed column included only Vandermark Creek and the tributary to Dingmans Creek.

The UPDE (adjacent) column included Nabby's Lake, Cooley Creek mouth, and all West Branch Delaware River sites.

Bold print indicates Priority I or II species.

Eleven other ponds were sampled in addition to the randomly selected ponds (Table 19). One, Lake Lenape, was targeted because of reports of goldfish (*Carassius auratus*) by R. Evans. Goldfish and fathead minnow (*Pimephales promelas*) were collected from this lake. The other lakes were sampled as opportunity permitted (e.g., proximity to other sampling sites). One of these (FB2) is adjacent to Flat Brook. Bluespotted sunfish and redbfin pickerel were common in this pond. Otherwise, ponds were similar to the randomly selected ponds, with pumpkinseed most frequent, and bluegill, golden shiner, and a few other species present as well.

Streams

Thirty-six species were caught in DEWA streams (Table 20). All of these except banded killifish, spotfin shiner, and satinfin shiner (all three caught in the mouth of Brodhead Creek) were caught in Flat Brook. Brook trout were caught in five streams. The size distribution of these (see section on brook trout below) suggests that reproduction occurred in at least three of these.

Flat Brook was extensively sampled because it is the largest stream in the park and contains several species of fish that are absent or uncommon elsewhere in the park. Five sites were sampled in Flat Brook with backpack electrofishing. Ten other sites were sampled by snorkeling, observation, and/or seining. Thirty-four species were collected in these samples (Tables 20 and 21), with 17–22 species collected in the four sites where electrofishing was done. Notable species collected include bridled shiner, swallowtail shiner, redbfin pickerel, northern hog sucker, bluespotted sunfish, and slimy sculpin (*Cottus cognatus*). Three specimens of western mosquitofish (*Gambusia affinis*) were collected at Haneys Mill Pond in 2004; no mosquitofish were caught at that site in 2005.

Samples were taken at Raymondskill Creek, Vancampens Brook, two sites in Dingmans Creek, the outlet to Catfish Pond, one site in Bushkill Creek (Table 20), Vandermark Creek, and at the mouth of Brodhead Creek (Table 21) (including a side channel between Brodhead Creek and the mouth of Michaels Creek). Northern hog sucker was caught at Raymondskill Creek, Bushkill Creek, and Brodhead Creek. Swallowtail shiner was caught at Vancampens Creek and Brodhead Creek. Bluespotted sunfish was caught in Catfish Pond and was caught at the pond's outlet stream as well. Satinfin and spotfin shiners were caught in Brodhead Creek; satinfin shiner was caught along the main channel, while spotfin shiners were caught in an isolated side channel. Slimy sculpin, as well as brook and brown trout (*Salvelinus fontinalis* and *Salmo trutta*), were caught in Vandermark Creek, which was targeted, based on previous collections of slimy sculpin. Brook trout were also relatively common in the two Dingmans Creek sites.

Several of the randomly selected streams or stream reaches were dry at the time of visitation. Among four plateau sections of streams which were randomly selected, one was dry, one was a pond-wetland system, and one had no fish. Of three flat sections of streams which were randomly selected, three were dry during summer site visits. None of the larger streams which were fixed for sampling (Bushkill, Flat Brook, and Vancampens Brook) were dry.

Fish Abundance and Habitat in the Delaware River

Catch rates of fishes in UPDE boat electroshocking samples (Tables 23 and 24) show few longitudinal patterns; brown bullhead and bluegill were more abundant at lower stations. A number of species (e.g., trouts, muskellunge [*Esox masquinongy*], and walleye) were caught in relatively low numbers, making it difficult to perceive trends. In addition, no standard boat electroshocking samples were taken above Hankins Reach. Within DEWA (Table 25) there was large variability in catch rates among stations, but there were few longitudinal trends. Striped bass (*Morone saxatilis*), carp (*Cyprinus carpio*), and walleye were caught only in lower stations, although all three were caught in UPDE. There were differences in abundance between the two parks. Gizzard shad, cutlip minnow (*Exoglossum maxillingua*), golden shiner, and fallfish had higher average catch rates in UPDE, while catch rates of spotfin shiner, muskellunge, tessellated darter (*Etheostoma olmstedi*), banded killifish (*Fundulus diaphanus*), spottail shiner, and swallowtail shiner were higher in DEWA (Tables 23–25).

There were differences in catch rates among samples containing different habitat types (Tables 26 and 27). A number of species, including American eel (*Anguilla rostrata*), brown bullhead, sea lamprey, brown trout, northern hog sucker, striped bass, and longnose dace (*Rhinichthys cataractae*), were more abundant in one or both parks in samples with relatively high velocity currents, while satinfish shiner, spotfin shiner, redbreast sunfish (*Lepomis auritus*), pumpkinseed, bluegill, common shiner, golden shiner, spottail shiner, and white sucker (*Catostomus commersoni*) were more common in one or both parks in samples containing low velocity areas.

Among habitat features, a number of species, including bullheads, white sucker, several minnows, and several sunfishes, were more common in backwater samples in UPDE. However, backwater samples in DEWA did not have notably high catch rates. A similar pattern was seen with samples containing tree or snag piles; these samples had high catch rates in UPDE, but not in DEWA. High catch rates of several species (common carp, golden shiner, yellow perch, and spotfin shiner) were found in samples at tributary mouths. However, there were few such samples (Tables 28–31) which would increase the likelihood of extreme values.

Table 23. Catch rates and average total catch rates per 100-m sample lengths of species collected between 2004 and 2007 by boat shock sampling at various stations throughout the upper Delaware River by the Academy of Natural Sciences as part of the Upper Delaware Scenic and Recreational River fish inventory.

| Station | U6 | U7 | U11 | U14 | U15 | U16 | |
|----------------------------|-------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Station name | Hankins | Callicoon upper | Narrowsburg | Lackawaxen | Shohola | Handsom Eddy | Average |
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| American eel | 11.55 | 18.42 | 7.51 | 13.41 | 4.81 | 11.80 | 11.25 |
| American shad | 2.67 | 4.41 | - | 1.52 | 0.50 | 0.88 | 1.66 |
| Banded killifish | - | - | 0.20 | - | - | - | 0.03 |
| Bluegill | - | 0.50 | 0.09 | 1.69 | 8.06 | 3.49 | 2.30 |
| Bluntnose minnow | - | - | 1.20 | - | 2.06 | - | 0.54 |
| Brook trout | - | - | - | 0.33 | - | - | 0.06 |
| Brown bullhead | - | - | 0.27 | 0.92 | 0.68 | 0.61 | 0.41 |
| Brown trout | 0.48 | 0.30 | - | 0.37 | - | - | 0.19 |
| Comely shiner | - | 0.91 | 2.75 | - | - | - | 0.61 |
| Common carp | 0.34 | 1.19 | - | 1.06 | 0.51 | - | 0.52 |
| Common shiner | - | - | 0.60 | 0.88 | 6.87 | - | 1.39 |
| Cutlip minnow | 1.91 | 0.50 | 0.71 | 1.48 | - | - | 0.77 |
| Fallfish | 8.86 | 8.40 | 3.08 | 5.56 | 16.69 | 1.21 | 7.30 |
| Fathead minnow | - | 0.30 | - | - | - | - | 0.05 |
| Gizzard shad | - | 4.48 | 0.43 | 2.39 | 0.81 | 2.28 | 1.73 |
| Golden shiner | 0.48 | - | - | 27.82 | 6.87 | - | 5.86 |
| Green sunfish | - | - | - | - | 0.34 | - | 0.06 |
| Largemouth bass | - | - | 0.48 | - | 0.34 | - | 0.14 |
| Longnose dace | - | 0.30 | - | - | - | - | 0.05 |
| Margined madtom | - | - | 0.27 | 0.37 | - | - | 0.11 |
| Northern hog sucker | - | 0.75 | 0.60 | - | - | - | 0.22 |
| Pickrel species | - | 0.77 | - | - | - | - | 0.13 |
| Pumpkinseed | - | 0.50 | 0.40 | 0.53 | 1.72 | - | 0.52 |
| Rainbow trout | 0.26 | 0.30 | - | - | - | - | 0.09 |
| Redbreast sunfish | 0.96 | 1.42 | 0.59 | 25.45 | 0.68 | 6.26 | 5.89 |
| Rock bass | 1.91 | 4.07 | 6.06 | 17.47 | 4.43 | 6.86 | 6.80 |
| Satinfin shiner | - | - | - | - | 4.12 | - | 0.69 |
| Sea lamprey | 0.26 | 0.84 | 0.46 | 0.37 | 2.00 | 0.73 | 0.78 |
| Shield darter | - | 0.50 | - | - | - | - | 0.08 |

| Station | U6 | U7 | U11 | U14 | U15 | U16 | |
|---------------------------|----------------|-----------------|----------------|----------------|----------------|----------------|----------------|
| Station name | Hankins | Callicoon upper | Narrowsburg | Lackawaxen | Shohola | Handsom Eddy | Average |
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| Smallmouth bass | 10.09 | 11.11 | 3.31 | 37.58 | 7.83 | 12.39 | 13.72 |
| Spottail shiner | - | 0.50 | 7.04 | 2.36 | 0.51 | - | 1.73 |
| Striped bass | - | 1.69 | - | 1.06 | - | - | 0.46 |
| Swallowtail shiner | - | - | 0.47 | - | - | - | 0.08 |
| Tesselated darter | - | - | 0.20 | - | - | 0.26 | 0.08 |
| Walleye | 0.26 | 0.72 | 0.26 | 1.31 | 0.26 | - | 0.47 |
| White sucker | 10.60 | 11.28 | 10.90 | 8.76 | 4.76 | 9.92 | 9.37 |
| Yellow bullhead | 0.48 | - | - | - | - | - | 0.08 |
| Yellow perch | 0.48 | 0.30 | 2.96 | 0.80 | 0.26 | - | 0.80 |
| Totals | 51.59 | 74.46 | 50.83 | 153.51 | 75.12 | 56.70 | 12.84 |
| Number of species | 16 | 25 | 24 | 23 | 22 | 12 | 38 |

Note: Sample lengths were not taken during sampling at Hancock (U1) and Callicoon lower (U8) and therefore average catch rates per 100 m could not be calculated for this table.

Bold print indicates Priority I or II species.

Table 24. Total number of species collected between 2004 and 2007 by boat shock sampling at various stations throughout the upper Delaware River by the Academy of Natural Sciences as part of the Upper Delaware Scenic and Recreational River fish inventory.

| Station | U1 | U6 | U7 | U8 | U11 | U14 | U15 | U16 |
|----------------------------|----------------|----------------|-----------------|------------------|----------------|----------------|----------------|----------------|
| Station name | Hancock* | Hankins | Callicoon upper | Callicoon lower* | Narrowsburg | Lackawaxen | Shohola | Handsome Eddy |
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| American eel | - | 34 | 68 | 168 | 39 | 60 | 13 | 29 |
| American shad | - | 9 | 19 | 85 | - | 14 | 1 | 5 |
| Banded killifish | - | - | - | - | - | - | - | - |
| Bluegill | - | - | 1 | - | - | 6 | 21 | 7 |
| Bluntnose minnow | - | - | - | - | 6 | - | 6 | - |
| Brook trout | - | - | - | - | - | 1 | - | - |
| Brown bullhead | 1 | - | - | - | 1 | 3 | 2 | 1 |
| Brown trout | - | 1 | 1 | 4 | - | 1 | - | - |
| Comely shiner | 1 | - | 3 | - | 23 | - | - | - |
| Common carp | - | 1 | 5 | 1 | - | 4 | 2 | - |
| Common shiner | 92 | - | - | - | 5 | 3 | 20 | - |
| Cutlip minnow | - | 4 | 1 | 1 | 3 | 4 | - | - |
| Fallfish | 33 | 26 | 25 | 4 | 22 | 26 | 49 | 2 |
| Fathead minnow | - | - | 1 | - | - | - | - | - |
| Gizzard shad | - | - | 17 | 7 | 5 | 9 | 2 | 13 |
| Golden shiner | 14 | 1 | - | - | - | 88 | 20 | - |
| Green sunfish | - | - | - | - | - | - | 1 | - |
| Largemouth bass | - | - | - | - | 4 | - | 1 | - |
| Longnose dace | - | - | 1 | 1 | - | - | - | - |
| Margined madtom | - | - | - | 1 | 1 | 1 | - | - |
| Northern hog sucker | - | - | 2 | 2 | 3 | - | - | - |
| Pickereel species | - | - | 1 | - | - | - | - | - |
| Pumpkinseed | - | - | 1 | - | 2 | 2 | 5 | - |
| Rainbow trout | - | 1 | 1 | 1 | - | - | - | - |
| Redbreast sunfish | - | 2 | 6 | 1 | 4 | 102 | 2 | 21 |
| Rock bass | - | 4 | 15 | 4 | 36 | 70 | 13 | 23 |
| Satinfin shiner | - | - | - | - | - | - | 12 | - |
| Sea lamprey | - | 1 | 3 | 99 | 2 | 1 | 4 | 2 |
| Shield darter | - | - | 1 | 1 | - | - | - | - |
| Smallmouth bass | - | 28 | 40 | 26 | 27 | 146 | 23 | 43 |

| Station | U1 | U6 | U7 | U8 | U11 | U14 | U15 | U16 |
|---------------------------|----------------|----------------|-----------------|------------------|----------------|----------------|----------------|----------------|
| Station name | Hancock* | Hankins | Callicoon upper | Callicoon lower* | Narrowsburg | Lackawaxen | Shohola | Handsome Eddy |
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| Spottail shiner | 149 | - | 1 | - | 46 | 8 | 2 | - |
| Striped bass | - | - | 6 | - | - | 4 | - | - |
| Swallowtail shiner | - | - | - | - | 2 | - | - | - |
| Tesselated darter | - | - | - | - | 1 | - | - | 1 |
| Walleye | - | 1 | 3 | 13 | 3 | 6 | 1 | - |
| White sucker | 81 | 33 | 39 | 128 | 51 | 36 | 14 | 37 |
| Yellow bullhead | - | 1 | - | - | - | - | - | - |
| Yellow perch | 4 | 1 | 1 | - | 20 | 3 | 1 | - |
| Totals | 375 | 148 | 262 | 457 | 308 | 598 | 215 | 184 |
| Number of species | 8 | 16 | 25 | 18 | 24 | 23 | 22 | 12 |

*Indicates stations where sample lengths were not taken during sampling and therefore average catch rates per 100 m could not be calculated in Table 21.

Bold print indicates Priority I or II species.

Table 25. Catch rates and average total catch rates per 100-m sample lengths and total number of each species collected between 2004 and 2007 by boat shock sampling at various stations throughout the Delaware River by the Academy of Natural Sciences as part of Delaware Water Gap National Recreation Area fish inventory.

| Station | D3 | D6 | D8 | D9 | D10 | | D3 | D6 | D8 | D9 | D10 |
|---------------------------|-----------------|----------------|----------------|----------------|--------------------|----------------|-----------------|----------|------------|-----------|--------------------|
| Station name | Dingman's Ferry | Walpack | Smithfield | Shawnee | Delaware Water Gap | Average | Dingman's Ferry | Walpack | Smithfield | Shawnee | Delaware Water Gap |
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish | # fish | # fish | # fish | # fish |
| American eel | 6.96 | 16.51 | 2.55 | 30.04 | 11.29 | 13.47 | 20 | 46 | 6 | 86 | 25 |
| American shad | - | - | - | 17.97 | - | 3.59 | - | - | - | 78 | - |
| Banded killifish | - | - | - | 3.33 | - | 0.67 | - | - | - | 1 | - |
| Bluegill | 4.00 | 0.18 | 0.33 | - | 0.61 | 1.02 | 9 | 1 | 1 | - | 1 |
| Brook trout | - | - | - | - | 0.36 | 0.07 | - | - | - | - | 1 |
| Brown bullhead | 0.50 | - | - | 3.33 | 0.72 | 0.91 | 1 | - | - | 1 | 2 |
| Brown trout | - | - | - | - | 0.72 | 0.14 | - | - | - | - | 2 |
| Comely shiner | 3.50 | - | 0.33 | 3.05 | 0.61 | 1.50 | 7 | - | 1 | 14 | 1 |
| Common carp | - | - | 0.32 | 0.23 | 0.90 | 0.29 | - | - | 1* | 1 | 2 |
| Common shiner | 6.77 | 1.30 | - | - | 0.61 | 1.73 | 11 | 2 | - | - | 1 |
| Cutlip minnow | 3.13 | 0.96 | - | 1.76 | 2.04 | 1.58 | 9 | 3 | - | 6 | 4 |
| Gizzard shad | - | - | 0.33 | - | - | 0.07 | - | - | 1 | - | - |
| Golden shiner | - | 0.65 | - | - | - | 0.13 | - | 1 | - | - | - |
| Largemouth bass | 1.16 | - | - | - | - | 0.23 | 3 | - | - | - | - |
| Muskellunge | - | 0.18 | 0.59 | 3.33 | - | 0.82 | - | 1 | 1 | 1 | - |
| Pumpkinseed | 0.50 | - | 4.00 | - | 1.21 | 1.14 | 1 | - | 6 | - | 2 |
| Redbreast sunfish | 9.23 | 0.94 | - | 6.54 | 23.30 | 8.00 | 30 | 3 | - | 16 | 48 |
| Rock bass | 3.38 | 3.29 | 0.98 | 4.99 | 19.86 | 6.50 | 11 | 9 | 3 | 18 | 44 |
| Satinfin shiner | 1.43 | - | - | 1.76 | 3.64 | 1.37 | 5 | - | - | 6 | 6 |
| Sea lamprey | - | - | - | 0.65 | 8.88 | 1.91 | - | - | - | 3 | 18 |
| Smallmouth bass | 4.00 | 2.26 | 0.58 | 5.60 | 17.48 | 5.98 | 12 | 6 | 2 | 23 | 42 |
| Spotfin shiner | 2.00 | - | 0.87 | 0.87 | 1.82 | 1.11 | 7 | - | 3 | 4 | 3 |
| Spottail shiner | 78.83 | 0.73 | 46.96 | 2.02 | 16.97 | 29.10 | 202 | 4 | 162 | 10 | 28 |
| Striped bass | - | - | - | - | 1.71 | 0.34 | - | - | - | - | 3 |
| Swallowtail shiner | 0.40 | 0.86 | - | 1.31 | - | 0.51 | 1 | 3 | - | 6 | - |
| Tessellated darter | - | 0.88 | 0.66 | - | 1.21 | 0.55 | - | 2 | 2 | - | 2 |
| Walleye | - | - | - | - | 6.29 | 1.26 | - | - | - | - | 11 |
| White sucker | 8.15 | 0.57 | 38.06 | 5.12 | 2.46 | 10.87 | 18 | 2 | 118 | 18 | 6 |

| Station | D3 | D6 | D8 | D9 | D10 | | D3 | D6 | D8 | D9 | D10 |
|-------------------|-----------------|----------------|----------------|----------------|--------------------|----------------|-----------------|---------|------------|---------|--------------------|
| Station name | Dingman's Ferry | Walpack | Smithfield | Shawnee | Delaware Water Gap | Average | Dingman's Ferry | Walpack | Smithfield | Shawnee | Delaware Water Gap |
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish | # fish | # fish | # fish | # fish |
| Yellow bullhead | - | - | - | 0.19 | 0.61 | 0.16 | - | - | - | 1 | 1 |
| Yellow perch | 0.50 | 0.88 | 0.66 | 0.92 | 1.21 | 0.83 | 1 | 2 | 2 | 4 | 2 |
| Totals | 134.44 | 30.21 | 97.21 | 93.04 | 124.50 | 95.88 | 348 | 85 | 309 | 297 | 255 |
| Number of species | 17 | 14 | 14 | 19 | 23 | - | 17 | 14 | 14 | 19 | 23 |

*Indicates that sample length had to be estimated from other samples taken using the same technique on the same date to calculate # fish/100 m.

Bold print indicates Priority I or II species.

Table 26. Summary of 2004 and 2006 boat shock habitat types and average catch rates per average 100-m sample length at specific habitats by the Academy of Natural Sciences as part of the Upper Delaware Scenic and Recreational River fish inventory.

| Habitat description | Shallow slope | Moderate slope | Gravel / Sand | Cobble / Boulder | Macro-phytes | Tributary mouth | Open shoreline | Backwater | Snags, brush pile | Slow to no flow (incl. eddy or CC) | Fast flow |
|----------------------------|----------------|----------------|----------------|------------------|----------------|-----------------|----------------|----------------|-------------------|------------------------------------|----------------|
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| American eel | 2.93 | 1.63 | 2.39 | 2.37 | 2.09 | 2.26 | 2.36 | 3.80 | 3.17 | 2.41 | 2.02 |
| American shad | 0.51 | 0.65 | 0.19 | 0.48 | 0.12 | - | 0.51 | - | - | 0.29 | 0.80 |
| Banded killifish | 0.02 | - | - | - | 0.02 | - | 0.01 | - | - | - | 0.02 |
| Bluegill | 0.27 | 0.61 | 0.39 | 0.40 | 0.06 | 0.53 | 0.34 | 1.14 | 0.89 | 0.39 | 0.21 |
| Bluntnose minnow | 0.13 | 0.24 | 0.10 | 0.07 | 0.12 | - | 0.13 | 0.57 | 0.38 | 0.10 | 0.11 |
| Brook trout | - | 0.04 | 0.02 | 0.01 | - | - | 0.01 | - | 0.06 | 0.02 | 0.02 |
| Brown bullhead | 0.08 | 0.04 | 0.07 | 0.07 | 0.06 | 0.13 | 0.05 | 0.19 | 0.13 | 0.10 | 0.02 |
| Brown trout | 0.06 | - | - | 0.04 | 0.02 | - | 0.03 | 0.10 | 0.13 | 0.03 | 0.04 |
| Comely shiner | 0.11 | - | - | 0.04 | 0.04 | - | 0.28 | 0.10 | - | 0.02 | 0.09 |
| Common carp | 0.13 | 0.20 | 0.20 | 0.14 | 0.12 | 0.53 | 0.06 | - | 0.25 | 0.14 | 0.09 |
| Common shiner | 0.02 | 0.94 | 0.39 | 0.27 | 0.02 | 0.27 | 0.28 | 10.65 | 1.46 | 1.96 | 0.04 |
| Cutlip minnow | 0.21 | - | 0.02 | 0.12 | 0.15 | - | 0.13 | 0.38 | 0.51 | 0.14 | 0.13 |
| Gizzard shad | 0.32 | 0.41 | 0.66 | 0.48 | 0.39 | 1.20 | 0.40 | 0.10 | 0.63 | 0.56 | 0.38 |
| Golden shiner | 0.04 | 4.35 | 1.81 | 1.27 | 0.02 | 10.77 | 0.30 | 3.33 | 6.90 | 2.10 | 0.13 |
| Green sunfish | - | 0.04 | 0.02 | 0.01 | - | - | 0.01 | 0.10 | 0.06 | 0.02 | - |
| Largemouth bass | 0.06 | 0.04 | 0.02 | 0.01 | 0.06 | - | 0.05 | 0.10 | 0.06 | 0.02 | 0.05 |
| Longnose dace | 0.02 | - | 0.02 | 0.02 | 0.02 | - | 0.01 | - | - | - | 0.04 |
| Margined madtom | 0.04 | - | - | 0.01 | 0.02 | - | 0.02 | - | 0.06 | 0.02 | - |
| Northern hog sucker | 0.08 | - | 0.03 | 0.02 | 0.08 | - | 0.05 | - | - | 0.02 | 0.07 |
| Pickrel species | - | - | 0.02 | 0.01 | 0.02 | - | - | - | 0.06 | - | 0.02 |
| Pumpkinseed | 0.04 | 0.28 | 0.14 | 0.09 | 0.06 | 0.27 | 0.09 | 0.48 | 0.44 | 0.12 | 0.05 |
| Rainbow trout | 0.02 | - | 0.02 | 0.01 | - | - | 0.02 | - | - | 0.03 | 0.02 |
| Redbreast sunfish | 2.08 | 0.81 | 1.40 | 1.49 | 1.93 | 0.53 | 1.41 | 4.75 | 3.48 | 2.22 | 0.29 |
| Rock bass | 2.32 | 0.53 | 1.27 | 1.54 | 1.91 | 0.27 | 1.69 | 3.99 | 2.47 | 1.81 | 0.80 |
| Satinfin shiner | - | 0.49 | 0.20 | 0.14 | - | - | 0.13 | 1.14 | 0.76 | 0.20 | - |
| Sea lamprey | 0.17 | - | 0.07 | 0.11 | 0.10 | - | 0.13 | - | 0.06 | 0.05 | 0.16 |
| Shield darter | - | - | 0.02 | 0.01 | 0.02 | - | 0.01 | - | - | - | 0.02 |
| Smallmouth bass | 3.69 | 2.69 | 2.87 | 3.00 | 2.73 | 1.20 | 3.01 | 8.08 | 7.92 | 4.13 | 1.77 |

| Habitat description | Shallow slope | Moderate slope | Gravel / Sand | Cobble / Boulder | Macro-phytes | Tributary mouth | Open shoreline | Backwater | Snags, brush pile | Slow to no flow (incl. eddy or CC) | Fast flow |
|---------------------------|----------------|----------------|----------------|------------------|----------------|-----------------|----------------|----------------|-------------------|------------------------------------|----------------|
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| Spottail shiner | 0.29 | 0.33 | 0.19 | 0.27 | 0.29 | 0.93 | 0.51 | 14.16 | 0.51 | 2.72 | 0.20 |
| Striped bass | 0.11 | 0.04 | 0.17 | 0.12 | 0.19 | 0.53 | 0.06 | - | 0.06 | 0.02 | 0.16 |
| Swallowtail shiner | 0.02 | - | - | 0.01 | 0.02 | - | 0.02 | - | - | - | 0.02 |
| Tesselated darter | 0.02 | - | - | - | 0.02 | - | 0.01 | - | - | - | 0.02 |
| Walleye | 0.11 | 0.16 | 0.07 | 0.12 | 0.08 | - | 0.14 | 0.10 | 0.13 | 0.09 | 0.14 |
| White sucker | 1.77 | 1.99 | 1.77 | 1.68 | 1.93 | 2.39 | 1.94 | 8.46 | 1.52 | 3.25 | 2.50 |
| Yellow bullhead | 0.02 | - | - | 0.01 | - | - | 0.01 | 0.10 | 0.06 | 0.02 | 0.02 |
| Yellow perch | 0.19 | 0.12 | 0.08 | 0.13 | 0.17 | 0.40 | 0.24 | 0.48 | 0.06 | 0.17 | 0.14 |
| Samples per habitat | 13 | 6 | 17 | 24 | 13 | 2 | 23 | 4 | 6 | 17 | 15 |
| Total number fish | 17 | 19 | 16 | 16 | 13 | 23 | 16 | 70 | 37 | 25 | 12 |

Note: Values are the number of fish caught in samples containing a given habitat feature. Since each sample may cover more than one habitat type, individuals may appear in more than one column resulting in a total of all the habitat columns that may exceed the total number of fish caught.

Bold print indicates Priority I or II species.

Table 27. Summary of 2004 and 2006 boat shock habitat types and average catch rates per average 100m sample length at specific habitats by the Academy of Natural Sciences as part of Delaware Water Gap National Recreation Area fish inventory.

| Habitat description | Shallow slope | Moderate slope | Gravel / Sand | Cobble / Boulder | Macrophytes | Tributary mouth | Open shoreline | Backwater | Snags | Slow to no flow (incl. eddy or CC) | Fast flow |
|---------------------------|----------------|----------------|----------------|------------------|----------------|-----------------|----------------|----------------|----------------|------------------------------------|----------------|
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| American eel | 2.13 | 0.74 | 1.14 | 1.27 | 0.28 | 3.10 | 0.56 | 0.37 | 1.13 | 0.69 | 2.15 |
| Banded killifish | 0.10 | - | - | - | - | - | - | - | 0.04 | - | - |
| Bluegill | 0.39 | 0.43 | 0.18 | 0.06 | - | 1.38 | 0.09 | 0.46 | 0.26 | 0.26 | - |
| Brook trout | 0.10 | - | 0.04 | 0.03 | - | - | - | - | 0.04 | - | 0.06 |
| Brown bullhead | 0.29 | 0.06 | 0.07 | 0.06 | - | - | - | 0.05 | 0.17 | 0.03 | 0.12 |
| Brown trout | 0.19 | - | 0.07 | 0.06 | - | - | - | - | 0.09 | - | 0.12 |
| Comely shiner | - | 0.55 | 0.07 | 0.03 | - | 0.34 | 0.06 | 0.37 | 0.35 | 0.29 | - |
| Common carp | 0.10 | 0.06 | 0.11 | 0.06 | - | 0.34 | 0.06 | 0.05 | 0.04 | 0.07 | 0.06 |
| Common shiner | 0.68 | 0.31 | 0.28 | - | - | 2.76 | 0.03 | 0.51 | 0.17 | 0.16 | - |
| Fallfish | 1.16 | 0.18 | 0.36 | 0.27 | 0.11 | 2.07 | 0.25 | 0.41 | 0.22 | 0.29 | 0.18 |
| Gizzard shad | - | 0.06 | 0.04 | 0.03 | - | - | 0.03 | 0.05 | 0.04 | 0.03 | - |
| Largemouth bass | 0.19 | 0.06 | 0.04 | 0.03 | - | 0.34 | 0.03 | 0.14 | 0.04 | 0.07 | - |
| Muskellunge | 0.10 | - | 0.04 | - | 0.06 | - | - | - | 0.09 | 0.03 | - |
| Pumpkinseed | 0.58 | 0.18 | 0.07 | 0.18 | 0.34 | 0.69 | 0.25 | 0.05 | 0.30 | 0.29 | - |
| Redbreast sunfish | 1.36 | 4.17 | 1.70 | 0.36 | - | 12.76 | 1.26 | 1.38 | 1.83 | 2.19 | 0.54 |
| Rock bass | 2.61 | 2.15 | 1.81 | 0.88 | 0.23 | 7.93 | 0.85 | 0.64 | 1.83 | 1.34 | 1.49 |
| Satinfin shiner | 0.58 | 0.37 | 0.28 | 0.21 | 0.17 | 2.07 | 0.35 | 0.18 | 0.22 | 0.39 | 0.12 |
| Sea lamprey | 1.26 | 0.31 | 0.64 | 0.39 | - | 1.72 | 0.16 | - | 0.57 | 0.16 | 0.78 |
| Smallmouth bass | 1.94 | 2.15 | 1.67 | 0.76 | 0.28 | 9.31 | 1.10 | 0.60 | 1.17 | 1.40 | 1.07 |
| Spotfin shiner | 0.19 | 0.31 | 0.21 | 0.27 | 0.34 | 1.03 | 0.41 | 0.23 | 0.30 | 0.26 | - |
| Spottail shiner | 17.52 | 12.21 | 13.07 | 5.38 | 0.79 | 70.69 | 6.46 | 16.18 | 8.00 | 6.66 | 0.06 |
| Striped bass | - | 0.18 | 0.11 | 0.09 | - | - | 0.09 | - | - | - | - |
| Swallowtail shiner | - | - | - | 0.03 | 0.06 | - | 0.03 | - | 0.04 | - | - |
| Tesselated darter | - | 0.25 | 0.14 | 0.06 | - | 0.69 | 0.13 | 0.09 | 0.09 | 0.13 | - |
| Walleye | - | 0.67 | 0.39 | 0.33 | - | - | 0.35 | - | - | - | - |
| White sucker | 4.94 | 4.97 | 3.23 | 1.97 | 6.51 | 2.07 | 4.17 | 3.91 | 5.35 | 3.92 | 0.78 |
| Yellow bullhead | - | 0.06 | 0.07 | 0.03 | 0.06 | 0.34 | 0.03 | - | 0.04 | 0.07 | 0.06 |
| Yellow perch | - | 0.31 | 0.14 | 0.06 | - | 0.69 | 0.13 | 0.14 | 0.13 | 0.16 | - |

| Habitat description | Shallow slope | Moderate slope | Gravel / Sand | Cobble / Boulder | Macrophytes | Tributary mouth | Open shoreline | Backwater | Snags | Slow to no flow (incl. eddy or CC) | Fast flow |
|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|------------------------------------|-----------------------|
| Common name | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m | # fish / 100 m |
| Samples per habitat | 5 | 6 | 10 | 11 | 6 | 2 | 11 | 7 | 9 | 10 | 5 |
| Total number fish | 36.40 | 30.73 | 25.96 | 12.91 | 9.23 | 120.34 | 16.88 | 25.79 | 22.58 | 18.91 | 7.58 |

Note: Values are the number of fish caught in samples containing a given habitat feature. Since each sample may cover more than one habitat type, individuals may appear in more than one column resulting in a total of all the habitat columns that may exceed the total number of fish caught.

Bold print indicates Priority I or II species.

Table 28. Number of boat electrofishing samples taken in 2004 and 2006 by the Academy of Natural Sciences as part of the Upper Delaware Scenic and Recreational River fish inventory that contain both a specific sample area or topography (columns) as well as a separate specific sample area, topography, current velocity, or substrate (rows).

| General habitat area | Sample area and topography | | | | | | | | | | |
|--------------------------|----------------------------|---------------|----------------|-------------|----------------|--------------|----------------|--------------------------|-----------|-----------------|--------|
| | Flat | Shallow slope | Moderate slope | Steep slope | Complex island | Side channel | Open shoreline | Snag/brush piles present | Backwater | Tributary mouth | Totals |
| Flat | 9 | 1 | 2 | 0 | 0 | 0 | 3 | 2 | 1 | 2 | 20 |
| Shallow slope | 1 | 13 | 1 | 1 | 1 | 0 | 12 | 2 | 2 | 0 | 33 |
| Moderate slope | 2 | 1 | 6 | 0 | 0 | 0 | 5 | 3 | 1 | 1 | 19 |
| Steep slope | 0 | 1 | 0 | 5 | 0 | 0 | 5 | 0 | 0 | 0 | 11 |
| Complex island | 0 | 1 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 5 |
| Side channel | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 |
| Open shoreline | 3 | 12 | 5 | 5 | 1 | 0 | 23 | 4 | 3 | 0 | 56 |
| Snag/brush piles present | 2 | 2 | 3 | 0 | 0 | 0 | 4 | 6 | 2 | 1 | 20 |
| Backwater | 1 | 2 | 1 | 0 | 0 | 0 | 3 | 2 | 4 | 0 | 13 |
| Tributary mouth | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 6 |
| Eddy/Counter current | 0 | 2 | 0 | 1 | 0 | 0 | 3 | 1 | 2 | 0 | 9 |
| No flow | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| Slow flow | 4 | 8 | 5 | 0 | 0 | 0 | 12 | 5 | 3 | 1 | 38 |
| Fast flow | 5 | 8 | 3 | 0 | 2 | 1 | 11 | 3 | 1 | 1 | 35 |
| Gravel/sand | 7 | 7 | 4 | 1 | 1 | 1 | 11 | 4 | 2 | 2 | 40 |
| Cobble | 8 | 10 | 5 | 2 | 1 | 1 | 16 | 6 | 3 | 2 | 54 |
| Boulder | 8 | 11 | 5 | 2 | 1 | 1 | 17 | 6 | 3 | 2 | 56 |
| Macrophytes present | 5 | 7 | 0 | 1 | 2 | 1 | 8 | 2 | 1 | 1 | 28 |
| Totals | 58 | 86 | 41 | 19 | 12 | 7 | 135 | 47 | 29 | 15 | 449 |

Note: The bold number running diagonally across the table represents the total number of samples per each individual habitat characteristic as this is where the row and column read the same characteristic.

Table 29. Number of boat electrofishing samples taken in 2004 and 2006 by the Academy of Natural Sciences as part of the Upper Delaware Scenic and Recreational River fish inventory that contain both a specific current velocity or substrate (columns) as well as a separate specific sample area, topography, current velocity, or substrate (rows).

| General habitat area | Current velocity | | | | Substrate | | | | |
|--------------------------|------------------------|----------|-----------|-----------|---------------|-----------|-----------|-------------|--------|
| | Eddy / Counter current | None | Slow | Fast | Gravel / Sand | Cobble | Boulder | Macrophytes | Totals |
| Flat | 0 | 1 | 4 | 5 | 7 | 8 | 8 | 5 | 38 |
| Shallow slope | 2 | 0 | 8 | 8 | 7 | 10 | 11 | 7 | 53 |
| Moderate slope | 0 | 0 | 5 | 3 | 4 | 5 | 5 | 0 | 22 |
| Steep slope | 1 | 1 | 0 | 0 | 1 | 2 | 2 | 1 | 8 |
| Complex island | 0 | 0 | 0 | 2 | 1 | 1 | 1 | 2 | 7 |
| Side channel | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 5 |
| Open shoreline | 3 | 1 | 12 | 11 | 11 | 16 | 17 | 8 | 79 |
| Snag/brush piles present | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Backwater | 1 | 0 | 5 | 3 | 4 | 6 | 6 | 2 | 27 |
| Tributary mouth | 0 | 0 | 1 | 1 | 2 | 2 | 2 | 1 | 9 |
| Eddy/Counter current | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 1 | 15 |
| No flow | 1 | 2 | 0 | 0 | 1 | 0 | 1 | 0 | 5 |
| Slow flow | 2 | 0 | 15 | 6 | 11 | 13 | 13 | 4 | 64 |
| Fast flow | 1 | 0 | 6 | 15 | 9 | 12 | 13 | 8 | 64 |
| Gravel/sand | 2 | 1 | 11 | 9 | 17 | 16 | 17 | 10 | 83 |
| Cobble | 2 | 0 | 13 | 12 | 16 | 22 | 21 | 12 | 98 |
| Boulder | 3 | 1 | 13 | 13 | 17 | 21 | 23 | 11 | 102 |
| Macrophytes present | 1 | 0 | 4 | 8 | 10 | 12 | 11 | 13 | 59 |
| Totals | 22 | 8 | 99 | 98 | 121 | 149 | 155 | 86 | 738 |

Note: The bold number running diagonally across the table represents the total number of samples per each individual habitat characteristic as this is where the row and column read the same characteristic.

Table 30. Number of boat electrofishing samples taken in 2004 and 2006 by the Academy of Natural Sciences as part of Delaware Water Gap National Recreation Area fish inventory that contain both a specific sample area or topography (columns) as well as a separate specific sample area, topography, current velocity, or substrate (rows).

| General habitat area | Sample area and topography | | | | | | | | | | |
|--------------------------|----------------------------|---------------|----------------|-------------|----------------|--------------|----------------|--------------------------|-----------|-----------------|--------|
| | Flat | Shallow slope | Moderate slope | Steep slope | Complex island | Side channel | Open shoreline | Snag/brush piles present | Backwater | Tributary mouth | Totals |
| Flat | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 6 |
| Shallow slope | 0 | 5 | 0 | 0 | 1 | 1 | 2 | 3 | 2 | 1 | 15 |
| Moderate slope | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| Steep slope | 0 | 0 | 0 | 6 | 0 | 0 | 5 | 3 | 4 | 1 | 19 |
| Complex island | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 5 |
| Side channel | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 6 |
| Open shoreline | 1 | 2 | 0 | 5 | 1 | 0 | 11 | 4 | 5 | 1 | 30 |
| Snag/brush piles present | 1 | 3 | 1 | 3 | 0 | 2 | 4 | 9 | 3 | 0 | 26 |
| Backwater | 1 | 2 | 0 | 4 | 1 | 0 | 5 | 3 | 7 | 1 | 24 |
| Tributary mouth | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 6 |
| Eddy/Counter current | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 1 | 1 | 6 |
| No flow | 1 | 1 | 0 | 3 | 0 | 0 | 5 | 3 | 4 | 0 | 17 |
| Slow flow | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 8 |
| Fast flow | 1 | 1 | 0 | 0 | 0 | 2 | 2 | 2 | 0 | 0 | 8 |
| Gravel/sand | 2 | 2 | 1 | 5 | 0 | 2 | 6 | 5 | 5 | 2 | 30 |
| Cobble | 2 | 3 | 0 | 1 | 1 | 2 | 7 | 5 | 3 | 0 | 24 |
| Boulder | 0 | 2 | 0 | 1 | 1 | 0 | 5 | 2 | 1 | 0 | 12 |
| Macrophytes present | 1 | 2 | 1 | 1 | 0 | 1 | 4 | 5 | 1 | 0 | 16 |
| Totals | 14 | 27 | 5 | 32 | 8 | 14 | 61 | 50 | 40 | 9 | 260 |

Note: The bold number running diagonally across the table represents the total number of samples per each individual habitat characteristic as this is where the row and column read the same characteristic.

Table 31. Number of boat electrofishing samples taken in 2004 and 2006 by the Academy of Natural Sciences as part of Delaware Water Gap National Recreation Area fish inventory that contain both a specific current velocity or substrate (columns) as well as a separate specific sample area, topography, current velocity, or substrate (rows).

| General habitat area | Current velocity | | | | Substrate | | | | Totals |
|--------------------------|------------------------|----------|----------|----------|---------------|-----------|----------|--------------|--------|
| | Eddy / Counter current | None | Slow | Fast | Gravel / Sand | Cobble | Boulder | Macro-phytes | |
| Flat | 0 | 1 | 1 | 1 | 2 | 2 | 0 | 1 | 8 |
| Shallow slope | 0 | 1 | 1 | 1 | 2 | 3 | 2 | 2 | 12 |
| Moderate slope | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 3 |
| Steep slope | 2 | 3 | 0 | 0 | 5 | 1 | 1 | 1 | 13 |
| Complex island | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 3 |
| Side channel | 0 | 0 | 1 | 2 | 2 | 2 | 0 | 1 | 8 |
| Open shoreline | 1 | 5 | 1 | 2 | 6 | 7 | 5 | 4 | 31 |
| Snag/brush piles present | 1 | 3 | 1 | 2 | 5 | 5 | 2 | 5 | 24 |
| Backwater | 1 | 4 | 1 | 0 | 5 | 3 | 1 | 1 | 16 |
| Tributary mouth | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 3 |
| Eddy/Counter current | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 |
| No flow | 0 | 5 | 0 | 0 | 4 | 3 | 1 | 2 | 15 |
| Slow flow | 0 | 0 | 3 | 1 | 2 | 2 | 1 | 2 | 11 |
| Fast flow | 0 | 0 | 1 | 5 | 2 | 5 | 2 | 2 | 17 |
| Gravel/sand | 1 | 4 | 2 | 2 | 10 | 4 | 1 | 3 | 27 |
| Cobble | 0 | 3 | 2 | 5 | 4 | 10 | 5 | 4 | 33 |
| Boulder | 0 | 1 | 1 | 2 | 1 | 5 | 6 | 3 | 19 |
| Macrophytes present | 0 | 2 | 2 | 2 | 3 | 4 | 3 | 6 | 22 |
| Totals | 9 | 32 | 19 | 25 | 57 | 57 | 31 | 38 | 268 |

Note: The bold number running diagonally across the table represents the total number of samples per each individual habitat characteristic as this is where the row and column read the same characteristic.

Review of Other Studies

As part of this study, records from other sampling programs have been compiled. Results of the most comprehensive studies are presented as tables. Other relevant records will be mentioned in discussions of individual species.

The New York portion of the Delaware and Susquehanna drainages were surveyed in 1935 as part of the New York biological survey (Greeley 1936). The study sampled a range of water bodies, including rivers, streams, ponds, and lakes. Sampling personnel included J. R. Westman, D. Pasco, J. R. Greeley, C. P. Zorsch, and R. M. Bailey. Sampling techniques are not documented in Greeley (1936), but seining is mentioned in individual species accounts. The survey data (Table 32) suggest that a number of changes in the fish fauna of the area have occurred since 1935. The bridle shiner was listed as moderately common, being found at 4% of all sites, and recorded in the Delaware River. The creek chubsucker (*Erimyzon oblongus*), satinfish shiner, and comely shiner were listed as common, and the bluespotted sunfish was listed as locally common. A number of species currently widespread in the Delaware River were not recorded at all. The spotfin shiner, northern hog sucker, and stoneroller (*Campostoma anomalum*) were specifically stated as not occurring in the Delaware drainage. The study made no reference to native Delaware drainage species such as the eastern mudminnow, alewife (*Alosa pseudoharengus*), gizzard shad, and white perch (*Morone Americana*), or nonnative species such as the bowfin, green sunfish (*Lepomis cyanellus*), muskellunge, or channel catfish. These differences could reflect major changes in range or timing of introduction, changes in abundance, or sampling effects related to gear, sites, and habitats sampled. These species not recorded by Greeley are currently uncommon or local in the upper Delaware River, with the possible exceptions of the northern hog sucker, gizzard shad, and channel catfish. While the northern hog sucker was widespread in the current survey, there were usually few individuals in any one sample, and the species was predominantly caught by electrofishing. In the current survey, all gizzard shad caught were relatively large (all greater than 34 cm [13 in] total length), and all but one (caught in a gill net) were caught by electrofishing. If present in numbers, some species, like channel catfish and muskellunge, could have been caught by anglers or commercial fishermen (e.g., eel weir operators) and reported to the biological survey. It is likely that some of the species, e.g., channel catfish, muskellunge, and green sunfish, had not been introduced or become widespread in the river at the time of the survey.

Greeley (1936) also noted occurrence of species in lakes or tributaries which were not recorded in the current survey. An eastern silvery minnow was caught in the West Branch of the Delaware. This species likely moved through the Delaware River to the West Branch. However, Greeley reported the species in two lakes in the Susquehanna drainage, so it is possible that the East Branch individual was a stray from an unknown lake stocking. Rainbow smelt (*Osmerus mordax*) were recorded in one lake; these were likely introduced as forage or food fish. The longnose sucker was recorded in the East Branch and the West Branch.

Table 32. Summary of fish status in the Delaware River drainage of New York as annotated by Greeley's (1936) Comprehensive Biological Survey of the Delaware River drainage.

| Pr | Species | | UPDE | General Status | Rank | Freq. | Del. River | Other tribs. | Notes |
|-----|--------------------------------|-------------------|------|----------------------------------|---------|-------|------------|--------------|---|
| | Scientific name | Common name | | | | | | | |
| IV | <i>Catostomus commersoni</i> | White sucker | ANS | Abundant | 1 | 0.442 | X | WENO | Throughout |
| IV | <i>Rhinichthys atratulus</i> | Blacknose dace | ANS | Abundant | 2 | 0.363 | X | WENO | Abundant (found in practically all smaller streams), but rarely found in larger streams |
| IV | <i>Semotilus corporalis</i> | Fallfish | ANS | Abundant (used for food, bait) | 3 | 0.312 | X | WENO | |
| IV | <i>Luxilus cornutus</i> | Common shiner | ANS | Abundant | 4 | 0.300 | X | WENO | In practically all streams except headwaters |
| IV | <i>Notemigonus crysoleucas</i> | Golden shiner | ANS | Abundant | 5 | 0.296 | X | WENO | In both steams and lakes, but absent from much of faster streams |
| IV | <i>Lepomis gibbosus</i> | Pumpkinseed | ANS | Abundant | 6 | 0.283 | X | WENO | Especially common in lakes |
| IV | <i>Etheostoma olmstedii</i> | Tesselated darter | ANS | Abundant | 9 | 0.256 | X | WENO | Practically all streams |
| IV | <i>Perca flavescens</i> | Yellow perch | ANS | Abundant | 10 | 0.233 | X | WENO | Lakes; scarce in more rapid areas of lakes and streams |
| IV | <i>Semotilus atromaculatus</i> | Creek chub | ANS | Abundant | 12 | 0.199 | X | WENO | Invariably present in smaller streams, but tendency to avoid larger streams |
| IV | <i>Rhinichthys cataractae</i> | Longnose dace | ANS | Abundant | 14* | 0.170 | X | WENO | Widely distributed, more common in larger streams than <i>R. atratulus</i> |
| IV | <i>Esox niger</i> | Chain pickerel | ANS | Very common | 7* | 0.272 | X | WENO | Lakes and rivers, especially sluggish streams |
| IV | <i>Salmo trutta</i> | Brown trout | ANS | Very common | 15 | 0.153 | X | WENO | in streams |
| III | <i>Lepomis auritus</i> | Redbreast sunfish | ANS | Very common | 16 | 0.138 | X | WEO | Lg ind. in Del. R.; most abund. sunfish in streams; present in some lakes |
| III | <i>Noturus insignis</i> | Margined madtom | ANS | Very common | 18 | 0.105 | X | WENO | In nearly all of the rocky streams of larger size |
| IV | <i>Ambloplites rupestris</i> | Rock bass | ANS | Very common | 19 | 0.086 | X | WEN | In larger streams and a few lakes |
| IV | <i>Percina peltata</i> | Shield darter | ANS | Very common | 21 | 0.069 | X | WENO | Larger streams |
| IV | <i>Exoglossum maxillingua</i> | Cutlip minnow | ANS | Very common | 32 | 0.010 | X | NO | |
| IV | <i>Micropterus dolomieu</i> | Smallmouth bass | ANS | Very common; probably introduced | 8 | 0.262 | X | WENO | |
| IV | <i>Salvelinus fontinalis</i> | Brook trout | ANS | Common | 11 | 0.220 | | WENO | Serious decline in numbers |
| IV | <i>Amieurus nebulosus</i> | Brown bullhead | ANS | Common | 13 | 0.180 | X | WENO | Most of the lakes and more sluggish parts of streams |
| II* | <i>Cyprinella analostana</i> | Satinfin shiner | ANS | Common | 17 | 0.115 | X | WENO | In main rivers and larger streams |
| III | <i>Notropis hudsonius</i> | Spottail shiner | ANS | Common | 20 | 0.075 | X | WENO | Mostly from larger streams |
| II* | <i>Notropis amoenus</i> | Comely shiner | ANS | Common | 25 | 0.048 | X | WEN | In many of the larger streams |
| IV | <i>Anguilla rostrata</i> | American eel | ANS | Common | 28*[29] | 0.029 | X | WENO | |
| III | <i>Erimyzon oblongus</i> | Creek chubsucker | ANS | Common | 22 | 0.065 | | WENO | Common, lakes, ponds and sluggish streams |
| | <i>Cottus cognatus</i> | Slimy sculpin | trib | Common | 23 | 0.054 | | WENO | Cold streams, especially headwaters |
| I | <i>Notropis bifrenatus</i> | Bridle shiner | ANS | Moderately common | 26 | 0.040 | X | WENO | Lakes and weedy, sluggish streams |
| III | <i>Fundulus diaphanus</i> | Banded killifish | ANS | Moderately common | 27 | 0.038 | X | WENO | Streams and lakes; large schools in Delaware at Port Jervis in May |
| IV | <i>Micropterus salmoides</i> | Largemouth bass | ANS | Moderately | 24 | 0.052 | | WENO | In many lakes |

| Pr | Species | | UPDE | General Status | Rank | Freq. | Del. River | Other trib. | Notes |
|-------|-------------------------------|------------------------|-------|---|---------|-------|------------|-------------|--|
| | Scientific name | Common name | | | | | | | |
| | | | | common; probably introduced | | | | | |
| II* | <i>Notropis procne</i> | Swallowtail shiner | ANS | Moderately common | 32 | 0.010 | X | W | Mainly streams, different habitat than <i>N. bifrenatus</i> |
| II | <i>Pimephales notatus</i> | Bluntnose minnow | ANS | Moderately common | 34** | 0.008 | X | O | |
| IV | <i>Petromyzon marinus</i> | Sea lamprey | ANS | Moderately common | 29*[30] | 0.025 | X | ENO | some streams (Callicoon Creek, Tenmile River) |
| IV | <i>Alosa sapidissima</i> | American shad | ANS | Moderately common (reduced in recent years) | 35** | 0.006 | X | WEO | Rare, reported as established in Lake Delaware |
| IV | <i>Sander vitreum</i> | Walleye | ANS | Locally common; introduced | 30** | 0.023 | X | WENO | |
| II | <i>Enneacanthus gloriosus</i> | Bluespotted sunfish | ANS | Locally common | 32 | 0.010 | | E | Basher Kill [Basher Kill] and Read Flat on East Branch |
| IV | <i>Pomoxis nigromaculatus</i> | Black crappie | ANS | Rare | 36 | 0.004 | | W | Silver Lake and Crystal Lake only |
| IV | <i>Lepomis macrochirus</i> | Bluegill | ANS | Rare | 36 | 0.004 | | N | One individual from Neversink River at Port Jervis |
| | <i>Hybognathus regius</i> | Eastern silvery minnow | N | Rare | 38 | 0.002 | | E | One specimen from West Branch near Bloomville |
| IV | <i>Cyprinus carpio</i> | Carp | ANS | Rare | | | | R | Reported from Pond Eddy and Barryville |
| IV | <i>Oncorhynchus mykiss</i> | Rainbow trout | ANS | Reports of occasional fish | | | | R | WENO |
| II | <i>Nocomis micropogon</i> | River chub | Hist? | Not found in Delaware Drainage | | | | | Not found in Delaware Drainage |
| II | <i>Cyprinella spiloptera</i> | Spotfin shiner | D | Not found in Delaware Drainage | | | | | Found in western Susquehanna drainage |
| II | <i>Hypentelium nigricans</i> | Northern hog sucker | ANS | Not found in Delaware Drainage | | | | | Very common in Susquehanna drainage |
| ex II | <i>Pimephales promelas</i> | Fathead minnow | ANS | Not found in Delaware Drainage | | | | | Not found in Delaware Drainage |
| III | <i>Campostoma anomalum</i> | Stoneroller | ANS | Not found in Delaware drainage | | | | | Common in Susquehanna drainage |
| | <i>Notropis rubellus</i> | Rosyface shiner | Hist? | Not found in Delaware drainage | | | | | Rare in Susquehanna drainage |
| ex II | <i>Carrasius auratus</i> | Goldfish | N | | | | | | |
| I | <i>Notropis chalybaeus</i> | Ironcolor shiner | N | | | 0.004 | | N | Basher Kill |
| I | <i>Noturus gyrinus</i> | Tadpole madtom | N | | | 0.008 | | N | A few specimens in Basher Kill and 2 specimens in Yankee Lake |
| II | <i>Esox americanus</i> | Redfin pickerel | N | | | 0.003 | | N | Basher Kill |
| | <i>Catostomus catostomus</i> | Longnose sucker | Hist | | | 0.031 | | WE | Moderately common, East and West Branch |
| | <i>Osmerus mordax</i> | American smelt | N | | | | | W | Rare, reported as established in Lake Delaware (upper West Branch) |
| | <i>Salvelinus namaycush</i> | Lake trout | N | | | 0.002 | | WE | Reported from Lake Delaware |
| | <i>Couesius plumbeus</i> | Lake chub | N | | 32 | 0.010 | | E | Limited numbers at 5 localities in East Branch |
| I | <i>Umbra pygmaea</i> | Eastern | ANS | [Not listed] | | | | | |

| Pr | Species | | UPDE | General Status | Rank | Freq. | Del. River | Other tribs. | Notes |
|-----|-----------------------------|---------------------|------|----------------|------|-------|------------|--------------|-------|
| | Scientific name | Common name | | | | | | | |
| | | mudminnow | | | | | | | |
| I | <i>Amia calva</i> | Bowfin | ANS | [Not listed] | | | | | |
| II | <i>Alosa pseudoharengus</i> | Alewife | ANS | [Not listed] | | | | | |
| | <i>Dorosoma cepedianum</i> | Gizzard shad | ANS | [Not listed] | | | | | |
| III | <i>Amieurus natalis</i> | Yellow bullhead | ANS | [Not listed] | | | | | |
| III | <i>Lepomis cyanellus</i> | Green sunfish | ANS | [Not listed] | | | | | |
| | <i>Morone americana</i> | white perch | Hist | [Not listed] | | | | | |
| IV | <i>Esox masquinongy</i> | Muskellunge | ANS | [Not listed] | | | | | |
| IV | <i>Ictalurus punctatus</i> | Channel catfish | D | [Not listed] | | | | | |
| IV | <i>Morone saxatilis</i> | Striped bass | ANS | [Not listed] | | | | | |
| II | <i>Strongylura marina</i> | Atlantic needlefish | D | [Not listed] | | | | | |

“Pr” is the priority in the ANS inventory program.

“UPDE” records indicate whether the species was caught the Academy of Natural Sciences (ANS), documented after 1990 (D), or documented by other sources prior to 1990 (Hist).

“General Status,” “Other tribs” and “Notes” paraphrases statements in species accounts about general abundance in Delaware drainage rivers, streams, ponds and lakes, streams, and other notes.

“Rank” is the rank of Freq. as listed in individual species accounts.

“Freq.” is the proportion of all samples (including rivers, streams, ponds and lakes) containing each species.

“Del River” and “Other tribs” indicates whether the species was reported (R) or caught (X) in the Delaware River, the West Branch drainage (W), East Branch drainage (E), Neversink River (N) or in other tributaries (O).

* Rank incorrectly listed in Greeley.

** Rank not assigned by Greeley; based on frequency

Summaries of fish stocking from 1925–1934 are also provided by Greeley (1936). In the Delaware River, the walleye was the most commonly stocked fish (27,450,000 fish stocked), followed by smallmouth bass (51,200 fish), with small numbers of yellow perch, rainbow trout, brook trout, brown trout, bullheads, and black crappie.

Robert Ross, of the USGS, conducted a large series of samples in DEWA and UPDE. These included samples in streams and the main river for IBI programs (see Gray et al. 2005), and in streams in DEWA to study the relationship between hemlocks, woolly adelgids, and fish assemblages (Ross et al. 2003). The IBI samples were taken by a variety of methods, including backpack electrofishing, seining, and diving. These were taken in streams and in the confluence of streams with the Delaware River (Tables 33–35). These samples provide records of a number of high priority species. Most notably, four bridle shiners were caught at the confluence of Vancampens Brook. For the hemlock woolly adelgid (WA) study, Ross targeted 24 sites, mostly in small streams, stratified to include sites with and without hemlock riparian cover, and located in plateau, slope, and flat sections of streams. Fish were collected in 13 of the 24 sites; some of the sites were dry. The individual site data from the WA study are not available, but Ross et al. (2003) provides a species list (see Table 33) and summary information. Twelve species were captured in Shimers Brook. Other streams (with fish) contained one to four species. Small headwater streams typically contained brook trout, blacknose dace (*Rhinichthys atratulus*), and small sunfishes (presumably derived from headwater impoundments). No high priority species were collected in the WA study.

Data are available from the Flat Brook and its tributaries and on several other New Jersey tributary streams from bioassessment data taken by the New Jersey Department of Environmental Protection (NJDEP), the US Environmental Protection Agency (USEPA) and the ANS (Table 36). These include sites in DEWA, as well as sites in headwaters upstream of DEWA and in Dunfield Creek in Worthington State Forest. Some of these samples are the basis of records in Arndt (2004). Several high priority species were collected in these samples. Slimy sculpin was widespread in the upper Flat Brook system. One specimen of American brook lamprey (*Lampetra appendix*) was reported from Big Flat Brook, upstream of DEWA. Twenty-nine specimens of the eastern silvery minnow were reported from Flat Brook; these are the basis of a record in Arndt (2004). This record is due to a data entry error (USEPA, J. Kurtenbach, pers. comm., November 30, 2004); the original data sheets show 29 spottail shiners instead.

David Arnold supplied presence/absence data on fishes collected by the Pennsylvania Fish and Boat Commission (PFBC) in the Delaware River and tributaries. Several high priority species were captured in the Delaware River (Table 37), including alewife (1980), bowfin (1983), white catfish (two records from 1983), quillback (1983), gizzard shad (three records from 1980 and 1983), redbfin pickerel (1983), northern hog sucker (1980), and comely shiner (two records from 1980 and two records from 1983). They also recorded northern pike (*Esox lucius*) in 1983. Several high priority species were recorded in streams tributary to the Delaware in DEWA or UPDE, though the sampling sites may have been outside DEWA. These include slimy sculpin, satinfish shiner, bluespotted sunfish, redbfin pickerel, Eastern mudminnow, and bluntnose minnow (*Pimephales notatus*).

Table 33. Summary of fishes caught by R. Ross of the United States Geological Survey (IBI, IBI2 studies in 1993, 1994 and 1998) in tributary streams (str.) and stream confluences (cnf.) in Delaware Water Gap National Recreation Area (DEWA).

| Common name | Adams | | Brodhead | | Bushkill | | Flat Brook | Saw | Sawkill | | Shimers | | Toms | | Vancampen | | Vandermark | WA* | |
|----------------------------|-------|-----|-----------|-----------|----------|-----------|------------|------|---------|------|---------|----|------|----------|-----------|-------|------------|-----|--|
| | | D3 | D10 | | D6 | D7 | | | D2 | | | | | U8 | | | | | |
| | Str. | Cnf | Conf. | Str. | Cnf | Stream | Str. | Str. | Cnf | Str. | Str. | D5 | Str. | Cnf | Stream | Sites | Spec | | |
| American eel | 24 | 24 | 4 | 815 | 3 | 186 | 138 | 13 | 22 | 42 | 7 | 6 | 41 | 6 | 36 | 2 | 25 | | |
| American shad | 14 | 540 | 150 | - | 1740 | - | - | - | 888 | - | - | 20 | - | 286 | - | - | - | | |
| Banded killifish | - | - | 4 | - | - | - | - | - | 10 | - | - | - | - | - | - | - | - | | |
| Black crappie | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | |
| Blacknose dace | 126 | - | - | 824 | 2 | 918 | 402 | 90 | - | 288 | 22 | - | 68 | - | - | 10 | 1021 | | |
| Bluegill | - | 2 | 42 | 73 | - | - | - | - | - | 12 | - | - | - | 12 | - | X | X | | |
| Bridle shiner | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | | |
| Brook trout | 4 | - | - | - | - | - | - | 18 | - | - | 3 | - | 16 | - | - | 5 | 128 | | |
| Brown bullhead | - | - | 90 | 45 | - | - | - | - | 26 | - | 1 | - | - | - | 3 | - | - | | |
| Brown trout | 162 | - | 6 | 62 | - | - | 12 | 231 | - | - | 211 | - | 114 | - | - | 2 | 93 | | |
| Common carp | - | 2 | 12 | - | - | - | - | - | 30 | - | - | 16 | - | 2 | - | - | - | | |
| Common shiner | - | 22 | 16 | 644 | - | 18 | 330 | - | 120 | - | - | - | - | 6 | - | X | X | | |
| Creek chub | - | - | - | - | - | - | 108 | - | - | - | - | - | - | - | - | 2 | 47 | | |
| Cutlip minnow | 84 | 10 | 4 | 682 | - | 240 | 312 | - | 46 | 66 | 4 | 4 | 1 | 20 | - | X | X | | |
| Fallfish | 44 | 206 | 8 | 564 | 11 | - | 6 | - | 166 | 18 | 1 | 58 | - | 204 | - | X | X | | |
| Fathead minnow | - | - | - | - | - | - | 6 | - | - | - | - | - | - | - | - | - | - | | |
| Golden shiner | - | 2 | 18 | 5 | 2 | - | - | - | 12 | - | 1 | - | - | - | - | X | X | | |
| Goldfish | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - | - | | |
| Largemouth bass | - | 6 | 94 | 87 | 24 | - | 12 | - | 14 | - | - | - | - | 18 | - | - | - | | |
| Longnose dace | - | - | - | 336 | - | 219 | 162 | - | - | 63 | - | - | - | - | 5 | X | X | | |
| Margined madtom | 6 | 10 | 2 | 192 | 13 | 6 | 36 | - | 4 | 12 | - | 4 | - | 2 | - | X | X | | |
| Muskellunge | - | - | 2 | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | | |
| Northern hog sucker | - | - | 12 | 20 | - | 30 | - | - | - | - | - | - | - | - | - | - | - | | |
| Pumpkinseed | - | 2 | 74 | 35 | 1 | - | - | - | 4 | 6 | - | 4 | 4 | 24 | - | 6 | 8 | | |
| Redbreast sunfish | - | 30 | 16 | 150 | 22 | - | - | - | 36 | - | - | 54 | - | 38 | - | - | - | | |
| Redfin pickerel | - | - | - | 15 | - | - | - | - | - | - | - | - | - | - | - | - | - | | |
| Rock bass | - | - | 182 | 36 | 20 | 30 | - | - | 246 | - | - | 6 | 1 | 28 | - | - | - | | |

| Common name | Adams | | Brodhead | Bushkill | | Flat Brook | Saw | Sawkill | | Shimers | Toms | | Vancampen | | Vandermark | WA* | |
|---------------------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|------------|------------|------------|------------|-------------|------------|-------|------|
| | Str. | D3 | D10 | Str. | D6 | D7 | Str. | Str. | D2 | Str. | Str. | D5 | Str. | Cnf | Stream | Sites | Spec |
| | | Cnf | Conf. | | Cnf | Stream | | | Cnf | | | U8 | | | | | |
| Satinfish shiner | - | 26 | - | 33 | 1 | - | - | - | 2 | - | - | 2 | - | 4 | - | - | - |
| Sea lamprey | - | - | - | 18 | - | 30 | - | - | - | - | - | - | - | - | - | - | - |
| Shield darter | 10 | 10 | 14 | 160 | 26 | 42 | 144 | - | 22 | 18 | - | 16 | - | 50 | - | - | - |
| Slimy sculpin | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 339 | - | - |
| Smallmouth bass | 2 | 82 | 90 | 121 | 55 | 12 | - | - | 102 | - | - | 44 | - | 98 | - | - | - |
| Spotfin shiner | - | 114 | 8 | - | - | - | - | - | 8 | - | - | 4 | - | 34 | - | - | - |
| Spottail shiner | 6 | 180 | 14 | 786 | 59 | - | - | - | 354 | - | - | 46 | - | 162 | - | - | - |
| Striped bass | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - |
| Swallowtail shiner | - | - | - | - | - | - | - | - | - | - | - | 2 | - | 4 | - | - | - |
| Tessellated darter | 26 | 124 | 94 | 287 | 28 | 72 | 240 | - | 178 | 36 | - | 38 | 2 | 152 | - | X | X |
| Walleye | - | - | - | - | - | - | - | - | 56 | - | - | - | - | 2 | - | - | - |
| White sucker | 58 | 252 | 78 | 305 | 9 | 6 | 72 | 22 | 192 | - | - | 44 | 9 | 82 | 3 | X | X |
| Yellow bullhead | 2 | - | - | - | - | - | - | - | 2 | 12 | - | - | 1 | - | 15 | - | - |
| Yellow perch | - | - | 2 | 5 | - | - | - | - | 20 | - | - | - | 1 | 24 | - | - | - |
| Totals | 568 | 1644 | 1038 | 6300 | 2019 | 1809 | 1980 | 374 | 2562 | 573 | 250 | 368 | 258 | 1264 | 401 | - | - |

* WA indicates species collected in 13 streams in DEWA as part of the woolly adelgid study.

Bold print indicates Priority I or II species.

Table 34. Summary of fishes caught by R. Ross of the United States Geological Survey (IB1 and IB2 samples in 1993, 1994 and 1998) in three streams near Delaware Water Gap National Recreation Area.

| Scientific name | Common name | Brodhead | Cherry | McMichaels |
|-------------------------------------|----------------------------|----------|-----------|------------|
| <i>Ameiurus nebulosus</i> | brown bullhead | - | 48 | - |
| <i>Ambloplites rupestris</i> | rock bass | 26 | 12 | - |
| <i>Anguilla rostrata</i> | American eel | 80 | 84 | 12 |
| <i>Catostomus commersoni</i> | white sucker | 209 | 132 | 45 |
| <i>Cottus cognatus</i> | slimy sculpin | - | - | 12 |
| <i>Cyprinella analostana</i> | satinfish shiner | 8 | - | - |
| <i>Etheostoma olmstedi</i> | tesselated darter | 127 | 48 | 96 |
| <i>Exoglossum maxillingua</i> | cutlip minnow | 11 | 60 | 159 |
| <i>Hypentelium nigricans</i> | northern hog sucker | - | 36 | - |
| <i>Lepomis auritus</i> | redbreast sunfish | 62 | - | - |
| <i>Lepomis gibbosus</i> | pumpkinseed | 18 | - | 6 |
| <i>Lepomis macrochirus</i> | bluegill | 22 | 12 | - |
| <i>Luxilus cornutus</i> | common shiner | 28 | - | 12 |
| <i>Micropterus dolomieu</i> | smallmouth bass | 39 | - | - |
| <i>Micropterus salmoides</i> | largemouth bass | 2 | - | 3 |
| <i>Morone saxatilis</i> | striped bass | 2 | - | - |
| <i>Notemigonus crysoleucas</i> | golden shiner | - | - | 3 |
| <i>Notropis hudsonius</i> | spottail shiner | 246 | - | - |
| <i>Noturus insignis</i> | margined madtom | - | 6 | - |
| <i>Petromyzon marinus</i> | sea lamprey | 52 | 6 | - |
| <i>Percina peltata</i> | shield darter | 81 | 174 | 54 |
| <i>Rhinichthys atratulus</i> | blacknose dace | 422 | 330 | 198 |
| <i>Rhinichthys cataractae</i> | longnose dace | - | 153 | 107 |
| <i>Salmo trutta</i> | brown trout | - | - | 3 |
| <i>Semotilus atromaculatus</i> | creek chub | 2 | - | 27 |
| <i>Semotilus corporalis</i> | fallfish | 408 | - | 18 |
| <i>Umbra pygmaea</i> | eastern mudminnow | - | - | 6 |
| Totals | | 1845 | 1101 | 761 |

Bold print indicates Priority I or II species.

Table 35. Summary of fishes caught by R. Ross of the United States Geological Survey (IBI, IBI2 studies in 1993, 1994 and 1998) in tributary streams (stream) and stream confluences (conf.) in Upper Delaware Scenic and Recreational River.

| Scientific name | Common name | Callicoon (U7) | | Tenmile (U12) | |
|-------------------------------------|----------------------------|----------------|----------|---------------|----------|
| | | Stream | Conf. | Stream | Conf. |
| <i>Alosa sapidissima</i> | American shad | - | 82 | - | 38 |
| <i>Ameiurus nebulosus</i> | brown bullhead | 2 | - | - | - |
| <i>Ambloplites rupestris</i> | rock bass | - | 2 | - | 5 |
| <i>Anguilla rostrata</i> | American eel | 44 | 16 | 90 | 6 |
| <i>Campostoma anomalum</i> | central stoneroller | 25 | 2 | - | - |
| <i>Catostomus commersoni</i> | white sucker | 1025 | 74 | 478 | 42 |
| <i>Cyprinella analostana</i> | satinfish shiner | 4 | - | - | - |
| <i>Cyprinus carpio</i> | common carp | - | 2 | - | - |
| <i>Cyprinella spiloptera</i> | spotfin shiner | - | 6 | - | 2 |
| <i>Etheostoma olmstedii</i> | tesselated darter | 210 | 120 | 40 | 57 |
| <i>Exoglossum maxillingua</i> | cutlip minnow | 396 | 24 | 120 | 3 |
| <i>Fundulus diaphanus</i> | banded killifish | - | 2 | - | 8 |
| <i>Hypentelium nigricans</i> | northern hog sucker | 26 | - | - | 2 |
| <i>Lepomis auritus</i> | redbreast sunfish | 6 | 28 | - | 3 |
| <i>Lepomis gibbosus</i> | pumpkinseed | 51 | 10 | - | 2 |
| <i>Lepomis macrochirus</i> | bluegill | - | 6 | - | 2 |
| <i>Luxilus cornutus</i> | common shiner | 193 | 54 | 158 | - |
| <i>Micropterus dolomieu</i> | smallmouth bass | 118 | 128 | 2 | 93 |
| <i>Micropterus salmoides</i> | largemouth bass | - | 68 | 8 | 2 |
| <i>Notemigonus crysoleucas</i> | golden shiner | - | - | - | 1 |
| <i>Notropis hudsonius</i> | spottail shiner | 9 | 100 | - | 80 |
| <i>Noturus insignis</i> | margined madtom | 34 | 10 | 26 | 4 |
| <i>Notropis procne</i> | swallowtail shiner | 2 | 8 | - | - |
| <i>Perca flavescens</i> | yellow perch | - | - | 2 | 1 |
| <i>Petromyzon marinus</i> | sea lamprey | 10 | - | - | - |
| <i>Percina peltata</i> | shield darter | 86 | 24 | 36 | 26 |
| <i>Pomoxis nigromaculatus</i> | black crappie | 2 | - | - | - |
| <i>Rhinichthys atratulus</i> | blacknose dace | 255 | 10 | 654 | 2 |
| <i>Rhinichthys cataractae</i> | longnose dace | 25 | - | 12 | - |
| <i>Salmo trutta</i> | brown trout | - | - | 4 | - |
| <i>Semotilus atromaculatus</i> | creek chub | - | 2 | - | - |
| <i>Semotilus corporalis</i> | fallfish | 287 | 412 | 124 | 99 |
| Totals | | 2810 | 1190 | 1754 | 478 |

Note: Corresponding Academy of Natural Sciences stations are shown.

Bold print indicates Priority I or II species.

Table 36. Summary of fish caught by the New Jersey Fish Index of Biotic Integrity program (NJFIBI), New Jersey Department of Environmental Protection (EPA), and the Academy of Natural Sciences (ANS) in New Jersey tributaries of the Delaware River near Delaware Water Gap National Recreation Area (DEWA).

| Waterbody: | Little Flat Brook | | Trib. Big Flat Brook | Big Flat Brook | | | Flat Brook | Vancampens Creek | | | Dunfield Creek |
|-------------------------------|----------------------------------|-----------------------|---------------------------------|------------------------------|----------------------|----------|-----------------|--------------------|-----------|-------------------------------------|------------------------|
| Project: | NJ FIBI | EPA | ANS | EPA | EPA | NJ FIBI | EPA | ANS | ANS | NJ FIBI | ANS-NJDEP |
| Station Name: | ANS1355 | ANS0152 | BFB | ANS0135 | ANS0136 | ANS1356 | ANS0439 | VCU | VCD | ANS0111 | DF |
| Location: | Rt. 645 / Layton Hainesville Rd. | East of Peters Valley | Deckertown Rd. in High Point SP | 1.5 km below Lake Ocquittunk | 0.5 km below Rt. 208 | Rt. 560 | Flatbrook-ville | East of Blue Lakes | Millbrook | Depew Rec Site Rd. off Old Mine Rd. | Picnic area near mouth |
| In DEWA? | No | No | No | No | No | No | Yes | Yes | Yes | Yes | No |
| Date: | 07/17/03 | 08/04/92 | 09/02/05 | 07/05/90 | 07/10/90 | 07/16/03 | 08/08/95 | 09/11/03 | 09/10/03 | 08/15/01 | 08/07/03 |
| American brook lamprey | - | - | - | 1 | - | - | - | - | - | - | - |
| American eel | 32 | 7 | - | 18 | 23 | 73 | 86 | - | - | 40 | 11 |
| Blacknose dace | 10 | 176 | 38 | 27 | 110 | 97 | 16 | - | 75 | 262 | 16 |
| Bluegill | 3 | - | - | - | - | 5 | 1 | - | - | - | - |
| Brook trout | 3 | 5 | 35 | - | - | 1 | - | 15 | 99 | 5 | 8 |
| Brown bullhead | - | - | - | - | - | 1 | - | - | - | - | - |
| Brown trout | - | 1 | - | - | 2 | 2 | - | - | - | 56 | 26 |
| Common shiner | 55 | 9 | - | 1 | 11 | 10 | 6 | - | - | - | - |
| Creek chub | 2 | 3 | 1 | - | - | - | - | - | - | 22 | - |
| Creek chubsucker | - | 1 | - | - | - | - | - | - | - | - | - |
| Cutlip minnow | 13 | 20 | - | 7 | 17 | 34 | - | - | - | 4 | - |
| Fallfish | - | - | - | - | - | - | 3 | - | - | 8 | - |
| Golden shiner | 1 | - | - | - | - | - | - | - | - | - | - |
| Green sunfish | - | - | - | - | - | 1 | - | - | - | - | - |
| Largemouth bass | 1 | - | - | - | - | - | - | - | - | - | - |
| Longnose dace | 6 | 14 | - | 19 | 25 | 20 | 15 | - | - | 9 | - |
| Margined madtom | 2 | - | - | - | - | 1 | - | - | - | 1 | - |
| Noturus species | - | - | - | 2 | - | - | - | - | - | - | - |
| Pumpkinseed | - | - | - | - | - | 2 | - | - | - | 3 | - |
| Rainbow trout | 1 | - | - | 1 | 1 | 4 | - | - | 59 | - | - |
| Redbreast sunfish | 9 | - | - | - | - | - | 6 | - | - | - | - |
| Redfin pickerel | 3 | 1 | - | - | - | - | - | - | - | - | - |
| Rock bass | - | - | - | - | - | - | 3 | - | - | - | - |
| Satfin shiner | - | - | - | - | - | - | 3 | - | - | - | - |
| Sea lamprey | 2 | 2 | - | - | - | 2 | - | - | - | - | - |
| Shield darter | - | - | - | - | - | - | 24 | - | - | - | - |

| Waterbody: | Little Flat Brook | | Trib. Big Flat Brook | Big Flat Brook | | | Flat Brook | Vancampens Creek | | | Dunfield Creek |
|----------------------|----------------------------------|-----------------------|---------------------------------|------------------------------|----------------------|-----------|-----------------|--------------------|-----------|-------------------------------------|------------------------|
| Project: | NJ FIBI | EPA | ANS | EPA | EPA | NJ FIBI | EPA | ANS | ANS | NJ FIBI | ANS-NJDEP |
| Station Name: | ANS1355 | ANS0152 | BFB | ANS0135 | ANS0136 | ANS1356 | ANS0439 | VCU | VCD | ANS0111 | DF |
| Location: | Rt. 645 / Layton Hainesville Rd. | East of Peters Valley | Deckertown Rd. in High Point SP | 1.5 km below Lake Ocquittunk | 0.5 km below Rt. 208 | Rt. 560 | Flatbrook-ville | East of Blue Lakes | Millbrook | Depew Rec Site Rd. off Old Mine Rd. | Picnic area near mouth |
| In DEWA? | No | No | No | No | No | No | Yes | Yes | Yes | Yes | No |
| Date: | 07/17/03 | 08/04/92 | 09/02/05 | 07/05/90 | 07/10/90 | 07/16/03 | 08/08/95 | 09/11/03 | 09/10/03 | 08/15/01 | 08/07/03 |
| Slimy sculpin | - | 3 | 30 | 1 | 15 | 33 | - | - | - | - | - |
| Smallmouth bass | - | - | - | - | - | - | 23 | - | - | - | - |
| Spottail shiner | - | - | - | - | 1 | - | 29 | - | - | - | - |
| Tesselated darter | 1 | 35 | - | - | 6 | 13 | 12 | - | - | 1 | - |
| White sucker | 11 | 30 | - | 2 | 4 | 3 | 2 | - | - | 2 | - |
| Yellow perch | - | - | - | - | - | - | - | - | - | 1 | - |
| Totals | 155 | 307 | 104 | 79 | 215 | 302 | 229 | 15 | 233 | 414 | 61 |

Bold print indicates Priority I or II species.

Table 37. Summary of fishes caught by D. Arnold of the Pennsylvania Fish and Boat Commission in reaches of the Delaware River in Delaware Water Gap National Recreation Area and Upper Delaware Scenic and Recreational River.

| Station | | 1 | 2 | 3 | 4 | 5 | 6 |
|-----------------------------|------------|------------|-----------|------------|------------|-----------|-----------|
| | | Confluence | Kellems | Peggy Run | Lackawaxen | Cummins | Slateford |
| ANSP Reach | | U1-U5 | U5-U11 | U11-U14 | U14-U18 | D1-D10 | down |
| Common name | # of Sites | Kellems | Peggy Run | Lackawaxen | Cummins | Slateford | Lehigh |
| Alewife | 1 | - | - | 1 | - | - | - |
| American eel | 4 | - | 1 | 1 | 1 | 1 | - |
| American shad | 4 | - | 1 | 1 | 1 | 1 | - |
| Black crappie | 2 | - | - | 1 | - | 1 | - |
| Blacknose dace | 4 | - | 1 | 1 | 1 | 1 | - |
| Bluegill | 3 | - | - | 1 | 1 | 1 | - |
| Bowfin | 1 | - | - | - | - | 1 | - |
| Brown bullhead | 2 | - | 1 | - | - | 1 | - |
| Brown trout | 5 | 1 | 1 | 1 | 1 | 1 | - |
| Chain pickerel | 4 | - | 1 | 1 | 1 | 1 | - |
| Channel catfish | 2 | - | - | - | - | 1 | 1 |
| Comely shiner | 4 | - | 1 | 1 | 1 | 1 | - |
| Common carp | 4 | - | 1 | 1 | 1 | 1 | - |
| Common shiner | 4 | - | 1 | 1 | 1 | 1 | - |
| Cutlip minnow | 3 | - | 1 | 1 | 1 | - | - |
| Fallfish | 4 | - | 1 | 1 | 1 | 1 | - |
| Gizzard shad | 3 | - | 1 | 1 | - | 1 | - |
| Golden shiner | 2 | - | 1 | 1 | - | - | - |
| Quillback | 1 | - | - | - | - | 1 | - |
| Largemouth bass | 4 | - | 1 | 1 | 1 | 1 | - |
| Longnose dace | 3 | - | 1 | 1 | 1 | - | - |
| Margined madtom | 1 | - | - | 1 | - | - | - |
| Muskellunge | 2 | - | - | - | 1 | 1 | - |
| Northern hog sucker | 1 | - | 1 | - | - | - | - |
| Northern pike | 1 | - | - | - | - | 1 | - |
| Northern pike x muskellunge | 1 | - | - | - | - | 1 | - |
| Pumpkinseed | 4 | - | 1 | 1 | 1 | 1 | - |
| Rainbow trout | 4 | 1 | 1 | 1 | 1 | - | - |
| Redbreast sunfish | 4 | - | 1 | 1 | 1 | 1 | - |
| Redfin pickerel | 1 | - | - | - | - | - | 1 |
| Rock bass | 4 | - | 1 | 1 | 1 | 1 | - |
| Sea lamprey | 1 | - | - | 1 | - | - | - |
| Shield darter | 4 | - | 1 | 1 | 1 | 1 | - |
| Smallmouth bass | 6 | 1 | 1 | 1 | 1 | 1 | 1 |
| Spottail shiner | 4 | - | 1 | 1 | 1 | 1 | - |
| Striped bass | 2 | - | - | - | - | 1 | 1 |
| Swallowtail shiner | 3 | - | 1 | - | 1 | 1 | - |
| Tesselated darter | 4 | - | 1 | 1 | 1 | 1 | - |
| Walleye | 6 | 1 | 1 | 1 | 1 | 1 | 1 |
| White catfish | 2 | - | - | - | - | 1 | 1 |
| White sucker | 4 | - | 1 | 1 | 1 | 1 | - |
| Yellow perch | 3 | - | - | 1 | 1 | 1 | - |
| Totals | 126 | 4 | 27 | 30 | 26 | 33 | 6 |

Bold print indicates Priority I or II species.

The New York State Department of Environmental Conservation (NYSDEC) participated in a tri-state survey of fishes of the Delaware River in 1959–1962, and conducted surveys of the upper river in 1993 (Table 38). Data from these surveys were provided to the ANS by the NYSDEC.

The 1993 studies focused on game species; in some cases, only game species were recorded. Several high priority species were reported, including alewife (two records), white catfish (two records), longnose sucker (one record based on an observation), satinfin shiner (several records), northern hog sucker, comely shiner, and swallowtail shiner (several records). Emerald shiners (*Notropis atherinoides*) were reported in 1993. Emerald shiners are not native to the Delaware River drainage. While these could have been introduced (e.g., by bait bucket release), the record may have been from misidentified comely shiners, since the two species are similar in appearance. No channel catfish were reported, and there is a possibility that the white catfish could have been large channel catfish (which can look like white catfish).

The NPS and the PFBC participated in an angler log program. Data from 2002–2003 from this program are summarized in Tables 39 and 40. These document the shift in game fish importance from brown and rainbow trout above Callicoon to smallmouth bass from Callicoon to Millrift to American shad in DEWA. They also provide data on the occurrence of large game species like striped bass, walleye, and channel catfish. River chubs are included in the database. These are assumed to be fallfish, which are often called chubs, rather than the river chub (*Nocomis micropogon*).

In 1973, Stockholm (1976) conducted analyses of habitat preferences, seasonal occurrence, and food habits of minnows and darters in the Delaware River at Smithfield Beach and at the Bushkill Access (Table 41). In 1991 and 1992, the ANS collected fish by seines, ichthyoplankton nets, and electrofishing at Smithfield Beach and at Milford (Table 41). In 1995, Vile (1997) collected fish in three ponds in the Slateford area of DEWA. Duck Pond contained pumpkinseed, largemouth bass, and golden shiner. Verin's and Begoni's ponds both contained bluegill, largemouth bass, and golden shiner.

Additional summaries of occurrence are plotted by Mihursky (1973), Cooper (1983), Argent et al. (1997), and Arndt (2004).

Table 38. Summary of fishes caught in the Delaware River by the New York State Department of Environmental Conservation.

| | | UPDE | UPDE | UPDE | UPDE | UPDE | UPDE | DEWA | DEWA |
|-------------------------------------|-------------|----------------------------|------------------------|----------------------------|--|--|--------------------------|------------|--|
| Dates: | | 08/31/1993 | 08/31-09/01/1993 | 07/27-28/1993 | 08/05/1959 07/12/1960 07/11/1961 | 08/06/1959 07/13/1960 07/12/1961 07/16/1962 | 08/05/1959 07/14/1960 | 08/02/1961 | 08/07/1959 07/25/1960 07/11/1961 07/17/1962 |
| New Station Number | | D02 | D03 | D01 | D03N | D04N | D05N | Do6bN | D07bN |
| Station Name: | | E-W Junction to Buckingham | 0.5 mi N of Buckingham | Abe Lord Creek down 0.5 mi | Long Eddy | Milanville | Mongaup | Montague | Delaware Water Gap |
| Location: | | Trout only tabulated | | | Long Eddy | Milanville | | Matamoras | Blacks Island (Minisink Island or Milford) |
| ANSP Reach: | | U1-U2 | U2 | U4 | U4-U5 | U9 | U18 | none | D10-down |
| Common name | Totals | | | | | | | | |
| Alewife | 2 | 1 | - | - | - | 1 | - | - | - |
| American eel | 112 | 100 | - | - | - | 1 | 5 | - | 6 |
| American shad | 2250 | - | - | - | 25 | 719 | 306 | 14 | 1186 |
| Banded killifish | 155 | - | - | - | 62 | 12 | - | - | 81 |
| Black crappie | 2 | - | - | - | - | 1 | - | - | 1 |
| Blacknose dace | 134 | 30 | - | - | 69 | 21 | - | - | 14 |
| Bluegill | 320 | - | - | - | 1 | 1 | 7 | 1 | 310 |
| Brook trout | 7 | 4 | - | 3 | - | - | - | - | - |
| Brown bullhead | 110 | 1 | - | - | 17 | 36 | 2 | - | 54 |
| Brown trout | 243 | 24 | 46 | 32 | 139 | 1 | - | - | 1 |
| Central stoneroller | 57 | - | - | - | 36 | 21 | - | - | - |
| Catostomus catostomus [sic?] | 2* | 2* | - | - | - | - | - | - | - |
| Chain pickerel | 41 | - | - | - | 14 | 6 | 4 | 7 | 10 |
| Comely shiner | 1172 | - | - | - | 65 | 966 | 13 | 3 | 125 |
| Common carp | 128 | 1 | - | - | - | - | - | 24 | 103 |
| Common shiner | 4286 | - | - | - | 1446 | 1036 | 10 | - | 1794 |
| Creek chub | 1239 | - | - | - | 6 | 1 | - | - | 1232 |
| Cutlip minnow | 2705 | 3 | - | - | 1360 | 791 | 169 | - | 382 |
| Emerald shiner [sic?] | 40 | 40 | - | - | - | - | - | - | - |
| Fallfish | 7043 | 1 | - | - | 1952 | 894 | 189 | 341 | 3666 |
| Gizzard shad | 5 | 3 | - | 2 | - | - | - | - | - |
| Golden shiner | 63 | - | - | - | 37 | 1 | - | - | 25 |
| Largemouth bass | 12 | - | - | - | - | 4 | 2 | 1 | 5 |
| Longnose dace | 611 | 6 | - | - | 167 | 2 | 39 | 17 | 380 |
| Margined madtom | 1957 | - | - | - | 396 | 670 | 245 | 1 | 645 |
| Northern hog sucker | 70 | 70 | - | - | - | - | - | - | - |

| | | UPDE | UPDE | UPDE | UPDE | UPDE | UPDE | DEWA | DEWA |
|---------------------------|---------------|-------------------------------|---------------------------|-------------------------------|--|--|--------------------------|------------|--|
| Dates: | | 08/31/1993 | 08/31-09/01/1993 | 07/27-28/1993 | 08/05/1959 07/12/1960 07/11/1961 | 08/06/1959 07/13/1960 07/12/1961 07/16/1962 | 08/05/1959 07/14/1960 | 08/02/1961 | 08/07/1959 07/25/1960 07/11/1961 07/17/1962 |
| New Station Number | | D02 | D03 | D01 | D03N | D04N | D05N | Do6bN | D07bN |
| Station Name: | | E-W Junction to Buckingham | 0.5 mi N of Buckingham | Abe Lord Creek down 0.5 mi | Long Eddy | Milanville | Mongaup | Montague | Delaware Water Gap |
| Location: | | Trout only tabulated | | | Long Eddy | Milanville | | Matamoras | Blacks Island (Minisink Island or Milford) |
| ANSP Reach: | | U1-U2 | U2 | U4 | U4-U5 | U9 | U18 | none | D10-down |
| Common name | Totals | | | | | | | | |
| Pumpkinseed | 121 | 2 | - | - | 31 | 57 | 2 | - | 29 |
| Rainbow trout | 82 | - | - | - | 79 | 3 | - | - | - |
| Redbreast sunfish | 1356 | 1 | - | - | 234 | 484 | 387 | 47 | 203 |
| Rock bass | 550 | 4 | - | 1 | 59 | 241 | 75 | 10 | 160 |
| Shield darter | 1570 | - | - | - | 271 | 629 | 16 | - | 654 |
| Smallmouth bass | 2342 | 8 | - | 9 | 158 | 1061 | 294 | 94 | 718 |
| Satinfin shiner | 2163 | - | - | - | 628 | 512 | 135 | 45 | 843 |
| Spottail shiner | 2518 | - | - | - | 608 | 399 | 18 | 103 | 1390 |
| Swallowtail shiner | 451 | - | - | - | 41 | 379 | 1 | - | 30 |
| Tesselated darter | 498 | - | - | - | 285 | 154 | 3 | 19 | 37 |
| Walleye | 207 | - | - | 3 | 14 | 115 | 7 | 16 | 52 |
| White catfish | 3 | - | - | - | - | 1 | - | - | 2 |
| White sucker | 4190 | 250 | - | - | 1137 | 242 | 128 | 350 | 2083 |
| Yellow perch | 52 | - | - | - | 6 | 10 | 6 | - | 30 |
| Totals | 38869 | 549 | 46 | 50 | 9343 | 9472 | 2063 | 1093 | 16251 |

* From collecting notes: "... observed longnose sucher; positive ID not certain ..."

"DEWA" Delaware Water Gap National Recreation Area

"UPDE" Upper Delaware Scenic and Recreational Area

Bold print indicates Priority I or II species.

Table 39. Summary of 2002 fish catch rates (total reported catch and % of each species within each reach) in the Delaware River from the National Park Service/Pennsylvania Fish and Boat Commission angler log survey program.

| Start location: | | | Confluence | Buckingham | Lordville | Long Eddy | Callicoon | Damascus | Narrowsburg | Lackawaxen | Millrift |
|------------------------|----------|-------|------------|------------|-----------|-----------|-----------|-------------|-------------|------------|-----------|
| Stop location: | | | Buckingham | Lordville | Long Eddy | Callicoon | Damascus | Narrowsburg | Lackawaxen | Millrift | Slateford |
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 10 |
| Common name | Sp. Code | Total | U1-U2 | U2-U3 | U3-U4 | U4-U7 | U7-U9 | U9-U11 | U11-U14 | U14-U18 | U18-D10 |
| American eel | AME | 0.29 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.49 | 0.00 |
| American shad | AMS | 3.87 | 0.35 | 0.00 | 0.00 | 0.82 | 0.00 | 0.00 | 0.48 | 4.41 | 70.28 |
| Brook trout | ST | 0.23 | 0.12 | 3.23 | 0.00 | 1.10 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 |
| Brown trout | BT | 11.81 | 44.64 | 26.45 | 34.88 | 21.98 | 3.02 | 0.69 | 0.66 | 1.72 | 0.00 |
| Chain pickerel | CP | 0.04 | 0.00 | 0.00 | 0.78 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Creek chub | RC | 0.02 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fallfish | FF | 4.05 | 1.65 | 6.45 | 3.10 | 5.22 | 7.76 | 11.72 | 2.81 | 9.96 | 0.00 |
| Largemouth bass | LMB | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 |
| Rainbow trout | RT | 18.04 | 51.71 | 54.19 | 56.59 | 60.16 | 21.98 | 3.45 | 0.44 | 0.00 | 0.00 |
| Rainbow trout (golden) | RTGD | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.86 | 0.00 | 0.00 | 0.00 | 0.00 |
| Redbreast sunfish | RBSF | 5.14 | 0.00 | 0.00 | 0.00 | 0.27 | 3.02 | 2.76 | 9.05 | 6.32 | 0.00 |
| Rock bass | RB | 3.17 | 0.00 | 0.00 | 0.00 | 0.27 | 7.33 | 4.83 | 5.45 | 0.77 | 0.94 |
| Smallmouth bass | SMB | 51.35 | 0.82 | 4.52 | 3.88 | 7.42 | 51.72 | 72.41 | 79.83 | 73.37 | 17.45 |
| Striped bass | STB | 0.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.57 | 11.32 |
| Walleye | WE | 1.27 | 0.47 | 5.16 | 0.78 | 2.47 | 3.88 | 4.14 | 1.10 | 0.00 | 0.00 |
| White catfish | CC | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.38 | 0.00 |
| White sucker | WSKR | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 |
| Totals | - | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Total number of fish | - | 4884 | 849 | 155 | 129 | 364 | 232 | 145 | 2276 | 522 | 212 |
| Number of angler-hours | - | 11393 | 4558 | 1062 | 589 | 1685 | 478 | 196 | 1632 | 438 | 755 |

Table 40. Summary of 2003 fish catch rates (total reported catch and % of each species within each reach) in the Delaware River from the National Park Service/Pennsylvania Fish and Boat Commission angler log survey program.

| Start location: | | | Confluence | Buckingham | Lordville | Long Eddy | Callicoon | Damascus | Narrowsburg | Lackawaxen | Millrift |
|----------------------|----------|-------|------------|------------|-----------|-----------|-----------|-------------|-------------|------------|-----------|
| Stop location: | | | Buckingham | Lordville | Long Eddy | Callicoon | Damascus | Narrowsburg | Lackawaxen | Millrift | Slateford |
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 10 |
| Common name | Sp. Code | Total | U1-U2 | U2-U3 | U3-U4 | U4-U7 | U7-U9 | U9-U11 | U11-U14 | U14-U18 | U18-D10 |
| American eel | AME | 0.19 | 0.00 | 0.00 | 1.07 | 0.45 | 0.00 | 0.00 | 0.04 | 1.95 | 0.00 |
| American shad | AMS | 1.64 | 0.13 | 0.00 | 2.14 | 1.35 | 0.36 | 0.00 | 0.26 | 6.34 | 52.81 |
| Bluegill | BG | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.95 | 0.00 |
| Brook trout | ST | 0.19 | 0.51 | 0.00 | 0.00 | 0.67 | 0.36 | 0.00 | 0.00 | 0.00 | 1.12 |
| Brown trout | BT | 15.79 | 46.52 | 43.85 | 46.52 | 22.47 | 7.27 | 0.00 | 0.04 | 2.44 | 15.73 |
| Chain pickerel | CP | 0.13 | 0.00 | 0.28 | 0.00 | 0.00 | 0.73 | 0.00 | 0.09 | 0.49 | 0.00 |
| Channel catfish | CC | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 |
| Creek chub | RC | 0.13 | 0.38 | 0.56 | 0.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fallfish | FF | 3.84 | 2.78 | 4.47 | 2.67 | 10.56 | 7.64 | 0.00 | 2.53 | 6.34 | 1.12 |
| Largemouth bass | LMB | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 |
| Rainbow trout | RT | 17.59 | 46.40 | 42.46 | 42.25 | 42.70 | 14.91 | 2.44 | 0.26 | 0.00 | 0.00 |
| Redbreast sunfish | RBSF | 4.18 | 0.00 | 0.00 | 0.00 | 0.45 | 1.09 | 13.01 | 5.98 | 18.54 | 3.37 |
| Rock bass | RB | 2.39 | 0.00 | 0.00 | 0.00 | 0.22 | 5.82 | 4.07 | 3.58 | 4.88 | 0.00 |
| Smallmouth bass | SMB | 50.42 | 2.02 | 6.70 | 3.74 | 17.75 | 57.09 | 80.49 | 82.80 | 50.73 | 21.35 |
| Striped bass | STB | 1.70 | 0.13 | 0.00 | 0.00 | 0.45 | 0.00 | 0.00 | 3.19 | 0.49 | 4.49 |
| Walleye | WE | 1.39 | 1.01 | 1.68 | 1.07 | 2.92 | 4.36 | 0.00 | 0.61 | 5.37 | 0.00 |
| White sucker | WSKR | 0.10 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 |
| Yellow perch | YP | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.00 | 0.35 | 0.49 | 0.00 |
| Totals | - | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Total number of fish | - | 4764 | 791 | 358 | 187 | 445 | 275 | 123 | 2291 | 205 | 89 |

Table 41. Summary of fish caught by Stockholm and the Academy of Natural Sciences (ANS) in the Delaware River in Delaware Water Gap National Recreation Area.

| Location(s): | Milford & Smithfield Beach (D1 and D8) | | Smithfield Beach (D8) | Smithfield Beach & Bushkill (U6 and U8) |
|-----------------------|---|------------|--------------------------|---|
| Date: | 1991 | | 08/25/1992 | 1973 |
| Source: | ANS | | ANS | Stockholm |
| Techniques: | Seine | Ichthy Net | Boat Electro | Tow Barge Electro |
| Alosa species | 1 | 13 | - | - |
| American eel | - | 1 | - | - |
| American shad | 354 | 27 | X | - |
| Banded killifish | 2 | - | - | - |
| Blacknose dace | 4 | - | - | 25 |
| Brown bullhead | - | 8 | - | - |
| cf darter (egg) | - | 3 | - | - |
| cf spotfin shiner | 2 | - | - | - |
| cf tessellated darter | - | 2 | - | - |
| Channel catfish | - | 4 | 3 | - |
| Comely shiner | 33 | - | - | 33 |
| Common shiner | 13 | - | - | 295 |
| Cutlip minnow | 16 | - | - | 29 |
| Fallfish | 1051 | 48 | - | 948 |
| Golden shiner | 1 | 14 | - | - |
| Quillback | 29 | - | - | - |
| Killifish species | 1 | - | - | - |
| Longnose dace | 3 | - | - | 145 |
| Margined madtom | - | 1 | - | - |
| Minnow species | 1 | 1 | - | - |
| Muskellunge | 2 | - | 1 | - |
| Pumpkinseed | 1 | - | - | - |
| Redbreast sunfish | 65 | - | - | - |
| Rock bass | 57 | 45 | - | - |
| Satinfin shiner | 94 | - | - | 957 |
| Sea lamprey | - | 5 | - | - |
| Shield darter | - | - | - | 151 |
| Smallmouth bass | 25 | 2 | 9 | - |
| Spotfin shiner | 7 | - | - | - |
| Spottail shiner | 510 | 1 | - | 248 |
| Striped bass | - | - | 1 | - |
| Sucker species | 1 | - | - | - |
| Swallowtail shiner | 82 | - | - | 287 |
| Tessellated darter | 55 | 272 | - | 445 |
| White sucker | 111 | 69 | - | - |
| Yellow bullhead | - | - | 1 | - |
| Yellow perch | - | - | 1 | - |
| Totals | 2520 | 502 | 16 | 3563 |

Note: Stockholm (1976) only enumerated minnows and darters.

Status of Target Species

Priority I

American Brook Lamprey (*Lampetra appendix*)

Arndt (2004) shows a number of records of American brook lamprey in Big Flat Brook and Little Flat Brook (outside DEWA) and in one site in or near Flat Brook. There is a record from Flat Brook from the USEPA, which may have been the basis of one of Arndt's records; however, only sea lampreys were collected in Flat Brook in this study. One specimen tentatively identified as American brook lamprey was collected in Big Flat Brook, along with a number of sea lamprey. Larvae of the two lamprey species are very similar, differing in subtle aspects of coloration and shape. While the specimen fits the color pattern of American brook lamprey, the identification is considered tentative at this point. Another specimen with a color pattern intermediate between that of American brook and sea lamprey was caught in the river at the Water Gap. This is identified as an anomalous sea lamprey.

Bowfin (*Amia calva*)

No bowfins were caught in the ANS survey. There is a 1983 PFBC record of bowfin from the Cummins-Slateford reach of the Delaware River. A bowfin was reported from eel weir collections at Milanville on August 28, 2002. Mark Boriek (NJDEP, pers. comm., 2004) reports that there are occasional reports by anglers of bowfin in the river; including the section within DEWA.

Eastern Mudminnow (*Umbra pygmaea*)

The eastern mudminnow was found in four reaches in the Delaware River in DEWA, where it was found in cover along banks of pools and backwaters. It was also caught in a floodplain pond north of the Bushkill Creek mouth. In UPDE, a number were collected near Barryville in 2004. They were found in small pools isolated from the main river channel; these pools were cool and likely were fed by subsurface flow from Halfway Brook and/or the river. The site was revisited in 2005, and it appeared to have been heavily affected by high flows. The pools were shallow, due to changes in water level and/or deposition into the pools, and unshaded, due to destruction of pondside willows. Ross collected eastern mudminnow in McMichaels Creek. The mudminnow apparently occurs in scattered locations along the margin, backwaters, and floodplain of the main river. These habitats may not be thoroughly covered in many surveys, so the species is probably more common than apparent from the number of records.

Bridle shiner (*Notropis bifrenatus*)

In this inventory, bridle shiners were caught in or near the Upper Delaware River and in the Flat Brook system in DEWA. In Flat Brook, bridle shiners were caught at one site in Big Flat Brook, four sites in Flat Brook, and in a nearby pond. Ross caught four bridle shiners at the mouth of Vancampens Brook. This site was sampled in the ANS inventory using several techniques (boat electrofishing, backpack electrofishing, seining, and snorkeling), but no bridle shiners were found. It is possible that these fish don't represent a resident population, but came from populations in Flat Brook. Bridle shiners are also known to occur in Marshalls Creek near the downstream boundary of DEWA.

In 2005, bridle shiners were caught by D. Carlson of NYSDEC in a backwater of the Delaware River in UPDE. They were also caught in a backwater of the West Branch Delaware River. The ANS found bridle shiners in the same Delaware River backwater in 2007 and 2008. Bridle shiners were collected in a second Delaware River site in 2006, but no bridle shiners were caught at this site in 2007. Bridle shiners were caught in a third site in the Delaware River in UPDE in 2008. Greeley (1937) listed the bridle shiner as occurring in the Delaware River and a number of other sites, but did not give specific locations. Harrington (1947) mapped two locations of the bridle shiner near UPDE, one in the lower East Branch and one on a tributary (probably between Long Eddy and Callicoon, possibly Callicoon Creek). Lee et al. show records from the same sites plus a site on the lower West Branch. Smith (1985) shows two locations on the lower East Branch and one on the Delaware River near Callicoon. Some of these records probably refer to the same collections, with small differences in mapping location.

Ironcolor Shiner (Notropis chalybaeus)

No documented records of ironcolor shiner have been located for UPDE or DEWA. Ironcolor shiner occurs in Marshalls Creek, a tributary of the Delaware River. There are also records of ironcolor shiner from Basher Kill, a tributary of the Neversink River, from 1935 (Greeley 1936) and 1998 (D. Carlson, pers. comm., September 22, 2005).

Tadpole Madtom (Noturus gyrinus)

Specimens in the ANS fish collection which were identified as tadpole madtom were examined. These were reported from “Delaware Water Gap” in the late 19th century. Examination of the specimens (by Richard Horwitz and Mark Sabaj-Perez of the ANS) indicates that the specimens are margined madtom (*Noturus insignis*). No other records of tadpole madtom have been found. Tadpole madtom has been recorded from Basher Kill, a tributary of Neversink River, (Greeley 1936) and from Big Flat Brook (Arndt 2004), so occurrence in DEWA is possible.

Slimy Sculpin (Cottus cognatus)

Slimy sculpin were found to be fairly common at two stream systems, Vandermark Creek and Flat Brook. Slimy sculpin have been previously reported from both streams (Ross et al. 2004). In Flat Brook, slimy sculpins were common in the reach below Three Bridges, but were not recorded from reaches further downstream. Slimy sculpins were also common in the section of Big Flat Brook within DEWA. Arnold reported slimy sculpin from Hornbecks Creek, although it is not known whether the record was within current DEWA boundaries. Argent et al. (1997) compiled several records of slimy sculpin in the lower West Branch Delaware River; the sources of these records are not known. Slimy sculpin have been recorded in several tributaries of the West Branch of the Delaware near UPDE; these tributaries include Shehawken Creek (Arnold) and Balls Brook (Arnold). Arnold and Horwitz (unpubl. data) have recorded slimy sculpin from a number of Delaware River tributaries in the Poconos (e.g., Middle Branch Dyberry Creek, Poplar Run, West Branch Lackawaxen River, Swiftwater Creek, and a tributary of Pocono Creek). There are also reports of mottled sculpin (*Cottus bairdi*) from the West Branch Delaware River and tributaries; these records are discussed under that species.

Priority II

Redfin Pickerel (Esox americanus)

The redfin pickerel was widespread in the Flat Brook drainage, but was not caught elsewhere. Redfin pickerels were caught in Big Flat Brook, four reaches of Flat Brook, in the artificial pond (P33) tributary to Flat Brook, and in two small ponds adjacent to Flat Brook. Some of the pickerel caught in the small ponds were small young-of-year, and these pond/wetland areas likely serve as spawning areas for the redfin pickerel. Ross caught redfin pickerel in Bushkill Creek. The PFBC has records of redfin pickerel from Bushkill Creek, Little Bushkill Creek, Dingmans Creek, and McMichaels Creek; these sites may be outside DEWA boundaries. Arndt (2004) shows a number of records in upper Flat Brook, Little Flat Brook, and Big Flat Brook (the latter two outside DEWA). There is also a PFBC record from the Delaware River below Slateford. Thus, the species appears to occur in a number of larger tributaries and in some ponds adjacent to these.

Blueback Herring (Alosa aestivalis)

Five juvenile blueback herring were caught in the Delaware River in the Smithfield Reach. In 2008, the ANS sampled the Delaware River near Poxono Island as part of another study. During this sampling event (not tabulated in this report), a school of adult blueback herring was found in a backwater of the Delaware River. Thus, there is likely to be some reproduction of blueback herring in the park. Arndt (2004) shows one record in DEWA. Boriek (pers. comm., 2004) noted one blueback herring among thousands of juveniles which have been recorded in the NJ juvenile shad monitoring program in DEWA. Upstream occurrence of blueback herring may be related to run size, i.e., with farther migration in years of strong runs. Thus, occurrence may be sporadic.

Alewife (Alosa pseudoharengus)

One alewife was captured in a backwater of the Delaware River at the junction pool in the Hancock reach. There are records of a few individuals, e.g., from NYSDEC and PFBC collections. The species has been reported to occur in the river due to fish washing out from reservoirs in the system (e.g., Mongaup River, R. Evans, pers. comm., 2005). Thus, records of the species do not indicate spawning in the river or occurrence from upstream migration of anadromous fish. Arndt (2004) shows a record near the headwaters of Big Flat Brook (outside DEWA); this probably reflects an introduction into a pond.

Gizzard Shad (Dorosoma cepedianum)

Gizzard shad were caught by electrofishing in Smithfield reach in DEWA and five reaches in UPDE by the ANS inventory. They were caught mainly in middle and lower reaches sampled (i.e., from Callicoon downstream) in UPDE. All gizzard shad caught were from 34.7–50.0 cm (13.7–19.7 in) in length; these represent large juveniles and adults, so it is possible that gizzard shad spawn elsewhere (e.g., farther downstream or in tributaries) and larger fish move upstream to forage. The ANS caught adult gizzard shad along with adult American shad in the Neversink River about three to four kilometers (1.9–2.5 mi) upstream of its mouth in the spring of 2007. A number of gizzard shad were reported in catches in the Milanville eel weir in 2002; it was the third most common species in the July–October samples. Gizzard shad have also been noted to be an important food for bald eagles in the Narrowsburg area (D. Hamilton, pers. comm., 2005). There are older records by the NYSDEC and the PFBC from various sections in the river in UPDE and DEWA.

Spotfin Shiner (Cyprinella spiloptera)

The spotfin shiner was caught at most reaches in the Delaware River in DEWA and from the mouth of Brodhead Creek (outside the park). It was not caught in UPDE, but Ross captured spotfin shiner at the confluence of Callicoon Creek and the Tenmile River confluence. The ANS captured spotfin shiner at Smithfield Beach in 1991, as well, and Arndt (2004) shows records in the Delaware River in DEWA as well. Carlson reported it from the East Branch Delaware River in 2003. Thus, the spotfin shiner appears to be an uncommon, but widespread species in the Delaware River in DEWA. It appears to be less common in UPDE, but its status there is still uncertain.

Bluntnose Minnow (Pimephales notatus)

The bluntnose minnow was caught in small numbers at six reaches in UPDE. The bluntnose minnow was one of the commonest species in beaver ponds at the mouth of Cooley Creek. The species has not been caught in DEWA in the inventory, no records for DEWA have been found, and it is not on the NPS base list for DEWA. There are PFBC records from the West Branch Delaware River and from Marshalls Creek.

Northern Hog Sucker (Hypentelium nigricans)

Northern hog suckers were caught at a number of sites in the Delaware River in UPDE and DEWA, in Bushkill Creek, in Flat Brook, and Raymondskill Creek. There are other records from the Brodhead confluence (Ross), Bushkill (Ross), Flat Brook (Ross), Cherry Creek (Ross), Callicoon Creek (Ross), Tenmile confluence (Ross), and Delaware River (NYSDEC and PFBC).

Quillback (Carpionodes cyprinus)

Quillback were caught in the Shapnack and Smithfield reaches in the ANS inventory. Ross observed quillback in the confluence of Vancampens Brook, which is close to the collection site by the ANS in the Smithfield reach. There is an older PFBC record in the Delaware River (Cummins to Slateford reach). Small (presumably young-of-year) quillbacks were caught by the ANS at Smithfield Beach in 1991 (Table 41).

White Catfish (Amieurus catus)

No white catfish have been caught in the ANS inventory to date. There is a record from Milanville from the NYSDEC 1959–1962 survey, and several records from the Delaware River in the vicinity of the Water Gap or downstream (NYSDEC 1959–1962, PFBC 1983). No channel catfish were reported in the NYSDEC tri-state survey, and it is possible that the records of white catfish refer to channel catfish (large channel catfish may be mistaken for white catfish). On August 10, 1992, the ANS sampled the Delaware River around Sandt's Eddy, about 32 km (20 mi) downstream of DEWA; ten white catfish and four channel catfish were caught in this sample, indicating relatively far upstream occurrence at times. It has been suggested that white catfish have decreased in abundance in the lower river in recent years (Horwitz et al. 2006). If so, upstream occurrence may decrease as well. However, the white catfish may occur as an occasional stray into DEWA.

Bluespotted Sunfish (Enneacanthus gloriosus)

The bluespotted sunfish was caught in a number of sites with low current velocity and abundant submerged vegetation. The bluespotted sunfish was caught in Catfish Pond, a floodplain pond north of Bushkill Creek, at several sites in Flat Brook, and in ponds adjacent to Flat Brook. In the Delaware River in DEWA, one individual was caught in the Water Gap reach (D10). Bluespotted sunfish were caught in a number of backwaters in UPDE. The PFBC has records from Bushkill Creek, Adams Creek, Shehawken Creek, and Shohola Creek. The sites of collection in Bushkill and Adams Creek may be outside DEWA boundaries. Arndt (2004) shows two records in or near the Delaware River between the Water Gap and Walpack Bend.

Swallowtail shiner (Notropis procne)

The swallowtail shiner was caught in the Delaware River in all six of the reaches extensively sampled in DEWA and in four reaches in UPDE. It was also caught in Flat Brook, in a pond adjacent to Flat Brook, and at the confluence of Vancampens Brook. Ross found a few swallowtail shiners in the Toms Creek confluence, the Vancampens Brook confluence, in Callicoon Creek, and the Callicoon Creek confluence. The PFBC reported it in several Delaware River reaches in DEWA. Relatively small numbers were reported from UPDE and DEWA by the tri-state survey, except for large numbers reported in the Milanville reach. It was also caught in DEWA by Stockholm in 1973 and the ANS in 1991. Thus, the species appears to be widespread and relatively common in the Delaware River in DEWA and less common in UPDE. Greeley (1936) noted that the swallowtail shiner was typically found in different habitats than the bridle shiner. The bridle shiner typically occurs in sites with abundant aquatic vegetation. In much of the Delaware drainage, the swallowtail shiner typically occurs on unvegetated sand or sand-silt bars (Horwitz, unpub. data). In this survey, the swallowtail shiner was frequently caught in sites with little aquatic vegetation; however, in Flat Brook, both bridle shiner and swallowtail shiners were found together in vegetated pools.

Comely Shiner (Notropis amoenus)

The comely shiner was caught in all six reaches of the Delaware River extensively sampled in DEWA and in four UPDE reaches. In UPDE, it was found mainly in upper and middle reaches (i.e., Narrowsburg and upstream). The PFBC also recorded it widely in DEWA. However, it was not reported by Ross. Relatively small numbers were reported in DEWA by the ANS in 1991 and Stockholm (1976) in 1973. Large numbers were reported by the NYSDEC in the tri-state survey of 1959–1962. Comely shiner may occur in deeper run and pool areas and may be under-represented in some types of near-shore sampling.

Satinfin Shiner (Cyprinella analostana)

The satinfin shiner was caught in the Delaware River in four reaches in DEWA and six reaches in UPDE. Ross captured relatively small numbers in several creeks in DEWA and in Callicoon Creek. There is a USEPA record from near the mouth of Flat Brook (Flatbrookville). The NYSDEC recorded large numbers in the Delaware River in UPDE and DEWA in the 1959–1962 survey. Stockholm (1976) also recorded large numbers in DEWA. The satinfin shiner appears to be a widespread species in the river, although it was not caught in large numbers.

New Species Records

Reports of the following species not on the original species list have been found.

Mottled Sculpin (Cottus bairdi)

Four specimens (three are listed in the catalogue, but the jar contains four specimens) identified as mottled sculpin from the West Branch Delaware River at Hancock are preserved in the U.S. National Museum of Natural History (USNM 354883). These were collected on September 18, 1998, by the USEPA EMAP program. No sculpins were caught in the West Branch in this study, but a single small specimen was caught at the mouth of Shehawken Creek, i.e., about 1.1 km (0.7 mi) downstream of the Rte 191 bridge. Mottled sculpin have been caught in several tributaries of the upper Delaware River in New York in recent years by the NYSDEC (D. Carlson, pers. comm., 2008). Argent et al. (1997) map one record of mottled sculpin in a Delaware River tributary near Hancock (e.g., Balls Creek, Sherman Creek, or Faulkner Run drainages). The four USNM and the single ANS specimen were examined and are consistent with mottled sculpin, based on several diagnostic characters (four principal pelvic rays, palatine teeth present, pectoral fin ray count, and last anal and dorsal rays doubled) cited in Smith (1985), Strauss (1986), and/or Jenkins and Burkhead (1993), and verified using a series of specimens from other localities in the ANS Fish Collection. Point locations in Argent et al. (1997) show a few occurrences of mottled sculpins in the lower Delaware River basin (two sites probably in the Lehigh River and several sites near the Susquehanna drainage); otherwise, no other older records of mottled sculpins in the Delaware drainage have been noted.

Strauss (1986) used genetic analyses to distinguish eight specimens as hybrids between mottled and slimy sculpins in Blockhouse Creek, a stream in the Susquehanna drainage. Hybrids could not be distinguished on the basis of intermediate characters, since most hybrid fish had morphological characters similar to one of the parents. However, the frequency of asymmetry (different counts on left and right sides for paired structures) was somewhat higher for hybrids than specimens of the parent species (for several characters, the two parent species differ by a single count, so that intermediate counts must be asymmetric). Notably, the number of pectoral fin rays and pelvic fin rays of hybrids were generally identical to that of mottled sculpin. Strauss distinguished additional hybrid specimens morphologically on the basis of characteristics of both species in multiple characters (usually, pelvic count typical of one species and palatine teeth typical of the other species). One of the USGS West Branch specimens and the ANS Shehawken Creek specimen had different pectoral fins counts, but were consistent with mottled sculpin in other characters. Thus, there is a possibility that there is some hybridization between the two species in the West Branch-Shehawken area, but this cannot be determined from the specimens at hand.

Strauss noted that the two species are usually spatially separated, with mottled sculpin in warmer waters and slimy sculpin in colder waters. He conjectured that the separation reduced development of behavioral or other mechanisms to prevent hybridization. Andreasson (1969) found natural hybrids of two Swedish sculpins in tributary mouths in a recently dammed river. He speculated that hybridization might be promoted by rarity of one of the species due to damming.

The slimy sculpin was reported from Shehawken Creek by Arnold (unpubl. data). Argent et al. (1997) show at least four records of slimy sculpin for the West Branch Delaware River in Pennsylvania, another record from a nearby tributary (likely Sherman Creek), and two records from tributaries of the Delaware River in DEWA.

Mottled sculpins may have been introduced into the West Branch of the Delaware River, e.g., as bait bucket releases. The mottled sculpin occurs naturally in Susquehanna tributaries near the West Branch, so anglers could have caught sculpins in the Susquehanna drainage for use in the Delaware. In some areas, sculpins are popular bait for trout and other fish (Scott and Crossman 1973). Although sculpins are not listed as legal baitfish in New York or Pennsylvania fishing regulations, sculpins are not explicitly listed as illegal bait fish. Hybridization (if it occurs) might be promoted by relative rarity of the introduced species or by fluctuations in water temperatures in the West Branch which might lead to movement and mixing of the species.

Atlantic Sturgeon (Acipenser oxyrhynchus)

A specimen of Atlantic sturgeon was reported from the Neversink River at Port Jervis in 1878. Colin Apse (pers. comm., April 25, 2005) supplied the text of a reprint of the 1878 text, published in the Sullivan County Democrat on October 6, 1998: "A party of young men discovered a large sturgeon in the Neversink River at Port Jervis Thursday morning. It was killed by being shot and after it was found to measure seven feet, four inches long and weighed 150 pounds." This record is shown in Arndt (2004). The sturgeon presumably went through the DEWA portion of the Delaware River. The Atlantic sturgeon is currently rare in the Delaware estuary, so upstream occurrence would be very rare at best. However, there are reports of sightings in the Delaware River near Dingmans Ferry by divers of large fish which might be Atlantic sturgeon (W. Lellis, pers. comm., May 19, 2005).

Atlantic Needlefish (Strongylura marina)

D. Carlson (NYSDEC) provided a report of an Atlantic needlefish caught in a weir in the East Branch Delaware River in 1997. The species is estuarine, and presumably went through UPDE and DEWA.

Species of Historic Occurrence

Longnose sucker (Catostomus catostomus)

This species is documented from the parks from observations by the NYSDEC. Field notes indicated that the identifications were tentative, based on visual observation. The NYSDEC also reported the species from the lower West Branch Delaware River. The longnose sucker is known to occur in the headwaters of the West and East branches of the Delaware River (Greeley 1936, Smith 1985), so occurrence of downstream strays prior to the completion of Cannonsville Dam and Pepacton Dam is reasonable. Since construction of dams, downstream occurrence would require straying into the reservoir, survival through bottom releases or spills, and subsequent survival during warm water periods. While occurrence is not precluded, there is no documentation of recent occurrence.

Longnose Gar (Lepisosteus osseus)

Arndt (2004) shows two records of longnose gar in the Delaware River near the Water Gap (one just downstream and one upstream of the gap). Mihursky (1962) notes historical records up to the Water Gap, possibly referring to the same records as Arndt. The longnose gar was historically common in the lower Delaware River. However, there are no recent records, and the species is considered extirpated in the drainage.

Eastern Silvery Minnow (Hybognathus regius)

Arndt (2004) showed a record of this species from near the mouth of Flat Brook. This apparently derives from reported occurrence in a collection by the USEPA at Flatbrookville. Based on review of the original field sheets (J. Kurtenbach, pers. comm., November 30, 2004), these records apparently derive from a data entry error and refer to *Notropis hudsonius*. There is a 1935 record from the East Branch Delaware River (Greeley 1936). The Eastern silvery minnow naturally occurs most commonly in the tidal lower river, so occurrence in the East Branch suggests occurrence in the main stem as well. There are a number of NYSDEC records from 1990–2001 from Swinging Bridge Reservoir. Individuals might occur in the Mongaup and Delaware Rivers from this source.

Atlantic Salmon (Salmo salar)

Attempts were made to introduce Atlantic salmon into the Delaware River in the late 19th century, with stocking in Pennsylvania from 1871 to at least 1891 (Meehan 1897, Raasch and Altemus 1991). Catches of a number of adult fish in 1896 (including catches from the shad fishery at the Delaware Water Gap) and a few fish in 1901–1906 later suggested some reproductive success, but the species did not become established. The U.S. National Museum of Natural History (USNM) has an undated specimen of Atlantic salmon from the Delaware River (no further locality information), which could derive from this stocking.

Species of Questionable Status

Literature reports include records of several species which are not native to the drainage and not known to be widely established, are erroneous, or which raise other questions about species status. Those concerning priority species are discussed in the previous section. Reports of other species are summarized here.

Tiger Muskellunge (Esox masquinongy x lucius)

The tiger muskie is a hybrid produced in fish culture. Tiger muskies are generally considered to be sterile, but there is a possibility that some reproduction may occur. The tiger muskie has been stocked in the Delaware River basin, e.g., in the tidal reach downstream of Trenton. The PFBC reported tiger muskie in the Delaware River in the Cummins-Slateford reach, which is almost entirely within DEWA. No further information on this record has been found. It is plausible that individuals stocked in the lower river strayed upstream into DEWA.

Northern Pike (Esox lucius)

The PFBC reported Northern pike in the Delaware River in the Cummins-Slateford reach. No further details on this record were found. The Northern pike is not native to the drainage; however, it is frequently stocked in lakes in the northeast, and individuals may have strayed from introduction sites into the river. It is also possible that the record could refer to tiger muskies. If tiger muskies reproduce, some progeny would be expected to look like Northern pike.

Rosyface Shiner (Notropis rubellus)

The NPS species list for the park includes rosyface shiner, a species common in the Susquehanna River, but not native to the Delaware River. Specimens have not been examined. The rosyface shiner is similar in appearance to the comely shiner, and records may represent misidentified comely shiner. The comely shiner was formerly considered a subspecies of the rosyface shiner (e.g., in Greeley 1936), and reports of rosyface shiner may predate the elevation of the comely shiner to full species. It is also possible that the species has been introduced, e.g., through bait bucket release.

Emerald Shiner (Notropis atherinoides)

NYSDEC records contained records of emerald shiner, a species native to the Hudson River, but not native to the Delaware River. These may represent misidentified comely shiner. However, the emerald shiner is a commonly used bait species, and it could have been introduced to the Delaware River. There are a number of other NYSDEC records of emerald shiner from the East Branch Delaware River and West Branch Delaware River (D. Carlson, pers. comm., September 22, 2005) from 1972–1996. These are listed as questionable by Carlson.

Stonecat (Noturus flavus)

The stonecat has been reported in tributaries of the Delaware River, e.g., Neversink River. The species is native to the Hudson River, and it could have been introduced to the Delaware, e.g., through bait bucket release, since madtoms are used as bait for bass. The stonecat is superficially similar to the margined madtom, and poorly marked margined madtoms may be mistaken for stonecats. No specimens of stonecat have been verified from the Delaware River or tributaries by the ANS, but madtoms should be examined to determine presence of the stonecat. Argent et al. (1997) mapped a large number of records of “stonecat” from the Delaware River, mainly downstream of Trenton, but with three records in UPDE and one or two records in DEWA. A number of records were also mapped for the lower Susquehanna River and lower Allegheny River. This distribution does not represent the distribution of *Noturus flavus*. This map may refer to records of an older colloquial or scientific name of another species or may represent a coding error.

Johnny Darter (Etheostoma nigrum)

The tessellated darter was formerly regarded as a subspecies of *E. nigrum*, and there are many older records from the Delaware drainage listed as *E. nigrum* or *E. nigrum olmstedii*. There are no known records of Johnny darter (as currently recognized as a separate species) in the Delaware drainage, and any records are assumed to represent the tessellated darter.

River Chub (Nocomis micropogon)

The river chub is native to the Susquehanna River but not the Delaware River. One record from 1900–1924 is shown for the Delaware River in Argent et al. (1997). The record is mapped at around Dingmans Ferry, now in DEWA. The species was also on the NPS base list based on a specimen from the 1978 report. These two reports are presumably based on the same specimen. This specimen has not been located as part of this study. The species may have occurred as a few individuals or as a temporary population derived from bait bucket release. It is also possible that the original locality data for the specimen were incorrect. No recent specimens of the species have been seen, and there is no recent evidence of its occurrence in the parks. Fallfish are frequently called chubs by anglers, and reports of “river chub” in anglers’ logs likely represent fallfish.

Sauger (Sander canadense)

A sauger was reported caught in the West Branch Delaware River (along with five walleye) on June 22, 2007 (<http://www.backwoodsangler.com/Fishing%20Reports.htm>; 4 July 2007). The sauger is native in the Mississippi and St. Lawrence drainages. It has been introduced to some areas, but is not otherwise known from the Delaware, Hudson, or Susquehanna drainages. Hybrid walleye x sauger (“saugeye”) have been produced and stocked in places as well. The sauger and walleye are most easily distinguished by color pattern. Without more documentation, it is unknown whether the report refers to an introduced fish or a walleye with unusual color pattern.

Notes on Other Species

Central Stoneroller (Campostoma anomalum)

Only one stoneroller was caught, an individual collected adjacent to Frisbie Island. Ross collected stonerollers in Callicoon Creek and at the confluence of the creek and the river. The NYSDEC tri-state survey caught a number of stonerollers at Long Eddy and Milanville in the 1959–1961 period. However, Greeley (1936) explicitly noted that stonerollers were only caught in the Susquehanna drainage where they were common. Argent et al. (1997) note one record in UPDE (mapped between Milanville and Narrowsburg) for the 1975–1995 period, and six records for the Upper Delaware Drainage from the 1950–1974 period; two or three of these records are mapped as being from the Delaware River (some or all of these may be USGS or NYSDEC records). Other than these records, Argent et al. show only two records of stoneroller in the Delaware River in Pennsylvania. These appear to be in the Schuylkill drainage where tributaries of the Schuylkill River and Susquehanna River approach each other in valleys of the Ridge and Valley Province. Argent et al. show many records for the stoneroller for the Susquehanna drainage, many near the Delaware/Susquehanna divide.

There are several explanations for the trend in stoneroller populations. The species may have been introduced to the Delaware drainage recently (possibly after Greeley’s survey in 1935), expanded its range and abundance, and then declined recently. Alternatively, it may have been native, but rare or local in the drainage, possibly increasing in abundance after Greeley’s survey. While other localities of the stoneroller may have been missed in the current survey, its limitation to a single area (in and

near Callicoon Creek) in Ross's and the current surveys suggests that the species has decreased in abundance. The stoneroller has a specialized feeding habit, scraping periphytic algae and associated materials from rocks. Thus, stoneroller populations might be affected by changes in periphyton production or quality, e.g., linked to changes in nutrient inputs. However, no documentation of changes in periphyton ecology has been found.

Brook Trout (Salvelinus fontinalis)

Recent surveys have indicated that brook trout are less abundant or extirpated from many streams in its native range, particularly in the southern part of its range. Brook trout require cold water and clean, well-oxygenated gravel sediments for reproduction, making the species sensitive to climate warming and changes in stream hydrology and sedimentation. Brook trout were found in several streams in DEWA.

Single individuals of adult brook trout were caught in the Delaware River and tributaries: a 38.5-cm ([15.2-in] all lengths are total length measured on live specimens in the field) fish from Lackawaxen in UPDE, a 37.5 cm (14.8-in) individual at the Water Gap in DEWA, and a 24.5 cm (9.6-in) individual from Bushkill Creek. Five adult fish, 22.1–25.3 cm (8.7–10 in), were caught in Dingmans Creek at Milford Road, and three fish, 29.0–30.5 cm (11.4–12.0 in) were caught in Blue Mountain Lakes.

Small individuals, indicative of reproduction, were caught in a tributary of Dingmans Creek, in Vandermark Creek, in Vancampens Brook, and in Dunnfield Creek, just outside the park. Multiple size classes of brook trout were caught at tributary 8.1, a left-bank tributary of Dingmans Creek which runs along and crosses Route 739. Twelve individuals, 6.1–7.1 cm (2.4–2.8 in) and 24 individuals, 13.5–24.6 cm (5.3–9.7 in), were caught on August 4, 2005. One 6.0-cm (2.4-in) brook trout was caught in Vandermark Creek in Milford. There were a large number of brown trout of various sizes at this site. It is possible that brook trout are more common upstream in this creek. In 2003, the ANS sampled Vancampens Brook as part of another study. In that study, multiple size classes were caught upstream of Millbrook Village. Out of 99 fish, 41 were 5.8–8.1 cm (2.3–3.2 in), 52 were 8.9–13.7 cm (3.5–5.4 in), and six were 14.8–19.9 cm (5.8–7.8 in). Smaller numbers were caught at an upstream station, at the Flatbrook-Spillwater Road: two fish 7.7–8.2 cm (3.0–3.2 in), five fish 9.8–13.7 cm (3.9–5.4 in), and eight fish 14.8–24.6 cm (5.8–9.7 in). The lower abundance of fish, the lower relative abundance of small fish, and the presence of a few larger fish at the upper station was attributed to acidification of the upper brook, which would affect reproduction more than adult survivorship. Dunnfield Creek, in Worthington State Forest, was also sampled as part of that project. Multiple size classes, including 7.6–8.5 cm (3.0–3.3 in) fish, were caught there as well.

Species of Potential Occurrence

Some species found in other parts of the drainage may have occurred in the UPDE and DEWA areas, although there are no records of them. These include:

Rainbow Smelt (Osmerus mordax)

The Delaware River supported anadromous smelt, but little is known of their biology in the river. While smelt could have migrated upstream into the upper river, there are no records of the species. Greeley reported smelt in one lake in the drainage (Delaware Lake on the West Branch), but it was presumably introduced there.

Trout-perch (Percopsis omiscomaycus)

The trout-perch was collected in a tributary of the Lehigh Valley (Mihursky 1962; ANS specimens). Mihursky notes that a record of the trout-perch in the lower Delaware River attributed to Abbott is probably wrong. The species is considered extirpated in the Delaware drainage. The trout-perch has a northern distribution, so its historical occurrence in the drainage south of DEWA suggests that it might have occurred in DEWA at one time.

Pirate-perch (Aphredoderus sayanus) and Mud Sunfish (Acantharchus pomotis)

These species are primarily found on the Coastal Plain, with scattered records in the Delaware River drainage from northern New Jersey. They often occur in vegetated habitats similar to those used by the ironcolor shiner, tadpole madtom, bluespotted sunfish, and Eastern mudminnow. The pirate-perch and/or the mud sunfish might have occurred in DEWA at some time, but there are no reports of these species.

Estuarine Species

Given the occurrence of a needlefish in the Upper Delaware, a number of other estuarine species might have occurred as strays in DEWA or UPDE at some time. The fourspine stickleback (*Apeltes quadracus*) is primarily an estuarine species, but Mihursky noted occurrence in alkaline waters in the middle Delaware drainage.

Introduced Species

Green Sunfish (Lepomis cyanellus)

Small numbers of green sunfish were caught in five reaches in UPDE, where they were found along shore or in backwaters. In DEWA, green sunfish was found only in a small pond/backwater upstream of the mouth of Brodhead Creek. This backwater had a small, apparently unused beaver dam at its outlet, but the dam did not appear to be controlling water level in the pond. A large number of green sunfish were caught in this pond, including small, presumably young-of-year fish. The rather widespread occurrence in UPDE and its very limited occurrence in DEWA are somewhat puzzling. The green sunfish often occurs in small ponds like those sampled in DEWA. The green sunfish is native to the Mississippi drainage, and it appears to be tolerant of a range of chemical and physical conditions (its occurrence is used as a metric for degradation in some bioassessments). Its occurrence in UPDE may reflect tolerance to changing temperature and flow conditions. Its absence from DEWA ponds might be due to relatively old stocking of these ponds, i.e., before green sunfish were commonly mixed in with other sunfish.

Fathead Minnow (Pimephales promelas)

Small numbers of fathead minnows were caught in the Hancock reach (U1) and Upper Callicoon reach (U7) in UPDE, and in Lake Lenape and an unnamed lake near Slateford in DEWA. The fathead minnow is commonly used as live bait, and its introduction is probably due to bait bucket release. The collection of numbers of fish of different sizes in the two ponds in DEWA indicates that the minnow is established there. Records from the main river could reflect small, established populations or occurrence of recently released fish.

Brown Trout and Rainbow Trout (Salmo trutta and Oncorhynchus mykiss)

Trout were not targeted in this survey because of the abundance of information on their distribution in the Delaware River. Small numbers of large juvenile or adult trout were observed or caught in the survey. Small, presumably young-of-year brown trout [3.8–5.3 cm (1.5–2.1 in)] and rainbow trout [2.6–3.2 cm (1.0–1.3 in)] were caught in the riffle downstream of the junction pool in U1. These trout were captured in small eddies behind rocks in shallow gravel-cobble riffles and in eddies at the shore in boulder riffles.

Frequency of Occurrence

The study used a stratified random sampling design, which allows estimation of occurrence of species in different waterbodies (streams, lakes, and ponds) and different reaches of the Delaware River. These are taken from the proportion of randomly selected sites in which each species was found among all sites in each stratum in which fish were present, and the proportion of randomly selected sites in each stratum in which fish were found (Table 22). The proportions of sites with each fish species used all randomly selected sites which were sampled, including original sites and replacement sites. The proportions of sites with fish were estimated from the original list of sites, i.e., estimates do not use the replacement sites which were sampled.

Discussion

Changes in Fish Fauna Over Time

The fish fauna of the area has changed from a variety of causes, including changes in watershed land use and water quality, construction of small dams, construction of large dams with cold releases, overfishing, introduction of nonnative fishes, and climate trends and cycles. Some of these effects are straight-forward:

- Establishment of brown and rainbow trout in streams and in portions of the upper Delaware cooled by dam releases.
- Introduction of sport fishes (see Meehan 1897 for a discussion of 19th century stocking history), including the most common predatory fish in the areas; in addition to trout, these include Atlantic salmon (not established), muskellunge, common carp, channel catfish, smallmouth bass, largemouth bass, bluegill, black crappie, rock bass, and walleye.
- Introduction of other nonnative species, including bowfin, goldfish, fathead minnow, yellow bullhead, and green sunfish.
- Warming of streams due to changes in hydrology, riparian cover, and climate changes; the brook trout was probably nearly ubiquitous in streams and small rivers (Meehan 1896 describes the brook trout as common in most of the Pennsylvania tributaries to the Delaware River from Brodhead Creek upstream); many of these streams now support warm water species; the slimy sculpin has probably become less frequent as well, although temporal trends of the sculpin are not well known.
- Changes in abundance of migratory and lower Delaware River species due to fishing and downstream water quality blocks. For instance, the abundance of American shad was reduced by fishing and then by inability of many juveniles to migrate downstream through the low-water-quality areas near Philadelphia. While American shad continued to occur in the Upper Delaware, its abundance was reduced. Subsequently, American shad abundance has increased, although there may have been decreases in the last few years. Striped bass have increased in abundance in the last few years, while the abundance of alewife and blueback herring may have decreased. There are a few old records of Atlantic sturgeon in the Delaware River; the species is now very rare in the lower Delaware River, decreasing chance of upstream occurrence. Similarly, the longnose gar was found mainly in the lower river (Mihursky 1962), but there were reports up to the Water Gap. The longnose gar is now extirpated in the Delaware drainage.

- Apparent extirpation of cold water or cool water species due to blockage by dams and fluctuating temperatures downstream. The longnose sucker probably occurred in the Upper Delaware River, but was likely never common. The lake chub might have occurred as well, although there are no records. The longnose sucker now occurs upstream of dams on the East and West branches of the Delaware River, and the lake chub occurs on the Upper East Branch (Smith 1985).
- Increase in pond and lake habitat by construction of small dams. Some native species, such as pumpkinseed, golden shiner, and chain pickerel, are frequent in these ponds, as well as a number of introduced species, such as largemouth bass, bluegill, and black crappie. In addition to creating pond habitat, these ponds can increase downstream temperatures, affecting brook trout. The construction of the dams may have destroyed wetlands and marshy streams, which could have affected abundance of species like bluespotted sunfish, tadpole matom, pirate perch, and redbfin pickerel. However, there is little information on changes in abundance of these species.

Other trends may be more complicated. For example, river temperatures will be affected by watershed use (which affects the relative amounts of base flow and storm flow), riparian cover, water withdrawals, dam outputs, and trends in air temperatures and precipitation. Large parts of the watershed were cleared in the 18th–20th centuries for agriculture and logging. There has been regrowth of forests and reversion of some agricultural land, especially after purchase of the land for DEWA. The withdrawal of water from the upper drainage would be expected to lead to increased temperatures, which would be intermittently mitigated in part of the upper river by coldwater releases. Cold tributaries and groundwater seeps would also maintain local areas of cooler water. The green sunfish is more widespread in the Upper Delaware River than in DEWA. The green sunfish is tolerant of temperature fluctuations, and its distribution pattern may be linked to temperature changes related to dam operations. Finally, there was a cool period in the mid-13th to mid-19th centuries (the “Little Ice Age”), followed by natural and anthropogenic warming. Likely effects of these trends would be an upstream increase of warm water species, with possible switch to more cool water species in the Upper Delaware River affected by tailwater releases (depending on the relationship of current and historical temperatures in the current cool water areas). The recent occurrence of some species in the Upper Delaware which were not recorded by Greeley, such as the eastern mudminnow and gizzard shad, could be an example of this trend. The eastern mudminnow is near the northern limit of its range in the Upper Delaware River, so it could show range expansions in this area. However, it is possible that these species were present, but missed, in early surveys. The mudminnow occurs in habitats which may be less heavily sampled, and gizzard shad may not be susceptible to seining.

Introduced species may affect native species. For example, white catfish appears to have declined in the lower Delaware River, possibly in response to increased abundance of the introduced channel catfish. As a result, it may be less likely to occur upstream, both because of lower abundance and greater restriction to downriver habitats which are less favorable to channel catfish. Brown trout may restrict brook trout to colder streams. The introduction of many piscivorous fishes could have an

effect on prey species, but this is difficult to document because of other simultaneous impacts. For example, no bass were found in sites where the bridge shiner was found, but bridge shiner was probably also affected by changes in the amount of clear, vegetated stream habitat. Similarly, effects of piscivorous fish on juvenile herrings and shad would be difficult to separate from effects of fishing and pollution.

Inputs of nutrients and waste to the river have changed with the increase and subsequent decrease of log-rafting on the main river, milling (saw and grist mills) on tributaries, agriculture (livestock pasturage and row crops) in parts of the watershed, and improvements in sewage treatments. The effects of these changes on fish is well known, in general (e.g., for the lower river), and they would have had major impacts on fish. However, there is relatively little documentation of effects in the study area, except for effects on brook trout. Many species would be affected by decreases in dissolved oxygen, increases in turbidity, etc., caused by nutrient inputs. However, production of some species could have increased in response to increased primary production. For example, the central stoneroller, which scrapes algae from rocks, may have increased in response to increased periphyton, at least where nutrients did not lead to unpalatable periphyton. Some species, such as golden shiner, may have fed directly on spilled grain; satinfish shiner has been observed to feed on sewage waste (pers. observation). Populations of these species may have increased and decreased in response to water quality and land uses.

Habitat Use of Fish

Fish occurrence and abundance will be closely linked to habitat conditions. In the short-term, habitat will be dependent on discharge and weather, which determine the distribution of depths, velocities, and temperature. Bovee et al. (2007) modeled depth, velocity, and temperature conditions in the upper Delaware River, East Branch, West Branch, and Neversink River, as functions of river discharge and weather. Modeled conditions were linked to habitat preferences of different life stages of trout, spawning and juvenile American shad, and groups of fish representing riffle fish and shoreline fish to produce estimates of habitat area integrated over time periods. The habitat estimates were made for different river reaches and different flow periods (representing natural variability in input discharges) under different management scenarios for the main tributary dams. Over the longer term, habitat will be determined by the geomorphology of the river, which will be affected by discharge, sediment supply, riparian condition, etc.

Small side channels, backwaters, and floodplain pools were found to be an important habitat for some species. In the river, eastern mudminnow, creek chubsucker, and bluespotted sunfish were found predominantly in such habitats, particularly isolated or nearly isolated pools with abundant debris or macrophyte growth. Pickerels, minnows, and sunfish were also common in some of these habitats. Fish use of these habitats depended on the local topography and relation to tributaries and the main channel, which affects connection with the main channel, depth, temperature, and permanence. For example, side channels often became isolated from the main channel at low flows, creating very shallow, warm pools, often with little cover. Fish abundance was usually low in these pools; banded killifish and young-of-year smallmouth bass were sometimes present. Deeper backwaters with a broad connection to the main channel often contained large numbers of fish, as evidenced by the analysis of boat electrofishing catch rates and the large catches of minnows and

other species in backwater pools at the Hancock junction pool and near the Bushkill access. In several places, small ponds were found adjacent to the main channel, partly or not connected to the wetted channel at low flows. These ponds were often found near tributary mouths (e.g., at Halfway Brook and Raymondskill). The ponds may be created by deposition and erosion of sediments carried by the tributaries and the river during high flows. Deposition may block old channels, causing tributaries to form new channels, leaving the former channels as isolated ponds. The ponds may be fed by subsurface flow from the tributary, maintaining water levels and decreasing temperatures at low flows. Beavers may also create pools on a tributary mouth and side channels. These ponds may support large numbers of fish, e.g., golden shiner and bridle shiner at the main Dillontown beaver pond, bluntnose minnow and other minnows at the mouth of Cooley Creek, and green sunfish and pumpkinseed at a pool upstream of the mouth of Brodhead Creek.

These habitats may be relatively ephemeral. For example, a series of such ponds just downstream of the mouth of Halfway Brook was sampled in August 2004, and a variety of fish, including a number of Eastern mudminnows were captured. The site was revisited in the summer of 2005, following high flows in September 2004, and April 2005. Willow and alder trees which had shaded the ponds were gone, and only shallow pools with no fish remained. The backwater at the Hancock junction pool appeared to be much shallower in 2007 than in 2006. This may be related to deposition of fine material from storm flows. Ponds farther from the channel may dry up at low flows, as at a small pool near Hornbecks Creek, in which fish were concentrated in the small remnant of the pond. The frequency of overbank flooding of the river, which will be affected by flow management of the river, will be critical to filling such ponds and immigration and emigration of fish between ponds and the river.

Future Study Needs

This study analyzed fish occurrence in UPDE and DEWA. The study identifies several areas of research which will be important in managing fish in the two parks. Major research questions include:

- Status and ecology of rare or decreasing species. Study of the bridle shiner was initiated as part of this project. Ongoing state and Federal studies address status of American shad. Trends in the abundance of the American eel in the parks, where the species remains common, are important in view of observed declines in other parts of its range. The central stoneroller is of interest, based on its rarity in this study. Brook trout may be decreasing throughout their range and are expected to be very vulnerable to climate change. DEWA and tributaries of UPDE support brook trout, so more information on status would be important.
- Status and trends of recently introduced species. Documented species include the mottled sculpin, western mosquitofish, and fathead minnow. Other species could potentially occur through bait-bucket introduction (e.g., several minnow species) or spread from other parts of the Delaware drainage (e.g., flathead catfish).
- Understanding effects of increases in beaver populations on fish habitat.

- Understanding effects of introduced plants (especially aquatic macrophytes) on aquatic systems.
- Improved modeling of relationships between flow management, climate change, etc., on water temperature and habitat suitability.
- Better understanding of long-term changes in geomorphology and habitat in response to discharge variability and flow management.

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Appendix. List of amphibians, crustaceans, and reptiles collected by Academy of Natural Sciences scientists between the years 2004 and 2007 as part of the Delaware Water Gap National Recreation Area and Upper Delaware Scenic and Recreational River fish inventory.

| Station groups | | Delaware Water Gap | | | | | Flat Brook | | Upper Delaware | Species collection stations |
|----------------|---|---------------------------|-------------------------------------|---|--|-------------------------|-------------------------------------|---------------|--------------------------------------|---|
| | | ANS Stations | Delaware River | Lakes | Ponds | Brooks & Creeks | Flat Brook | Ponds | "U" Station | |
| Taxon | Station numbers | 04, 33.9, 38.1, 42 | 3, 4, 6, 8, 8.0, 8.1, 8.2, 9 | DWGL- 14, 19, 20 L- 01, 02, 03, 05, 08, 11, LL | P-9, 15, 20, 25, 31, 42, 43, 48, 51, 55, 57, 60, 71, 77, 78, 90 | BK1, VAN, VC, W1 | 1, 1.1, 3, 4, 5, 6, 7, 8, 10 | 2, HMP | 1, 2, 6, 7, 8, 13, 14, 15, 16 | |
| Amphibian | American toad; <i>Bufo americanus</i> | - | 2 (D6) | - | - | - | - | - | - | D6 |
| | Two-lined salamander; <i>Eurycea bislineata</i> | - | - | - | - | 10 (VC) | 17 | - | - | VC; FB1,3,8 |
| | Red-spotted newt; <i>Notophthalmus viridescens</i> | 4 (42) | - | 114 | 121 | 11 (VC,W1) | 13 (5,6,10) | 13 (both) | 10 | DWGL20,L01,05,11,LL; P-all except 20,60,71; U2,7,8,15 |
| | Red salamander; <i>Pseudotriton ruber</i> | - | 1 (D8.2) | 1 (L01) | - | - | - | - | - | D8.2,L01 |
| | Bullfrog; <i>Rana catesbiana</i> | - | - | 2 | - | 1 (W1) | 3 | - | 2 | DW GL14,LL; W1; FB3,4; U1,2 |
| | Green frog; <i>Rana clamitans</i> | 12 | - | 8 (L08,11) | 10 | - | 6 | 1 (FB2) | - | ANS04,33,9,38.1; FB3,4,6; P9,25,31,48,51,77,78 |
| | Pickereel frog; <i>Rana palustris</i> | 4 | - | 4 | 5 | - | 1 (FB1) | - | 1 (U2) | ANS33.9,38.1; L20,71; U2 |
| | Salamander species | 1 (04) | 1 (D3) | 3 | 7 (P9) | 11 | 1 (FB1) | - | 4 | ANS04; D3; L05,11; P9; BK1,VC,W1; FB1; U1,6 |
| Crustacea | Appalachian brook crayfish; <i>Cambarus bartonii</i> | - | 1 (D8.1)) | - | - | - | - | - | - | D8.1 |
| | Crayfish | - | - | 3 (L03) | 5 (P9) | 1 (VAN) | 20 | - | 3 | L03; P9; VAN; FB1,1.1,3,4,8; U2,13 |
| | Spinycheek crafish; <i>Orconectes limosus</i> | - | 18 | - | - | 1 (BK1) | 26 | - | 103 | D3,4,6,8,0,9; BK1; FB1,1.1,3,4,7; U(all) |
| | Rusty crayfish; <i>Orconectes rusticus</i> | - | - | - | 2 (P9) | - | - | - | - | P9 |
| Reptile | Common snapping turtle; <i>Chelydra serpentina</i> | - | - | - | 1 (P43) | - | 1 (FB1) | - | 2 | P43; FB1; U2,7 |
| | Painted turtle; <i>Chrysemys picta</i> | - | - | 1 (L11) | 1 (P60) | - | - | - | - | L11; P60 |
| | Wood turtle; <i>Clemmys insculpta</i> | - | 1 (D3) | - | - | - | - | - | - | D3 |
| | Northern water snake; <i>Nerodia sipedon</i> | 1 (42) | - | 6 | 1 (P9) | - | - | - | - | ANS42; DWGL19; L08; P9 |
| | Stinkpot / Musk turtle <i>Sternotherus odoratus</i> | - | 1 (D3) | - | - | - | - | - | - | D3 |

| Station groups | | Delaware Water Gap | | | | Flat Brook | | Upper Delaware | Species collection stations |
|-------------------|------------------------|--------------------|------------------------------|---|---|------------------|------------------------------|----------------|-------------------------------|
| | | ANS Stations | Delaware River | Lakes | Ponds | Brooks & Creeks | Flat Brook | Ponds | |
| Taxon | Station numbers | 04, 33.9, 38.1, 42 | 3, 4, 6, 8, 8.0, 8.1, 8.2, 9 | DWGL- 14, 19, 20 L- 01, 02, 03, 05, 08, 11, LL | P-9, 15, 20, 25, 31, 42, 43, 48, 51, 55, 57, 60, 71, 77, 78, 90 | BK1, VAN, VC, W1 | 1, 1.1, 3, 4, 5, 6, 7, 8, 10 | 2, HMP | 1, 2, 6, 7, 8, 13, 14, 15, 16 |
| Number of species | | 5 | 8 | 11 | 10 | 6 | 9 | 2 | 7 |
| Total number | | 22 | 30 | 144 | 163 | 35 | 88 | 14 | 125 |

Note: See Tables 4 and 5 for description of station locations.

Number in parenthesis represents the station number where a single species was collected and is usually repeated in the species collection stations column which lists the individual station numbers where each species was collected.

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