Field Guide to the Fishes of Eastern Washington

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Authors

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Field Guide to the Fishes of Eastern Washington

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**The 20 chapters in this book are color-coded based on the guide at the left.
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The following photographs are courtesy of Wydoski and Whitney (2003):

- Page 30, Figure 5.1 Photo of Pacific lamprey mouth.
- Page 31, Figure 5.2 A and C Photo of mouths of Pacific and western brook lamprey.
- Page 35, Figure 5.5 Photos of western brook lamprey.
- Page 37, Figure 5.7 Photos of Pacific lamprey.
- Page 134, Figure 12.3 Photo of coastal cutthroat trout.
- Page 136, Figure 12.4 Photo of golden trout.
- Page 165, Figure 12.11 Photo of pygmy whitefish.
- Page 183, Figure 12.29 Photo of golden trout.

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## ACRONYMS

Acronyms employed in this book include: AFS (American Fisheries Society), IDFG (Idaho Department of Fish and Game), NMFS (National Marine Fisheries Service = NOAA Fisheries), ODFW (Oregon Department of Fish and Wildlife), USBF (United States Bureau of Fisheries), USFC (United States Fish Commission), WDFW (Washington Department of Fish and Wildlife), EWU (Eastern Washington University), UW (University of Washington), Counties (Cos.), County (Co.), pers. comm. (personal communication), and RKM (river kilometer).
This book is intended as a companion to our *Fishes of the Columbia and Snake River Basins in Eastern Washington* (Scholz and McLellan 2009), *Fishes of Eastern Washington: A Natural History* (Scholz and McLellan 2010), and to *Inland Fishes of Washington, 2nd Edition* (Wydoski and Whitney 2003). All three books are thick, oversized volumes that are awkward to carry in the field because they contain a large amount of detailed information about the life history of each species. Here we have condensed that information and focused on the identification and distribution of fishes in eastern Washington. Our aim was to construct a slim volume that could serve as a pocket field guide. (We assume that any field biologist worth his or her salt will own a sensible field jacket with deep pockets).

Our specific target area was east of the crest of the Cascade Mountain range, in the Columbia River Basin upstream of Bonneville Dam within the borders of the state of Washington. This guidebook contains dichotomous keys to the families of fishes found in the middle and upper Columbia Basin. For each family there is also a dichotomous key to species. The keys will work only for fishes found in eastern Washington, the Panhandle region of north Idaho (north of the Clearwater River), and the Columbia River drainage of western Montana and southern British Columbia. They are not designed to identify fish in other areas because different sets of fish would be present.

This book is organized into 20 chapters. Chapter 2 provides a checklist of species, arranged by family, that have been documented to occur in eastern Washington. Chapter 3 provides information on how to identify fishes, including diagrams and some of morphological and anatomical terms, counts and measurements used for fish identification. Chapter 4 is a dichotomous key to families. Chapters 5–19 each contain one family of fishes, organized in the same way. A limited amount of background information about the family is presented first, followed by a dichotomous key to the species contained in that family. Individual species accounts, arranged in alphabetical order by scientific name, contain information on identification of the species, including: 1) a list of the principle identifying characters that are easy to discern in the field, 2) photograph(s) of the species, 3) a list of confirming characters that include morphometric measurements and meristic counts, 4) a list of similar species together with information on how to distinguish them, 5) the etymology of the scientific name, and 6) a distribution map with notes on distribution. Each species is shown on facing pages with the taxonomic identification information on the left page and the distribution map and notes on the right page. Chapter 20 describes fish that are rarely found in eastern Washington.

**BIOLOGICAL/MORPHOLOGICAL SPECIES CONCEPTS**

Individual species can be described by their external appearance (morphology) and by their ability to interbreed with other individuals that are members of their species. A biological species is defined as a population of individuals that can successfully interbreed either with other individuals in their population or with an individual from another population of the same species, but which do not successfully interbreed with individuals of another species. Thus, biological species are reproductively isolated from one another and represent different kinds of organisms. Implicit in this definition is that haploid gametes produced by the parents form a viable diploid zygote that is fertile upon reaching sexual maturity. For example, all individuals of the brown trout can successfully interbreed with each other, but not with brook trout. When brown trout are bred with brook trout, a hybrid tiger trout will result that is sterile, just as a donkey bred with a horse produces a sterile mule.
Species are usually recognized by the number of differences in their morphological characters (external appearance). For example, a largemouth bass is obviously a different species from a brown trout because the largemouth has two dorsal fins (spiny and soft) and spines in the anal, pectoral, and pelvic fins, whereas the brown trout has one dorsal fin (soft) and no spines in the anal, pectoral, and pelvic fins.

Conversely, similarity in morphological characters may indicate that the two species are closely related or even that some interbreeding (hybridization) occurs. For example, the morphological characters of the cutthroat trout overlap those of the rainbow almost completely. Moreover, rainbow and cutthroat trout will hybridize in the wild to form viable offspring that will be fertile at maturity. However, cutthroat and rainbow trout usually do not interbreed with each other in nature, indicating that some type of reproductive isolating mechanism is maintaining the subtle difference between them.

CLASSIFICATION AND LIFE HISTORY STRATEGIES

Fishes are arranged in a taxonomic hierarchy that reflects their morphological resemblance and evolutionary relationships (Figure 1.1). Orders (identified by the suffix -iformes, as in Salmoniformes) are groups of similar families. Families (which are identified by suffix -dae, as in Salmonidae) are groups of related genera. Subfamilies (identified by the suffix -inae, as in Salmoninae) are groups of closely related genera. Genera are groups of closely related species. Species are groups of individuals (populations) that can successfully interbreed with each other. Subspecies are populations of species that have been geographically isolated from each other for some time, so they are beginning to look different from each other. Populations are composed of interbreeding individuals.

Populations of migratory fishes that display natal homing (return to the place of their birth) during reproductive migrations are called stocks or races. Usually the accuracy of their homing is so precise that they are effectively isolated from other populations of the same species that are homing with equal precision to their own home tributaries. Each stock is usually distinguished either by unique alleles only found in that stock or by alleles that are held in common among stocks but at a distinctive frequency. Because small numbers of migratory fish from each home tributary are known to stray, home tributary populations are not totally reproductively isolated. Instead they could be considered “a population of populations” or what geneticists and conservation biologists call a metapopulation. The flow of genetic information between stocks in a metapopulation prevents inbreeding depression and increases genetic variability. A run is a group of migratory populations (stocks) that enter a river together (or in temporal proximity). For example, Chinook salmon entering the Columbia River are divided into spring, summer, and fall runs.

Migratory fish populations are usually characterized by having a multiplicity of life history strategies: anadromous, potamodromous (adfluvial, fluvial), and/or resident. Within one stock, some individuals may be anadromous, some may be potamodromous and others may be resident. Anadromous fishes are hatched in freshwater, migrate to forage in the ocean and back into freshwater again to spawn. Their life cycle is typically semelparous (i.e., they die after they spawn once) and they usually exhibit natal homing. Potamodromous fishes migrate between breeding areas and foraging areas in freshwater. They are prone to be iteroparous (spawn more than once) and make annual migrations back and forth between spawning grounds and feeding grounds. Often they exhibit site fidelity to both habitats.

Potamodromous fish are one of two types: fluvial or adfluvial. Individuals with fluvial life histories are hatched in a tributary, migrate into a larger river where they feed and mature, then migrate back into the same tributary where they were hatched to spawn. Individuals with adfluvial life histories are hatched in a river and migrate to a lake to forage and mature before returning to spawn in their natal tributary.
**Order:** Salmoniformes  
Suffix -iformes identifies Order. Order name capitalized.

**Family:** Salmonidae  
Suffix -idae identifies families. Family name capitalized.

**Subfamily:** Salmoninae  
Suffix -inae identifies subfamily. Subfamily name capitalized.

**Genus:** Oncorhynchus  
Generic name capitalized and written in italics.

**Subgenus:** Oncorhynchus (Rhabdofario)  
Subgeneric name capitalized, written in italics and enclosed in parenthesis following generic name.

**Species:** Oncorhynchus mykiss  
Species name includes generic name (capitalized) and specific epithet (not capitalized). Both names italicized.

**Subspecies:** Oncorhynchus mykiss gairdneri  
Subspecies name follows specific epithet, not capitalized and written in italics.

**Common (vernacular) name:** Rainbow trout  
Name approved by the American Fisheries Committee on Names of Fishes.

**Scientific name of redband rainbow trout:**  
*Oncorhynchus (Rhabdofario) mykiss gairdneri* (Walbaum, 1792)

---

**Genus name**  
L. Onco = hooked and *rhynchus* = snout. A secondary sexual characteristic of spawning male salmon and trout.

**Subgenus name**  
Name given to Pliocene (5–2 MYBP) fossil relative of rainbow trout that lived in Pluvial Lake Idaho.

**Specific epithet**  
Vernacular name used by Kamchatkan natives and adopted as the specific epithet by the discoverer.

**Subspecies name**  
Honored Dr. Merideth Gairdner, a British naturalist who explored the Columbia Basin in the 1830’s.

**Discoverer’s name and date specific epithet first applied.**  
Name in parentheses means the specific epithet is currently in a different genus than the discoverer first used. If not enclosed in parentheses, the generic name is the same one used by the discoverer.

---

**Example:** interior Columbia Basin rainbow (redband) trout.

---

**Figure 1.1** Quick reference guide to classification and scientific names of fishes.
Individuals with secondary adfluvial life histories had ancestors that historically exhibited a fluvial life history, but were forced into becoming adfluvial when a dam converted a lotic (free-flowing) river environment to lentic (placid water) lake environment. Fish making this conversion from river to reservoir habitat were faced with certain problems. For example, they had probably evolved to feed in flowing water on aquatic insects crawling along the gravel substrate on the bottom of the river, or on aquatic insects that had become dislodged from the bottom and were floating downstream in the drift, or on terrestrial insects blown into the river and drifting downstream. Conversion to reservoir habitat often reduces the availability of these types of foods, but increases the abundance of zooplankton. Hence, if a species was going to successfully adapt to a secondary adfluvial life history, it would have to switch from a diet of aquatic insects to a diet of zooplankton.

Individuals with resident life histories are hatched and remain in one habitat for their entire lives. River dwelling resident fish often stake out a home territory. They may make short distance migrations within the occupied river (or tributary) between spawning and feeding grounds. Individuals with resident life histories are most commonly found in small headwater tributaries above barrier falls that prevent migration of individuals with anadromous, fluvial, or adfluvial life histories. Lake-dwelling resident fish may move inshore to spawn along gravel, cobble and rubble shoreline or may remain offshore and spawn on deepwater reefs. A few species are limnetic spawners; their eggs drift and develop in the water column. Limnetic spawning is rare among freshwater fishes because of the danger of eggs drifting onto shore and becoming desiccated before they can hatch.

**SCIENTIFIC AND COMMON NAMES: A GUIDE TO NOMENCLATURE**

Scientific names are Latin binomials i.e., two Latinized names. They are either italicized or underlined. All scientific names used in this key are italicized. The first name is the generic name (Genus). The first letter of a generic name is always capitalized. The second part of the name is called the trivial name or specific epithet. The first letter of the trivial name is always written in lower case. The species name always includes both the generic and trivial names, not just the specific epithet. To be complete, the name of the discoverer who first named that species and the year of publication are attached at the end of the name. For example, the scientific name of the Pacific lamprey is written Lampetra tridentata (Gairdner, 1836). The Latin (or sometimes Latinized Greek) names, when translated into English (etymology), usually convey information about the morphology or behavior of the species. For example, the generic name Lampetra is derived from the Greek words lambere (to suck) and petra (stone), and means sucker of stone. This name describes their behavior of attaching to rocks by means of their sucking disc. The trivial name tridentata is derived from the Latin words tri (three) and dentat (tooth) and means three-toothed. The name refers to three cusps on their suproraal tooth bar. Occasionally, one of the Latin binomials may be a Latinized version of a proper name to honor the discoverer or given by the discoverer to honor another person. For example, the trivial name of the western brook lamprey, Lampetra richardsoni Vladykov and Follet, 1965 honored Sir John Richardson, the first author to describe a large number of fishes from the Pacific Northwest.

Scientific names of fishes in North America are assigned by the American Fisheries Society (AFS) Committee on Names of Fishes, which maintains a current list of names. The committee updates the list periodically (about once every ten years) and publishes these revisions as American Fisheries Society Special Publications under the title Common and Scientific Names of Fishes from the United States, Canada, and Mexico. The most recent (6th) edition was published in 2004 (Nelson et al. 2004). The AFS Committee on Names of Fishes also standardizes the common (or vernacular) names of fishes used in their publications. All scientific and common names used for eastern Washington fishes in this field guide follow those approved by the AFS.
Chapter 2
Checklist of Fishes Found in Eastern Washington

We have observed all the species included on Table 2.1 either in the field in eastern Washington or as voucher specimens collected in eastern Washington placed in fish collections at museums. The fishes in this list are arranged in the taxonomic order recommended by the AFS’s Committee on Names of Fishes (Nelson et al. 2004). Within each order, family, or subfamily, fishes are arranged in alphabetical order by scientific name. The scientific name is followed by the common name. Both names are the current AFS approved names for these fish. Subspecies have been designated for some salmonids following R.J. Behnke’s (1979, 1992, 2002) classification of the trout and salmon of North America. Behnke has suggested that these names be assigned as official subspecies, but the AFS currently does not recognize them. We have included Behnke’s proposed subspecies names on our list as varieties (var.) because we feel that they represent evolutionary significant units within the species. The list contains 39 species of indigenous native fishes (N) and 43 species of non-indigenous introduced fishes (I). See also rare species list at end of this table.

Table 2.1 Checklist of fishes occurring in eastern Washington. The boxes are for the reader to make a personalized checklist. (Page 1 of 4).

<table>
<thead>
<tr>
<th>ORDER</th>
<th>Family</th>
<th>Subfamily</th>
<th>Species (discoverer, date) ~ common name (N/I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORDER PETROMYZONTIFORMES</td>
<td>Family Petromyzontidae: lampreys</td>
<td></td>
<td>Lampetra ayresi (Gunther, 1870) ~ river lamprey (N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lampetra richardsoni Vladykov &amp; Follett, 1965 ~ western brook lamprey (N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lampetra tridentata (Gairdner, 1836) ~ Pacific lamprey (N)</td>
</tr>
<tr>
<td>ORDER ACIPENSERIFORMES</td>
<td>Family Acipenseridae: sturgeons</td>
<td></td>
<td>Acipenser transmontanus Richardson, 1836 ~ white sturgeon (N)</td>
</tr>
<tr>
<td>ORDER CLupeiformes</td>
<td>Family Clupeidae: herrings</td>
<td></td>
<td>Alosa sapidissima (Wilson, 1811) ~ American shad (I)</td>
</tr>
<tr>
<td>ORDER CYPRINIFORMES</td>
<td>Family Cyprinidae: carps and minnows</td>
<td></td>
<td>Acrocheilus alutaceus Agassiz &amp; Pickering, 1855 ~ chiselmouth (N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Carassius auratus (Linnaeus, 1758) ~ goldfish (I)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Couesius plumbeus (Agassiz, 1850) ~ lake chub (N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cyprinus carpio Linnaeus, 1758 ~ common carp (I)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gila bicolor (Girard, 1856) ~ tui chub (N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mylocheilus caurinus (Richardson, 1836) ~ peamouth (N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Notemigonus crysoleucas (Mitchill, 1814) ~ golden shiner (I)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pimephales promelas Rafinesque, 1820 ~ fathead minnow (I)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ptychocheilus oregonensis (Richardson, 1836) ~ northern pikeminnow (N)</td>
</tr>
</tbody>
</table>

Table 2.1 continued on next page.
### Checklist of Fishes Found in Eastern Washington

**Table 2.1 (continued). Checklist of fishes. (Page 2 of 4).**

<table>
<thead>
<tr>
<th>ORDER CYPRINIFORMES (CONTINUED...)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family Cyprinidae</strong>: carps and minnows (continued...)</td>
</tr>
<tr>
<td><em>Rhinichthys cataractae</em> (Valenciennes, 1842) ~ longnose dace (N)</td>
</tr>
<tr>
<td><em>Rhinichthys falcatus</em> (Eigenmann &amp; Eigenmann, 1893) ~ leopard dace (N)</td>
</tr>
<tr>
<td><em>Rhinichthys osculus</em> (Girard, 1856) ~ speckled dace (N)</td>
</tr>
<tr>
<td><em>Richardsonius balteatus</em> (Richardson, 1836) ~ redside shiner (N)</td>
</tr>
<tr>
<td><em>Tinca tinca</em> (Linnaeus, 1758) ~ tench (I)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Family Catostomidae</strong>: suckers</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Catostomus catostomus</em> (Forster, 1773) ~ longnose sucker (N)</td>
</tr>
<tr>
<td><em>Catostomus columbianus</em> (Eigenmann &amp; Eigenmann, 1893) ~ bridgelip sucker (N)</td>
</tr>
<tr>
<td><em>Catostomus macrocheilus</em> Girard, 1856 ~ largescale sucker (N)</td>
</tr>
<tr>
<td><em>Catostomus platyrhynchus</em> (Cope, 1874) ~ mountain sucker (N)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORDER SILURIFORMES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family Ictaluridae</strong>: bullhead catfishes</td>
</tr>
<tr>
<td><em>Ameiurus melas</em> (Rafinesque, 1820) ~ black bullhead (I)</td>
</tr>
<tr>
<td><em>Ameiurus natalis</em> (Lesueur, 1820) ~ yellow bullhead (I)</td>
</tr>
<tr>
<td><em>Ameiurus nebulosus</em> (Lesueur, 1819) ~ brown bullhead (I)</td>
</tr>
<tr>
<td><em>Ictalurus punctatus</em> (Rafinesque, 1818) ~ channel catfish (I)</td>
</tr>
<tr>
<td><em>Noturus gyris</em> (Mitchill, 1817) ~ tadpole madtom (I)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORDER ESOCIFORMES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family Esocidae</strong>: pikes</td>
</tr>
<tr>
<td><em>Esox americanus</em> Lesueur, 1846 ~ redfin pickerel (I)</td>
</tr>
<tr>
<td><em>Esox lucius</em> Linnaeus, 1758 ~ northern pike (I)</td>
</tr>
<tr>
<td><em>E. lucius × E. masquinongy</em> ~ tiger muskellunge (northern pike × muskellunge) (I)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORDER SALMONIFORMES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family Salmonidae</strong>: salmon, trout, char, whitefish, and grayling</td>
</tr>
<tr>
<td><strong>Subfamily Coregoninae</strong>: whitefish</td>
</tr>
<tr>
<td><em>Coregonus clupeaformis</em> (Mitchill, 1818) ~ lake whitefish (I)</td>
</tr>
<tr>
<td><em>Prosopium coulteri</em> (Eigenmann &amp; Eigenmann, 1892) ~ pygmy whitefish (N)</td>
</tr>
<tr>
<td><em>Prosopium williamsoni</em> (Girard, 1856) ~ mountain whitefish (N)</td>
</tr>
<tr>
<td><strong>Subfamily Salmoninae</strong>: salmon, trout, and char</td>
</tr>
<tr>
<td><em>Oncorhynchus clarkii</em> (Richardson, 1836) ~ cutthroat trout (N)</td>
</tr>
<tr>
<td><em>Oncorhynchus clarkii</em> var. <em>clarkii</em> ~ coastal cutthroat trout (I)</td>
</tr>
<tr>
<td><em>Oncorhynchus clarkii</em> var. <em>lewisi</em> ~ westslope cutthroat trout (N)</td>
</tr>
<tr>
<td><em>Oncorhynchus clarkii</em> var. <em>bouvieri</em> ~ Yellowstone cutthroat trout (I)</td>
</tr>
<tr>
<td><em>Oncorhynchus clarkii</em> var. <em>henshawi</em> ~ Lahontan cutthroat trout (I)</td>
</tr>
<tr>
<td><em>Oncorhynchus gorbuscha</em> (Walbaum, 1792) ~ pink salmon (N)</td>
</tr>
<tr>
<td><em>Oncorhynchus keta</em> (Walbaum, 1792) ~ chum salmon (N)</td>
</tr>
<tr>
<td><em>Oncorhynchus kisutch</em> (Walbaum, 1792) ~ coho salmon (N)</td>
</tr>
<tr>
<td><em>Oncorhynchus mykiss</em> (Walbaum, 1792) ~ rainbow trout/steelhead (N, I)</td>
</tr>
<tr>
<td><em>Oncorhynchus mykiss</em> var. <em>aguabonita</em> (Jordan, 1893) ~ golden trout (I)</td>
</tr>
<tr>
<td><em>Oncorhynchus mykiss</em> var. <em>irideus</em> ~ coastal rainbow/steelhead trout (I)</td>
</tr>
<tr>
<td><em>Oncorhynchus mykiss</em> var. <em>gairdneri</em> ~ interior (redband) rainbow/steelhead trout (N)</td>
</tr>
<tr>
<td><em>Oncorhynchus nerka</em> (Walbaum, 1792) ~ sockeye/kokanee salmon (N)</td>
</tr>
<tr>
<td><em>Oncorhynchus nerka</em> var. <em>kennerlyi</em> (Suckley, 1858) ~ kokanee salmon (N, I)</td>
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<tr>
<td><em>Oncorhynchus tshawytscha</em> (Walbaum, 1792) ~ Chinook salmon (N, I)</td>
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</table>

Table 2.1 continued on next page.
Table 2.1 (continued). Checklist of fishes. (Page 3 of 4).

<table>
<thead>
<tr>
<th>ORDER</th>
<th>Family</th>
<th>Subfamily</th>
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<tr>
<td>ORDER SALMONIFORMES (CONTINUED...)</td>
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<td>Subfamily Salmoninae: salmon, trout, and char (continued...)</td>
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<td>Salmo salar Linnaeus, 1758 ~ Atlantic salmon (I)</td>
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<td></td>
<td>Salmo trutta Linnaeus, 1758 ~ brown trout (I)</td>
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<td>Salvelinus fontinalis (Mitchill, 1814) ~ brook trout (I)</td>
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<td>Salvelinus namaycush (Walbaum, 1792) ~ lake trout (I)</td>
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<td>Salvelinus fontinalis × Salmo trutta (hybrid) ~ tiger trout</td>
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<td>Cottus cognatus Richardson, 1836 ~ slimy sculpin (N)</td>
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<td>Cottus marginatus (Bean, 1881) ~ margined sculpin (N)</td>
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<td>Micropterus dolomieu Lacepede, 1802 ~ smallmouth bass (I)</td>
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<td>Micropterus salmoides (Lacepede, 1802) ~ largemouth bass (I)</td>
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<td>Pomoxis nigromaculatus (Lesueur, 1829) ~ black crappie (I)</td>
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Table 2.1 (concluded). Checklist of fishes. (Page 4 of 4).

<table>
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<td>yellow perch (I)</td>
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<td><em>Sander vitreus</em></td>
<td>(Mitchill, 1818)</td>
<td>walleye (I)</td>
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<td>Species reported but very rare</td>
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<td><em>Ctenopharyngodon idella</em></td>
<td>(Valenciennes, 1844)</td>
<td>grass carp (I)</td>
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<td><em>Rhinichthys umatilla</em></td>
<td>(Gilbert and Evermann, 1894)</td>
<td>Umatilla dace</td>
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<td>Family Catostomidae</td>
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<td><em>Catosmus commersonii</em></td>
<td>(Lacépède, 1803)</td>
<td>white sucker (I)</td>
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<td>Family Ictaluridae</td>
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<td><em>Ameiurus catus</em></td>
<td>(Linnaeus, 1758)</td>
<td>white catfish (I)</td>
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<td><em>Ictalurus furcatus</em></td>
<td>(Lesueur, 1840)</td>
<td>blue catfish (I)</td>
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<td><em>Pylodictis olivaris</em></td>
<td>(Rafinesque, 1818)</td>
<td>flathead catfish (I)</td>
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<td>Family Fundulidae (= Cyprinodontidae)</td>
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<td></td>
<td><em>Fundulus diaphanous</em></td>
<td>(Lesueur 1827)</td>
<td>banded killifish (I)</td>
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<td>Family Centrarchidae</td>
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<td><em>Lepomis gulosus</em></td>
<td>(Cuvier, 1829)</td>
<td>warmouth (I)</td>
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<td>Family Percidae</td>
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<tr>
<td></td>
<td><em>Sander vitreus</em></td>
<td>× <em>S. canadensis</em></td>
<td>saugeye (walleye × sauger) (I)</td>
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</tbody>
</table>

1. Behnke (1979, 1993, 2002) classified the golden trout as a subspecies of rainbow trout *Oncorhynchus mykiss aquabonita*. We believe that Behnke’s classification accurately reflects the relationship between golden trout and rainbow trout because they can interbreed to produce fertile hybrids. Hence, we believe that Behnke’s classification better describes the evolutionary divergence between the two forms and better fits the biological species concept than the AFS classification which treats the two forms as independent species. Golden trout were classified as *Oncorhynchus aquabonita* by the AFS in 1991 (Robins et al. 1991) and were included as rainbow trout *Oncorhynchus mykiss* but not designated as a subspecies in 2004 (Nelson et al. 2004).

2. Fishes belonging to the genus *Salvelinus* are often described as char rather than trout.
Chapter 3
Fish Identification and Classification

This chapter contains information on how to identify and classify fishes. Diagrams illustrating important morphological and anatomical characters used in classification are provided.

Fishes belong to the Phylum Chordata: Subphylum Vertebrata. Chordates are distinguished by the presence of four characters at some point in their life cycle: 1) a notochord (rod-like supporting structure along the back); 2) a dorsal hollow nerve cord above the notochord; 3) pharyngeal gill slits that develop from outpocketings of the pharynx; and 4) post-anal tail. Vertebrates are characterized by 1) differentiation of the anterior end of the dorsal hollow nerve cord into a brain; 2) development of a skull surrounding the brain; and 3) strengthening of the notochord as a supporting and protecting structure of the nerve cord. During development segmented blocks of tissue (somites) form around the notochord and dorsal hollow nerve cord. These eventually form a cartilage template of the vertebrae. The skull forms around the brain in a similar manner. Eventually, nerves and blood vessels anastomose to the cartilage templates of the skull and vertebrae and cause these structures to ossify (form bone). The notochord is incorporated into the centrum of the vertebrae. This gradual transformation of the notochord into the bony base of the vertebrae occurs in nearly all vertebrates, including most fishes. However, agnathans and members of the Class Chondrichthyes (G. chondro = cartilage, ichthyes = fish) retain the cartilage templates throughout their lives. Additionally, a few primitive species of bony (ray-finned) fishes in the Class Actinopterygii: Infraclass Chondrostei: Order Acipenseriformes (sturgeons) also retain not only the cartilaginous template of the skeleton, but also the notochord throughout their lives.

The presence of jaws is also characteristic of most vertebrates, including most fishes. However, the most primitive fishes lacked jaws. Fishes are classified into Superclasses based on the absence or presence of jaws. Those lacking jaws are classified in the Superclass Agnatha (G. A = without, -gnatho = jaws). Those with jaws are classified in the Superclass Gnathostoma (G. gnatho = jawed, stoma = opening). Three species of jawless fishes belonging to the Order Petromyzontiformes; Family Petromyzontidae (lampreys) occur in eastern Washington. They are easily distinguished by the presence of an oral hood (in juveniles) or sucking disc with circumoral teeth and rasp-like tongue (in adults). They also lack paired fins (pectoral and pelvic fins). All of the other species of fishes found in eastern Washington are gnathostomes with jaws and paired fins. The gnathostomes are divided into the Class Chondrichthyes (cartilaginous fishes), Class Sarcopterygii (bony fish with lobed fins and swim bladders, often modified into a lung), and Class Actinopterygii (bony fishes with rayed fins). The Class Actinopterygii is divided into two Subclasses: Subclass Chondrostei (ancient ray-finned fish with skeletons composed predominantly of cartilage) and Subclass Neopterygii (recent ray-finned fishes with bony skeleton and swim bladders used primarily to maintain buoyancy or hydrostatic equilibrium in the water column). Most of the fishes that occur in eastern Washington belong to the Class Actinopterygii, Subclass Chondrostei (ancient ray-finned fish with cartilaginous skeletons), or Subclass Neopterygii, so we will generally classify them to Order, Family, Genera, and species.

Figure 3.1 Morphology and anatomy of a primitive (ancestral) fish. A) External morphology (side view); B, C) head morphology (side view); D) naris (one or two nasal openings); E) cycloid scale; F) side view of gill region; G) tooth bearing bones on roof of mouth (ventral view); H) tooth bearing bones on floor of mouth (dorsal view; I, J) gill region (ventral view) in fish with sub-terminal (I) and terminal (J) mouths; K) anatomy (side view) illustrating principal internal organs.
AIDS TO IDENTIFICATION OF FISHES

Characters that are used to identify fish are shown in Figures 3.1 and 3.2. In general, characters useful for fish identification fall into one of four categories: anatomical, morphological, morphometric, and meristic.

**Anatomical characters** (traits) are internal characters that require dissection to observe. Anatomical characters useful in fish identification/classification include the bones of the skull, vertebrae and fin girdles, type of swim bladder, and modifications of the digestive tract. The gastrointestinal tract is usually a straight tube, with little differentiation between the stomach and intestine in planktivores, insectivores and piscivores; whereas the intestine is highly convoluted in herbivores.

**Morphological characters** (traits) are external characters that can be seen on the surface of the body, and in the mouth or gills. Morphological characters that are most important for fish identification and classification include the shape/form of the body; the types, shapes, and arrangement of fins; type of scales; mouth and teeth; structures associated with the gills such as gill rakers, pharyngeal teeth, and branchiostegals; and structures associated with the skin such as scutes, keels, lateral plates, and spawning tubercles.

One morphological character that is less important for fish identification is color. Fish have two types of pigment cells (**melanophores** and **iridocytes**) embedded subcutaneously in the skin and use them to blend in with their background. Also, many species have distinctive spawning coloration that is markedly different from their usual color. However, fish do possess certain contrasting color patterns or colored spots that can be useful for identification.

Fish possess teeth on many bones, not just in the upper and lower jaws. Teeth are usually (but not always) present on the pre-maxillary and maxillary bones that form the upper jaw, and on the dentary bone that forms the mandible (lower jaw). Teeth may be present on the head and shaft of the vomer (a median bone that runs along the center of the roof of the mouth) and the palatine bones (paired bones on the roof of the mouth that are medial to the maxillaries and lateral to the vomer). In the floor of the mouth, teeth may be present on the tongue (called lingual or tongue teeth) and/or behind and underneath the tongue on the hyoid bone (called hyoid or basibranchial teeth). In some species, teeth are present on the 5th gill arch (called pharyngeal teeth).

The presence or absence of teeth on various bones can be a useful keying character. For example, one characteristic that separates cutthroat trout *Oncorhynchus clarkii* and rainbow trout *Oncorhynchus mykiss* is the presence of basibranchial teeth on the hyoid bone. Cutthroat trout usually have them; rainbow trout usually don’t. In another example, one character that distinguishes the minnows (Family Cyprinidae) is the absence of teeth in the upper and lower jaws and in the bones of the floor and roof of their mouths. However, they have highly developed pharyngeal teeth.

**Morphometric characters** can be measured using a caliper or measuring tape. Some standard measurements, illustrated in Figure 3.3, include: total length, standard length, fork length, snout length, head length, gape width, body depth, caudal peduncle length, caudal peduncle depth, length of base of dorsal and anal fins, and eye, pupil, and orbital lengths. **Total length** is the maximum length of the fish from the tip of the snout to the tip of the tail when the caudal fin is squeezed together. **Fork length** is the distance from the tip of the snout to the tip of the middle ray of the caudal fin. **Standard length** is the distance from the tip of the snout to the base of the caudal peduncle. Morphometric measurements are usually presented as ratios in comparison to body length; e.g., head length to the body length. Making morphometric measurements is time consuming work, making these characters impractical for rapid field identification.
Figure 3.2  Morphology and anatomy of an advanced (derived) fish. A) Morphology (side view) having pelvic fins in thoracic position (below and slightly behind the pectoral fins); B) morphology showing position of the pelvic fins in the juguler position, anterior to the pectoral fins. Compare these positions to the thoracic position of the pelvic fins in Figure 3.1A. Note also that the base of the pectoral fin is oriented vertically in Figure 3.2A and 3.2B and horizontally in Figure 3.1B; C) morphology showing alternate shape of operculum; D) morphology of a ctenoid scale; E) anatomy (side view) illustrating principle internal organs.
Figure 3.3 Some different morphometric measurements. This diagram also illustrates the methods for making meristic counts of scales.

Meristic characters are countable characters such as the number of vertebrae, fin rays, branchiostegal rays, scales in the lateral line row, scales above the lateral line row, or gill rakers on first gill arch. One advantage of making meristic counts is that the data are useful for making statistical comparisons between species or populations. A second advantage is that meristic counts will often diagnose two closely related species. For example, both longnose sucker *Catostomus catostomus* and largescale sucker *Catostomus macrocheilus* closely resemble each other. Both species have sub-terminal mouths bordered by large lips with papillae. In both species the lower lip is usually completely divided into right and left lobes by a cleft along the midline. One diagnostic character that unmistakably separates the two species is the number of rays in the dorsal fin. Longnose suckers have 9–11 and largescale suckers have 13 or more dorsal rays.

It is not unusual, however, for two closely related species to overlap in meristic counts. For example, mountain sucker *Catostomus platyrhynchus* and bridgelip sucker *Catostomus columbianus* both have incompletely cleft lower lips, with at least 2–4 rows of papillae crossing the midline at the base of the cleft. Mountain suckers have 10–11 dorsal rays whereas bridgelip suckers have 11–14 dorsal rays, so a fish with 11 dorsal rays cannot be identified with certainty based on meristic counts of dorsal rays.

Moreover, there are two disadvantages to using meristic characters. First, meristic counts are time consuming to make. In field studies, when large numbers of fish are handled, it may not be possible to make meristic counts of every individual. Second, some meristic characters are subject to environmentally induced phenotypic plasticity (Lindsey 1981). For example, Lindsey (1981) determined that the lake whitefish *Coregonus clupeaformis* was typically a bottom feeder with few, short gill rakers in lakes where they occurred with ciscoes, e.g., *Coregonus artedi*, or *Coregonus autumnalis*, which are small whitefishes with more, longer gill rakers adapted for feeding on zooplankton in the limnetic zone. However, in lakes where ciscoes were absent, lake whitefish occupied both benthic and limnetic habitats. Benthic lake whitefish had short, stubby gill raker spaced far apart whereas limnetic lake whitefish that fed on zooplankton had gill rakers that were longer and spaced closer together. Artificial transplants of benthic lake whitefish into lakes that had a vacant ecologi-
cal niche for limnetic planktivores resulted in a rapid change in gill raker counts from the benthic to the limnetic type (Lindsey 1981).

Because certain meristic characters (e.g., gill rakers counts) can change so rapidly, their utility for identifying species has been called into question. Since an aim of this book is to promote easy, accurate field identification of fishes, we have minimized meristic counts as primary identification characters except where they are particularly useful to diagnose a species. Instead, we have listed some important meristic counts as confirming characters.

**COUNTING MERISTIC CHARACTERS**

This section is intended as a guide for how to make meristic counts.

**Fin Ray Counts**

There are three types of fin rays:

- **Soft rays** are usually segmented and branched at the distal end. Soft rays are present on primitive (ancestral), intermediate and advanced (derived) Neopterygiians;
- **True spiny rays** are unsegmented, unbranched, bony and sharp. Spiny rays are found on advanced (derived) Neopterygiians (spiny-rayed fishes); and
- **False spiny rays** are actually hardened soft rays. They are stiffer and stouter than true spiny rays. They often have sharp barbs on the posterior edge, in some cases making the posterior edge serrated (saw-toothed). When present, they usually are represented as a single spine on the dorsal and/or pectoral fins. In eastern Washington, false spiny rays occur only in carp, goldfish (Family Cyprinidae), and catfishes and bullheads (Family Ictaluridae).

In making meristic counts of fin rays all true spiny rays in any fin are counted. By convention spiny ray counts are recorded in Roman numerals (Figure 3.4). When counting soft rays, all rays are counted in pectoral or pelvic fins. On the dorsal and anal fins, only the principle rays are counted. Principle rays include the number of branched soft rays plus one or two unbranched soft rays, all of which have their own base. The first and last rays are usually unbranched. In some species the last dorsal and/or anal ray is rudimentary and appears to share a base with the branched ray preceding it. In this case the last unbranched ray is excluded from the count unless otherwise specified. By convention soft-rayed counts are recorded in Arabic numerals. Thus, the anal fin of bluegill *Lepomis macrochirus*, which always has three true spiny rays and usually 11 (range 8–11) soft rays in recorded as III + 8–11.

**Gill Raker Counts**

In making meristic counts of gill rakers, the total number (well developed + rudimentary) on the first (most anterior) gill arch is counted on one side of the body. The gill arch must be dissected out to make an accurate count. The gill arches are bent like a boomerang, so gill raker counts are sometimes presented as the number on the lower limb and the number on the upper limb with the two figures separated by a + sign. In this book, all gill raker counts represent total counts unless otherwise stated.

**Branchiostegal Ray Counts**

In making meristic counts of branchiostegal rays, the number of rays attached to the hyoid arch is counted. Usually the counts are presented as the number of branchiostegal rays attached to the ceratohyal bone plus the number attached to the epihyal bone, two of the bones that comprise the hyoid arch. The two figures are separated by a + sign (# attached to ceratohyal + # attached to epihyal). Thus, redfin pickerel *Esox americanus* have a total of
Figure 3.4  Methods for making meristic counts of dorsal fin rays on a fish with one A) or two B) dorsal fins and anal fin rays on a soft-rayed C) or spiny-rayed D) fish. See text for explanation for how these counts are made.

12 or 13 branchiostegal rays with $5 + 7–8$ on each side and northern pike *Esox lucius* usually have a total of 15 branchiostegal rays, usually $7 + 8$, on each side.

**Scale Counts**

In making meristic counts of scales, the number of scales in the lateral line are counted between the cleithrum (shoulder girdle) underneath the operculum (gill cover) and the hypural plate at the posterior base of the last caudal vertebrae (where the caudal fin connects to the caudal peduncle). These scales are recognized by the presence of a pore in the middle of the scale that connects to the lateral line canal. In a few species, pored scales of the lateral line extend onto the caudal fin. In this case, the count is still terminated at the hypural plate. In some other species, the lateral line is incomplete (does not extend all the way to the base of the caudal fin). In this case, the lateral line count is still made to the end of the hypural plate.

The number of scales above the lateral line is made starting at the anterior insertion of the dorsal fin and counting down and backwards along the oblique row of scales to the lateral line (Figure 3.3). The number of scales below the lateral line is made starting at the anterior insertion of the anal fin and counting upward and forward along the oblique row of scales to the lateral line (Figure 3.3).

**Pharyngeal Tooth Formulae**

In making meristic counts of pharyngeal (throat) teeth in minnows (Family Cyprinidae), the left and right fifth gill arches must be dissected out. Each bone bears 1–3 rows of teeth, the number of teeth in each row are counted from left to right. A pharyngeal *tooth formula* of $2,5–4,2$ would indicate that the fish has two teeth in the outer row and five teeth in the inner row of the left arch, and four teeth in the inner row and two teeth in the outer row of the right arch (Figure 3.5). The pharyngeal tooth formula in combination with the shape of the teeth (e.g. canine-like, molar-like) can be used to diagnose many species of minnows.
Figure 3.5 Pharyngeal arches of: A) a minnow with shredding pharyngeal teeth (northern pikeminnow; B) a minnow with grinding/pulverizing pharyngeal teeth (peamouth); C) a sucker with a comb-like row of pharyngeal teeth (largescale sucker); D) photograph of pharyngeal arches of a northern pikeminnow.

(e.g., 2,5–4,2 or 2,5–5,2 canine-like and hooked, in northern pikeminnow Ptychocheilus oregonensis and 1,5–5,1 molar-like, with distinct grinding surfaces, in peamouth Mylocheilus caurinus). The pikeminnow use their teeth like a shredding machine to dice up fish and aquatic insects. The peamouth use their teeth to crush snails.

Pyloric Caeca Counts

In making meristic counts of pyloric caeca, the body cavity of the fish must be opened and the stomach dissected out by cutting at the esophagus (anterior) and at the pylorus (posterior) ends. The pyloric caeca are a branching network of ducts connected to the pylorus end. Pyloric caeca are particularly well developed and highly variable in number among salmonid fishes. For example, coho salmon Oncorhynchus kisutch and sockeye salmon Oncorhynchus nerka have about 45–115, Chinook salmon Oncorhynchus tsawytscha have about 98–210, and cutthroat trout Oncorhynchus clarkii have about 27–57. Pyloric caeca are enumerated by counting all the tips.

ARRANGEMENT OF FISHES IN THIS BOOK/FAMILIES OF EASTERN WASHINGTON FISHES

With the exception of lampreys (Class Agnatha), characterized by the absence of jaws and paired fins, all of the fishes found in eastern Washington belong to the Class Actinopterygii, Subclass Neopterygii (bony fishes with rayed fins). One Order/Family, Acipenseriformes/ Acipenseridae (sturgeons), belongs to the Class Actinopterygii, Subclass Chondrostei (carti-
laginous fishes with rayed fins).

The Chondrostei are considered to be the most primitive group of Actinopterygii because they appeared earlier in the fossil record and “achieved their greatest abundance and diversity in the Carboniferous Period [Paleozoic Era]” (Moyle and Cech 2004). The sturgeons have a fossil record that extends back to the middle Mesozoic Era. Sturgeons share some characters with primitive (ancestral) chondrosteans (e.g., heterocercal tail, spiracle, skeleton composed mainly of cartilage) but have some derived characters [e.g., inferior, sectorial mouth with protrusable lips, four sensory barbels lined up in a row in advance of the mouth, and five rows armor-like plates (scutes) constructed of dermal bone].

Typical chondrosteans had terminal mouths and heavy ganoid scales composed of a bony interior and outer layer of enamel called ganonine, which are also considered primitive chondrostean traits. It is thought that a chondrostean with primitive traits gave rise to the Infraclass Neopterygii because two of the most primitive orders/families of Neopterygians, the bowfins (Amiiformes: Amiidae) and gars (Lepisosteiformes: Lepisosteidae), shared some of these characters. Thus, sturgeon are specialized (derived) chondrosteans, not on the evolutionary line to more advanced (derived) Actinopterygians. Their heterocercal tail and scutes are diagnostic characters that immediately distinguish sturgeon from any other group of fish found in eastern Washington.

The remainder of the fish species found in eastern Washington belong to the Subclass Neopterygii. Neopterygians are characterized by skeletons composed of bone and highly maneuverable fins. During their evolution, Neopterygians underwent several modifications (Moyle and Cech 2004):

• The tail was modified from heterocercal (dorsal lobe larger than ventral lobe) to homocercal (dorsal lobe same size as ventral lobe). This change enabled fish to direct all the thrust produced by their caudal fin in a forward direction. (In fish with heterocercal tails, a part of thrust by the caudal fin pushes the tail down and lifts the front end).

• Their swim bladder, was initially a large, vacularized structure, often used as a lung for breathing air. This trait was inherited from the earliest bony fishes, Class Osteichthyes: Subclass Sarcopterygii (lobe-finned fishes including coelocanths and lung-fishes). Over time, the swim bladder of Neopterygians gradually became reduced in size and was used primarily as a hydrostatic organ to regulate buoyancy.

• The structure of the pectoral and pelvic fins became modified from the lobed condition of the Sarcopterygii, which were characterized by narrow range of movement, to fins that were highly maneuverable.

• Scales became modified from thick, heavy ganoid scales to thinner, lighter cycloid and/or ctenoid scales. Cycloid and ctenoid scales are composed of two thin layers; an external fibrous and an internal bony (isopedine) layer. Ctenoid scales have patches of tooth-like projections (called cteni) on the exposed (posterior) edge of the scales which function to improve hydrodynamic efficiency of swimming (Moyle and Cech 2004). Cycloid scales lack cteni. Some species of Actinopterygians possess both types of scales but most possess one type or the other.

• Vertebrae became ossified, which made them lighter. Instead of solid construction, they became cylinders supported by struts, similar to spokes of a bicycle wheel.

• The jaw structure changed from being rigid to being more flexible. In Chondrosteans, the maxilla and premaxilla were united with the skull and toothbearing. The maxilla was the larger of the two bones. In primitive (ancestral) Neopterygians, the premaxilla became separated from the maxilla by a groove, although in some species a fleshy bridge called a frenum still connected the two bones. Both bones bore sharp teeth.
and were adapted for grasping and biting prey. In advanced (derived) Neopterygians, the maxilla is not attached to the skull and is smaller than the premaxillaries. It functions as a lever to make the premaxillaries protrusable, which made the mouth and jaws more flexible. This increased flexibility permits feeding specializations such as suction feeding and plankton straining (Moyle and Cech 2004). Water containing zooplankton is sucked into the mouth and plankton collects on the gill rakers as the water passes through the gills into the opercular chamber. Gill rakers are comb-like projections attached to the anterior surface of the gill arches opposite the gill filaments.

- The gill cover and floor of the opercular chamber was rigid in the Chondrosteii. Several novelties emerged in the Neopterygians that increased the size of the opercular cavity and, thus, increased the efficiency of the “two pump” respiratory system. The “two pump” respiratory system refers to the synchronous expansion and contraction of the buccal and opercular chambers. As water enters the mouth, the buccal cavity expands until the oral valve on the roof of the mouth snaps shut. Simultaneously, the opercular valve on the posterior margin of the gill cover clamps down against the floor of the branchial chamber. Accordion-like branchiostegal rays expand, thereby increasing the volume of (and decreasing the pressure in) the opercular chamber. According to Boyle’s Law Pressure × Volume = Constant; so as the volume of the opercular chamber expands, the pressure lessens. Water under high pressure in the oral chamber then irrigates the gills as it percolates through the gill filaments into the lower pressure opercular chamber. Oxygen is extracted across the gill lamellae. An ancestral (primitive) trait shared by all members of the Neopterygian clade was the modification of one branchiostegal ray on each side becoming part of the gill cover (i.e., the interopercle bone).

The extant Neopterygian fishes currently occupying eastern Washington can be categorized into three groups. The first group includes species with the following suite of primitive (ancestral) characters (Table 3.1):

1. Body plan usually fusiform or torpedo shaped.
2. Pectoral and pelvic fins inserted on the belly.
3. Pectoral and pelvic fins well separated along belly; pelvic fins usually in abdominal position.
5. No bony spiny rays in fins. (The first ray of the dorsal and pectoral fin of some species appear spiny. These spines are compressed, fused and hardened soft rays, not true spines).
6. Swim bladder physostomous, connected to esophagus by the pneumatic duct (Figure 3.6). Fill swim bladder by gulping air on the surface.
7. Cycloid scales.

Six families of eastern Washington fishes share these primitive (ancestral) characters: Clupeidae (herrings shad), Cyprinidae (minnows), Catostomidae (suckers), Ictaluridae (bullhead catfish), Salmonidae (salmon, trout, whitefish, grayling) and Esocidae (pikes). The Clupeidae are recognized by their keeled (saw-toothed) bellies: The Cyprinidae are characterized by the absence of teeth in their jaws and distinctive pharyngeal teeth that occur in rows on the last gill arch, and are canine or molar shaped (Figure 3.5). The Catostomidae are identified by the absence of teeth in the jaws, the presence of comb-like pharyngeal teeth (Figure 3.5), and sub-terminal mouth large with fleshy lips that contain sensory papillae. The Ictaluridae are recognized by the combination of an adipose fin, eight sensory barbels (two on the snout, two on the maxilla, and four on the chin), teeth arranged on cardiform plates, and
absence of scales. The Salmonidae are characterized by the combination of an adipose fin and axillary process at the base of the pelvic fin (Figure 3.1). The Ecosidae are identified by their torpedo-shaped bodies, dorsal and anal fins situated far back on the body near the tail and mouths shaped like a duck’s bill.

The second group includes species with the following suite of advanced (derived) characters (Table 3.1):

1. Body plan variable (fusiform, dorso-ventrally flattened, laterally compressed).
2. Pectoral fin shifted dorsally; sits underneath gill cover instead of on belly.
3. Pelvic fin shifted forward into thoracic position (slightly behind and below pectoral fins).
4. Base of pectoral aligned along dorsal/ventral axis of body (vertical insertion). These changes in the pectoral and pelvic fins increase maneuverability. Ancestral species must turn their whole bodies to face backward. Advanced species can pivot around the vertical axis of their bodies to face backward.
5. Two dorsal fins usually present (first with spiny rays, second with soft rays). In some species, the two fins are separated; in others, the two fins are broadly connected and may even appear as a single fin.
6. Spiny rays present in dorsal, anal, pectoral, and pelvic fins.
7. Dorsal and anal fins increased in size in comparison to species that have primitive characters. This is an adaptation for remaining stationary in the water column. Increasing the surface area of these fins counters the tendency for the fish to roll sideways while hovering in the water column.
8. The swim bladder is *physoclist*, i.e., not connected to esophagus by pneumatic duct. Instead, of gulping air, oxygen displaced from hemoglobin in the circulatory system is used to fill the swim bladder (Figure 3.6). The gas gland is an emergent novelty that performs this function. The gas gland is composed of long U-shaped, blind loop capillary networks, called rete mirabile, that are anastomosed to the bottom front end of the swim bladder. These capillaries are surrounded by actively metabolizing tissue. The build up of carbon dioxide, heat and hydrogen ions (lower pH) caused by this metabolic activity causes a bohr shift that reduces the binding affinity of oxygen to hemoglobin. The long, blind loop capillaries retain the displaced oxygen near the swim bladder until it diffuses across the membrane into the air space. This adaptation enables the fish to become independent of the surface. [In a few Neopterygiians, e.g., sculpins (Cottidae) that occupy swift water habitats, the swim bladder was reduced or lost. This adaptation reduced their buoyancy, thereby decreasing the chance of downstream displacement].

Three families of eastern Washington fishes share these advanced (derived) characters: Cottidae (sculpins), Centrarchidae (bass, sunfish), and Percidae (yellow perch, walleye). The Cottidae are characterized by being dorso-ventrally flattened, flat head, large pectoral fins, eyes at the top of their head, and smooth, scaleless body (although patches of sand paper-like prickles may be present). The Centrarchidae are characterized by two dorsal fins (spiny and soft) that are connected to varying degrees ranging from a slight connection to such a broad connection that the two fins appear as one. Centrarchids also have 3–6 anal spines. The Percidae are characterized by two dorsal fins that are separated by a notch and two anal spines.

The third group contains five families with characters that are intermediate between the primitive and advanced states (Table 3.1). In eastern Washington, each of the families with primitive or advanced characters is typically represented by several species, whereas each
of the families with intermediate characters is represented by only one or two species. Families with intermediate characters include: Fundulidae (killifishes), Poeciliidae (livebearers—mosquitofish), Percopsidae (trout-perches—sandroller), Gadidae (cods—burbot), and Gasterosteidae (sticklebacks). The Fundulidae are characterized by an oblique (upturned) mouth. The Poeciliidae are characterized by a single soft-rayed dorsal fin, but the pelvic fin insertion is shifted forward to a point midway between the abdominal and thoracic position. The anal fin of males is modified into an intromittent organ for internal fertilization of females. The Gadidae (burbot) are characterized by having pelvic fins are shifted forward into the jugular position (in front of the pectoral fins). Burbot also have a single chin barbel and deeply embedded cycloid scales. Additionally, burbot have two dorsal fins, one short the other long, but both fins contain only soft rays. The Gasterosteidae have 2–7 isolated dorsal spines, each with its own membrane preceding a soft-rayed dorsal fin. Their pelvic fins are reduced to one sharp spine and 1–2 soft rays. The pelvic fin is shifted forward to a point midway between the abdominal and thoracic position. Their body is armored in bony lateral plates instead of scales. The Percopsidae have one soft dorsal fin with 1–3 spiny anterior rays. A few spines are also present on the anal fin. Percopsidae also have an adipose fin, ctenoid scales, and pelvic fins inserted midway between abdominal and thoracic positions.

Figure 3.6 Swim bladders of: A) phytostome fish; B) Physoclist fish. Lower portion of B shows detail of blind loop capillary networks (rete mirabile). Metabolically active cells in the gas gland produce CO$_2$ and lactic acid causing a bohr shift so that the hemoglobin molecule releases oxygen. The rete network traps the displaced oxygen and uses it to fill the swim bladder; C) Physostome swim bladder from largescale sucker. 

Field Guide to the Fishes of Eastern Washington
Table 3.1 Diagnostic characters that distinguish the 16 families of fishes found in eastern Washington. Families shaded in yellow represent ancient lineages. Families shaded in orange share a suite of primitive (ancestral) characters. Families shaded in green share a suite of advanced (derived) characters. Families shaded in pink are intermediate between advanced and primitive groups. (Page 1 of 2).

<table>
<thead>
<tr>
<th>Family</th>
<th>Diagnostic Character(s) of Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petromyzontidae (lampreys)</td>
<td>• Seven pairs of gill openings.</td>
</tr>
<tr>
<td># Genera = 1 # Species = 3</td>
<td>• Jaws absent. Instead, have sucking disc with circumoral teeth and rasp-like tongue (adults) or oral hood with endostyle (ammocoetes larvae).</td>
</tr>
<tr>
<td></td>
<td>• Paired fins absent.</td>
</tr>
<tr>
<td>Aciicoperidae (sturgeons)</td>
<td>• Caudal fin heterocercal.</td>
</tr>
<tr>
<td># Genera = 1 # Species = 1</td>
<td>• Five rows of scutes (bony plates, one dorsal on middle of back (n = 1), one on middle of each side (n = 2) and one on each side of side of belly (n = 2).</td>
</tr>
<tr>
<td></td>
<td>• Inferior mouth with protrusable lips.</td>
</tr>
<tr>
<td></td>
<td>• Four sensory barbels in a row in advance of the anterior (upper) lip.</td>
</tr>
<tr>
<td></td>
<td>• Notochord persistent in adults.</td>
</tr>
<tr>
<td>Clupeidae (herring and shad)</td>
<td>• Scales on ventral midline overlapping to form a saw-toothed keel.</td>
</tr>
<tr>
<td># Genera = 1 # Species = 1</td>
<td>• Body fusiform in profile but strongly laterally compressed in cross section.</td>
</tr>
<tr>
<td>Cyprinidae (minnows)</td>
<td>• Teeth absent in jaws.</td>
</tr>
<tr>
<td># Genera = 12 # Species = 14</td>
<td>• Pharyngeal teeth present on 5th gill arches; canine or molar-like, adapted for macerating or grinding prey. Teeth usually present in 1–3 rows (each species has a diagnostic tooth formula).</td>
</tr>
<tr>
<td></td>
<td>• Body generally fusiform.</td>
</tr>
<tr>
<td>Catostomidae (suckers)</td>
<td>• Teeth absent in jaws. Pharyngeal teeth in a single comb-like row.</td>
</tr>
<tr>
<td># Genera = 1 # Species = 4</td>
<td>• Mouth sub-terminal with large, fleshy lips that contain sensory papillae.</td>
</tr>
<tr>
<td></td>
<td>• Body fusiform.</td>
</tr>
<tr>
<td>Ictaluridae (bullhead catfishes)</td>
<td>• Adipose fin present.</td>
</tr>
<tr>
<td># Genera = 4 # Species = 6</td>
<td>• Eight sensory barbels (two on snout, two on maxilla, and four on the chin) present.</td>
</tr>
<tr>
<td></td>
<td>• No scales (skin ‘naked’).</td>
</tr>
<tr>
<td>Salmonidae (salmon, trout, char, grayling)</td>
<td>• Adipose fin present.</td>
</tr>
<tr>
<td></td>
<td>• No sensory barbels present on the snout, maxilla or chin.</td>
</tr>
<tr>
<td></td>
<td>• Well developed axillary process at the anterior base of each pelvic fin. Body generally fusiform.</td>
</tr>
<tr>
<td>Esocidae (pikes)</td>
<td>• Bodies torpedo-shaped.</td>
</tr>
<tr>
<td># Genera = 3 # Species = 3</td>
<td>• Dorsal and anal fins inserted on the caudal peduncle.</td>
</tr>
<tr>
<td></td>
<td>• Snout shaped like a duck’s bill.</td>
</tr>
<tr>
<td>Percopsidae (trout-perches)</td>
<td>• Adipose fin present but no sensory barbels near mouth and no axillary process at base of pelvic fins. One dorsal fin (primitive state).</td>
</tr>
<tr>
<td># Genera = 1 # Species = 3</td>
<td>• First two dorsal rays and first pelvic ray usually spiny (intermediate between primitive and advanced states).</td>
</tr>
<tr>
<td></td>
<td>• Pectoral fin shifted upward (behind operculum), orientation of base vertical instead of horizontal (advanced state). Pelvic fins shifted forward, about midway between abdominal and thoracic positions (intermediate between primitive and advanced states).</td>
</tr>
</tbody>
</table>

Table 3.1 continued on next page.
### Table 3.1 (concluded). Diagnostic characters of fish families. (Page 2 of 2).

<table>
<thead>
<tr>
<th>Family</th>
<th>Diagnostic Character(s) of Family</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gadidae</strong> (burbot)</td>
<td>• Two dorsal fins (anterior fin short, posterior fin long), both fins soft-rayed (intermediate between primitive and advanced states).</td>
</tr>
<tr>
<td># Genera = 1</td>
<td>• Pelvic fins in jugular position, i.e., below and in front of pectoral fins (advanced state).</td>
</tr>
<tr>
<td># Species = 1</td>
<td>• Single large barbel present on chin.</td>
</tr>
<tr>
<td><strong>Fundulidae</strong> (killifish)</td>
<td>• Mouth oblique (upturned).</td>
</tr>
<tr>
<td># Genera = 1</td>
<td>• Premaxillary protractile.</td>
</tr>
<tr>
<td># Species = 1</td>
<td>• One soft-rayed dorsal fin (primitive state).</td>
</tr>
<tr>
<td></td>
<td>• Pectoral fins near midline of body behind operculum. Orientation of base vertical (advanced state).</td>
</tr>
<tr>
<td></td>
<td>• Pelvic fins in thoracic position (advanced state).</td>
</tr>
<tr>
<td></td>
<td>• Origin of anal fin is posterior to origin of dorsal fin.</td>
</tr>
<tr>
<td><strong>Poeciliidae</strong> (livebearers, mosquitofish)</td>
<td>• Mouth oblique (upturned, protractile premaxilla).</td>
</tr>
<tr>
<td># Genera = 1</td>
<td>• Origin of anal fin is anterior to origin of dorsal fin.</td>
</tr>
<tr>
<td># Species = 1</td>
<td>• One soft-rayed dorsal fin (primitive state).</td>
</tr>
<tr>
<td></td>
<td>• Pectoral fins near midline of body behind operculum, orientation of base vertical (advanced state).</td>
</tr>
<tr>
<td></td>
<td>• Pelvic fins in thoracic position (advanced state).</td>
</tr>
<tr>
<td></td>
<td>• First two anal rays of males modified into gonopodium (copulatory organ) to accomplish internal fertilization.</td>
</tr>
<tr>
<td><strong>Gasterosteidae</strong> (sticklebacks)</td>
<td>• 2–7 isolated predorsal spines, each with its own membrane, precede soft dorsal fin (intermediate between primitive and advanced state).</td>
</tr>
<tr>
<td># Genera = 2</td>
<td>• Pectoral, pelvic, and anal fins usually with prominent spine. Pelvic fin reduced to long, sharp spine and one soft ray.</td>
</tr>
<tr>
<td># Species = 2</td>
<td>• Bony lateral plates form shield-like armor along sides of body.</td>
</tr>
<tr>
<td><strong>Cottidae</strong> (sculpins)</td>
<td>• Dorsoventrally flattened.</td>
</tr>
<tr>
<td># Genera = 1</td>
<td>• Eyes close together on top of head.</td>
</tr>
<tr>
<td># Species = 7</td>
<td>• Large pectoral fins.</td>
</tr>
<tr>
<td></td>
<td>• Spiny and soft dorsal fin separated.</td>
</tr>
<tr>
<td><strong>Centrachidae</strong> (sunfishes, bass)</td>
<td>• Spiny and soft dorsal fins connected to varying degrees, ranging from a slight connection to such a broad connection the two fins appear as one.</td>
</tr>
<tr>
<td># Genera = 3</td>
<td>• Body shape variable, ranging from fusiform in profile (but with slight amount of lateral compression in cross section) to distinctly laterally compressed in both profile and cross section.</td>
</tr>
<tr>
<td># Species = 7</td>
<td>• Species with distinct lateral compression usually with high dorsal and anal fins, i.e., these fins have a large surface area.</td>
</tr>
<tr>
<td></td>
<td>• 3–6 anal spines.</td>
</tr>
<tr>
<td><strong>Percidae</strong> (yellow perch, walleye)</td>
<td>• Spiny and soft dorsal fins distinctly separated by a notch (space) between them.</td>
</tr>
<tr>
<td># Genera = 2</td>
<td>• Body shape fusiform in profile and cross section.</td>
</tr>
<tr>
<td># Species = 2</td>
<td>• 1–2 anal spines.</td>
</tr>
</tbody>
</table>
How to use this key. This dichotomous key contains numbered couplets (Arabic numerals) that describe one or a few morphological character(s) with two alternatives (A or B). The fish being examined will be described correctly only by one of the alternatives. Following each alternative is either a “Go to” statement directing the user to another couplet or a family name that identifies the Family of the fish being examined. A line drawing of a representative species in the family is provided to help determine if your diagnosis is correct. In the latter case two page numbers are listed that direct the user to: 1) information about the natural history of species contained in that family; and 2) a key to the species in that family. To continue with the identification of your specimen, turn to the page number of the Family Key and work through it in the same manner as this key until a species is tentatively identified. Along with the species’ common and scientific names is a page number that directs the user to more information about that species. The user should flip to that page to confirm the identification.

### Couplet 1

A. Jaws and paired fins present. Gills covered by bony plate (operculum). Mouth with jaws.  

B. Jaws and paired fins absent. Seven pairs of gill openings. Mouth a sucking disk.

- **Family**: Petromyzontidae (Lampreys)  
  - Life history on page 29  
  - Species key on page 32

### Couplet 2

A. Caudal fin heterocercal (upper lobe distinctly larger than lower lobe. Five long individual rows of scutes (bony plates) present.

B. Caudal fin homocercal (upper and lower lobes symmetrical). Scutes absent (body covered by scales or naked).

- **Family**: Acipenseridae (Sturgeon)  
  - Life history on page 39  
  - Species key on page 44  
  
- **Go to 3**
3. A. One dorsal fin, usually with only soft rays, or dorsal and adipose fin.  \(\text{Go to 4}\)

B. Two dorsal fins. Anterior fin usually spiny rayed, posterior fin usually soft-rayed. The two fins may be distinctly separate, broadly joined, or have isolated spines preceding the soft dorsal fin. One species has two soft-rayed dorsal fins.  \(\text{Go to 12}\)

4. A. One soft-rayed dorsal fin only (first ray may be spinous in some species). No adipose fin.  \(\text{Go to 5}\)

B. One soft-rayed dorsal fin (first ray may be spinous in some species) plus adipose fin.  \(\text{Go to 9}\)

5. A. Scales along ventral midline modified into sharp scutes, overlapping to form a saw-tooth keel that resembles a serrated knife.  \(\text{Clupeidae (Herring)}\)
   Life history on page 47
   Species key on page 48

   ![saw tooth keel]

B. Knife-like saw-tooth keel absent.  \(\text{Go to 6}\)

6. A. Dorsal fin situated far back along body near caudal peduncle and over anal fin. Mouth resembles duck’s bill.  \(\text{Esocidae (Pikes)}\)
   Life history on page 117
   Species key on page 122

   ![dorsal fin and mouth]

B. Dorsal fin situated near middle of body, well in advance of anal fin. Mouth not like duck’s bill.  \(\text{Go to 7}\)
Chapter 4

7. A. Mouth terminal. Pre-maxillaries not protracted. **Go to 8**

B. Mouth oblique. Pre-maxillaries protracted. **Go to 12**

8. A. Teeth absent in jaws and/or mouth. **Go to 9**

B. Teeth present in jaws and/or mouth. **Go to 10**

9. A. Mouth terminal, sub-terminal, or oblique (not sucker-like). **Cyprinidae** (Minnows)
   Life history on page 51
   Species key on page 54

B. Mouth inferior, sucker-like. Lower lip thick with fleshy papillae. **Catostomidae** (Suckers)
   Life history on page 87
   Species key on page 92

10. A. One dorsal and adipose fin but maxillary barbels absent. **Go to 11**

B. One dorsal and adipose fin plus maxillary barbels present. **Ictaluridae** (Bullhead catfishes)
   Life history on page 101
   Species key on page 104

---

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
**Key to Families of Eastern Washington Fishes**

### 11.

A. Pelvic fins abdominal (between dorsal and anal fins). Spiny rays absent from fins. Axillary process present at base of each pelvic fins.

\[\text{Salmonidae} \text{ (Salmon, trout)}
\]
Life history on page 129
Species key on page 156

B. Pelvic fins thoracic (underneath and slightly behind pectoral fins) and with one spine. Two spiny rays present in dorsal and anal fins. Axillary process absent at base of pelvic fins.

\[\text{Percopsidae} \text{ (Trout-perches)}
\]
Life history on page 207
Species key on page 208

### 12.


\[\text{Poecilidae} \text{ (Liverbearers)}
\]
Life history on page 217
Species key on page 218

B. Oblique mouth. Origin of anal fin underneath or slightly posterior to origin of dorsal fin.

\[\text{Fundulidae} \text{ (Killifishes)}
\]
Life history on page 286
Species key on page 286
13. A. Fish with isolated pre-dorsal spines anterior to soft-rayed dorsal fin; pelvic fins modified into stout, sharp spine (pelvic spine).

B. Fish with two dorsal fins. All spiny rays connected by membranes. Pelvic fins lack prominent spine. Go to 14

14. A. Two dorsal fins—anterior spiny-rayed, posterior soft-rayed (may be separated or fused). Pelvic fins thoracic (below and behind pectoral fins). No barbel on chin. Go to 15

B. Two soft-rayed dorsal fins; pelvic fins jugular (in front of pectoral fins). Single long fleshy barbel at tip of chin. Gasterosteidae (Sticklebacks)
Life history on page 221
Species key on page 224

Gadidae (Cod-Burbot)
Life history on page 211
Species key on page 214
15. A. Large pectoral fins in relation to body. Eyes on top of head (close together). Caudal fin rounded or truncate (square). Scales embedded (prickles sometimes present). Spines often present on head and opercles.

B. Pectoral fins not large in relation to body. Eyes on opposite sides of the head. Caudal fins forked or indented. Scales not embedded. Spines not present on head or opercles.

16. A. Spiny and soft dorsal fins united (may be almost separated or broadly joined but are always anastamosed (connected) to each other. Three or more anal spines.

B. Spiny and soft dorsal fins separated by distinct notch. One or two anal spines.
Lampreys belong to the Class Agnatha (jawless fishes), Order Petromyzontiformes. The order is composed of one family (Petromyzontidae) that contains six genera and 41 species (Hubbs and Potter 1971; Nelson 1984). In Washington, lampreys are represented by one genus (*Lampetra*) and three species—Pacific lamprey *Lampetra tridentata*, river lamprey *L. ayresi* and western brook lamprey *L. richardsoni*. Pacific lamprey and river lamprey are anadromous parasites whereas the western brook lamprey is a freshwater, free-living form. Pacific and river lampreys are widely distributed in coastal streams of Puget Sound, on the Olympic Peninsula, and throughout the Columbia River Basin in the mainstems of the Columbia and Snake rivers and in many tributaries. Western brook lamprey occur in the coastal streams of Puget Sound and the Olympic Peninsula. They are present in the Columbia Basin as far upstream as the confluence of the Walla Walla and Yakima rivers and are more abundant in tributaries than the mainstem.

Lampreys are semelparous (spawn once in a lifetime). All species spawn in freshwater from April to July, at temperatures of 10–16°C. Eggs are deposited in nests constructed by the parents in fast flowing, gravel bottom streams. Both parents participate in digging the nest by using their suckorial disc to pick up pieces of gravel and carry it away from a central depression. The female then positions herself over the nest by attaching to a large rock at the upstream end. A male courts the female by gently nudging along the side of her body with his oral disc, moving from a posterior to anterior direction until reaching her head. The male then attaches to the female's head and coils his body around hers, squeezing out the eggs. Eggs and sperm are released into the nest together. Eggs are sticky and adhere to the bottom of the nest until the parents cover them up by moving rocks and pebbles with their sucking disc.

Eggs hatch into ammocoetes larvae 10–14 days after being deposited. Ammocoetes are blind (eyes are present but covered by a thick layer of skin) and have mouths modified into a U-shaped oral hood (Figure 5.1). They respire by sucking water into their mouth and pumping it past their gills through seven branchiopores on either side of the body. The pharynx is modified into a filter basket (endostyle) that secretes a sticky mucous. Ammocoetes drift downstream into quiet pools and burrow into soft sand or mud bottoms. Ammocoetes remain in this habitat for several years, surviving by sticking their heads above the substrate and using their oral hood to direct food particles that drift downstream on water currents onto the sticky endostyle. Thus, the ammocoetes larval is a free-living life stage.

At age 4–7 years, Pacific lamprey ammocoetes transform into a second larval stage called macrophthalmia. This transformation, which occurs from July to November (Richards and Beamish 1981), is a complicated metamorphosis that involves changes in morphology, physiology and behavior. Structural changes include: 1) the oral hood changes into a suckorial mouth and eyes become visible; 2) circumoral teeth develop and the endostyle is replaced by a rasp-like tongue; 3) initially, the circumoral teeth are soft but then they harden. In some species, the circumoral teeth become pointy and vampire-like (Figure 5.1), whereas in others they remain blunt and non-functional; and 4) their respiratory system changes from a unidirectional flow of water into the mouth and out the branchiopores, to a tidal flow in which water enters and exits the branchiopores. Transforming larvae also undergo behavioral changes They move out of their burrows and migrate, *en masse*, to the sea.

Transforming lampreys exhibit two primary life history patterns. Anadromous species migrate to the ocean where they complete their transformation to a blood-sucking parasitic adult life stage. They use their sucking disc and circumoral teeth to attach to prey. They then use their rasp-like tongue to burrow a hole into the side of their host. Their saliva contains an
Family Petromyzontidae

Figure 5.1 Pacific lamprey lifecycle. (Clockwise from top left) Adult pacific lamprey sucking disc; parasitic adult lampreys attacking rainbow trout; lamprey scar on lake trout; and ammocoetes larvae with oral hood.

anticoagulant that prevents clotting and keeps blood and body fluids flowing from the host. While attached to a host they oxygenate their gills by pumping water in and out of their branchiopores. They feed until satiation, then drop off, leaving the host fish with a distinctive lamprey scar (Figure 5.1). Parasitic lampreys spend from 1.5–3.5 years at sea before returning to freshwater to spawn (Close et al. 2002). Lampreys with this type of life cycle have teeth with sharp cusps. Pacific and river lampreys both exhibit this type of life history.

The second life history pattern is exhibited by non-parasitic freshwater lampreys. At metamorphosis lampreys usually develop weak, blunt, non-functional teeth. They either attach to stones and do not feed, or locate the carcass of dead fish and feed on body fluids in the decomposing flesh. These free-living lampreys often have an abbreviated adult life stage, sometimes as short as three months. Western brook lampreys exhibit this type of life history.

River, western brook and Pacific lamprey attain maximum lengths of 320, 216, and 762 mm respectively, and maximum fecundities of 37, 288, 3,700 and 106,000 eggs/female respectively (Moyle 2002; Wydoski and Whitney 2003).

Lampreys are thought to be attracted to suitable spawning streams by pheromones emitted by ammocoete larvae residing in them (Sorenson and Close 2000). Weaver (1935) reported that ammocoete larvae were preyed on by birds and inland fishes after they hatched out and after they had transformed and were migrating downstream. He noted that "supplying important food for inland fish and birds may compensate for their parasitism." Close et al. (1995, 2002) hypothesized that lamprey ammocoetes and macrophthalmia larvae were formerly an important buffer that protected migrating juvenile salmon from predation by birds and fishes. Likewise, migrating adult salmon were protected from predation by marine mammals, which preyed on adult lamprey instead.
Lampreys are divided into genera and species by their dentition. The teeth form three concentric circles surrounding the mouth. Each circle is subdivided into four quadrants called the anterior, posterior, left lateral and right lateral fields. Teeth of the outer ring are uniform in appearance and form a near perfect circle. In the middle ring, teeth of the lateral fields are usually much larger and modified with more cusps than the teeth of the anterior and posterior fields. These teeth are called inner laterals. In the interior row, there are no teeth in the lateral fields and teeth of the anterior and posterior fields are often connected together to form tooth bars called respectively the supra-oral lamina and infra-oral lamina.

**Generalized Lamprey Dentition**

The supra-oral lamina bears three sharp cusps in the Pacific lamprey, two sharp cusps in the river lamprey and two blunt (nonfunctional) cusps in the western brook lamprey. There are four pairs of inner laterals (#1 and 4 with two sharp cusps, and #2 and 3 with three sharp cusps) in the Pacific lamprey but only three pairs (each usually with two sharp cusps) in the river lamprey and the western brook lamprey (cusps blunt and non-functional). The teeth in the posterior field of the middle tooth row are conspicuous in the Pacific lamprey and form a semicircle that is continuous with the inner laterals. These teeth are absent in the river lamprey and western brook lamprey.

**Figure 5.2** Primer on lamprey identification. Photograph of River lamprey courtesy of United States Geological Survey, Biological Resources Division, Cook, Washington.
KEY TO FAMILY PETROMYZONTIDAE

General Family Characters

Confirm these characters before keying to species.

1. No jaws, mouth is circular sucking disc with circumoral teeth and rasp-like tongue (adults) or U-shaped oral-hood (ammocoetes larvae).

2. Long eel-like bodies.

3. Absence of paired fins and fin girdles.

4. A long dorsal fin, usually in two lobes.

5. A single median nostril between the eyes not connected to the pharynx.

6. Seven pairs of gills in pouches, each pouch opening to the outside through an individual brachiopore.

Key to the Species of the Petromyzontidae of Eastern Washington

1. A. Mouth a U-shaped oral hood. Eyes absent or covered over by membrane. Note: Ammocoetes larvae are too similar to accurately identify species.

B. Mouth a sucking disc, surrounded by circumoral teeth. Rasp-like tongue present in oral cavity. Eyes present.

2. A. Teeth blunt and not functional (free-living). See page 31, Figure 5.2C.

B. Teeth sharp and pointed (parasitic).

3. A. Supra-oral tooth bar with three vampire-like cusps. Lateral teeth in four pairs. See page 31, Figure 5.2A.

B. Supra-oral tooth bar with two vampire-like cusps. Lateral teeth in three pairs. See page 31, Figure 5.2B.

1. There is some doubt about the occurrence of river lamprey in eastern Washington because some Pacific lamprey have been shown to initially have two cusps then develop a third. Therefore, it could be that specimens identified as river lamprey in eastern Washington could have actually been immature Pacific lamprey.

Ammocoetes larvae
Page 30, Figure 5.1

Transforming or adult lamprey
Go to 2

Western brook lamprey
Lampetra richardsoni
Page 35

Go to 3

Pacific lamprey
Lampetra tridentata
Page 37

River lamprey
Lampetra ayresi
Page 33
RIVER LAMPREY

Lampetra ayresi (Günther, 1870)

Figure 5.3 River lamprey. Photographs courtesy of United States Geological Survey, Biological Resources Division, Cook, Washington.

Primary Identification

1. Supra-oral tooth bar with two distinctly pointed cusps.
2. Usually three pairs of lateral teeth, the middle pair with three sharp cusps, the anterior and posterior pairs with two sharp cusps.

Confirming Characters

1. Infra-oral tooth bar with about five cusps.
2. No row of semicircular teeth posterior to infra-oral tooth bar.
3. Sharp tooth on center of tongue.

Similar Species

1. Western brook lamprey have two cusps on supra-oral tooth bar and three pairs of lateral teeth. All cusps on supra-oral tooth bar, lateral teeth and infra-oral tooth bar are blunt and non-functional. No tooth on tongue.
2. Pacific lamprey have three cusps on supra-oral tooth bar and four pairs of lateral teeth. The middle two lateral teeth each bear three cusps. Semi-circular row of teeth posterior to infra-oral tooth bar.

Etymology

Lampetra: (L.) Lambere (to suck) and petra (stone), hence, sucker of stone. Refers to their behavior of clinging to rocks on the river bottom using their sucking disc.

ayresi: (L.) Named after W.O. Ayres, the California naturalist who discovered the species.

Common Name(s)

River lamprey (AFS name), western lamprey.
Field Guide to the Fishes of Eastern Washington

Family Petromyzontidae

Figure 5.4 River lamprey distribution in eastern Washington.

Distribution

River lamprey are an anadromous species restricted to the west coast of North America. They are distributed in saltwater and coastal streams from the Sacramento River, California to Juneau, Alaska (Beamish and Neville 1992). In Washington, river lamprey are most abundant in coastal tributaries of Puget Sound and the Olympic Peninsula. They are rare in the Columbia Basin above Bonneville Dam but were historically reported in the Columbia mainstem as far upstream as the Hanford Reach below Priest Rapids Dam (Gray and Dauble 1977b, 1977c) and in the Snake River from the mouth to its junction with the Grand Ronde River. They have also been collected in the Yakima Basin (Patten et al. 1970) and were historically present in the Walla Walla drainage (Bean 1882). River lamprey (called *Lampetra fluviatilis*) were reported in Lake Pend Oreille, Idaho in 1966, 1967, and 1968, attached to kokanee salmon and Kamloops trout (Mallet 1968, 1969). This was the first report ever of lampreys in the Pend Oreille Basin, and they have not been reported since then, so their occurrence there remains a mystery (Simpson and Wallace 1982).

No authenticated river lamprey have been collected in the Columbia Basin above Bonneville Dam since 1980 (J. Bayer, USGS, Cook, WA, pers. comm.). Recently reported in Hanford Reach, Columbia River (Dawley 1996) and Chiwawa River, tributary of the Wenatchee River (Miller and Schonning 2004), but voucher specimens were not retained in a museum. They may have been young Pacific lamprey (See note on bottom of page 32).
WESTERN BROOK LAMPREY
*Lampetra richardsoni* (Vladykov and Follet, 1965)

Figure 5.5  Western brook lamprey. Richards Creek (Lake Washington drainage).

**Primary Identification**
1. Supra-oral tooth bar with two blunt cusps.
2. Three pairs of lateral teeth, each with two blunt cusps.

**Confirming Characters**
1. Infra-oral tooth bar essentially a blunt ridge. Cusps, if present, blunt.
2. No row of semi-circular teeth posterior to infra-oral tooth bar.
3. No sharp teeth on tongue.

**Similar Species**
1. River lamprey have two sharp cusps on supra-oral tooth bar and three rows of lateral teeth. Lateral teeth and infra-oral tooth bar with pointed cusps and a sharp tooth on tongue.
2. Pacific lamprey has three sharp cusps on supra-oral tooth bar, four pairs of lateral teeth, sharp tooth on tongue, and row of semi-circular teeth posterior to infra-oral tooth bar.

**Etymology**
*Lampetra*: (L.) *Lambere* (to suck) and *petra* (stone), hence, sucker of stone. Refers to their behavior of clinging to rocks on the river bottom using their sucking disc.

*richardsoni*: (L.) Named in honor of British naturalist Sir John Richardson, author of *Fauna Borealis Americana*, the first publication to describe a large number of northwest fishes.

**Common Name(s)**
Western brook lamprey (AFS name), nonparasitic brook lamprey.
Figure 5.6 Western brook lamprey distribution in eastern Washington.

Distribution

The distribution of western brook lamprey is restricted to freshwater streams of the Pacific Coast from Coos Bay, Oregon to the Nass River, British Columbia including Vancouver Island. In the Fraser River drainage, British Columbia it occurs in many tributaries but not the Fraser mainstem (Beamish and Neville 1992). In Washington, it is distributed throughout most of the tributaries that flow into Puget Sound and on the Olympic Peninsula. In the Columbia Basin, western brook lamprey occur in the mainstem from the mouth to the Yakima River confluence, and in the Cowlitz, Lewis, Willamette, John Day, Walla Walla, Touchet, and Yakima River sub-basins. In the Walla Walla watershed, western brook lamprey have been reported in the Walla Walla River from the mouth to about the city of Walla Walla, Touchet River, Mill Creek, Yellowhawk Creek, Dry Creek, Cottonwood Creek and Little Walla Walla River (Schultz and Delacy 1935/1936; Michaelis 1972; Jackson et al. 1998; Close and Jackson 2000; Mendel et al. 1999, 2000, 2001a, 2001b, 2002, 2003). Western brook lamprey have also been collected in a WDFW (Washington Department of Fish and Wildlife) migration trap on the Touchet River at Dayton. Not reported in the Snake River Basin. In the Yakima system, western brook lamprey occur throughout the Yakima mainstem, and in the Naches and Tieton rivers and many smaller tributaries (Patten et al. 1970).
PACIFIC LAMPREY

*Lampetra tridentata* (Gairdner, 1836)

**Figure 5.7** Pacific lamprey. Big Beef Creek (Hood Canal).

**Primary Identification**

1. Supra-oral tooth bar with three cusps.
2. Four pairs of inner lateral teeth, with two cusps on the anterior and posterior teeth on each side, and three cusps on the two middle teeth on each side.

**Confirming Characters**

1. Infra-oral tooth bar with about five cusps.
2. Row of small uni-cuspid teeth arranged posterior in field of middle tooth row (arranged in a semi-circle posterior to infra-oral tooth bar).

**Similar Species**

1. River lamprey have two pointed cusps on supra-oral tooth bar and three pairs of inner lateral teeth. No row of teeth in a semi-circle posterior to infra-oral tooth bar.
2. Western brook lamprey has two blunt cusps on supra-oral tooth bar and three pairs of inner lateral teeth. No row of teeth in a semi-circle posterior to infra-orbitol tooth bar.

**Etymology**

*Lampetra*: (L.) *Lambere* (to suck) and *petra* (stone), hence, sucker of stone. Refers to their behavior of clinging to rocks on the river bottom using their sucking disc.

*tridentata*: (L.) Three-toothed, because the supra-oral tooth bar and the two middle inner lateral teeth have three cusps.

**Common Name(s)**

Pacific lamprey (AFS name), three-toothed lamprey.
**Figure 5.8** Pacific lamprey distribution in eastern Washington.

**Distribution**

Pacific lamprey occur in fresh and saltwater along the Pacific Coast of North America from Baja, California to the Aleutian Islands, Alaska. Historically, Pacific lamprey ascended the Columbia River to Kettle Falls and the Spokane River to Spokane Falls. Grand Coulee Dam blocked migration to these areas in 1939. Pacific lamprey were once abundant in the Grand Ronde, Wallowa and Immaha rivers (Snake Basin) but none have been observed in recent years (Moser and Close 2003). In Idaho, Pacific lamprey historically ascended the Snake River to Shoshone Falls. Hells Canyon Dam blocked migrations in 1967 and caused their extirpation in the Snake River.

Pacific lamprey currently occur in tributaries of the Columbia (John Day, Umatilla, Walla Walla, Yakima, Wenatchee, Methow) and Snake rivers (Palouse River below Palouse Falls and Tucannon). Counts of Pacific lamprey in the fish ladders at Bonneville Dam decreased from 370,000 in 1969 to 61,780 in 2004. Counts at Ice Harbor Dam on the Snake River have decreased from 49,700 in 1968 to 805 in 2004. These data indicate that current Pacific lamprey abundance in the Columbia and Snake rivers are respectively at 17% and 2% of their historical peak abundance. Populations in both the Columbia and Snake above the confluences of each river are in jeopardy of extinction. Factors that contributed to their decline were screened irrigation withdrawals that diverted downstream migrating macrophthalmia stage lamprey out of rivers into agricultural fields; hydroelectric dams that blocked passage of adults, and declines in their Pacific salmon prey base (Moser et al. 2002; Moser and Close 2003).
The Sturgeon Family is composed of 24 species worldwide, found in temperate waters of the Northern Hemisphere. Some species are anadromous and others spend their entire lives in freshwater. Two species occur in Washington, the white sturgeon *Acipenser transmontanus* and the green sturgeon *A. medirostrus*. Green sturgeon are anadromous, and white sturgeon exhibit either an anadromous or strictly freshwater life history. Both species occur in larger rivers of the Pacific coast between the Fraser River, British Columbia and Sacramento River, California. They have been collected in coastal waters from Monterey, California to the Gulf of Alaska. In Washington, they occur in Puget Sound, Olympic Peninsula, and the Columbia River.

In the Columbia River Basin, green sturgeon are restricted to waters below Bonneville Dam, whereas white sturgeon occur throughout the Columbia mainstem from the mouth to Revelstoke, British Columbia and in the Snake River mainstem from the mouth to Shoshone Falls, Idaho. Individual fish were thought to have roamed freely throughout this range before hydroelectric dams constructed on the Columbia and Snake rivers isolated segments of the white sturgeon population. White sturgeon are usually unable to negotiate fish ladders that were designed primarily for passage of salmonids.

In the Columbia Basin, between 1865 and 1888, sturgeon were considered a nuisance species because they became entangled in and damaged salmon gill nets. Commercial salmon fisherman clubbed sturgeon to death and threw them overboard. Phillips (1876) wrote: “The sturgeon of the Pacific coast is dreaded by the salmon-fisherman in the Columbia River as he has a dead weight of some 1200 lbs and can barrel through a series of nets like an iron-clad.” Collins (1892) noted, “The fish wheels often take in a day, many tons of sturgeon less than 22.5 kg in weight. Such are not marketable and are now thrown back [dead] into the rivers. Their utilization would be a boon to the fisherman for [their carcasses] now help to contaminate the water. Many sturgeons are also taken near the mouth of the Columbia in pond nets and gill nets. Their size and strength often enables them to tear the nets in their efforts to get free. They are, therefore, considered as pests to the fisherman of the lower river, who never save such fish, but generally knock them on the head and throw them back into the water.” Mr. M. J. Kinney of Astoria, Oregon, in a letter to the USFC in 1894 wrote, “For years every sturgeon taken was mutilated or killed with an axe and thrown back into the water. The shores of the river [were] lined with dead sturgeon and numbers could always be seen floating down the river” (cited in Anderson 1988).

Intensive commercial harvest of white sturgeon began on the Columbia River in 1888. Caviar and flesh were sold for three to five cents/lb. Most of the roe was sent to Hamburg, Germany. Sturgeon bladders were sold for five cents to make a gelatin called isinglass. The commercial fishery peaked in 1892 when 37,000 fish with an average length of 2.1 m and weight of 67.5 kg each, and combined weight of 2.4 million kg were harvested (Craig and Hacker 1940a). Individual weights ranged from 22.5 to 225 kg. Within four years, all the large fish were gone. In 1899, only 1,330 fish with an average weight of 22.5–27.0 kg and a combined weight of 33,250 kg were harvested (Craig and Hacker 1940b).

Protective regulations allowed sturgeon populations to rebuild so that by 1987 commercial fisherman and sport anglers harvested about 11,600 and 60,400 sturgeon respectively below Bonneville Dam. However, the total weight of the catch was only about a quarter that of the peak catch in 1892. Rieman and Beamesderfer (1990b) warned that harvests were too high, prompting additional restrictions on sport and commercial harvest. By 1991, the estimated commercial and recreational harvest declined to 3,800 and 22,700 white sturgeon respec-
Family Acipenseridae

White sturgeon are abundant in the unimpounded portions of the Columbia River downstream from Bonneville Dam (DeVore et al. 1995) and lower Columbia reservoirs (Bonneville, The Dalles, John Day) (Beamesderfer et al. 1995), where populations are sufficiently large to support commercial and sport fisheries (Rieman and Beamesderfer 1990b). Below Bonneville Dam, where sturgeon abundance was 100,000 individuals, the estimated annual sport and commercial harvest between 1995 and 2000 ranged from 38,200–45,100 per year and 6,200–13,900 per year respectively (WDFW/ODFW 2002). Fishing at or below that level allowed full recruitment of all legal-sized age classes to the population. Hence, this population remains healthy.

White sturgeon populations are also in relatively good shape in the reservoirs behind Bonneville, The Dalles, and John Day dams. Between 1987 and 1991, ODFW used baited set lines to capture white sturgeon in these reservoirs (3,862 in Bonneville Reservoir, 2,641 in The Dalles Reservoir and 657 in John Day Reservoir). In this study set lines were set every 7–12.5 km along the length of the reservoirs. Sturgeon were distributed throughout the length of each reservoir although the greatest catch was near the upstream end (in the tailrace of the dam preceding it) (North et al. 1997). Populations were estimated at 17,900–48,700 individuals in Bonneville Reservoir in 1988–1999 (Kern et al. 2001), 45,000–46,500 in The Dalles Reservoir in 2000 (Burner et al. 2000) and 2,200–24,000 in John Day Reservoir in 1990–1996 (Burner et al. 2000). From 1995–2000, the sport and Treaty Indian commercial harvest in these three reservoirs ranged respectively from 1,240–1,630 and 1,000–1,850 (Bonneville), 50–860 and 310–1,342 (The Dalles) and 80–600 and 310–1,260 (John Day), with comparatively larger catches during the latter years. However, in the three reservoirs above Bonneville Dam, successive year-class failure and poor recruitment occasionally occurs (Parsley and Beckmann 1994). This is offset by transplanting sturgeon collected below Bonneville Dam into these reservoirs (Rien and North 2002; Kern et al. 2003). The higher populations in the above estimates reflected this transfer.

White sturgeon are relatively abundant between McNary and Priest Rapids dams, including the Hanford Reach (Haynes et al. 1978; Crass and Gray 1982). The population was estimated at 4,600 individuals in 1995 (Burner et al. 2000). In this section most of the sturgeon resided in the free-flowing Hanford Reach upstream from Ringold Springs. Sturgeon are also known to ascend the Yakima River to a point 68 km above its confluence with the Columbia near Prosser (Patten et al. 1970).

In contrast, sturgeon populations in the upper Columbia Basin, particularly above Grand Coulee Dam, are severely depressed and still declining because few juveniles are recruited to adult populations. Currently (2009), no sport harvest is allowed. White sturgeon populations that occur in reservoirs above the confluence of the Snake and Columbia rivers vary, with some reservoirs in both rivers supporting large numbers and others very few. At some of the upriver locations such as Kootenai River and Lake Roosevelt, large-sized adult sturgeon are relatively common but few juveniles or subadults are present, indicating that
Chapter 6

recruitment failure is persistent and threatening to cause extirpation of these populations.

In the middle Columbia reservoirs populations were estimated at 134, 551, and 114 white sturgeon in Priest Rapids, Wanapum and Rocky Reach reservoirs, respectively (Golder and Associates 2003a, 2003b). In the upper Columbia River, DeVore et al. (2000) set out baited long lines and gill nets at 1 km intervals between Rock Island Dam and the international border in 1998. They collected four white sturgeon in Rock Island Reservoir ranging from 1,440–1,920 mm in fork length, seven in Rufus-Woods (Chief Joseph) Reservoir ranging from 1,390–2,150 mm in fork length, and 204 white sturgeon in Lake Roosevelt (Grand Coulee Reservoir) ranging from 320–2,700 mm in fork length. Only three of the Lake Roosevelt fish were less than 1,100 mm in fork length. All of the Lake Roosevelt sturgeon were captured between Hunters, WA (about 104 km above Grand Coulee Dam) and the international border (about 176 km above Grand Coulee Dam). Most of the fish were caught between the mouth of the Colville River and Marcus Island. Previously, between 1988 and 1990, 159 white sturgeon ranging from 699–2,252 mm in fork length were captured between Gifford, WA and the international border (Brannon and Setter 1992). Only 17 of these fish were less than 1,000 mm in fork length.

In Canada, 135 white sturgeon, ranging from 694–2,030 mm in fork length, were caught in the free-flowing portion of the Columbia mainstem between the international border and tailrace of Hugh Keenlyside (Arrow Lake) Dam (Hildebrand 1991). Only 12 of these fish were less than 1,000 mm.

Collectively, these data indicated that the sturgeon population between Grand Coulee and Keenlyside dams is comprised primarily of large-sized fish, older than 20 years (217 of 221 aged by DeVore et al. 2000, and Hildebrand 1991) with few juvenile fish recruiting to the population. In 1995, the upper Columbia population of white sturgeon was estimated at 1,120 individuals (95% CI = 980–1,300) (Hildebrand et al. 1999). Howell and McLellan (2006) estimated the Lake Roosevelt population was about 1,600–1,900 individuals, so about 3,000 white sturgeon are distributed between Grand Coulee and Keenlyside dams. The majority of fish in the population were hatched after Grand Coulee dam blocked fish runs in 1939 but few were hatched after 1980.

In British Columbia, white sturgeon were present in Arrow Lakes (Keenlyside) Reservoir (Hildebrand et al. 1999). Anecdotal reports suggested that remnant populations may still be present in Revelstoke Reservoir above Revelstoke Dam and Kinbasket Reservoir above Mica Dam, but recent sampling was unable to verify their presence (Hildebrand et al. 1999).

DeVore et al. (2000) sampled for sturgeon in the lower 45 km of the Spokane River between its confluence with the Columbia and Little Falls Dam in 1998 and caught none. However, three white sturgeon were collected in the Spokane River prior to that date near Porcupine Bay (about 16 km above the mouth), below Little Falls Dam (about 45 km above the mouth) and between the Nine Mile and Monroe Street dams (about 104 km above the mouth).

Spawning white sturgeon have been observed at the confluence of the Pend Oreille River below Waneta Dam (Hildebrand 1991), but the species does not occur in the Pend Oreille/Clark Fork/Flathead drainage in British Columbia, Washington, Idaho and Montana (Brown 1971; Holton and Johnson 1996; Simpson and Wallace 1982; Ashe and Scholz 1992; McLellan 2000; Howell and McLellan 2006).

In the Kootenai Basin, white sturgeon were present in Slocan Lake (Hildebrand et al. 1999). White sturgeon were also historically distributed from Kooteney Lake British Columbia to Kootenai Falls (Kootenai River, Montana) (Carl et al. 1967; Brown 1971; Simpson and Wallace 1982; Holton and Johnson 1996; Hildebrand et al. 1999).
Family Acipenseridae

In the lower Snake River, Washington, sturgeon eggs, juveniles, and adults have been collected in Ice Harbor, Lower Monumental and Little Goose reservoirs. From 1993 to 1998, spawning sites were identified at three locations in Ice Harbor Reservoir, two locations in Lower Monumental Reservoir, and five locations in Little Goose Reservoir (Parsley et al. 2001). Population abundance was estimated at 4,560 individuals in Ice Harbor Reservoir in 1996 (DeVore et al. 1998), 3,891 in Lower Monumental Reservoir in 1997 (DeVore et al. 1999a), and 4,861 in Little Goose Reservoir in 1997 (DeVore et al. 1999a).

White sturgeon are present between Lower Granite and Hells Canyon dams, which includes Lower Granite Reservoir and a free-flowing reach of the Snake River (Hells Canyon). They are more prevalent in the riverine section than reservoir section. In a study conducted from 1972–1975, the population in this reach was estimated at 8,000 to 12,000 individuals (Coon et al. 1977). Small sturgeon (< 91 cm) were most abundant (86% of the 876 sturgeon caught). Large sturgeon (> 183 cm) comprised 10% of the fish caught (Coon et al. 1977). This population is currently in decline because more recent population estimates (1997–2000) estimated only 3,886 white sturgeon in this reach. This decline may be related to over-harvest by sport anglers during the 1980’s. White sturgeon are present in the reservoirs between Hells Canyon Dam and Shoshone Falls (Cochnauer 1981, 1983; Lukens 1982, 1985; Cochnauer et al. 1985).

White sturgeon spawn in May and July, migrating to spawn in fast flowing water below rapids, waterfalls, and dams (Parsley et al. 2001; Paragamian et al. 2001a, 2001b, 2002). Females broadcast demersal, adhesive eggs over rock, rubble or rip-rap substrate. Fertilized eggs stick to rocks and incubate 7–8 days at 14–16°C before hatching. After hatching, yolk sac fry swim up into the water column and continue to draw nourishment from their yolk sac for 8–14 more days (Brannon et al. 1985; Muir et al. 2000).

Maximum life expectancy of white sturgeon is approximately 100 years. The oldest specimen recorded to date (from Lake Roosevelt) had a fork length of 2.7 m and was aged at 96 years. However, specimens twice this length were recorded in the historical fisheries. White sturgeon attain sexual maturity at about age 9–11 (males) and 12–32 (females). They are iteroparous but after spawning it takes several years before they can develop a sufficient store of gametes to spawn again, probably about 2–3 years for males and 3–10 years for females. Sturgeon have enormous fecundity: about 300,000 eggs in a 1.1 m long female to 4.7 million eggs in a 2.8 m long female. Sturgeons grow rapidly, typically attaining lengths of about 30 cm by the end of their first year. After this, until age 30–35 they grow about 5–8 cm per year. After age 35, growth slows to about 1–3 cm per year and growth is mainly added by weight. The white sturgeon is the largest freshwater fish in North America (Figure 6.1). The largest specimens ever recorded in the Columbia Basin was a 863 kg specimen captured in the Columbia River at Astoria, Oregon in 1892 and exhibited at the World’s Fair in Chicago (Gudger 1942) and a 675 kg, 5.6 m long specimen caught in the Snake River, Idaho in 1920 (Anderson 1988).

Subadult and adult white sturgeon are opportunistic omnivores. They use their protrusable mouth to vacuum the bottom, eating whatever live or dead fish is most abundant. Species eaten by sturgeon include: eulachon, lampreys, salmon, three-spined stickleback, sculpins, starry flounder, herring, striped bass, sucker, northern pikeminnow, smelt, carp, anchovy, and even other sturgeon (Scott and Crossman 1973; Moyle 1976a; Wydoski and Whitney 1979). Besides fish, adult sturgeon ate a variety of other prey including: mollusks (clams, snails), crustaceans (crayfish, crab, shrimp, amphipods, isopods, cladocerans), aquatic insects (chironomids), and amphibians (frogs) (Carlander 1969; McCabe et al. 1993; Muir et al. 2000).

Results from tagging and biotelemetry studies indicate that white sturgeon are usually rather sedentary, although a few individuals have migrated distances up to 1,056 km (660 miles) between the Sacramento and Columbia rivers or Columbia and Fraser rivers (Chadwick 1959; DeVore et al. 1998).
Figure 6.1  Historical photograph of a large white sturgeon from the Columbia River
(Photograph courtesy of the Oregon Historical Society, Image No. bboo6315, image sepia toned and sky color altered)
KEY TO FAMILY ACIPENSERIDAE

General Family Characters

Confirm these characters before keying to species.

2. Five longitudinal rows of scutes.
3. Inferior protrusible mouth.
4. Row of four sensory barbels in front of mouth.
5. Dorsal and anal fins inserted closer to tail than middle of body.
6. Skeleton cartilaginous, notochord persists to adult stage.

Key to the Species of the Acipenseridae of Eastern Washington

In eastern Washington, the family is represented by a single species: the white sturgeon (*Acipenser transmontanus* Richardson, 1836). The family characteristics identify this species (Figure 6.2, go to page 45).

Figure 6.2  White sturgeon are primitive bony fish considered to be “living fossils.” Their skeleton is composed mainly of cartilage rather than bone. They have many unique external identification characters that make them readily identifiable from most other fishes, including: 1) heterocercal tail (top half of caudal fin bigger than bottom half); 2) five rows of bony scutes and skin with dermal denticles (make skin feel like sandpaper); 3) notochord persists throughout life of the sturgeon; 4) sub-terminal mouth (overhung by snout), protrusible lips that drop down like a vacuum hose to suck up detritus off the bottom; and 5) row of four sensory barbels in advance of mouth to detect prey.
WHITE STURGEON

*Acipenser transmontanus* Richardson, 1836

![White sturgeon](image)

**Figure 6.3** White sturgeon (juvenile specimen), Lake Roosevelt, Stevens Co., WA.

**Primary Identification**

2. Five longitudinal rows of scutes (bony plates); one along middle of back (dorsal row), one along the middle of each side (lateral rows), and one on each side of belly (ventral rows).

**Confirming Characters**

1. Inferior, protrusible mouth.
2. Row of four large sensory barbels in advance of mouth.
3. Dorsal and anal fins situated far back along body, close to caudal fin.
4. Skin naked except for scutes and bony denticles that make bare spots of skin between scutes feel like sandpaper.

**Similar Species**

1. Similar to green sturgeon, which occurs in the Columbia River below Bonneville Dam. Differentiated by number of scutes in lateral row (23–30 in green sturgeon, 38–48 in white sturgeon), adult snout shape (V-shaped in green sturgeon, U-shaped in white sturgeon (Figure 6.2); but juvenile white sturgeon tend to also have V-shaped snouts(Figure 6.3)), and position of barbels in relation to mouth and snout (closer or about equidistant to mouth in green sturgeon, closer to snout than mouth in white sturgeon).

**Etymology**

*Acipenser*: Ancient Latin name for the sturgeon.

*transmontanus*: Across the mountains; a reference to its wide distribution in the Columbia River Basin.

**Common Name(s)**

White sturgeon (AFS name), Pacific sturgeon, Columbia River sturgeon, Sacramento sturgeon, Fraser River sturgeon.
Family Acipenseridae

Figure 6.4 White sturgeon distribution in eastern Washington.

Distribution

White sturgeon occur along the Pacific coast from Monterey, California to Cook Inlet, in the Gulf of Alaska. The Sacramento, Columbia, and Fraser rivers form the core of their range. In the Columbia Basin, they occur in the Columbia mainstem as far upstream as Revelstoke, British Columbia. In the Snake River, they occur as far upstream as Shoshone Falls, Idaho. They are present in the lower 68 km of the Yakima River, in the lower 45 km of the Spokane River (to Little Falls Dam), and in the lower 32 km of the Kootenai River (to Bonnington Falls Dam). A land-locked population occurs in the Kootenai system above Bonnington Falls in Kootenay Lake, British Columbia and the Kootenai River, Idaho and Montana. White sturgeon below Priest Rapids Dam in the Columbia mainstem are reproducing naturally in the river, their populations are relatively stable, and harvest is allowed. Those populations in the upper Columbia and Kootenai River Basin have low reproduction, their populations are decreasing, and no harvest is allowed. A white sturgeon was recovered from Sprague Lake by WDFW during a lake rehabilitation in 1985. It was transplanted into the lake by an angler who originally caught it in the Snake River.
The members of Clupeidae are distinguished by having a keel-like, knife-edged belly and conspicuous adipose eyelids. Adipose eyelids are clear flaps of tissue that function as a nictitating membrane to protect the eye. Only a single species of clupeid occurs in eastern Washington, the non-indigenous, anadromous, American shad *Alosa sapidissima*. Shad were introduced into the Sacramento River, California by the United States Fish Commission in 1871, and by 1876 had migrated as far north as the Columbia and Fraser rivers (Smith 1896; Doane 1902a, 1902b). In 1885 and 1886, 910,000 American shad were planted in the Columbia River near the confluence of the Walla Walla River, Washington and in the Willamette River, Oregon. Shad fry introduced into the Columbia River in 1885 were native to the Susquehanna River, Pennsylvania. Over the next several decades a total of 50,951,240 American shad fry were stocked routinely in the Willamette River by the USFC.

The Family Clupeidae contains economically valuable fishes such as anchovies, herrings, and sardines. These fishes are sought for their lipid (oil) content. Lipids store more calories than carbohydrates or proteins, so their flesh has a higher energy content than that of most other fishes. Clupeids are sold for human consumption and for making energy-rich food-pellets fed to a variety of animals. Clupeids are planktivorous and, in turn, prey for piscivorous fish, birds, and mammals. Their high caloric content makes them especially valuable contributors to the bioenergetics of the fish that eat them.

Clupeids are primitive deep-bodied, moderately laterally compressed, silvery fish. Clupeids have a single soft dorsal fin near the middle of the body, an anal fin positioned about midway between the dorsal and caudal fins, and pectoral and pelvic fins that lie close to the ventral midline. The pelvic fins are abdominal, inserted under the dorsal fin, with a prominent axillary process. No spines are present on any fin. They have cycloid scales and a physostome swim bladder. Clupeids lack lateral lines and have relatively larger scales than other families with the primitive body plan. Clupeids have protractile jaws and long, slender gill rakers, which are an adaptation for plankton feeding in surface waters. Their big, silvery scales reflect the sunlight filtering down from above. This camouflages them from predators below because they blend in with the many spectral points of light glittering off the surface. The ventral edge of their belly is modified into a keel, formed from a row of saw-like scales (or scutes) on either side of the midline. The scales come together to form a sharp edge similar to the scalloped serrations of a bread knife.

American shad, like salmon, are anadromous and return to the same river where they were hatched to spawn (Leggett 1973). American shad become reproductively mature at age 3–4 (males) or 4–5 (females) and have a maximum life expectancy of 8–11 years (Scott and Crossman 1973; Wydoski and Whitney 1979). They are considered to be an iteroparous species that can potentially survive to spawn a second or third time. Of 25 spawning adults examined in the Columbia River, 32% were repeat spawners in their second (n = 5) or third (n = 3) spawning run (Petersen et al. 2003).

American shad spawn in the open waters of large rivers and do not usually enter smaller tributary streams. In the Columbia River, hydroelectric dams created ideal spawning habitat for shad by forming deep, wide impoundments. Females produce about 100,000 to 600,000 eggs annually. Eggs are small, non-adhesive, semi-buoyant and drift along above the bottom carried downstream by water currents. Eggs hatch in 3–8 days. In the Columbia River, female shad typically measure 410 to 500 mm and weigh 1.1 to 1.8 kg, while males measure 410 to 500 mm and weigh 1.6 to 2.3 kg (Wydoski and Whitney 1979). The state angling records for American shad is 2.4 kg in Washington and is 2.6 kg in Oregon. Both fish were taken in the Columbia River below Bonneville Dam.
Fanily Clupeidae

Shad are size-selective planktivores that consume zooplankton such as copepods, cladocerans, amphipods, opposum shrimp, and midge larvae *Chironomous* spp. (Moyle 1976a; Wydoski and Whitney 1979). In John Day Reservoir juvenile shad (n = 134) consumed predominately copepods, cladocerans, amphipods, opposum shrimp, aquatic insects, and Asian clams (Petersen et al. 2003; Haskell et al. 2006). Wydoski and Whitney (1979) noted that little was known about the food habits of shad in the Columbia River and surrounding marine waters, so it was unknown if they competed for the same resources as salmonids.

**KEY TO FAMILY CLUPEIDAE**

**General Family Characters**

Confirm these characters before keying to species.

1. One soft-rayed dorsal fin over middle of body.
2. Pelvic fins abdominal (under dorsal fin).
3. Base of anal fin longer than base of dorsal fin.
4. Scales along ventral midline, modified into sharp scutes, overlapping to form a sawtooth keel that resembles a serrated knife.
5. Body laterally compressed.

**Key to the Species of the Clupeidae of Eastern Washington**

In eastern Washington the family is represented by a single species—the American shad *Alosa sapadissima*, (Wilson, 1811) (Figure 7.1). The family characteristics identify this species. Go to page 49.

![American shad. Drawing by USFC (in public domain) colorized by J. McMillan, EWU Graphics (top), and drawing emphasizing the sawtooth keel on the belly (bottom).](Figure 7.1)
AMERICAN SHAD

*Alosa sapidissima* (Wilson, 1811)

Figure 7.2  American shad, McNary Dam, WA.

**Primary Identification**

1. Scales of ventral midline modified into scutes that form a saw-toothed keeled edge akin to the scalloped edges of a serrated knife.
2. Large dark blotch behind gill cover followed by 2–23 (usually 3–8) smaller (fainter) spots (not always visible unless scales are removed).

**Confirming Characters**

1. Body moderately laterally compressed.
2. Anal fin longer than wide, length of base greater than length of dorsal fin base, anal rays 18–24 (usually 20–22).
3. Gillrakers numerous (about 60), long and slender.
4. Axillary process present at base of pelvic fins.

**Similar Species**

1. Salmon, trout, whitefish (*Salmonidae*): Shad have a fusiform body and axillary process at base of pelvic fins, similar to salmonids, but do not have an adipose fin. Salmon and trout have smaller scales than shad, but whitefish have scales that are similar in size to shad. Shad have belly scales modified into saw-toothed keel, not present in salmonids.
2. Sandroller (*Percopsidae*): Sandrollers possess an adipose fin and lack belly scutes.

**Etymology**

*Alosa*: Latinized old English (saxon) name (allis) of the European shad *Alosa alosa*.

*sapidissima*: From Latin *sapid* (flavor, taste) and *issima* (superlative ending); hence, most savory or most delicious. This name was originally intended to compare the American shad only to other Clupeid fishes, not other fishes in general.

**Common Name(s)**

American shad (AFS name), common shad, Atlantic shad, Potomac shad, Susquehanna shad (named for several rivers on the east coast).
Figure 7.3  American shad distribution in eastern Washington.

Distribution

In the Columbia River, before 1957, an average (range) of 125,000 (50,100 to 401,300) American shad migrated to Celilo Falls (RKM 309). In 1957, construction of The Dalles Dam inundated Celilo Falls and its shad friendly fish ladders allowed shad to annex new spawning territory above the falls. Four years later (1962), when the progeny from the 1958 brood year returned, the shad run size was estimated at 671,600. The shad run continued to increase as additional dams were constructed upstream of The Dalles in the Columbia and Snake rivers during the 1960’s and 70’s. The fish passage facilities at these dams provided easy access into new spawning territory, and the newly created reservoirs provided near perfect spawning and fry rearing habitat for shad. Shad counts at Bonneville Dam climbed to 3.0 million by 1990 and 5.3 million by 2004. In recent years, shad numbers have decreased to about 1.5–2 million fish.

At present shad ascend the Columbia as far upstream as Priest Rapids Dam. Shad cannot successfully negotiate the Priest Rapids ladder. Shad ascend the Snake River to the pool above Lower Granite Dam. The number observed in the fish ladders at Lower Granite increased from one (1975) to a peak of 33,987 (2004). Spawning shad appear to be confined to the mainstems of the Columbia and Snake rivers, although some may ascend a short distance up larger tributaries such as the Yakima, Palouse, and Tucannon rivers. For example, in 2005, seven shad were collected in a WDFW fishtrap in the Tucannon River (Mark Shuck, WDFW, Dayton, WA, pers. comm.).
Chapter 8

Family Cyprinidae: Carps and Minnows

The Family Cyprinidae contains approximately 2,000 species found in Asia, Europe, Africa, North America, and South America. Nearly all species are strictly freshwater and intolerant of even slight elevations in salinity. A few species, such as carp *Cyprinus carpio* and goldfish *Carassius auratus*, will tolerate brackish water up to 10–15 ‰ salinity for short periods of time. Most tropical freshwater aquarium fish belong to this family. At 53 genera and 256 species (Nelson et al. 2004), the Cyprinidae have the greatest diversity and widest distribution of any North American freshwater family. However, west of the Continental Divide they are limited. Only seven genera (nine species) of native minnows and six genera (six species) of introduced minnows occur in Washington. Native species include: chiselmouth *Acrocheilus alutaceus*, lake chub *Cousius plumbeus*, tui chub *Gila bicolor*, peamouth *Mylocheilus caurinus*, northern pikeminnow *Ptychocheilus oregonensis*, longnose dace *Rhinichthys cataractae*, leopard dace *R. falcatus*, speckled dace *R. osculus*, redside shiner *Richardsonius balteatus*, and introduced species include: goldfish *Carassius auratus*, carp *Cyprinus carpio*, tench *Tinca tinca*, golden shiner *Notemigonus crysoleucus*, and fathead minnow *Pimephales promelas*. One additional introduced species is the grass carp *Ctenopharyngodon idella*, which have been reported in a few isolated lakes, so we have not included them in our main key but, instead, included them in Chapter 20.

The American Fisheries Society has recently recognized the Umatilla dace *Rhinichthys umatilla* as occurring in eastern Washington (Nelson et al. 2004). We have not included it because we believe it is a color variant of the speckled dace (See Figure 8.4, page 81). Umatilla dace resembled the light colored variant of speckled dace but are supposed to more closely resemble leopard dace because they have weakly developed pelvic stays. However, we have observed both the light and dark colored forms together at several locations (Spokane, Palouse, Crab Creek basins) in eastern Washington and never found any with rudimentary pelvic stays.

Minnows, along with the suckers (Family Catostomidae), belong to the order Cypriniformes. Members of both families have a primitive body plan, relatively fusiform (variable in minnows) with a single soft-rayed dorsal fin (usually attached over the midpoint of the body). Pelvic fins are usually in the abdominal position under the dorsal fin. Cypriniformes have cycloid scales and a physostome swim bladder. They do not have spines in their fin rays (except carp and goldfish which have spines that develop in a different manner from those possessed by spiny-rayed fishes). Neither minnows nor suckers have teeth in their mouth. Instead, in both families, the fifth gill arch bears pharyngeal teeth (Figure 3.5). Minnows have one to three rows of pharyngeal teeth, with never more that six teeth in any one row. Suckers have one row of 16 or more pharyngeal teeth that resemble a picket fence (Figure 3.5). The mouth of the minnows are usually terminal but can vary from sub-terminal to oblique. The mouth of suckers is usually sub-terminal (inferior) and they have large lips with many sensory papillae.

The pharyngeal teeth of minnows are a useful character that can be used for taxonomic identification. These teeth are located in the back of the throat. One to three rows are present on the last gill arches. The teeth on each side are oriented inward in an overlapping arrangement to form a basket in the throat. In some species the teeth are knife-like, resembling canines or incisors. In this case the teeth on opposite sides bear against each other like a milling machine to cut up prey. In other species the pharyngeal teeth are molar-like with grinding surfaces. In this case, they pulverize food against the hard palate on the roof of the mouth. Each species has its own distinctive pharyngeal tooth formula, similar to the dental formula that is used for mammal identification. The teeth in each row are counted and read from left to right. A comma is used to separate rows on the same side and a dash is used to separate sides; so the formula 2,4–4,2 indicates that there are two teeth in the outer row, and four teeth on the inner
row of the left arch, and four teeth on the inner row, and two on the outer row of the right arch. In order to see the teeth and discern the tooth formula, the last gill arch must be dissected out and examined under a magnifying glass; so pharyngeal teeth are of limited value in field investigations. However, since the tooth formula in combination with tooth shape are diagnostic, pharyngeal teeth make an excellent confirming character. See Eastman and Underhill (1973) which discusses variation in the pharyngeal tooth formulas of cyprinids.

Minnows spawn in the late spring and summer. Their reproductive behavior is keyed to water temperature. Spawning begins when water warms beyond a lower set point (typically in the range of 10–20°C) and stops when temperatures increase above an upper set point (typically 15–25°C). If the water cools back down below the upper set point; a second episode of spawning may occur in one season. In lowland valleys spawning may occur earlier (May) than in mountain streams where temperatures are influenced by snowmelt, which can postpone spawning until late June or July. Male minnows typically develop nuptial tubercles and become more brightly colored during the breeding season (Figure 8.1). Minnows typically move into shallow water to spawn over gravel, rocky, or cobble substrate. Species that spawn over this type of substrate include chiselmouth, carp, lake chub, peamouth, northern pikeminnow, longnose dace, leopard dac, and redside shiner. Others species, including goldfish, tui chub, golden shiner, and tench spawn over vegetation.

A contrasting type of reproductive behavior is displayed by fathead minnow, which lay their eggs underneath macrophytes, logs, or rock ledges. Males select the nest site, herd receptive females into position below it, and assist the female in turning on her side. The female deposits its adhesive eggs on the underside of these structures. Males develop a distinctive fleshy pad on their back between the nape and dorsal fin, which is a secondary sexual character (Smith and Murphy 1974). This pad is used to collect eggs and press them tight against the nest in order to cement them to it. The male also uses this pad to stroke and roll the developing eggs. Males guard the nest and provide parental care by fanning the eggs to circulate oxygenated water through them. Male fathead minnows develop formidable nuptial tubercles on their head and jaws. They drive intruders away from the nest by butting them with the tubercles.

![Figure 8.1](image-url)  Male redside shiner in spawning coloration. Inset shows minute spawning tubercles (pearl organs) on head and back.

Maximum lifespan attained by various species of minnows was 7 years for chiselmouth, 14 years for goldfish, 21 years for carp, 5 years for lake chub, 7 years for tui chub, 10 years for golden shiner, 14 years for peamouth, 2 years for fathead minnow, 19 years for northern pikeminnow, 5 years for longnose dace, 4–5 years for leopard dace, 4 years for speckled dace, 6 years for redside shiner, and 12 years for tench (reviewed by Scholz and McLellan 2009).
Sexual maturity occurred at age 3–5 years for chiselmouth, age 2–3 for goldfish, age 1–5 for carp, age 3 for lake chub, age 1–3 for tui chub, age 1–2 for golden shiner, age 3–5 for peamouth, age < 1 year for fathead minnow, age 3–5 for northern pikeminnow, age 2 for longnose dace, age 2 for leopard dace, age 2 for speckled dace, age 3–4 for reside shiner, and age 3–4 for tench (reviewed by Scholz and McLellan 2009).

Maximum total length attained by various species of minnow in eastern Washington was 300 mm for chiselmouth, 434 mm for goldfish, 851 mm for carp, 227 mm for lake chub, 175 mm for tui chub, 300 mm for golden shiner, 310 mm for peamouth, 80 mm for fathead minnow, 710 mm for northern pikeminnow, 127 mm for longnose dace, 120 mm for leopard dace, 99 mm for speckled dace, 178 mm for redside shiner, and 483 mm tench (reviewed by Scholz and McLellan 2009).


Diets of cyprinid fish are variable. Some species are piscivores; others eat aquatic insects, periphyton (algae on rocks), or macrophyte vegetation. A few species (e.g., peamouth), specialize in snails, and others are omnivorous. This variation is related to the type of pharyngeal teeth and modifications of gastrointestinal tract possessed by each species (reviewed by Scholz and McLellan 2009).

The development of the hydrosystem has made young salmon more vulnerable to predation by concentrating them at dams. They are disoriented after passing through turbines or over spillways, which make them easy prey for predators, including northern pikeminnow, which move into the tailrace to consume them (Beamesderfer and Rieman 1991; Rieman 1991; Vigg et al 1991; Zimmerman 1999).

Beamesderfer et al. (1996) estimated that northern pikeminnow consumed approximately 16.4 million salmon and steelhead smolts annually throughout the Columbia and Snake rivers. When compared to the estimated 200 million smolts produced annually in these rivers, northern pikeminnow are believed to consume 8% of the total number. Based on these results, state, federal, and tribal fisheries agencies devised a plan to reduce northern pikeminnow abundance in four lower Columbia River and four lower Snake River reservoirs. Essentially, this program pays a bounty or cash reward to anglers that turn in a pikeminnow.

The northern pikeminnow management program (NPMP) was initiated in 1990 and has continued to the present time. The purpose of the NPMP was to reduce northern pikeminnow predation on salmon smolts. The NPMP was an outgrowth of the work of Rieman and Beamesderfer (1990) whose research documented that a 10–20% exploitation rate applied to the largest members of the pikeminnow population could result in a 50% reduction in consumption of juvenile salmonids by northern pikeminnow. This is because northern pikeminnow don’t consume many salmon smolts until they attain a length of about 280 mm. The NPMP pays anglers to harvest larger sized pikeminnow by offering a bounty or “sport reward.” The program requires that anglers check their fish at one of 12 check in stations located on the Columbia and Snake rivers. In 2007 anglers received $4.00/fish for the first 100 fish > 280 mm turned in, $5.00/fish for fish number 101 to 400, and $8.00/fish for each fish number 401 and above. Researchers also have tagged...
fish to measure exploitation rates. In 2007, anglers received $500.00 for turning in a tagged fish. The program is paid for by Bonneville Power Administration hydroelectric ratepayer dollars. From 1990–2006, 2,855,253 northern pikeminnow > 280 mm were eradicated by anglers. During the period 1991–2006, the sport reward exploitation rate averaged (ranged) 12.3 (6.8–19.0%) per year based on the number of marked fish of this size turned in by anglers. This amount of pikeminnow removal has decreased their predation on salmon by 25% (Friesen and Ward 1999). Since 16 million salmon were annually consumed by pikeminnow before the NPMP began, this translates into 4 million smolts per year that are saved, provided that smallmouth bass, walleye, and channel catfish did not consume more smolts. No evidence of compensatory feeding by these species was found (Ward and Zimmerman 1999; Friesen and Ward 2000). The annual budget for the NPMP has varied from about $1.4 million to $6.8 million per year and averaged $3,028,759 per year over the past 17 years (1990–2006), for a total of $50,154,291. Of this total, payouts to anglers totalled $14,325,560 and averaged (ranged) $842,680 ($12,508–$1,786,777) per year. The remainder was used to cover administrative, research, and monitoring costs associated with the program. The cost to remove each fish was $17.56.

Minnows occupy diverse habitats and often serve as vital links in the food chain within their communities. Because they are relatively small-sized and have only soft fins they make ideal prey for piscivorous fishes, piscivorous wading birds, kingfishers, water snakes, and other predators. Tagging and radiotracking studies have revealed that most species of minnows are rather sedentary (reviewed by Scholz and McLellan 2009).

KEY TO FAMILY CYPRINIDAE

General Family Characters

Confirm these characters before keying to species.

1. One dorsal fin, usually in about the middle of the body.

2. Pelvic and pectoral fins inserted near ventral midline; pelvic fins in abdominal position, origin slightly in front of or under anterior insertion of dorsal fin.

3. Origin of anal fin slightly in front, under, or slightly behind posterior insertion of dorsal fin.

4. All fins without spines (except a few species) may have one (anterior-most) spiny dorsal, anal, and pectoral rays.

5. No teeth in jaws.

6. Mouth position variable (sub-terminal, terminal, or oblique), without thick lips.

7. Pharyngeal teeth present on last pharyngeal arch in one, two, or three rows, with no more than six teeth in any row. (Difficult to see unless dissected out).

Key to the Species of the Cyprinidae of Eastern Washington

1. A. Dorsal fin long with ≥ 13 rays. First ray of dorsal and anal fins have stout spine with serrated posterior edge.  
Go to 2

B. Dorsal fin short with ≤ 12 rays. Spine absent on first ray of dorsal and anal fins.  
Go to 3
2. A. Two maxillary barbels present on each side of upper jaw.

   ![Diagram of Terminal Mouth and Two Maxillary Barbels]

   - Terminal mouth
   - Two maxillary barbels

B. Maxillary barbels absent from upper jaw.

   ![Diagram of Terminal Mouth and No Barbels]

   - Terminal mouth
   - No barbels

3. A. Caudal fin truncate (square); not forked. Marigold eye.

   ![Diagram of Marigold Eye and Caudal Fin Truncate]

   - Marigold eye
   - Mouth oblique
   - One maxillary barbel

B. Caudal fin moderately or distinctly forked (upper and lower tips may be pointed or lobed).

   ![Diagram of Caudal Fin Forked]

   - Caudal fin forked

**Carp**
*Cyprinus carpio*
Page 65

**Goldfish**
*Carassius auratus*
Page 61

**Tench**
*Tinca tinca*
Page 85

**Go to 4**
Family Cyprinidae

4. A. Lower jaw straight-edged and chisel-like palate.  
   
   ![Lower jaw subterminal, straight-edged and chisel-like](image)

   B. Lower jaw not straight-edged and chisel-like.  

5. A. Fleshy keel present on abdomen between pelvic fins and anus. Scales do not pass midline. Keeled edge along midline with half scales.  

   ![Fleshy keel](image)

   B. Fleshy keel not present on abdomen between pelvic fins and anus.  

6. A. Anal fin long, with ≥ 10 rays (usually more than 13). Body somewhat (noticeably) laterally compressed.  

   ![Anal fin](image)

   B. Anal fin short, with < 9 rays (except northern pikeminnow which occasionally have ten rays). Body usually not noticeably laterally compressed.  

7. A. First dorsal fin ray stubby (about ½ size of other dorsal fin rays). Lateral line incomplete (ends below dorsal fin or somewhere on anterior part of caudal peduncle).  

   ![First dorsal fin](image)

   B. First dorsal fin ray not stubby. Lateral line complete (extends to posterior margin of caudal peduncle).  

Chiselmouth  
*Acrocheilus alutaceus*  
Page 59

Golden shiner  
*Notemigonus crysuseas*  
Page 71

Redside shiner  
*Richardsonius balteatus*  
Page 83

Fathead minnow  
*Pimephales promelas*  
Page 73
8.  A. Mouth sub-terminal or inferior, overhung by snout.  
   B. Mouth terminal or oblique, not overhung by snout (except in peamouth, snout may slightly overhang terminal mouth).  

9.  A. Frenum connects upper lip to snout (i.e., groove not completely separating upper lip from snout). Snout extends far beyond mouth (somewhat shark-like).  
   B. Frenum absent (i.e., groove completely separates upper lip from snout). Snout extends only slightly beyond mouth.  

10. A. Top edge of dorsal fin falcate (concave or indented). Pelvic fin joined to body by fleshy stays (pelvic rays that insert directly onto body).  
    B. Top edge of dorsal fin not falcate (straight or rounded). Fleshy pelvic stays absent.
11. A. Mouth terminal (may be slightly overhung by snout).  
B. Mouth distinctly oblique.  

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Tui chub  
Gila bicolor  
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12. A. Mouth large, terminal, long upper jaw extends back to or beyond front margin of the eye, no maxillary barbel or axillary process.  
B. Mouth small, short upper jaw, does not extend back to eye, small maxillary barbels present (may be inconspicuous).  

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Northern pikeminnow  
Ptychocheilus oregonensis  
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13. A. Small (inconspicuous) maxillary barbels present at each corner of the jaw; small, weakly developed axillary process present at base of each pelvic fin.  
B. Small thread-like maxillary barbels present slightly in advance of the corner of the jaw. No axillary process at base of each dorsal fin.  

Peamouth  
Mylocheilus caurinus  
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Lake chub  
Couesius plumbeas  
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CHISELMOUTH

_Acrocheilus alutaceus_ (Agassiz and Pickering, 1885)

**Figure 8.2** Chiselmouth, Little Falls Reservoir, Spokane River, Lincoln/Stevens Cos., WA. Inset shows detail of chisel-like lower lip. See also photo in 4A page 56 of key for another view of the lip.

**Primary Identification**

1. Lower jaw with hard, straight, beveled cutting edge (like a chisel).
2. Mouth overhung by snout; in sub-terminal position.
3. Lateral line complete, curved slightly downward with 85–93 scales.

**Confirming Characters**

1. Upper lip fleshy, but has a small hard palate upon which the lower lip bears.
2. Pelvic fin origin underneath or slightly in advance of dorsal fin.
3. Anal fin origin underneath or slightly behind posterior insertion of dorsal fin.
4. Eyes relatively large.

**Similar Species**

1. Distinguished from other minnows by its chisel-like lower jaw, adapted for scraping periphyton off rocks. No other minnow has a lower jaw so straight (from side to side). Most often confused with peamouth, which have small, rounded mouths, and northern pikeminnow, which have terminal mouths that open to a large gape.
2. Like suckers, the mouth of a chiselmouth is sub-terminal. In suckers the lower lip is fleshy with papillae instead of with a smooth, hard, chisel-like edge.

**Etymology**

_Acrocheilus_: Sharp lip (refers to chisel-like lower lip).

_alutaceus_: Leathery texture.

**Common Name(s)**

Chiselmouth (AFS name), hardmouth, hardmouthed chub.
Figure 8.3  Chiselmouth distribution in eastern Washington.

Distribution

The chiselmouth is restricted to the Columbia and Fraser River Basins above the points of tidewater influence. It occurs in Washington, Oregon, Idaho, and British Columbia, and in the Harney Basin (Malheur Lake Drainage) in Oregon and northern Nevada. Prefers slow moving rivers and streams, but occasionally found in lakes. In Washington, it occurs throughout the Columbia and Snake river mainstems and in the Lewis, Walla Walla, Touchet, Tucannon, Grande Rhonde, Palouse, Yakima, Crab Creek, Okanogan, and Spokane sub-basins (Wydoski and Whitney 1979; Lee et al. 1980). In the Spokane Basin, it does not occur above Spokane Falls but does occur in Latah (Hangman) Creek, Little Spokane River, and Chamokane Creek. In the Palouse River, it occurs both above and below Palouse Falls. In the Crab Creek Basin it occurs in upper Crab Creek, in and above Moses Lake. It was historically reported in Moses Lake (Groves 1951), and lower Crab Creek (Schultz and DeLacy 1935/1936), but has not been reported from these locations for many years. It has not been collected in the mainstem or tributaries of the Pend Oreille River. It is not present in coastal streams of Washington, Oregon, or British Columbia and does not occur in Montana or Wyoming.
GOLDFISH

*Carassius auratus* (Linnaeus, 1758)

Figure 8.4  Goldfish, Clear Lake, Spokane Co., WA.

**Primary Identification**

1. Long dorsal fin with 15–18, usually 17, rays.
2. First ray of dorsal and anal fins have stout spines, with serrated posterior edges.
3. No maxillary barbels.

**Confirming Characters**

1. Goldfish are highly variable in color, ranging from blood red, to brilliant orange, to gold, to olive-green, to mottled white-orange calico colors. Wydoski and Whitney (1979) noted that goldfish usually revert to olive-green coloration because the brightly colored ones are eaten by piscivorous fish or birds. However, in lakes of eastern Washington, most individuals have retained their brilliant colors.

**Similar Species**

1. Like goldfish, carp have a long dorsal fin (18–20 rays) and spinous first dorsal and anal rays, but are distinguished by the presence of two pairs of maxillary barbels.
2. All other cyprinids have short dorsal fins (≤ 12 rays) and first dorsal ray is not spiny.
3. Suckers have sub-terminal mouths with big fleshy lips covered by papillae.

**Etymology**

*Carassius*: Latinization of vernacular names Karausche or Karass applied to native eastern European Crucian carp (*Carassius carassius*).

*a auratus*: (L.) Golden or gilded.

**Common Name(s)**

Goldfish (AFS name), golden carp.
Distribution

Goldfish are native to Asia and Eurasia, where artificial breeding and pond culture began as early as 960 A.D. by the Chinese Royal Court. They were introduced to Washington and Idaho in 1878, when the USFC began to supply applicants who wanted them for decorative ponds. Goldfish escaped from these ponds and became established in natural waters. Additional goldfish populations resulted from unauthorized releases of pets into Washington waters by well-meaning people who, tired of caring for them, thought it would be more humane to release them in the wild rather than kill them. Goldfish have also been intentionally (and illegally) introduced as forage for warmwater sport fish by so called “bucket biologists.”

Wild goldfish were established in Washington waters (Schultz and Delacy 1935/1936), in Moses Lake by 1942 (Chapman 1942; Groves 1951). Since then large populations have become established in Clear and Medical lakes (Spokane Co.) and Jump Off Joe Lake (Stevens Co.) (Krival 1982). Smaller numbers have been collected in Amber, Down’s, Fish, Liberty, Newman, and West Medical lakes (Spokane Co.) and in the Spokane River (Lincoln and Stevens Cos.), Pend Oreille River (Pend Oreille Co.) (Bennett and Liter 1991), Yakima River (Benton Co.) (Karp et al. 2002) and reservoirs, and reservoirs of the lower Columbia River. Wild goldfish also occasionally occur in the Snake River Basin, Idaho (Simpson and Wallace 1982).
LAKE CHUB
_Couesius plumbeus_ (Agassiz, 1850)

Figure 8.6  Lake chub. Photograph courtesy of University of Michigan, Museum of Zoology. Used with permission.

**Primary Identification**

1. Maxillary barbels small, thread-like, slightly in front of the corner of the mouth.
2. Caudal peduncle long and slender.
3. A single dark mid-lateral stripe is present along the entire length of the body in individuals < 50 mm, but becomes indistinct on the posterior half of the body of individuals > 50 mm.
4. Anal fin with eight rays. Origin is slightly to moderately far behind the posterior insertion of the dorsal fin.
5. Pelvic fin usually slightly in front of or beneath anterior insertion of dorsal fin.

**Confirming Characters**

1. Head separated from trunk by distinct notch.
2. Lateral line complete with slight downward curve.
3. Color is leaden silvery on sides, lighter below, with darker mid-lateral band. Both sexes develop small nuptial tubercles on head, nape, on breast in front of pectoral fins, and on rays of pelvic fins.

**Similar Species**

1. Lake chub are most similar to tui chub. The two species are distinguished by the relative thickness of their caudal peduncle. It is relatively thick in tui chub and relatively narrow in lake chub.

**Etymology**

_Couesius_: Named in honor of American ornithologist and naturalist, Dr. Elliot Coues.

_plumbeus_: Lead-colored.

**Common Name(s)**
Lake chub (AFS name), northern chub.
Distribution

The lake chub is dispersed across the northern United States and Canada between the Atlantic and the Pacific coasts, north to the Arctic Ocean and interior of Alaska. Lake chub were not discovered in Washington until 1978 when 117 specimens were collected at Bonaparte Lake, Okanogan River Basin (Beecher and Beecher 1979). An unreported collection event actually occurred prior to that date, in 1950, when nine specimens were sampled from Twin Lakes, Snohomish Co. and placed in the UW Fish Collection (UW 12531). Apparently, the population in Twin Lakes was extirpated because none have been found since. A single lake chub was collected among 53,552 total fish sampled in Box Canyon Reservoir of the Pend Orielle River (Ashe and Scholz 1992). A lake chub was also collected in Cedar Lake (Pend Oreille Co.) in 2001 by Molly Hallock and Paul Mongillo (WDFW).

In Idaho, lake chub were collected in Pend Oreille Lake (Schultz 1936) and Kootenai River Basin (Simpson and Wallace 1982). In Montana, it occurs throughout most of the Missouri River Basin but not in the Kootenai or Clark Fork/Flathead River Basins (Holton and Johnson 1996). In British Columbia, lake chub occur at the following locations in the Columbia Basin: Okanagan, Similkameen, Kettle, and Kootenay rivers. It also occurs throughout most of the Fraser River and Peace River Basins.
CARP

*Cyprinus carpio* (Linnaeus, 1758)

**Figure 8.8** Carp, Sprague Lake, Adams/Lincoln Cos., WA. Inset shows details of two barbels on upper jaw.

**Primary Identification**

1. Long dorsal fin with 18–20 rays. First dorsal and anal rays have stout spine with serrated (saw-toothed) posterior edges. Short anal fin (always five rays).
2. Two large, fleshy maxillary barbels on each upper jaw. Mouth terminal.
3. Carp typically have large scales, usually 35–39 in lateral line row.

**Confirming Characters**

1. “Mirror carp” have enlarged scales, scattered over body with intervening patches of naked skin. “Leather carp” lack scales, except for maybe one row along the dorsal midline below the dorsal fin.
2. Nuptial tubercles present on both sexes during spawning season, small and scattered over body.

**Similar Species**

1. Like carp, goldfish have 18–20 dorsal rays and first dorsal and anal fin rays are spiny, but goldfish lack maxillary barbels.
2. Suckers have sub-terminal or inferior mouths, with fleshy lips covered by papillae.

**Etymology**

*Cyprinus*: An ancient Greek common name for the carp. The Greek and Latin root *Cypr(i)* means lovely and refers to Aphrodite or Venus, Goddess of Love. The name was given to carp in reference to its great fecundity.

*carpio*: Latinized form of carp. *Carp-* is a Greek root for fruit, which again may be an indirect reference to its enlarged ovaries during the spawning season.

**Common Name(s)**

Common carp (AFS name), carp, Asiatic carp, German carp, mirror carp, leather carp. Koi are common carp that are, in Japan, selectively bred to accentuate certain decorative characters such as calico coloration or enlarged fins for raising in ornamental ponds.
Distribution

The common carp was originally indigenous to temperate regions of Asia and introduced to Europe during the Crusades. Asian carp from Germany were distributed throughout the United States and Canada by USFC between 1877 and 1896. Shipments were sent separately to Washington and Idaho each year from 1882 to 1896. Eventually, carp became established in each state. In eastern Washington they spread throughout the Columbia River Basin and entered southern British Columbia in about 1917, using the Okanogan River as a migration corridor (Carl et al. 1967; McCrimmon 1968). Today they are widespread throughout eastern Washington. Comparatively fewer carp are found in the panhandle region of Idaho (Simpson and Wallace 1982), where they are apparently confined to portions of the Palouse (Maughan et al. 1980) and Latah (Hangman) creek drainages (Laumeyer and Maughan 1973; Maughan and Laumeyer 1974). Carp have not been reported from the Columbia River headwater tributaries in either Montana (Brown 1971; Holton and Johnson 1996) or Wyoming (Baxter and Stone 1995).
Primary Identification
1. Mouth oblique.
2. Thick caudal peduncle.
3. Lateral line starts below the eye, circles behind the eye, forms a distinct hump over the operculum and is strongly down-curved behind this point.

Confirming Characters
1. Pelvic fin origin is under anterior insertion of dorsal fin.
2. Anal fin origin is under or behind posterior insertion of dorsal fin.
3. Scales are relatively large (41–63, usually 44–60, scales in a lateral series).
4. Eyes relatively large. No maxillary barbel or pelvic axillary process.

Similar Species
1. Most similar to northern pikeminnow, redside shiner, and lake chub. Pikeminnow have large terminal mouths. Redside shiners have a long anal fin (with 10–24, usually 13 or more, rays) whereas tui chub has short anal fin (with 7–9, usually eight, rays). Lake chub have a thin caudal peduncle and small thread-like maxillary barbel (difficult to see without magnifying lens) in the corner of the mouth.

Etymology
*Gila*: After the Gila River, tributary of the Colorado River. The generic name was so called to differentiate the morphologically distinctive minnows of the Colorado and Great Basins from other North American minnows (Baird and Girard 1854). Later, related species including the tui chub where found in the Columbia Basin, Washington, Oregon, and Idaho.

*bicolor*: Two-colored. Adults have dusky olive, brown, or brassy-colored backs above the lateral line and white to silver belly below the lateral line.

Common Name(s)
Tui chub (AFS name), roach, Columbia River roach. Moyle (1976a) noted the name derived from Paiute Indian names for the species “tui-pagwi.” *Pagwi* in the Paiute language means minnow (Loud and Harrington 1929). The meaning of the modifier *tui* is unknown. Chub is an old European name for large-sized minnows.
Tui chub distribution in eastern Washington.

**Distribution**

Tui chub is a native, primarily lake-dwelling, species, occurring in the Columbia, Snake, Klamath, Sacramento, Lahontan, Humbolt, Owens, and Mojave river basins in Washington, Idaho, Oregon, Nevada, and California. They are most numerous in isolated lakes of the desert basins east of the Sierra Nevada Mountains in northern California and coastal range in southern Oregon. The Columbia Basin is at the edge of their distribution. They have been reported in the Central Columbia Basin, primarily in lakes of the lower Crab Creek Basin and Potholes Reservoir, and the lakes of the Grand Coulee between Banks and Moses lakes. Historically, tui chub were abundant in this region, but since 1945 populations in many of these lakes were extirpated when the WDFW converted many of them to trout production by periodically treating them with rotenone. During the first rotenone treatments of these lakes thousands or tens of thousands of tui chub were killed. At the present time tui chub are uncommon or rare throughout this region.
PEAMOUTH  
*Mylocheilus caurinus* (Richardson, 1836)

Figure 8.12 Peamouth, Pend Oreille River, Pend Oreille Co., WA, in breeding colors. Inset shows detail of small, rounded mouth.

**Primary Identification**
1. Mouth small and rounded. Small maxillary barbels present slightly in advance of the corner of the jaw.
2. Usually two dark lateral bands visible: Top stripe runs approximately along lateral line from head to caudal peduncle, bottom stripe below lateral line from head to about insertion of pelvic fins.
3. Axillary process (weakly developed) present at the base of each pelvic fin.

**Confirming Characters**
1. Pelvic fin origin is slightly behind anterior insertion of dorsal fin. Anal fin origin is distinctly behind posterior insertion of dorsal fin.
2. Breeding males develop nuptial tubercles on head and anterior part of back, and bright red patches of color on lower lips and at bases of paired fins. Lateral bands may also develop red or orange coloration. Breeding females also ‘color up’ but usually not as vivid as in males. Females do not develop tubercles.

**Similar Species**
1. Most similar to northern pikeminnow and chiselmouth. The relative shape and size of the mouth (small and round in peamouth, large in pikeminnow, chisel-like lower lip in chiselmouth) separates these species.

**Etymology**
*Mylocheilus*: *Mylo* = a mill or millstone (grinder); *cheilus* = lip. The name refers to their propensity for crushing snails.

*caurinus*: Scott and Crossman (1973) noted that the name was derived from *caurus*, the northwest wind; so *caurinus* would mean something like “of the northwest.”

**Common Name(s)**
Peamouth (AFS name), peamouth chub, Columbia River chub (Bean 1882; Doane 1902a, 1902b). The Spokane Indians called this fish ‘kw-tseen’, which means ‘red-mouth,’ which is the color of the lips in spawning fish (Osterman 1995).
Peamouth occur in the Columbia, Snake, Fraser, Nass, Skeena, Athabasca, and upper Peace River basins of Washington, Idaho, Montana, Oregon, British Columbia, and Alberta. They also occur in coastal streams of the Olympic Peninsula and Puget Sound (McPhail 1967) and on Vancouver Island and other islands off the British Columbia Coast (Carl et al. 1967; Scott and Crossman 1973). Peamouth occur in varying degrees of abundance throughout most of the Columbia and Snake rivers and their principle tributaries in Washington, but appear to be absent from the Palouse Basin upstream from Palouse Falls and from upper Crab Creek Basin above Moses Lake. In the Columbia River Gilbert and Evermann (1894) called the peamouth “an abundant and a widely distributed fish in the lower Columbia Basin.” Few have been reported in the Walla Walla Basin. They are particularly abundant in the Pend Oreille River. They are rare in the Spokane River above Little Falls Dam (RKM 45). They were abundant in Lake Roosevelt, but are now rare, probably due to predation by walleye.

In Idaho, peamouth occur in the Snake River below Shoshone Falls, but not in any tributaries, such as the Clearwater, Salmon, or Boise rivers (Simpson and Wallace 1982). Peamouth are widely distributed in British Columbia, south of the 55°N latitude (Carl et al. 1967; Scott and Crossman 1973). They are common in most lakes of southern British Columbia in the Columbia, Okanagan, and Kootenai drainages (Dymond 1936).
**GOLDEN SHINER**

*Notemigonus crysoleucas* (Mitchill, 1814)

Figure 8.14  Golden shiner North Twin Lake, Ferry Co., WA. Inset shows detail of the fleshy keel.

**Primary Identification**

1. Fleshy keel on abdomen between pelvic fins and anus. Scales extend to, but do not pass over, the keel. Keeled edge with half scales.
2. Posterior edge of anal fin falcate (sickle shaped) with 11–13 anal rays.
3. Lateral line strongly decurved.
4. Mouth oblique (upturned) at 45° angle.

**Confirming Characters**

1. Anal fin base longer than dorsal fin base.
2. Base of pelvic fins distinctly in front of anterior insertion of dorsal fin.
3. Pelvic axillary process present in some individuals, absent in others.

**Similar Species**

1. Redside shiner: Lateral line decurved. Lack the fleshy keel between pelvic fins and anus.
2. Tui chub: Lack the fleshy keel between the pelvic fins and anus.

**Etymology**

*Notemigonus*: (G.) Angled back.

*crysoleucas*: (G.) Golden white.

**Common Name(s)**

Golden shiner (AFS name), roach, bream, gudgeon.
Family Cyprinidae

Distribution

The golden shiner was originally distributed throughout eastern North America, from the Gulf of Mexico to southern Canada, from the Atlantic Ocean west to the Great Plains. It is one of the most popular bait fish in North America and has been introduced illegally at many locations west of the Continental Divide by bait bucket transfer (Fuller et al. 1999). Golden shiners were recorded from Round Lake and North and South Twin Lakes, on the Colville Indian Reservation, Ferry Co. in eastern Washington (Fairbanks et al. 2004). They were first observed in these lakes in the 1980’s. In 2003, electrofishing, gill net, and trap net surveys were conducted at North and South Twin Lakes. Golden shiner accounted for 49% of the relative abundance (n = 460 of 939 total fish sampled) in North Twin Lake and 48.5% of the relative abundance (n = 1,446 of 2,981) fish sampled in South Twin Lake (Fairbanks et al. 2004). No golden shiners were collected in either lake during fish surveys made in 1965 and 1975 (Halfmoon 1978). Specimens of golden shiner in the UW Fish Collection include UW111064 (ten specimens collected in Swauk Creek, Kittitas Co. in 1993) and UW111102 (11 specimens collected in the Tucannon River, Columbia Co., near Starbuck, WA on 14 September 1980).

Figure 8.15  Golden shiner distribution in eastern Washington.
FATHEAD MINNOW

*Pimephales promelas* (Rafinesque, 1820)

![Fathead minnow, Pine Creek, Whitman Co., WA. Large photo is a male with spawning tubercles on face and spongy dorsal pad in front of dorsal fin (preserved in alcohol). Inset shows a nonspawning fish (natural color).](image)

**Figure 8.16**

**Primary Identification**

1. First dorsal fin ray short (about ½ the length of other rays).
2. Lateral line incomplete, usually terminates below dorsal fin. However, the character is variable. Some specimens have lateral lines that extend to anterior of caudal peduncle.
3. Breeding males have spongy pad extending from nape to middle of dorsal fin and nuptial tubercles in three main rows on snout and on lower jaw.

**Confirming Characters**

1. Posterior edge of dorsal fin rounded.
2. Origin of anal fin under or behind posterior insertion of dorsal fin.
3. Origin of pelvic fins are under or slightly behind anterior insertion of dorsal fin.
4. Scales relatively large 41–54, usually 40–50, in lateral series. Only carp and goldfish have larger scales (fewer in a lateral series).

**Similar Species**

1. Distinguished from other minnows by the short, stubby, first dorsal ray and incomplete lateral line. These characters are diagnostic for this species in eastern Washington; no other minnow has an anterior dorsal ray as short as this. All other minnows in eastern Washington have complete lateral line extending to posterior edge of caudal fin.

**Etymology**

*Pimephales*: (G.) Fat head.

*promelas*: (G.) Before black, refers to dark patches usually present on head and operculum, particularly in spawning males.

**Common Name(s)**

Fathead minnow (AFS name), northern fathead minnow, blackhead minnow.
Distribution

The native distribution of the fathead minnow was in the Mississippi River and Great Lakes drainage between the Appalachian and Rocky Mountains. Historically, fathead minnow did not occur west of the Continental Divide. There is no record of introduction in Washington, but they are now established at various locations throughout the state. Fathead minnows collected in July 1979 from Martha Lake, Snohomish Co. were placed in the UW Fish Collection (Scholz et al. 2004). Since then, they have been collected at the following sites in eastern Washington: 1) North and South Twin lakes and Elbow Lake on the Colville Indian Reservation, Ferry Co. in 1981 and 1982; 2) a farm pond connected by an irrigation canal to the Yakima River, Yakima Co., in 1995 (E. Anderson, WDFW, Yakima, pers. comm.); and 3) Rock Creek drainage (Palouse River Basin), Spokane and Whitman Co. in 2002 (Scholz et al. 2004; Glover 2004; Fox 2005; Porter 2006). Additionally, fathead minnow were collected from 1998–2001 at seven locations in western Washington (Scholz et al. 2004).

Fathead minnow occur throughout the Missouri River drainage, Montana and have been reported at a few locations in the Clark Fork drainage of western Montana (Brown 1971, Holton and Johnson 1996). Fuller et al. (1999) noted that fathead minnow have been introduced both intentionally (to provide forage for predators) or unintentionally (by bait anglers who purchased them from bait supply companies and then discarded unused minnows in the lakes and streams). Their occurrence in Washington is probably related to this type of activity.
NORTHERN PIKEMINNOW

Ptychocheilus oregonensis (Richardson, 1836)

Figure 8.18  Northern pikeminnow, Pend Oreille River, Pend Oreille Co., WA. Inset shows detail of large terminal mouth and fold in upper lip.

Primary Identification


Confirming Characters

1. Juveniles (30–70 mm) have black spot (schooling mark) present on caudal peduncle. This disappears when the fish attains a length of about 70 mm.

2. Breeding males develop small (nearly inconspicuous) nuptial tubercles on head, back, paired fins, anal and caudal fin.

Similar Species

1. Pikeminnows are the largest western minnow. Small pikeminnows resemble redside shiners, chiselmouth and peamouth. The presence of a schooling mark on the caudal peduncle in small specimens can help to separate them from other species.

2. Anglers often confuse pikeminnows with walleye. Pikeminnow have one dorsal fin (soft-rayed) whereas walleye have two dorsal fins (spiny and soft-rayed).

Etymology

Ptychocheilus: Folded lip. The skin of the mouth behind the inner surface of the upper lip has a series of radiating folds all around its edge and the lower lip is separated from the jaw by a furrow when the mouth is open (Agassiz 1855).

oregonensis: Of Oregon (or Oregon River) being an old name for the Columbia River.

Common Name(s)

Northern pikeminnow (AFS name). Known for many years by the common name northern squawfish (considered to be pejorative to Indian women) (Nelson et al. 1998).
Northern pikeminnow occur west of the Continental Divide in the Columbia and Fraser River Basins of Washington, Oregon, Idaho, Montana, and British Columbia (Lee et al. 1980). Found in virtually all of the lakes, rivers, and tributaries in the Columbia, Okanogan, Pend Oreille, and Kootenai drainages, British Columbia (Dymond 1936; Carl et al. 1967). Northern pikeminnow are relatively abundant in the Yakima River drainage (Patten et al. 1970; Mongillo and Faulconer 1982). They occur in the Wenatchee, Chiwawa, Entiat, Stehekin, Methow, Similkamen, Okanogan, and San Poil rivers and in lakes Chelan and Wenatchee. They are present in the Spokane and Little Spokane river drainages and their tributaries (McLellan 2002, 2003, 2004; Lee 2005). They occur in the Colville, Kettle, and Pend Oreille rivers and their tributaries (Bennett and Liter 1991; Ashe and Scholz 1992; McLellan 2001; Conner et al. 2003, 2005, 2006; McLellan and Vail 2005). They are abundant in the Snake River reservoirs (Bennett et al. 1983). In the Palouse system, they are present in the mainstem (Maughan et al. 1980) and throughout Union Flat Creek (Havens 1996, 1997) but absent in the Cow Creek above lower Cow Creek Falls and Rock Creek above Towell Falls. They have been collected throughout the Walla Walla mainstem (Mendel et al. 2006), in Palmer Lake, Okanogan Co. (Osborne et al. 2003a), Curlew Lake, Ferry Co. (Phillips and Divens 2001), and Bead Lake, Pend Oreille Co. (Rader 2006).
LONGNOSE DACE

*Rhinichthys cataractae* (Valenciennes, 1842)

**Figure 8.20** Longnose dace, Rock Creek, Whitman Co., WA. Inset shows details of frenum.

**Primary Identification**

1. Mouth sub-terminal, greatly overhung by snout.
2. Upper lip not completely separated from snout by groove. Instead, the anterior portion of lip is broadly fused to snout forming bridge-like frenum.
3. Pelvic fin origin under or slightly in front of anterior insertion of dorsal fin.
4. Anal fin origin under or slightly in front of posterior insertion of dorsal fin.

**Confirming Characters**

1. Maxillary barbels present at corner of mouth (tiny and inconspicuous, virtually impossible to see without magnifying lens).
2. Lateral line complete and straight.
3. Breeding males develop red or orange patch on mouth, pectoral, and pelvic fins.

**Similar Species**

1. Most similar to speckled dace and leopard dace. Neither of these species has a frenum. Instead the upper lip is completely separated from the snout by a groove.
2. The sub-terminal mouth makes the longnose dace superficially resemble a baby sucker. However, the lips of suckers are fleshy and covered by papillae.

**Etymology**

*Rhinichthys*: (G.) Snout fish. (Refers to prominent snout that overhangs the mouth).

cataractae: (G.) Falling down (as in a water fall or cataract) a reference to Niagra Falls where the first named specimen was collected.

**Common Name(s)**

Longnose dace (AFS name). *Mot-to-nut-se* of the Shoshone-Bannock Indians (Fort Hall Reservation). Refers to the motion of the nose in eating (Gilbert and Evermann, 1894).
Distribution

The longnose dace is distributed throughout North America, from coast to coast, from South Carolina and Texas to the Arctic Ocean. It is most abundant in a belt between about 40° to 50°N latitude and occurs sporadically northward of this band. Within this range the distribution is somewhat bifurcated; one center along the Appalachian Mountains and Great Lakes region, the other along the Rocky Mountains. The longnose dace is widely distributed in Washington. In eastern Washington they are present in the Columbia mainstem, Yakima, Wenatchee, Entiat, Methow, Okanogan, Spokane, Kettle, Palouse and Tucannon, Walla Walla, and Snake river basins. We have also collected it in the Little Spokane River and Latah (Hangman) Creek.

Longnose dace are also widely distributed in Oregon (Bisson and Reimers 1977), Idaho (Simpson and Wallace 1982), Montana (Brown 1971; Holton and Johnson 1996), Wyoming (Baxter and Stone 1995), British Columbia (Carl et al. 1967; Scott and Crossman 1973), and Alberta (Nelson and Paetz 1992).

Figure 8.21 Longnose dace distribution in eastern Washington.
LEOPARD DACE
Rhinichthys falcatus (Eigenmann and Eigenmann, 1893)

Figure 8.22  Leopard dace, Willamette River, Benton Co., OR (OSU fish collection No. 15877). Inset shows detail of pelvic stays.

Primary Identification
1. Mouth slightly sub-terminal, not greatly overhung by snout. Groove completely separates upper lip from snout.
2. Pelvic fin rays modified into strut-like fleshy stays that connect the fin to the body. Upper edge of dorsal fin falcate (indented in sickle-like curve). Small maxillary barbel present at each corner of mouth.

Confirming Characters
1. Pelvic fin origin under or slightly in front of anterior insertion of dorsal fin. Anal fin origin under slightly in front of posterior insertion of dorsal fin. Lateral line complete and straight.
2. Breeding males develop small tubercles on head, back, sides, and pectoral fins. Lips and base of pelvic fins become tinged with orange or red patches.

Similar Species
1. Most similar to speckled dace and longnose dace. Neither species has pelvic rays modified into strut-like stays that connects the fin to the body.

Etymology
Rhinichthys: Snout fish. (Members of this genus have snouts that overhang the mouth to varying degrees. This species is intermediate between the longnose and speckled dace).
falcatus: Sickle-shaped (refers to indented upper edge of dorsal fin).

Common Name(s)
Leopard dace (AFS name), dace, silver grey minnow.
The leopard dace is confined to the Columbia and Fraser River Basins (Scott and Crossman, 1973; Lee et al. 1980). It inhabits the mainstem of the Columbia from the estuary to the Arrow Lakes in British Columbia. It occurs in the Snake River above Hells Canyon Dam, but has not been found above Shoshone Falls. In Washington, leopard dace have been reported from the Cowlitz, Yakima, Wentachee, Entiat, Okanogan, Similkamen, and Walla Walla rivers (Peden 1991; Mongillo and Hallock 1995).

Leopard dace are most consistently observed in the Yakima River. In 1957/1958 they accounted for 0.6% of the relative abundance throughout the Yakima Subbasin (220 of 34,733 total fish sampled) (Patten et al. 1970). Of these 28 were found at 4 of 9 sites sampled in Benton Co., 129 were found at 7 of 11 sites sampled in Yakima Co., and 63 were found at 5 of 15 sites sampled in Kittitas Co. In 1997–1999, one leopard dace was found among 1,041 total fish sampled below Prosser Dam (Benton Co.), two were among 3,234 total fish sampled below Sunnyside Dam (Yakima Co.), and none were sampled among 3,546 total fish sampled below Roza Dam (Kittitas Co.) (Karp et al. 2002). Thus, their relative abundance in the Yakima had declined to less than 0.1% (3 of 7,821 total fish). Pearsons et al. (1999) described the leopard dace as being in “low abundance and narrowly distributed” in the Yakima Basin. It should probably be listed as threatened or endangered by the State of Washington.
**SPECKLED DACE**

*Rhinichthys osculus* (Girard, 1856)

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**Figure 8.24**  Speckled dace, Latah Creek, Spokane Co., WA. The two fish illustrate the variations in color pattern. The light-colored variant (larger fish) may also be called Umatilla dace *Rhinichthys umatilla* (Gilbert and Evermann, 1894).

**Primary Identification**

1. Mouth slightly sub-terminal, not greatly overhung by snout. Groove completely separates upper lip from snout.

2. Body usually speckled. Two variations in speckle pattern. Dark gray or brown-colored individuals have silver and black-colored spots on dark background (this is most common variant). Light-colored individuals have dark spots against a light background.

3. Pelvic fin origin under or slightly in front of anterior insertion of dorsal fin.

**Confirming Characters**

1. Maxillary barbel at each corner of mouth (if present), small and inconspicuous (difficult to see without magnifying lens). Barbels absent in most specimens collected in Kettle (Peden and Hughes 1988) and Spokane (Gilbert and Evermann 1894) rivers.

2. We have observed males with red patches around mouth, pectoral, and pelvic fins, but did not notice any nuptial tubercles. Lateral line complete and straight.

**Similar Species**

1. Most similar to longnose and leopard dace. Upper lip of longnose dace is fused to the snout, forming a frenum. In leopard dace, the pelvic fin rays form strut-like stays that join the fin to the body. Speckled dace lack both a frenum and pelvic stays.

**Etymology**

*Rhinichthys*: Snout fish. (Members of this genus have snouts that overhang the mouth to varying degrees. This species has the shortest snout length, the mouth is nearly terminal).

*osculus*: (L.) Kiss, a little mouth (refers to small, puckered mouth).

**Common Name(s)**

Speckled dace (AFS name), blacked-nosed dace, or black-sided dace in lower Columbia River (Schultz 1936). Called dusky dace, western dace, Pacific dace in Idaho (Keil 1928).
Distribution

Speckled dace are the most widely distributed native western minnow. They occur on the western slopes of the Rocky Mountains in the United States from the Canadian to Mexican borders. They are abundant along the routes of the Columbia, Snake, Green, and Colorado rivers. They are common in the desert basins of Washington and Oregon east of the Cascade Mountains and also in the coastal streams of those states. Speckled dace are rare in the Columbia and Snake river mainstem reservoirs; however, they are abundant in their tributaries. These include the Crab Creek drainage in Grant and Lincoln counties, and the Yakima, Walla Walla, Wenatchee, Entiat, Methow, and Okanogan/Similkamen rivers in Chelan and Okanogan counties (e.g., see Patten et al. 1970; Mendel et al. 2000, 2001a, 2001b, 2002, 2003, 2004a, 2004b, 2004c, 2005, 2006). Speckled dace are rare in the mainstem reservoirs of the Spokane River but are abundant in its tributaries (McLellan 2002, 2003, 2004, 2005). Speckled dace have been collected in the Colville and Kettle rivers (McLellan and Vail 2005), but have not been reported from the Pend Oreille mainstem. However, they are abundant in Bead Lake, an isolated lake in Pend Oreille Co. (Radar 2006). In southeastern Washington, speckled dace are both widely distributed and relatively abundant throughout the Snake and Palouse river drainage. They are particularly abundant in Palouse River tributaries such as Cow Creek, Union Flat Creek (Havens 1996, 1997), Rock Creek (McLellan 2000; Porter 2006), Pine Creek (Glover 2004), and Cottonwood Creek (Fox 2005).

Figure 8.25 Speckled dace distribution in eastern Washington.
**REDSIDE SHINER**  
*Richardsonius balteatus* (Richardson, 1836)

![Redside shiner, Cottonwood Creek, Whitman Co., WA.](image)

**Figure 8.26** Redside shiner, Cottonwood Creek, Whitman Co., WA.

**Primary Identification**

2. Body deep and noticeably laterally compressed.
3. Narrow caudal peduncle.
4. Lateral line complete and down-curved.

**Confirming Characters**

2. Back dusky, lighter below, but a dark band just above the lateral line bisects the light area, which gives a girdled appearance.
3. Males develop stunning coloration and profuse nuptial tubercles on the head, front part of body, and paired fins during the spawning season. See Figure 8.2. Females lack nuptial tubercles and have drab coloration.

**Similar Species**

1. Carp/goldfish have long dorsal fin (18–20 rays). Redside shiner has a short dorsal fin (< 12 rays).
2. Redside shiners have a relatively long anal fin (10–24, usually at least 13 rays) compared to most other minnows (9–10 dorsal rays).

**Etymology**

*Richardsonius*: After Sir John Richardson, MD., author of *Fauna Borealis Americana*.

*balteatus*: Girdled (refers to the dark band above the lateral line).

**Common Name(s)**

Redside shiner (AFS name), bream; red-sided bream; Columbia River minnow, Richardson’s minnow, silver-sided shiner (Keil 1928).
Figure 8.27  Redside shiner distribution in eastern Washington.

Distribution

The redside shiner is a native minnow distributed west of the Rocky Mountains from the Bonneville Basin in northern Utah and Nevada to the Nass and Peace river systems in British Columbia and Alberta. The interior Columbia Basin in Washington, Oregon, Idaho, western Montana, and southern British Columbia forms the heart of its range.

TENCH
*Tinca tinca* (Linnaeus, 1758)

Figure 8.28 Tench, Silver Lake, Spokane Co., WA. Inset shows detail of marigold eyes.

**Primary Identification**
1. Square caudal fin. (This character is diagnostic).
2. Bright orange or marigold eye.
3. Slimy to touch (makes this minnow slippery, like a greased pig, to handle).
4. Scales very small, embedded (95–105 in lateral series).
5. Mouth oblique. Large, fleshy maxillary barbel at each corner of mouth.

**Confirming Characters**
1. Pelvic fins origin under anterior insertion of dorsal fin. Anal fin origin behind posterior insertion of dorsal fin.
2. Color is olive-green to gold (skin looks like leather). Variation shown in Figure 8.28.
3. Short dorsal fin with nine rays. First dorsal and anal rays are not spiny.

**Similar Species**
1. Minnows. Tench is the only cyprinid found in eastern Washington with square tail, all others are forked. No other minnow has so many scales in lateral series.
2. Tench resemble carp and goldfish, but both species have long dorsal fins (18–20 rays) and first dorsal and anal fin rays are spiny.
3. Suckers. Tench has oblique (upturned) mouth; suckers have sub-terminal or inferior mouths with fleshy lips covered by papillae.

**Etymology**
*Tinca*: Latinization of the Old English word for tench.

**Common Name(s)**
Tench (AFS name), golden tench, yellow tench, “doctor of fishes” (English name). Refers to the ability of tench slime to cure other fishes of sores or fungal spots.
Figure 8.29  Tench distribution in eastern Washington.

Distribution

Tench, native to Europe, Eurasia, and eastern Asia, were introduced to North America by the USFC in 1883; into eastern Washington and north Idaho in 1895–1896. In 1895 they were introduced in several lakes near Spokane and into Diamond Lake near Newport at the head of the Little Spokane River. Local populations became established in eastern Washington, Idaho, Oregon, and southern British Columbia. Tench are no longer present in Diamond Lake (Phillips and Divens 2000b), but they have colonized several lakes that are farther down the Little Spokane drainage—Sacheen (Divens et al. 2002c), Fan (Divens et al. 2002b), Horseshoe (McLellan et al. 2005), and Eloika (Divens et al. 2001) lakes. Tench occur in many lakes near Spokane, Cheney, and Deer Park. It occurs throughout much of the Spokane River in Long Lake (Osborne et al. 2003), Little Falls (Heaton 1992), and Grand Coulee reservoirs. It occurs in the Palouse drainage in Sprague, Bonnie, and Rock lakes (Taylor 2000; McLellan 2000; Phillips 2006). Tench are abundant in the Pend Oreille reservoirs (Ashe and Scholz 1992; McLellan 2001). Tench were captured in Sullivan Lake (Pend Oreille Co.) (Nine and Scholz 2005). Tench occur throughout the Columbia mainstem in John Day, McNary, Priest Rapids, Wanapum, Rocky Reach, Rock Island, Wells, Chief Joseph, and Grand Coulee reservoirs and in the Hanford Reach of the Columbia River (Gray and Dauble 1977b, 1977c; Dell et al. 1975; Burley and Poe 1994; Pfeifer et al. 2001; Gadomski et al. 2004). Tench have also been reported from the Columbia basin project area in Banks (Polacek et al. 2003) and Moses (Burgess 2003a, 2003b, 2003c) lakes.
Chapter 9
Family Catostomidae: Suckers

The Family Catostomidae (suckers) is composed of 14 genera and about 76 species distributed in freshwaters of China, Siberia, and North America (Nelson 1984, 1994; Moyle and Cech 2004). Of these, 13 genera and 75 species occur in North America (Burr and Mayden 1992; Harris and Mayden 2001). One genus and four species are native to eastern Washington: longnose sucker *Catostomus catostomus*, bridgelip sucker *Catostomus columbianus*, largescale sucker *Catostomus macrocheilus*, and mountain sucker *Catostomus platyrhynchus*.

Catostomids have a primitive body plan, with a fusiform body and a single soft-rayed dorsal fin. Their pelvic fins are abdominal, with both sets of fins attached on the ventral side of the body close to the midline. They are physostomes and have cycloid scales.

Catostomids are among the most abundant fishes inhabiting rivers and streams throughout North America (Moyle and Cech 2004), including the Columbia Basin. For example, suckers comprised 12% of 16,855 fish sampled in five mid-Columbia River reservoirs (Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells) (Burley and Poe 1994). Suckers comprised 39% of 7,460 fish sampled in Chief Joseph (Rufus Woods) Reservoir (Gadomski et al. 2004), and 21% of 176,719 fish sampled in Grand Coulee Reservoir (Lake Roosevelt) from 1966 to 2006 (Colville and Spokane Tribes of Indians, EWU, USFWS, and WDFW).

Catostomids were also relatively abundant in the 2nd order tributaries of the Columbia River. Suckers comprised 34% of 48,029 total fish sampled in four reservoirs (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) on the Snake River, Washington (Bennett et al. 1983), 14% of 59,076 total fish sampled on the Yakima River (Patten et al. 1970); 45% of 8,279 total fish sampled in Little Falls Reservoir on the Spokane River (Heaton 1992); 27% of 5,791 total fish sampled on Long Lake Reservoir on the Spokane River (Osborne et al. 2003c); 61% of 1,991 total fish sampled in Nine Mile Reservoir on the Spokane River (McLellan 2003); 71% of total fish sampled in a free-flowing segments of the Spokane River between Spokane and the Idaho border (McLellan 2004b); 29% of 1,930 total fish sampled in Boundary Reservoir on the Pend Oreille River (McLellan 2001); and 8% of 77,037 total fish sampled in Box Canyon Reservoir on the Pend Oreille River between 1987 and 1991 (Bennett and Liter 1991; Ashe and Scholz 1992).

Some noteworthy aspects of catostomid distribution in eastern Washington are:

1. Catostomid distribution data for eastern Washington indicated that suckers were generally more abundant in U-shaped river valleys, in meandering streams with low gradient, slow to moderate current velocities and a balance of riffle, run, and pool habitats. In such streams sucker occupied the runs and pools. Typically, catostomids were most abundant at the head of a pool rather than the tail. Riffle habitat was usually avoided by suckers, but produced aquatic insects they preyed on.

2. Catostomids were generally absent or rare in V-shaped river valleys with steep gradients, characterized by few pools, and a predominance of falls, cataracts, and cascades with fast current velocity.

3. Largescale and longnose suckers are “big river” fishes, i.e., they thrive in big rivers with slow currents, reservoirs, and lakes. They are more numerous in the Columbia mainstem and large 2nd order tributaries than in 3rd, and 4th, or 5th order tributaries.

4. In contrast, bridgelip and mountain suckers occupy riverine habitats with moderate current. Bridgelip suckers are usually the dominant species in 3rd, 4th, and 5th order streams.
5. Bridgelip sucker are absent in 2nd order tributaries (e.g., Kettle, Pend Oreille, and Kootenai rivers) that join the Columbia above Kettle Falls. They are also absent in the portions of these rivers that occur in British Columbia, Idaho, and Montana.

6. Longnose suckers occur east and west of the Continental Divide throughout Canada and bordering U.S. states. In the Columbia Basin, longnose suckers are fairly common in the Columbia River and 2nd order tributaries above Chief Joseph Dam, but rare below it. Longnose suckers were uncommon between Chief Joseph and Priest Rapids dams. We found no records that verified their presence below Priest Rapids Dam, although it is possible that high runoff might displace longnose suckers downstream, so it would not be surprising to encounter them occasionally in the Lower Columbia River.

7. The center of mountain sucker distribution was in the Rocky Mountains of Idaho, Montana, Utah, and Wyoming. Eastern Washington is at the edge of their range.

Suckers are known to hybridize with each other in nature, particularly largescale and bridgelip suckers (Dauble 1980, 1986; Dauble and Buschbom 1981). In the Hanford Reach of the Columbia River the percentage of largescale × bridgelip sucker hybrids in the total catostomid population was estimated at 3.0–14.6% based on the number of individuals that were intermediate in meristic characteristics. For example, the number of scales in the lateral line row was 62–83 in bridgelip sucker, 88–124 in largescale suckers, and 80–92 in their hybrids.

Suckers spawn from April–July usually over cobble substrate. Suckers are group spawners, where one female is surrounded by four to eight males. The female broadcasts adhesive, dermersal eggs over the surface of the substrate. Conspicuous nuptial tubercles (pearl organs) develop on the anal fin, lower lobe of the caudal fin, caudal peduncle, pelvic fins, and on the head in advance of the spawning season (Figure 9.1). These are more pronounced in males than females.

During the spawning season, longnose, bridgelip, and mountain suckers develop a bright red lateral stripe that runs the length of their body, whereas largescale suckers develop a black stripe (Figure 9.1). Eggs hatch in about 5–10 days. Newly hatched fry have terminal mouths and feed in the water column on zooplankton. By age of 2 months, as a consequence of their growth, their mouths shift into the inferior position and begin to develop fleshy lips. They begin to orient to the substrate and take up their bottom-dwelling existence.

Maximum lifespan in eastern Washington (based on aging scales) was about 12 years for longnose sucker, 11–12 years for bridgelip sucker, 15 years for largescale sucker, and 7 years for mountain sucker (reviewed by Scholz and McLellan 2009). Age at sexual maturity in eastern Washington (based on aging scales) was 4–5 years for longnose suckers, 5–7 years for bridgelip suckers, 5–9 years for large scale suckers, and 2–5 for mountain suckers (reviewed by Scholz and McLellan 2009). Maximum total length attained in eastern Washington was about 450 mm (17.7 in) for longnose suckers, 568 mm (22.4 in.) for bridge-lip suckers, 693 (27.3 in.) for largescale suckers, and 225 mm (8.9 in.) for mountain suckers (reviewed by Scholz and McLellan 2009).


Suckers are bottom feeders, locating and sucking up invertebrates, algae, and organic detritus with their sensitive, flexible lips. Suckers lack teeth in their jaws, but possess 16 or more pharyngeal teeth in one comb-like row on the fifth gill arch, which acts like a picket fence to prevent large indigestible items from entering the gastrointestinal tract (GI) (Figure 3.5).
When food passes through the pharyngeal teeth it is broken up similar to the way a multi-blade vegetable slicer works. As suckers consume much vegetation composed of cellulose, passage through the GI tract must be slow for them to be able to digest and absorb nutrients from it. In most fish, the stomach and intestine of the GI tract forms a straight tube that is shorter than the total length of the fish. In contrast, suckers have a long, highly convoluted intestine that is about 1.5–2.0 times the total length of the fish. This is an adaptation associated with herbivory. Animals generally lack enzymes that digest plants, so plant material (periphyton, filamentous algae, and aquatic macrophytes) must remain in the GI tract for a longer period of time for a fish to digest and absorb nutrients from it.

Food takes longer to pass through the looped intestine of suckers than the straight GI tract of most fish, so suckers can actually gain nutrients by eating and digesting plants. It is unknown if the GI tract of suckers contains symbiotic bacteria to aid in the digestion of plants, similar to the situation with grazing terrestrial mammals where the bacteria digests the grass and the mammal absorbs the excretory products produced by the bacteria. Suckers also have gill rakers on their gill arches, which are used to strain zooplankton.

North American suckers have evolved into three basic types (Smith 1966; 1992):

1. Typical medium-sized suckers, with inferior mouths, which occupy a wide range of habitats. They are considered a “big river fish” because they are most often found in mainstem portions of large rivers or in lakes connected to large rivers. They are adapted to sluggish water and they are usually substrate feeders. Most members of genus *Catostomus*, including the longnose sucker and largescale sucker, fall into this category;
2. Small, often slender-bodied, suckers that are more specialized to occupy tributaries. A few members of the genus *Catostomus* including the mountain sucker and bridgelip sucker are of this type. They have cartilaginous plates (or “bridges”) underneath their lips (particularly noticeable below the lower lip), which have evolved for scraping invertebrates and periphyton off rocks in fast flowing streams; and

3. Deep bodied suckers that inhabit the open waters of lakes and big rivers. They have terminal mouths that are adapted for zooplankton feeding. Suckers of this type are classified under different genera from *Catostomus* and are not found in the Columbia River.

However, largescale, bridgelip, and possibly longnose suckers, can sometimes become facultative planktivores. Lake Roosevelt, the reservoir behind Grand Coulee Dam, experiences 50–80 ft annual drawdowns for flood control, which precludes the development of a stable littoral zone. As a result, benthic macroinvertebrate production in the reservoir is minimal and fish species that are normally dependent on the benthic component of the food web have shifted to feeding on limnetic zooplankton (Black et. al. 2003). In Lake Roosevelt, largescale and bridgelip suckers were routinely observed in embayments on the surface eating zooplankton.

Suckers mainly eat a variety of aquatic insects, (crustaceans, cladoceran zooplankton, amphipods, cray fish) and molluscs (clams and snails), periphyton, diatoms and filamentous algae (reviewed by Scholz and McLellan 2009). They occasionally eat fish eggs and larvae.

Suckers are often despised by anglers, and sometimes even by fish managers, as ‘trash’, ‘rough,’ or ‘coarse’ fish, because they have the mistaken reputation for competing with game fish and preying upon eggs of salmonids. For example, Carl (1936) reported that kokanee eggs were found in the stomach contents of largescale sucker in a lake in British Columbia. While it is true that suckers occasionally eat the eggs of salmon and trout, these claims have been greatly exaggerated. In nearly every food habits investigation of a variety of sucker species, the dominant food eaten was aquatic invertebrates, plant material, and organic detritus. Dauble (1986) found no salmon eggs in the diet of largescale suckers collected in the Hanford Reach of the Columbia River in the vicinity of where Chinook salmon were spawning. The Hanford Reach is a major fall Chinook salmon spawning ground and their eggs are readily available to suckers patrolling the area. Holey et al. (1979) conducted an extensive literature review regarding sucker predation on game fish eggs. They concluded there was no evidence of harmful interactions between suckers and game fish.

In point of fact, suckers have co-evolved with salmonid fishes. Salmonids typically bury their eggs, which protects them from suckers which probe only the surface of the bottom substrate searching for food. Also, salmonids spawn in the fall and spring, when water temperatures are cold and the metabolism of suckers slows appreciably.

Suckers actually benefit game fish populations because:

1. Fry and juvenile suckers are present in the diets of a variety of game fish.
2. Suckers eat food (algae and detritus) that are not utilized by game fish. By eating these types of food, then being eaten by game fish, suckers link this material into the game fish biomass.
3. Suckers are broadcast spawners, laying adhesive eggs that stick on the surface of the substrate and make easy targets for predatory fishes.

In fact, sucker eggs may actually be more prone to predation by salmonids than the other way around. For example, we have observed rainbow trout in California Creek, Spokane Co., consuming eggs of bridgelip sucker that had migrated into the lower reaches of the creek from Latah Creek to spawn. When the rainbow stomachs were pumped, sucker eggs were the dominate food item found in the gut contents, comprising > 90% of the total food.
consumed. The Idaho Department of Fish and Game (IDFG) found that cutthroat trout in Coeur d’Alene Lake migrated into the Spokane River during the largescale sucker spawning season and gorged exclusively upon sucker eggs. MacPhee (1960), Dauble (1986), and Beauchamp (1995) also reported that Chinook salmon, sockeye salmon, and steelhead trout seasonally foraged on sucker eggs and larvae.

One advantage of consuming eggs is that their lipid content makes them an especially rich source since 1 g of lipid contains more calories of energy than 1 g of carbohydrate. Thus, salmonids made up for their own energetically taxing migration and spawning by consuming an especially nutritious food. Moreover, salmonids expended minimal energy to search for, capture, and subdue their prey because sucker eggs were immobile. Individual trout or salmon stomachs contained hundreds to thousands of sucker eggs, indicating that sucker eggs may be seasonally important in the diet. Mountain suckers were eaten by brown trout, rainbow trout, and brook trout as well as by birds and mammals (Wydoski and Wydoski 2002).

Juvenile largescale suckers living in large rivers or lakes move inshore during the day to feed and offshore at night presumably to avoid predatory fish that move inshore at night to feed (McPhail and Lindsey 1970). However, in Lake Roosevelt we have observed, young-of-the-year and yearling walleye in shallow water during the day preying on sucker fry. Sucker fry were the most important (> 50% by weight) fish prey found in the diets of young walleye in Lake Roosevelt (Nigro et al. 1983). Juvenile suckers were the important fish in the diet of channel catfish and smallmouth bass in John Day Reservoir (Gray et al. 1984). Juvenile suckers were found in the diets of northern pike, channel catfish, and white sturgeon in the Hanford Reach of the Columbia River (Dauble 1986).

Suckers also couple aquatic and terrestrial food webs. For example, in a study of bald eagle Haliaeetus leucocephalus nesting behavior in Lake Roosevelt, over the entire nesting season 13% of the prey delivered by adults to their nests throughout the reservoir were catostomids (SAIC 1996). Adult largescale sucker was the most common resident fish in the diet of bald eagles wintering in the Hanford Reach of the Columbia River (Fitzner and Hanson 1979). Subadult and adult sucker are also prey in diets of osprey Pandion haliaetus, and great blue heron Ardea herodias (reviewed by McEvoy 1998).

KEY TO FAMILY CATOSTOMIDAE

General Family Characters

Confirm the specimen has these characters before keying to species.

1. No teeth in jaws; mouth inferior and sucker-like, with large fleshy lips covered in rows of papillae.
2. One dorsal fin, usually in about middle of body.
3. Pelvic and pectoral fins inserted near ventral midline; pelvic fins in abdominal position, origin is about under the posterior insertion of the dorsal fin.
4. Origin of anal fin always far behind the posterior insertion of the dorsal fins, about midway between dorsal and caudal fin.
5. All fins without spines.
6. Pharyngeal teeth present on last pharyngeal arch, always in one row, with 16 or more comb-like teeth (difficult to see without dissection) (See Figure 3.5, page 16).
Figure 9.2  Comparison of sucker mouths. A) Longnose sucker; B) Largescale sucker; C) Bridgelip sucker; D) Mountain sucker

Key to the Species of the Catostomidae of Eastern Washington

1.  A. Lower lip completely cleft.
    Refer to Figure 9.2 A, B.  
    Go to 2

    B. Lower lip incompletely cleft.
    Refer to Figure 9.2 C, D.  
    Go to 3

2.  A. Dorsal fin with 9–12 rays.  
    Longnose sucker
    *Catostomus catostomus*
    Page 93

    B. Dorsal fin with 13–15 rays.  
    Largescale sucker
    *Catostomus macrocheilus*
    Page 97

3.  A. No notch on each side of mouth between upper and lower lip.
    Bridgelip sucker
    *Catostomus columbianus*
    Page 95

    B. Distinct notch on each side of mouth between upper and lower lip.
    Mountain sucker
    *Catostomus platyrhynchus*
    Page 99
LONGNOSE SUCKER

*Catostomus catostomus* (Foster, 1773)

Figure 9.3  Longnose sucker, Lake Roosevelt, Ferry/Lincoln/Stevens Cos., WA. Inset shows completely cleft lower lip.

**Primary Identification**

1. Lower lip “completely” cleft. Rows of papillae 0–1 (rarely two) between anterior end of cleft and mouth.
2. Dorsal fin taller than wide (at base), with 9–11 rays.
3. Scales relatively small, and uniform in size along length of body.

**Confirming Characters**

1. Scales in lateral line row 95–120. More than 15 scales in diagonal row above lateral line.
2. Breeding males have nuptial tubercles on anal, caudal, pelvic fins; develop bright red band along side of body (Figure 9.1, page 89).

**Similar Species**

1. Largescale suckers have a completely cleft lower lip, and posterior scales much larger than anterior scales. Dorsal rays 12–16 (usually 13–15).
2. Bridgelip and mountain suckers have an incomplete cleft on the lower lip. At least two rows of papillae, usually 3–4 cross the midline.

**Etymology**


**Common Name(s)**

Longnose sucker (AFS name), northern sucker, and fine scaled sucker. Salish sucker refers to a distinct form found in the Puget Sound drainage of Washington and lower Fraser River of southwestern British Columbia. The Spokane Indians did not distinguish between species of suckers but called them all "chl-ene," which means ‘face hangs down’ (Osterman 1995).
Figure 9.4 Longnose sucker distribution in eastern Washington.

Distribution

The longnose sucker is the most widely distributed species of sucker in North America. In the contiguous United States, it occurs in New England, Great Lakes, Northern Great Plains (Upper Missouri River System), and Pacific Northwest (throughout the Columbia and Snake River Basins).

Longnose suckers are present in at least 11 of 20 eastern Washington counties. Longnose suckers were reported from Columbia River reservoirs upstream of Priest Rapids Dam, but no records were found indicating their presence in the Columbia River reservoirs below this point (e.g., Hjort et al. 1981) or in the Snake River reservoirs (e.g., Bennett et al. 1983). Longnose suckers have also been reported in various water bodies associated with the Columbia Basin irrigation project in Adams, Douglas, Franklin, and Grant Cos., and in the Hanford Reach of the Columbia River. Longnose sucker was not present in upper Crab Creek in eastern Grant and Lincoln Cos. (Scholz 2002, 2003).

Longnose sucker have also been reported in the Yakima, Wenatchee, Chelan, Okanogan, Sanpoil, Spokane, Colville, Kettle, and Pend Oreille sub-basins. They have not been reported in the Snake, Klickitat, Walla Walla/Touchet, Palouse, Tucannon, or Grand Ronde sub-basins.
BRIDGELIP SUCKER

*Catostomus columbianus* (Eigenmann and Eigenmann, 1893)

![Image of Bridgelip sucker](image)

**Figure 9.5**  Bridgelip sucker, Lake Roosevelt, Ferry/Lincoln/Stevens Cos., WA. Male with spawning tubercles. Inset shows incompletely cleft lower lip.

**Primary Identification**

1. Lower lip incompletely cleft (usually 2–5 rows of papillae between anterior end of cleft and mouth).
2. No notches between upper and lower lip.
3. Cartilaginous plates form bridge below lower and upper lips.
4. No axillary process at base of pelvic fins.

**Confirming Characters**

1. Scales intermediate to large size; those on posterior are slightly larger than those on anterior (< 1.5 ×).
3. Dorsal rays 11–14 (usually 12).

**Similar Species**

1. Mountain sucker: Lower lip incompletely cleft but with distinct notches at corners of mouth. Axillary process present at base of pelvic fins.
2. Longnose and largescale suckers: Lower lip of both species completely cleft.

**Etymology**

*Catostomus*: (G.) Inferior mouth.

*columbianus*: Of the Columbia River.

**Common Name(s)**

Bridgelip sucker (AFS name), fine scaled sucker, Columbia fine scaled sucker (Hubbs and Schultz 1932a), Palouse River fine scaled sucker (Hubbs and Schultz 1932).
Figure 9.6  Bridgelip sucker distribution in eastern Washington.

Distribution

The bridgelip sucker is confined to the Columbia and Fraser river systems. They were the only suckers found in the Upper Crab Creek Basin (Lincoln Co.). It occurs in the Walla Walla/Touchet Basin. It is also common in the Snake River and its tributaries below Shoshone Falls, especially in the Palouse River, Tucannon River, and Asotin Creek basins. Bridgelip suckers have been recorded in 19 of 20 eastern Washington counties. No record of presence was found for Pend Oreille Co.

Bridgelip suckers occur, but are uncommon in the mainstem and tributaries of the lower Columbia River below Bonneville Dam (Wydoski and Whitney 2003). Bridgelip suckers are present in the Columbia River reservoirs behind Bonneville, The Dalles, John Day, McNary, Priest Rapids, Wanapum, Rock Island, Rocky Reach, Wells, Chief Joseph, and Grand Coulee dams and the Snake River reservoirs behind Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams.

They occur in the mid-Columbia tributaries in the Yakima, Wenatchee, Entiat, Chelan, Methow, and Okanogan river drainage basins. In the upper Columbia region, bridgelip suckers also occurred in the Sanpoil, Spokane, and Colville river sub-basins, but were absent in the Kettle, Pend Oreille, and Kootenai sub-basins.
LARGESCALE SUCKER

*Catostomus macrocheilus* (Girard, 1856)

![Largescale sucker, Lake Roosevelt, Ferry/Lincoln/Stevens Cos., WA. Inset shows completely cleft lower lip. Specimen preserved in formalin transferred to 70% ethanol.](image)

**Figure 9.7** Largescale sucker, Lake Roosevelt, Ferry/Lincoln/Stevens Cos., WA. Inset shows completely cleft lower lip. Specimen preserved in formalin transferred to 70% ethanol.

**Primary Identification**

1. Lower lip “completely” cleft; 0–1, rarely 2, rows of papillae between anterior end of cleft and mouth.
2. Scales relatively large; those on posterior distinctively larger than those on anterior end (> 2 × the size).
3. Dorsal fin with long base and 12–16; usually 13–15 rays.

**Confirming Characters**

1. Breeding males have pronounced nuptial tubercles on anal, caudal, pelvic fins, and on head; develop black lateral stripe along the length of the body. Females have fewer and smaller tubercles. No stripe.

**Similar Species**

2. Bridgelip and mountain suckers: Lower lip incompletely cleft (at least two rows of papillae present).

**Etymology**

*Catostomus:* Inferior mouth.

*macrocheilus:* (G.) *macro* = large, (G.) *cheilus* = lip.

**Common Name(s)**

Largescale sucker (AFS), Columbia River sucker, coarse-scaled sucker.
Figure 9.8  Largescale sucker distribution in eastern Washington.

Distribution

The largescale sucker is distributed throughout the Columbia and Fraser river systems. In the Columbia it has been found throughout the mainstem from the mouth to headwaters; and in the Snake River mainstem from its confluence with the Columbia to Shoshone Falls (Wydoski and Whitney 1979; Simpson and Wallace 1982; Bennett et al. 1983). It is also found in most of the major sub-basins of the Columbia and Snake rivers in Washington, Idaho, Oregon, Montana, and British Columbia (Schultz and DeLacy 1935/1936; Clemens 1939; Scott and Crossman 1973; Simpson and Wallace 1982; Brown 1971; Holton and Johnson 1996). It is absent in the upper Crab Creek drainage in eastern Grant, Lincoln, and Spokane Cos. Largescale suckers occur in 19 of 20 eastern Washington counties. We did not find any record of presence in Adams Co., although it probably occurs in the canals associated with the Columbia Basin Irrigation Project in the vicinity of Othello.

Largescale sucker have been reported from many locations in the Columbia Basin Project area in Grant and Franklin Cos. Largescale suckers were present in the Wenatchee, Entiat, Chelan, Methow, and Okanogan drainages, but their distribution and abundance are not well documented (Mullan et al. 1992a). It occurs in the Spokane, Colville, Kettle, and Pend Oreille rivers. It also occurs in the Walla Walla and Palouse rivers.
**MOUNTAIN SUCKER**

*Catoostomus platyrhynchus* (Cope, 1874)

![Mountain sucker](image)

**Figure 9.9** Mountain sucker, Yakima River, WA. Inset shows incompletely cleft lower lip with distinct notches at corners of mouth between upper and lower lip.

**Primary Identification**

1. Lower lip incompletely cleft.
2. Distinct notch at corners of mouth between upper and lower lip.
3. Axillary process present at base of pelvic fin.
4. Upper lip with 0–2 rows of papillae.

**Confirming Characters**

1. Cartilaginous plates form bridge below lower and upper lips.
3. Scales about the same size on both the anterior and posterior.

**Similar Species**

1. Bridgelip sucker: Lower lip incompletely cleft, but no notches at corners of mouth between upper and lower lips. No axillary process present at base of pelvic fin.
2. Longnose and largescale suckers: In both species the lower lip is completely cleft.

**Etymology**

*Catoostomus*: (G.) Inferior mouth.

*platyrhynchus*: (G.) *platy* = flat, *rhynchus* = snout. The specific epithet is somewhat misleading because the shape of the snout is not any flatter that the other three species of suckers in this key.

**Common Name(s)**

Mountain sucker (AFS name), Jordan's sucker.
Distribution

Mountain sucker distribution is centered in the basin and range topography of Utah, Wyoming, Montana, and eastern Idaho. It occurs east of the Rocky Mountain front range from Colorado, Nebraska, the Dakotas, Alberta, and Saskatchewan in tributaries of the Missouri River. It occurs in the upper Colorado River Basin of Wyoming, Utah, and Colorado; Great Basin, Nevada and Oregon; and the Columbia/Snake basins in Washington, Idaho, and British Columbia. In Washington, it is occasionally found in the Columbia, Grand Ronde, Palouse, Yakima, and Wenatchee rivers. It occurs in the Okanogan Basin, British Columbia. The mountain sucker is declining in parts of its historical range and is a candidate for listing as a protected species in Washington state (Mongillo and Hallock 1995).

In Washington, mountain suckers in the Columbia River mainstem are confined to the Hanford Reach (Gray and Dauble 1977b, 1977c). This is probably related to mountain suckers being adapted to lotic conditions. The Hanford Reach is the last remaining free-flowing segment of the Columbia River in the United States above Bonneville Dam. Lentic reservoirs apparently hold little appeal for mountain suckers. Mountain suckers have also not been recorded in the four lower Snake reservoirs (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite reservoirs) in Washington, although they do occur in a free-flowing segment of the Snake River in the Hells Canyon Reach (Idaho) between the head of the Lower Granite Reservoir and the tailrace of Hells Canyon Dam.
Chapter 10

Family Ictaluridae: Bullhead Catfishes

Ictalurids are classified in the Order Siluriformes, which is composed of 31 families and 2,211 species distributed in both fresh and saltwater (Burgess 1989). The family Ictaluridae, composed of six genera (39 species), is restricted to North America. Ictalurids are warm-water fish distributed throughout most of the United States east of the Rocky Mountains, but absent in Canada except near the international border. Five species, black bullhead *Ameiurus melas*, yellow bullhead *A. natalis*, brown bullhead *A. nebulosus*, channel catfish *Ictalurus punctatus* and tadpole madtom *Noturus gyrinus* occur in the interior waters of Washington. A 6th species, flathead catfish *Pylodictus olivarus* has occasionally been reported in Snake River reservoirs and/or Idaho waters but its establishment in Washington is doubtful. Instead, occasional specimens appear to drift downstream from Idaho where the species is established. Blue catfish *Ictalurus furcatus* and whitefish *Ameiurus catus* have been rarely reported in eastern Washington. See Chapter 20 for more details about flathead, blue, and white catfish.

Bullheads, catfish, and madtoms were originally distributed east of the Continental Divide and were introduced into Washington waters by the USFC commencing in 1896. They continued to be planted periodically at numerous locations throughout the state for several decades thereafter and eventually became establish in many lakes and reservoirs. At present, brown bullheads are relatively abundant throughout the state, and yellow bullheads are locally abundant in selected areas. Black bullheads, channel catfish, and tadpole madtom have more restricted distributions.

Ictalurids have a primitive body plan with a single dorsal fin attached ahead of the midpoint of the body, an adipose fin, pelvic, and pectoral fins arising near the midline on the ventral surface of the body, pelvic fins in the abdominal position, and physostome swim bladder. Like cyprinids and catostomids, ictalurids are classified in the superorder Ostariophysii. Like cypriniform fishes, they possess a Weberian apparatus (anterior vertebrae modified to connect the swim bladder to the inner ear), and schreckstoff (alarm substance pheromones). Unlike cypriniform fishes, siluriform fish have hundreds of tiny cardiform teeth arranged in bands on the floor and roof of the mouth (Figure 10.1).

Bullheads and catfish are iteroporous spawners and spawn annually after reaching sexual maturity. Ictalurids spawn from May–July at water temperatures of 18 to 28°C. Eggs are laid in hollow logs, beneath undercut banks or debris (tin cans, tires, or barrels). Eggs hatch in 5–10 days. Males select and clean nest sites, construct a saucer-like nest in soft bottom and line it with a layer of mucous upon which eggs are laid. Eggs are covered with a gelatinous coat. Males guard the nest and exhibit parental care by fanning the eggs. After hatching, males continue to guard offspring until they attain lengths of 25–50 mm.

After the parents leave, juvenile catfish continue living together in aggregations of hundreds to thousands of individuals moving through the water in huge balls of swirling bodies. Eventually this behavior ceases and the fish become solitary. Age and growth statistics for the five species that occur in Washington are described below.

Maximum lifespan in eastern Washington is 7–9 years for black bullhead, 7–8 years for yellow bullhead, 7–8 years for brown bullhead, 14 years for channel catfish, and 4–5 years for tadpole madtom (Scholz and McLellan 2009). Age of first spawning in eastern Washington is 2–4 years for yellow bullhead, 3 years for brown bullhead, 4–5 years for channel catfish, and 1–2 years for tadpole madtom (Scholz and McLellan 2009). Maximum total length in eastern Washington was 302 mm (11.9 in.) for black bullhead, 380 mm (15.0 in.) for yel-
Family Ictaluridae

low bullhead, 443 mm (17.4 in.) for yellow bullhead, 820 mm (32.3 in.) for channel catfish, and 112 mm (4.4 in.) for tadpole madtom (Scholz and McLellan 2009). Fecundity ranged from 3,283–6,820 eggs/female for black bullhead, from 1,500–7,000 eggs/female for yellow bullhead, from 2,000–13,000 eggs/female for brown bullhead, from 2,000–70,000 eggs/female for channel catfish, and from 48–324 eggs/female from tadpole madtom (Scholz and McLellan 2009).

Figure 10.1 Cardiform teeth of a brown bullhead.

Catfishes and bullheads are nocturnal bottom feeders. They use their eight sensory barbels to locate prey. Additionally, their entire integument is well supplied with taste receptors used for prey detection. Blind catfish grow nearly as well as those with intact vision (Houser 1960). They tend to be opportunistic scavengers that consume a variety of food types. Most species have long, coiled digestive tracts, which indicates that they can retain plant material for a long enough period to digest and extract energy from it. Black, yellow, and brown bullheads consume crustaceans (Cladocera, copepods, amphipods and crayfish), molluscs (snails and clams), aquatic insects (especially midges) and aquatic plants.

Stomachs of 655 channel catfish collected in John Day Reservoir in 1983–1986 contained 68.3% fish, 18.1% crayfish, 0.2% amphipods, 0.9% aquatic insects, 5.2% molluscs, and 7.0% other food items (Poe et al. 1991). Of the fish consumed by channel catfish, about 32.9%
were juvenile salmonids, 3.2% were castostomids, 0.1% were centrarchids, 19.4% were cotto-
dids, 5.2% were cyprinids, and 4.2% were unidentified salmonids (Vigg et al. 1991).

Of 234 channel catfish examined from the lower Yakima River from 1998 to 2002, 101
were empty, 40 contained fish (six salmonids), 89 contained aquatic insects, 37 contained
crayfish, 30 contained seeds, three birds, and three rodents (Pearsons et al. 1998a, 1998b,
2001b, 2002, 2003a). A total of 133 fish were observed, comprised of one coho salmon,
77 fall Chinook salmon, two spring Chinook salmon, one wild steelhead, six mountain
whitefish, two unidentifiable salmonids, two carp, five chiselmouth, two dace, two northern
pikeminnow, 15 suckers, three channel catfish, one sculpin, and seven smallmouth
bass. Tadpole madtom juveniles eat zooplankton and ostracods. Adults feed mainly on
aquatic insect larvae and crustaceans.

Black, yellow, and brown bullhead occur in sloughs and quiet backwaters of rivers, shallow
bays of large lakes, small lakes and ponds, in association with submergent or emergent
macrophytes (rooted aquatic plants). They tend to prefer vegetative cover, muck or silt
to sand substrates, sluggish currents, and shallow water less than four feet deep. Channel
catfish occur predominately in lakes, reservoirs, and large rivers, and prefer sand, bottoms
with moderate currents. Ictalurids generally prefer clean, clear water, but brown and black
bullheads tolerate turbidity.

After being swallowed bullheads erect their spines in the predators throat, causing them to
become lodged. Although the dorsal and pectoral spines of bullheads and catfish are a for-
midable defense mechanism, small bullheads occasionally appear in the diets of predatory
fishes such as walleye, northern pike, largemouth bass, and northern pikeminnow.

Ictalurids have a highly developed olfactory sense that is used primarily for chemical com-
munication (Todd et al. 1967, 1971). Male bullheads are normally solitary and attack other
males that encroach on their territory. They secrete aggression pheromones which warn
other males away and function to reduce aggressive encounters. Bullheads sometimes also
form aggregations. At such times they secrete a different pheromone which elicits a stereo-
typed ‘chummy’ behavior. In their classic experiment, Todd et al. (1967) and Todd (1971)
siphoned the water out of a tank of aggregated bullheads that were secreting the friendly
pheromone, and added it to a tank that contained two males each defending a territory. The
males in the second tank immediately ceased being territorial and began to associate with
one another. As this experiment was conducted in the 1960’s, the researchers called the
friendly pheromone, the ‘love-in’ pheromone. M.C. Carr and J.E. Carr (1986), of Central
Washington University, determined that the pheromone was a protein with a molecular
weight less than 10,000 daltons. When water from a aggregating group of brown bullheads
was either passed through a filter that removed particles < 10,000 MW, or had proteins
destroyed by adding proteolytic enzymes, and then piped into a tank with two aggressive
males, the two males remained aggressive. In contrast, when water from an aggregating
group of bullheads was piped into the tank with the aggressive males without being treated,
as a control, the two combatants became ‘chummy.’

Channel catfish and brown bullhead produce sounds by stridulation when the pectoral
spine is erected (Fine et al. 1997). Movement of the spine against other bones in the pectoral
girdle produces the sound. Sound production is thought to serve three purposes. First, it may function in courtship to attract mates, with members of the opposite sex detecting the sounds with their Weberian apparatus. Second, it may be intended as a warning against encroachment into a defended nest territory. Third, some authors have suggested that defensive locking of the spines and sound production are used together to warn predators about the dangers associated with these spines (Fine et al. 1997).

KEY TO FAMILY ICTALURIDAE

General Family Characters

Confirm the specimen has these characters before keying to species.

1. Adipose fin and barbels present.
2. One dorsal fin, closer to head than tail. First ray spiny.
3. Pelvic and pectoral fins inserted near ventral midline. First pectoral ray spiny.
4. Pelvic fins in abdominal position inserted behind posterior margin of dorsal fin.
5. Anal fin with longer base than dorsal fin.
7. Tiny cardiform teeth present on the floor and roof of the mouth (on the dentary and premaxillary bones) (see Figure 10.1).

Key to the Species of the Ictalurids of Eastern Washington

1. A. Adipose fin adnate (long, low; fused to or contiguous with caudal fin). Anal fin also in contact with caudal fin.  
   Tadpole madtom  
   Notorus gyrinus  
   Page 115

   B. Adipose fin short, fleshy, free from caudal fin. Anal fin well separated from caudal fin.  
   Go to 2

Page 115
2. A. Caudal fin deeply forked.  
   ![Caudal fin deeply forked]

   B. Caudal fin square or rounded.  
   ![Caudal fin square or rounded]

   Go to 3

3. A. Anterior chin barbels white or yellow.  
   ![Anterior chin barbels white or yellow]

   B. Anterior chin barbels brown, black, or gray.  
   ![Anterior chin barbels brown, black, or gray]

   Go to 4

4. A. Posterior edge of pectoral spine with strong serrations (can feel them with probe or fingernail—rough to the touch) (Figure 10.2).  
   ![Posterior edge of pectoral spine with strong serrations]

   B. Serrations on posterior edges of pectoral spine weak or absent (cannot feel them with probe or fingernail—smooth to the touch) (Figure 10.2).  
   ![Serrations on posterior edges of pectoral spine weak or absent]

   Go to 4

Channel catfish
_Ictalurus punctatus_
Page 113

Yellow bullhead
_Ameiurus natalis_
Page 109

Brown bullhead
_Ameiurus nebulosus_
Page 111

Black bullhead
_Ameiurus melas_
Page 107
Figure 10.2  Comparison of the five species of ictalurids that occur in eastern Washington.
BLACK BULLHEAD

*Ameiurus melas* (Rafinesque, 1820)

Figure 10.3  Black bullhead, Deer Lake, Stevens Co., WA. Inset shows pectoral spine that lacks serrations.

**Primary Identification**

1. Brown, black, or gray barbels.
2. Adipose fin free from caudal fin.
3. Caudal fin square or slightly rounded.
4. Posterior edge of pectoral spine not serrated, smooth to touch.

**Confirming Characters**

1. Membranes between dorsal and anal fin rays conspicuously black, darker colored than the fin rays.
2. Color on dorsal surface above lateral line is dark brown to black, usually solid (not mottled); belly yellow to milky white. Vertical bar on base of caudal fin.
3. Anal fin rays 15–19 (usually less than or equal to 18) (not including two anterior rudimentary rays).

**Similar Species**

1. Brown bullhead: Posterior edge of pectoral spine is serrated and rough to touch. Dorsal surface is dark brown to black but usually mottled.
2. Yellow bullhead: has white or yellow barbels.

**Etymology**

*Ameiurus*: Caudal fin not notched. Name intended to separate members of this genus from the genus *Ictalurus*, which have forked tails. The caudal fin of *Ameiurus* is usually truncate (square) or rounded.

*melas*: Black.

**Common Name(s)**

Black bullhead (AFS name), horned pout.
Figure 10.4  Black bullhead distribution in eastern Washington.

**Distribution**

Black bullheads were originally distributed throughout the entire Mississippi, Missouri, and Ohio river drainages, between the western slopes of the Appalachian Mountains and the eastern slopes of the Rockies. They also occurred in Gulf Coast tributaries from Mississippi to the Rio Grande River, Texas. Black bullheads were naturally distributed throughout the Missouri drainage in Montana (Brown 1971; Holton and Johnson 1996) and Wyoming (Baxter and Stone 1995). Mixed lots of black, brown, and yellow bullhead were distributed widely by the USFC in the late 1800’s, including numerous locations in the Pacific Northwest. In Montana, their presence has been recorded in the Clark Fork/Flathead drainage (including Flathead Lake) and in Kootenai River drainage (including Lake Koocanusa) of the Columbia River Basin. Black bullheads are rare in Washington (Wydoski and Whitney 1979) and Idaho (Simpson and Wallace 1982). Wydoski and Whitney (1979) were unable to verify its presence in Washington. However, WDFW biologists have collected black bullhead at a few locations in eastern Washington, including Sacheen Lake, Pend Oreille Co. (Divens et al. 2002b), Downs Lake, Spokane Co. (Phillips 2006), and Deer Lake, Stevens Co. (Divens 2002). The first confirmed black bullhead in north Idaho was collected in Round Lake, one of the lateral lakes adjacent to the lower Coeur d’Alene River in 1965 (Howse and Simpson 1969). They were also collected in Chatcolet Lake and in tributaries of the Snake River in southwestern Idaho (Simpson and Wallace 1982).
YELLOW BULLHEAD

_Ameiurus natalis_ (LeSueur, 1819)

**Figure 10.5** Yellow bullhead, Fan Lake, Pend Oreille, Co., WA.

**Primary Identification**

1. Anterior chin barbels white or yellow.
2. Adipose fin free from caudal fin.

**Confirming Characters**

1. Abrupt rise in body profile just anterior to caudal peduncle.
2. Posterior side of pectoral spine is serrated; distal anterior side of pectoral spine with 3–4 barbs.

**Similar Species**

1. Black and brown bullhead do not have any white or yellow chin barbels. All are gray, black or brown.

**Etymology**

_Ameiurus_: Caudal fin not notched. Name intended to separate members of this genus from the genus _Ictalurus_ which have forked tails. The caudal fin of _Ameiurus_ is usually truncate (square) or rounded.

_natalis_: Having large nates or buttocks. This refers to the region just anterior to the caudal peduncle having an abrupt high profile in yellow bullhead.

**Common Name(s)**

Yellow bullhead (AFS name), yellow catfish.
Figure 10.6  Yellow bullhead distribution in eastern Washington.

Distribution

The natural distribution of yellow bullhead was from the Gulf Coast of the United States to just north of the international border of Canada (north to south), and from the Atlantic seaboard (65°W longitude) to the Great Plains (about 100°W longitude). Yellow bullhead were introduced into eastern Washington along with other bullhead species by the USFC in the late 1800’s. Yellow bullhead have been collected at numerous locations in eastern Washington, including: Lake Roosevelt (McLellan et al. 1999; McLellan and Scholz 2001, 2002) in Ferry, Lincoln, and Stevens Cos., Long Lake (Osborne et al. 2003c) in Stevens and Spokane Cos.; Eloika (Zook 1978, Divens et al. 2001) and Fan Lakes (Divens et al. 2002a) and in the west branch of the Little Spokane River (McLellan 2003) in Spokane and Pend Oreille Cos., Liberty (Phillips et al. 1999), Newman (Fletcher 1982; Osborne et al. 2004) and Downs (Phillips 2006) Lakes in Spokane Co., Deer Lake (Divens 2002) in Stevens Co., Mesa Lake (Divens and Phillips 2000a) in Franklin Co.; Bennington Lake (Phillips and Divens 2001) in Walla Walla Co., Moses Lake (Burgess 2003a, 2003b, 2003c) and Billy Clapp Lake (Walton 1983) in Grant Co. They were present in Rock Island ponds, Douglas Co. prior to their rehabilitation with rotenone but none were found during electrofishing, gill netting, and fry net surveys conducted in 2000 (Osborne and Petersen 2005). They are not reported in Idaho (Simpson and Wallace 1982), Montana (Brown 1971; Holton and Johnson 1996), or Wyoming (Baxter and Stone 1996).
BROWN BULLHEAD

*Ameiurus nebulosus* (LeSueur, 1819)

**Figure 10.7** Brown bullhead, Clear Lake, Spokane Co., WA. Inset shows detail of pectoral spine serrations.

**Primary Identification**

1. Brown, black, or gray barbels.
2. Adipose fin free from caudal fin.
3. Caudal fin square or slightly notched.
4. Posterior edge of pectoral spine serrated; rough to touch.

**Confirming Characters**

1. Membranes between dorsal and anal fin rays not conspicuously black.
2. Color on dorsal surface above lateral line is dark brown to black, usually mottled. Belly yellow to white. No bar present at base of caudal fin.
3. Anal fin rays 18–21 (usually ≥ 19) (not including two anterior rudimentary rays).

**Similar Species**

1. Black bullhead: Posterior edge of pectoral spine smooth. Color of dorsal surface is dark brown to black but usually solid (not mottled).

**Etymology**

*Ameiurus*: Caudal fin not notched. Name intended to separate members of this genus from the genus *Ictalurus* which have forked tails. The caudal fin of *Ameiurus* is usually truncate (square) or rounded.

*nebulosus*: Clouded. Refers to the mottled coloration.

**Common Name(s)**

Brown bullhead (AFS name), common bullhead, mudcat, hornpout, horned pout.
Brown bullhead originally ranged along the Atlantic Coast from Nova Scotia to Florida; west to Oklahoma; north to central North Dakota and southeastern Saskatchewan; and east along the international boundary. They did not occur in Montana (Brown 1971; Holton and Johnson 1996), Wyoming (Simon 1946; Baxter and Simon 1970; Baxter and Stone 1995), or Alberta (Nelson and Paetz 1992). They were introduced by the USFC in 1881. They were first recorded as established in Washington in 1882 and 1883 (Smith 1896) and are presently distributed widely throughout the state. Brown bullhead are also distributed widely in Idaho in the Snake, Spokane, Pend Oreille, and Kootenai river corridors (Simpson and Wallace 1982).

Brown bullhead have been documented in all of the mainstem reservoirs on the Columbia and Snake rivers, and throughout the Columbia Basin Project Area. Brown bullhead also occur in most of the principle tributaries of the Columbia and Snake rivers (e.g., Walla Walla, Yakima, Okanogan, Spokane, Colville, Kettle, Pend Oreille, and Palouse rivers). They are widely distributed in lakes in all 22 eastern Washington counties.

Brown bullhead have not been reported from the Wenatchee, Entiat, Chelan, or Methow rivers.
CHANNEL CATFISH

*Ictalurus punctatus* (Rafinesque, 1818)

Figure 10.9  Channel catfish, Spokane River, Lincoln/Stevens Cos., WA. Inset shows serrated posterior edge of pectoral spine.

**Primary Identification**

1. Adipose fin free from caudal fin.
2. Caudal fin forked.

**Confirming Characters**

1. A few irregularly shaped, scattered black spots usually present on sides of body. (May be absent in juveniles).
2. Barbels on nostrils distinctly shorter (~¼ of the size) than those on the chin.
3. Posterior edge of pectoral spine serrated (rough to touch).

**Similar Species**

1. Black and brown bullheads: caudal fin square or or rounded; barbels on nostrils about same size as those on chin.
2. Yellow bullhead: caudal fin rounded; nostril barbels about same size as those on chin.

**Etymology**

*Ictalurus*: Fish cat.

*punctatus*: Spotted. Scott and Crossman (1973) reported that spots are not always present, particularly in specimens over 185 mm. However, all the specimens we have collected in Washington, which include individuals over 457 mm in length, had spots.

**Common Name(s)**

Channel catfish (AFS name), spotted catfish, Great Lakes catfish, Mississippi River catfish.
Family Ictaluridae

Figure 10.10  Channel catfish distribution in eastern Washington.

Distribution

Native distribution of channel catfish was between the crests of the Appalachian and Rocky mountains, from the Gulf Coast north to Southern Canada. Channel catfish were first stocked in Washington by the USFC in 1896. WDFW has also periodically stocked channel catfish at several locations in eastern Washington. Channel catfish occur in the Columbia River from about Longview, WA to Chief Joseph Dam and throughout the entire length of the Snake River in Washington. They also occur in Cow, Finnel, Hallin, and Sprague lakes (Adams/Lincoln Cos.), Yakima River, and several ponds (Benton Co.), Tucannon River (Columbia Co.), Rock Island and Washburn Island ponds (Douglas Co.), Kahlots Lake and Scooteney Reservoir (Franklin Co.), Alkali, Banks, Lower Goose, Moses, and Stan Coffin lakes, Potholes Reservoir, and several smaller lakes (Grant Co.), McCabe Pond (Kittitas Co.), Whitestone Lake (Okanogan Co.), Bear Lake (Spokane Co.), Walla Walla and Tocuchet rivers (Walla Walla Co.), and the Yakima River, Griffin Lake, Wenas Lake, I-82 fishing ponds, and several small ponds in Yakima Co. One was collected in Lake Roosevelt that had most likely migrated downstream from Lake Coeur d'Alene, where it was stocked by the IDFG.
TADPOLE MADTOM

Noturus gyrinus (Mitchill, 1817)

Figure 10.11  Tadpole madtom.

Primary Identification

1. Adipose fin adnate (fused to caudal fin).
2. Caudal fin rounded.
3. Small size (< 150 mm TL). Be careful if you handle a bullhead catfish smaller than 150 mm TL in the Snake River or Walla Walla River drainages because it may be poisonous.

Confirming Characters

1. Barbels on nostrils about the same size as those on the chin.
2. Pectoral spine not serrated or barbed, but sculpted or scalloped. Posterior surface is grooved to accommodate poison released from venom gland at base of spine.
3. Anal fin rays 14–16 with slight connection to the caudal fin.

Similar Species

1. Black, brown, and yellow bullhead, and channel catfish: All of these species have adipose fins that are distinct from the caudal fin.

Etymology

Noturus: (G.) Tail over back—refers to adipose fin joined to caudal fin.

gyrinus: (G.) Tadpole.

Common Name(s)

Tadpole madtom (AFS name), tadpole stonecat.
The original distribution of this species was restricted to eastern and central North America, from the Gulf Coast north to southern Canada and from the Atlantic Coast west to the prairies (~103°W longitude). The Appalachian Mountains formed “islands” from which they were excluded within their native range. They were not listed as occurring in Washington by either Doane (1902a, 1902b) or Schultz and Delacy (1935/1936). There is no record of their introduction into the Pacific Northwest. They probably arrived in a shipment of bullheads or catfish that were introduced in Idaho’s Snake River prior to 1942, the year they were first collected in Idaho. Three specimens were collected from the Snake River at Homedale, Idaho on 13 November 1942 and put in the University of Michigan’s Museum of Zoology (Catalog No. UMMZ 136204: listed as *Schilbeodes mollis*, Bond and Bisbee 1955). Simpson and Wallace (1982) noted that tadpole madtom were common in the Boise River and Snake River near Weiser, Idaho. By 1972, they had extended their range down the Snake River into the Columbia River. In that year, two specimens were collected near the mouth of the Walla Walla River (Wydoski and Whitney 1979). Bennett et al. (1983) collected tadpole madtom in Ice Harbor (n = 1 of 3890), Lower Monumental (n = 1 of 4,702), and Little Goose (n = 72 of 405,983) reservoirs on the Snake River. Six were collected among 178,548 total fish sampled in Lower Granite Reservoir between 1885 and 1995 (Bennett and Shrier 1986, 1987; Bennett et al. 1988a, 1988b, 1991, 1993a, 1993b, 1994, 1995a, 1995b, 1996, 1997). They are uncommon in Washington. They were collected in the lower Walla Walla River in 1998 and 2004 (Mendel et al. 1999, 2005).
Chapter 11

Family Esocidae: Pikes

Pike are found in freshwaters of the Northern Hemisphere. The family is composed of one genus *Esox* and five species. The northern pike *E. lucius*, has a circumpolar distribution. The Amur pike *E. reicherti* is endemic to Siberia and three are endemic to eastern North America. The North American species include the muskellunge *E. masquinongy* and two species of pickerel. Muskellunge ranged from the Great Lakes and Ohio River Valley north and west to Lake-of-the-woods and Rainy Lake in western Ontario. Chain pickerel, *E. niger*, were historically distributed along the East Coast. Redfin pickerel *E. americanus* were distributed along the eastern and western slopes of the Appalachian Mountains westward to the Mississippi Valley, from the Gulf of Mexico to the Great Lakes. For many years those east of the Appalachian mountains were designated *E. americanus americanus* and called redfin pickerel and those west of the Appalachian Divide were designated *E. americanus vermiculatus* and called grass pickerel (Crossman 1978). In 2004, the AFS Committee for Names of Fishes decided to do away with subspecies names (Nelson et al. 2004). Both varieties are currently listed as *E. americanus* and called redfin pickerel. Northern pike, redfin pickerel (of the grass pickerel variety), and a hybrid between northern pike and muskellunge (tiger muskellunge) have been introduced in eastern Washington. Each of these species has a limited distribution within the state.

Pike are unique from other families found in eastern Washington because they have torpedo-like bodies with slight lateral compression. This shape is associated with fish that have maximum acceleration and burst speed. The dorsal and anal fins are positioned far back on the body near the caudal peduncle; they are about equal in size and situated opposite one another like stabilizers of a torpedo. Their snout is diagnostic, being long and flat, resembling a duck's bill. No other family of fishes in eastern Washington has a snout shaped remotely like this. Needle sharp teeth are present on the jaws, roof of mouth (on vomer and palatine bones), and tongue. Other characters are typical of “primitive” fishes. All fins are soft-rayed. Pectoral and pelvic fins are inserted on the ventral belly and separated by a wide distance. Pelvic fins are in the abdominal position. The caudal fin is distinctly forked. The swim bladder is physostomus.

Crossman (1966) described the taxonomy and distribution of North American esocids. All the species in this family are closely related because artificial hybrids can be made by fertilizing the eggs of one species with milt from another (Crossman and Buss 1965). Moreover, natural hybrids occur between northern pike and muskellunge, called tiger muskellunge (Eddy 1941; Black and Williamson 1946; Crossman and Buss 1965); northern pike and grass pickerel (Crossman and Buss 1965; Searns and McKnight 1977); northern pike and redfin pickerel (Crossman and Buss 1965); and grass pickerel and redfin pickerel (Crossman and Buss 1965). Only the latter cross produces fertile hybrids, which was why the AFS Committee for Names of Fishes decided to consolidate grass pickerel and redfin pickerel into one species.

Tiger muskellunge are shorter and stouter than the muskellunge parent. Male offspring resulting from this cross are always sterile, but the females are often fertile and can backcross with either parent (Crossman and Buss 1965; Becker 1983). Because the hybrid is functionally sterile (since males can’t reproduce), fish managers in eastern Washington and the Idaho Panhandle have used tiger muskellunge as a biological control agent in waters that are infested with stunted populations of panfish or undesirable rough fishes. The planted tiger muskellunge reduce the target fish populations and grow to a size that produces a trophy fish. At some locations where northern pike and muskellunge occur in sympatry, as much as 17% of the total population is tiger muskellunge (Scott and Crossman 1973). Because of their close genetic relationship, it is therefore not surprising that esocids have common life histories.
Redfin pickerel, northern pike, and fertile tiger muskellunge females all spawn in the spring soon after the ice cover melts, at water temperatures of about 4–5°C. Esocids usually do not make long distance migrations. Instead, they move from deep water overwinter areas into shallow marshy embayments of lakes or into the flooded backwaters of rivers adjacent to their overwintering sites. Because these types of habitats are subject to pronounced fluctuations in water level during the spring, the environmental conditions at the time of spawning tend to be a major factor regulating year class strength in these species. If water levels recede before the eggs hatch and larvae complete their development, recruitment failure of that cohort occurs.

All esocids are broadcast spawners that construct no nests and abandon their eggs. Females usually spawn with one or two partners in water less than 25 cm deep. Spawning sites are usually heavily vegetated. The eggs are demersal and adhere to vegetation. Eggs hatch in about 11–14 days at a temperature of 7–8°C. Eggs hatch into a yolk sac larvae that remain clinging to the vegetation by means of an adhesive pad for about 6–10 more days until their yolk sac is absorbed. During this period the larvae grow from about 6–20 mm. They have to feed off their yolk because their mouth does not develop until they attain a length of about 13 mm (Franklin and Smith 1960). Their caudal fin is initially heterocercal and gradually becomes homocercal as the larvae grow from 20–40 mm (Franklin and Smith 1960).

Maximum lifespan is 6–7 years for redfin pickerel, 12 years for northern pike, and 10–12 years for tiger muskellunge (Scholz and McLellan 2009). Age at first spawning is 2 years for redfin pickerel, 2–4 years for northern pike, and 3–5 years for female tiger muskellunge (Scholz and McLellan 2009). Maximum total length in eastern Washington was 508 mm (20.0 in.) for redfin pickerel (most did not exceed 305 mm), 1,210 mm (47.6 in.) for northern pike, and 1,295 mm (51.0 in) for tiger muskellunge (Scholz and McLellan 2009). Fecundity ranged from 15,000–45,000 eggs/female for redfin pickerel, 8,000–100,000 eggs/female for northern pike, and 6,000–120,000 eggs/female for tiger muskellunge (Scholz and McLellan 2009).

Redfin pickerel, northern pike, and tiger muskellunge are all categorized as ambush predators that make “fast-starts” to capture prey. Ambush predators are sit-and-wait predators that capture prey by stealth. They wait, camouflaged in weeds and then burst after prey that swim by their hiding spot. The esocids have four adaptations that make them effective ambush predators. First, their pattern of markings, either chain link spots or wavy (slanted) dark stripes, is cryptic, allowing them to blend in with their surrounding vegetation. Second, their torpedo-shaped body, combined with the placement of the dorsal and anal fins close to the caudal fins, provides them with the power output and hydromechanical efficiency needed to make fast starts (Firth and Blake 1990, 1995; Harper and Blake 1991). The dorsal and anal fins add surface area to the caudal region and join with the caudal fin in displacing water to generate powerful forward thrust. This provides the rapid acceleration or burst speed needed to capture prey. Burst speeds of northern pike have been measured at over 30 mph. Third, they employ an S-start to focus their angle of attack when darting after prey (Firth and Blake 1995). Pike exhibit two types of fast starts: C-starts for escaping predators and S-starts for prey capture. In C-starts, the fish makes a U-turn to avoid capture. Although faster than an S-start, the C-start is not so fine tuned to propel the fish in a particular direction. In the S-start, the fish’s body assumes an S-shaped crouch, which enables the pike to precisely direct their movements (Firth and Blake 1995). Fourth, pike have musculature that is adapted for making fast bursts of short duration. Most fish species have a mix of both red and white fibers. In contrast, pike muscles contain nearly all white fibers. White muscle fibers generate a small amount of energy (2 ATP) very quickly by glycolysis, the first stage of respiration, so they are ideally suited to a predator that needs to manufacture energy quickly. Red muscle fibers generate a greater amount of energy (34 ATP), but more slowly during the second (Kreb’s cycle) and third (electron transport) stages of aerobic respiration, so they are suited to fish species that must swim continuously at a sedate pace for long periods of time (e.g., a
migrating salmon). The implication is that if pike don’t catch their prey quickly, they soon break off the attack because they quickly run out of energy. Most attacks by pikes are initiated and completed within about six seconds. Their limited energy supply also predicts when a pike, waiting in ambush, will strike at potential prey. If a small prey fish is too far away pike avoid striking it until it moves closer.

Redfin pickerel eat cladocerans, chironomids, amphipods, and fish. Minnows, suckers, salmonids, shad, sunfish, yellow perch, bullhead, and stickleback have been reported in the diets of redfin pickerel. The amount of fish consumed gradually increases up to about 63% of the diet in adult pickerel (reviewed by Scholz and McLellan 2009).

Northern pike eat aquatic insect larvae for about 7–10 days after their yolk sac is absorbed, then become piscivorous at a length of about 50 mm (Scott and Crossman 1973). Fish account for about 90% of the diets of adult northern pike. Teeth on the palatine and dentary bones are modified for seizing and holding prey. Pike usually catch prey fish sideways in their mouth by impaling them with their large canine teeth. They then retreat back into protective cover where the prey is rotated and swallowed headfirst. Recurved teeth in patches on the tongue facilitate the passage of prey down the throat (Hoyle and Keast 1988).

A food habit investigation is currently being conducted in Box Canyon Reservoir Pend Oreille River, Washington by EWU and KNRD (Bean et al. 2007). Northern pike consumed large numbers of cyprinid fishes, primarily peamouth and northern pikeminnow. Bones of mountain whitefish, tench, black crappie, yellow perch, pharyngeal teeth from largescale and/or longnose suckers, and a frog were also present in their stomachs.

A review of 27 papers on northern pike food habits revealed that 49,902 northern pike collected from various locations in North America consumed predominately fish and aquatic insects (reviewed by Scholz and McLellan 2009). In addition, their stomach contents collectively contained 46 waterfowl, two red-winged blackbird, 90 mice, voles or shrews, 417 frogs, 11 snakes, plus fully grown muskrats, tadpoles, crayfish, lampreys, sandpipers, red squirrels and mink. In one report, an 813 mm northern pike had swallowed another 413 mm northern pike (Becker 1983).

Rich (1992) pumped the stomachs of 511 northern pike collected in Coeur d’Alene Basin, Idaho: 272 (64%) were empty, the rest (n = 239) contained exclusively fish, with the exception of one vole. The pike ate 14 of the 16 species of fish that occurred in the lake (northern pikeminnow, tench, longnose sucker, bull head, northern pike, cutthroat trout, rainbow trout, kokanee salmon, Chinook salmon, sculpin, pumpkinseed, largemouth bass, black crappie, and yellow perch). Yellow perch, cutthroat trout, kokanee, and longnose sucker were the most common prey.

Scott (2002) examined stomach contents of 26 northern pike, 293–740 mm long, collected in Coeur d’Alene Lake. Her findings were similar to Rich’s. Yellow perch and cutthroat trout occurred more frequently than other species of prey in the stomachs that contained food. Yellow perch were most important numerically, but cutthroat trout were most important by weight. Scott obtained the following values (in descending order by weight): cutthroat trout (23%), yellow perch (12%), unidentifiable fish remains (10%), black crappie (4%), mountain whitefish (3%), brown bullhead (2%), northern pikeminnow (2%), and bass (largemouth and smallmouth 1%). Other items in the stomachs included insects (14%), gastropods (1%), feathers (>1%), and a small mammal (>1%) in one stomach. Plant material and detritus accounted for about 20% of the stomach contents.

Diet of tiger muskellunge was composed almost exclusively of fish. Tiger muskellunge (n = 48) at Curlew Lake (Ferry Co.), in 2001–2004, consumed: 27% northern pikeminnow, 23% rainbow trout, 14% largemouth bass, 14% invertebrates, 4% peamouth, 2%
bridgelip sucker, 6% unidentified non-salmonid fishes, and 8% unidentified fish (Baker and Bolding 2007).

Tiger muskellunge (n = 77) in Silver Lake, (Spokane Co.) in 2002–2004 consumed 25% rainbow trout, 17% largemouth bass, 7% bluegill, 7% invertebrates, 5% brown trout, 5% black crappie, 4% pumpkinseed, 3% tench, 3% yellow perch, 18% unidentified non-salmonid fish, and 5% unidentified salmonid fishes (Baker and Bolding 2007). Tiger muskellunge in Silver Lake ignored goldfish, brown bullhead, and walleye. Goldfish and walleye were rare in the lake, but brown bullhead were abundant.

Redfin pickerel, northern pike, and tiger muskellunge all occupy the vegetated shorelines of slowly meandering rivers, lakes or ponds. They are usually sedentary and found associated with submergent and emergent macrophytic vegetation such as pond weed, milfoil and cat-tails. They rarely stray far from protective cover, although adult northern pike sometimes move into deeper water during the summer.

In a study conducted in Coeur d’Alene Lake, Idaho, 366 northern pike, captured in different areas of the lake and lower Coeur d’Alene River, were tagged with individually numbered jaw tags and released at the site of capture. Of the 116 subsequently recaptured within about one week to one year later, only two had moved from the area where originally tagged (Rich 1992). In the same investigation, 21 fish captured in two embayments of Coeur d’Alene Lake were tracked via radio telemetry for about six months. The fish were sedentary, remaining in the embayment where they were captured and released. They preferred shallow, vegetated habitat and spent 93% of their time in that type of habitat (Rich 1992).

Biotlemetry investigations in the Pend Oreille River, Pend Oreille Co., in 2005 and 2006 also revealed that northern pike were rather sedentary (J. Connor, Kalispel Natural Resources Department (KNRD), pers. comm.). Most (21 of 23) remained in or near a slough where they had spawned and were originally captured. As the sloughs filled with macrophyte growth during the summer, most pike moved into the Pend Oreille River, adjacent to the slough. During the winter they remained in deep water near the mouth of the slough. In April and May they migrated into the sloughs with high water to spawn (J. Connor, KNRD, pers. comm.). Most individuals spawned in the same slough that they had spawned in the previous year.

Despite their propensity for being sedentary, esocids that are introduced into rivers where they were not indigenous inhabitants have a strong tendency to be displaced downstream. This is especially true in western rivers that are subject to strong spring freshets due to snowmelt runoff from mountains. This has happened in the Couer d’Alene/Spokane River Basin in Idaho and Washington, where northern pike stocked illegally in Coeur d’Alene Lake Idaho have been displaced down the lake outlet (the Spokane River) into Washington. This has also happened in the Flathead/Clark Fork/Pend Oreille Basin in Montana, Idaho, and Washington, where northern pike stocked illegally in the Flathead River, Montana were gradually displaced down the Clark Fork and Pend Oreille rivers into Idaho and Washington. They were first reported in Box Canyon Reservoir of the Pend Oreille River in 1998, following a year with record discharges (1997). Dams block their return path, so gradually new territory is annexed. In 2006, young-of-the-year northern pike were observed in the Pend Oreille River indicating that successful natural reproduction is occurring and a self-sustaining population is becoming established (J. Connor, KNRD, pers. comm.). Soon after they became established in Box Canyon Reservoir, the first northern pikeminnow was observed in Lake Roosevelt in 2004 (Chuck Lee, Spokane Tribe Department of Natural Resources, pers. comm.).
KEY TO FAMILY ESOCIDAE

General Family Characters

Confirm these characters before keying to species.

1. Long, torpedo-shaped body with one soft-rayed dorsal fin.

2. Dorsal and anal fins far back on body near caudal peduncle, situated opposite each other and about equal in size (like stabilizing fins of a torpedo).

3. Snout, long and dorso-ventrally flattened, like a duck's bill. Lower jaw slightly longer than the snout.

4. Pectoral and pelvic fin insertion on ventral belly. Pectoral fin origin under opercular flap. Pelvic fins in abdominal position well separated from pectoral fins.


![Figure 11.1](image) Comparison of identifying characters in A) Redfin pickerel; B) Northern pike; and C) Tiger muskellunge. Redfin pickerel with dark oblique bars slanted forward, 8 submandibular pores (4 on each side of jaw), and 12 branchiostegal rays (5 on ceratohyal and 7 on epiphyal). Northern pike with white bean shaped spots on dark background, 10–11 (usually 10) submandibular pores, and 15 or 16 branchiostegal rays (7 on ceratohyal, 8 on epiphyal). Tiger muskellunge with alternating dark and light bands, oblique, slanted forward, with a few spots on dorsal, caudal, and anal fins, 10–13 (usually 12) submandibular pores, and 12–18 branchiostegal rays (3–9 on ceratohyal, 9 on epiphyal).
Key to the Species of the Esocidae of Eastern Washington

1. A. Vertical black bar below eye absent. Horizontal black bars in front and back of eyes may be inconspicuous. Opercula not fully scaled.

B. Vertical black bar below eye present. Conspicuous horizontal black bars in front and back of eye. Cheek and opercula fully scaled. Branchiostegal rays 12, 5 on ceratohyal and 7 on epihyal. (See Figure 11.1)

2. A. Oblong (bean-shaped) white spots on dark background (adults). Cheeks fully scaled. Scales confined to upper part of operculum. Branchiostegal rays 13–16, on each side usually 7 on ceratohyal and 8 on epihyal (not more than 8 on epihyal). (See Figure 11.1)

B. Oblong white spots on dark background absent. Instead have “tiger stripes,” i.e., alternating, wavy, dark and light bands, slanting forward, from back to below lateral line. Cheeks not fully scaled. Operculum not fully scaled. Branchiostegal rays 12–18 on each side, number on ceratohyal/epihyal varies from 3/9 to 9/9. Always 9 on epihyal. (See Figure 11.1)

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Redfin pickerel
Esox americanus
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Northern pike
Esox lucius
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Tiger muskellunge
E. lucius × E. masquinongy
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REDFIN PICKEREL

*Esox americanus* (Gmelin, 1788)

**Figure 11.2**  Redfin pickerel, Down's Lake, Spokane Co., WA.

**Primary Identification**
1. Body torpedo-shaped, dorsal and anal fins situated far back near caudal peduncle.
2. Snout long and shaped like a duck’s bill.
3. Prominent black vertical bar below eye (sub-orbital bar).
4. Cheek and opercula with scales on both dorsal and ventral halves.

**Confirming Characters**
1. Submandibular pores eight or fewer; usually four on each side of jaw. Small and often difficult to see without magnifying lens.
2. Branchiostegal rays 10–14 on each side (usually 12), five on ceratohyal, seven on epiphysal.
3. Sides with 15–23 wavy, dark oblique bars, slanted forward. Bars colored olive, brown or black, separated by light colored patches (creamy to buttery).

**Similar Species**
1. Northern pike and tiger muskellunge. Both species have similar body profile and snout shape, but neither has a sub-orbital black bar. Also, both species have ten or more submandibular pores and scales are confined to dorsal half of opercula.

**Etymology**

*Esox*: An old European vernacular name for pike.

*americanus*: (L.) From America.

**Common Name(s)**

Redfin pickerel (AFS name), grass pickerel, western pickerel, mud pickerel, piccanu (an Indian name).
Figure 11.3  Redfin pickerel distribution in eastern Washington.

Distribution

The natural distribution of redfin pickerel was roughly from the Atlantic Coast west to the Mississippi Valley, from the Gulf of Mexico to the Great Lakes (Crossman 1962, 1966; Lee et al. 1980). Their western limit appeared to be 95°W longitude. In their reports upon fishes collected along the various routes of Pacific Railroad Surveys, Girard (1858) and Suckley (1860) noted that no pickerel were collected west of this line.

Schultz and DeLacy (1935/1936) first reported redfin pickerel in eastern Washington, in Rock Creek at the outlet of Rock Lake, in Rock Creek about 4 km below the outlet (Whitman Co.) and in Cow Creek (Adams Co.). Rock and Cow creeks are tributaries of the Palouse River.

Redfin pickerel have been reported at Pepoon, Perkins, and Ryan lakes (Stevens Co.); Park, Blue, Brooks, Moses, and Alkali lakes in the Grand Coulee below Banks Lake (Grant Co.); upper Crab Creek above Sylvan Lake, Fishtrap Lake, and Negro Creek (Lincoln Co.); Buck Creek, Horseshoe, and Fan lakes (Pend Oreille Co.); Little Spokane River, Marshall and Hog Canyon creeks, Amber, Downs, Eloika, Fish, Hog, Queen Lucas, and Williams lakes (Spokane Co.); Long Lake Reservoir (Spokane and Stevens Cos.); Bonnie Lake (Spokane and Whitman Cos.); Rock Creek (Whitman Co.); Davis Lake and Pend Oreille River (Davis Slough) (Pend Oreille Co.); Sprague Lake (Lincoln and Adams Cos.); Cow and Lugondeel Springs creeks, Hallin, Cow, Lost, and Finnel lakes (Adams Co.).
NORTHERN PIKE
*Esox lucius* (Linnaeus, 1758)

**Figure 11.4**  Northern pike, Pend Oreille River, Pend Oreille Co., WA. Inset shows juvenile Northern pike.

**Primary Identification**
1. Body torpedo-shaped with dorsal and anal fins near caudal peduncle.
2. Snout long and shaped like a duck’s bill.
3. Coloration: 7–9 rows of milky white to butter yellow oval or bean-shaped spots on a dusky gray or green background (light spots on a dark background).
4. Cheeks fully scaled. Opercula with scales only on upper half.

**Confirming Characters**
1. Branchiostegal rays 13–16, usually 15, with seven on ceratohyal and eight on epihyal. Epihyal with maximum of eight rays.
2. Sub-mandibular pores 10–11, usually five on each side, large and conspicuous.

**Similar Species**
1. Redfin pickerel have a sub-orbital dark bar that northern pike lack. Redfin pickerel have fewer submandibular pores (8) than northern pike (10–11).
2. Tiger muskellunge have alternating light and dark bands that resemble tiger stripes and always nine branchiostegal rays arising on the epihyal (in contrast to the maximum of eight in northern pike). Note: the color pattern of juvenile northern pike more closely resembles that of a tiger muskellunge than an adult northern pike. Photograph above shows typical markings of an adult (top) and juvenile (bottom) northern pike.

**Etymology**
*Esox*: An old European vernacular name for pike.

*lucius*: Latin vernacular name for pike, from Lucifer ‘the devil.’

**Common Name(s)**
Northern pike (AFS name), jackfish, jack.
Figure 11.5  Northern pike distribution in eastern Washington.

Distribution

The natural distribution of northern pike in North America was north of 40°N latitude to Hudson’s Bay, east of the Continental Divide. In northern British Columbia, the Yukon and Alaska, they also occurred in Pacific and Arctic drainages. Northern pike were native to Missouri River Basin, Montana, east of the Continental Divide (Brown 1971). Their current presence west of the Continental Divide resulted from unauthorized introductions prior to 1971 (Brown 1971). Northern pike illegally planted in the Flathead River, Montana, dispersed down the Clark Fork River into the Pend Oreille River.

In Idaho, northern pike were discovered in 1974 at two locations (Horner 1999); one from the Clark Fork River below Cabinet Gorge Dam, the other from Cave Lake, a lateral lake connected to the Coeur d’Alene River which was the result of an illegal introduction from Lone Pine Reservoir, Montana in 1972. By the mid-1980’s northern pike had colonized all of the lateral lakes and bays in Lake Coeur d’Alene, and were being caught in the Spokane River. Northern pike also began to appear in other lakes in the Coeur d’Alene area, such as Fernan, Hauser, and Hayden lakes, the result of illegal introductions.

In Washington, northern pike have been reported in the Spokane River from above Upriver Dam to Long Lake, Little Spokane River, Eloika, and Fan lakes (Spokane Co.), Pierre Lake (Stevens Co.), Banks and Moses lakes (Grant Co.), and Box Canyon Reservoir (Pend Oreille Co.). Natural spawning has been documented for the Box Canyon population (J. Connor, KNRD, pers. comm.).
**TIGER MUSKELLUNGE**

_Esox lucius_ (Linnaeus, 1758) × _Esox masquinongy_ (Mitchell, 1824) (hybrid)

**Figure 11.6** Tiger muskellunge, Newman Lake, Spokane Co., WA.

**Primary Identification**

1. Body torpedo-shaped with dorsal and anal fins near caudal peduncle.
2. Snout long and shaped like a duck's bill.
4. Scales absent on about lower half of cheeks and lower half of opercula.

**Confirming Characters**

1. Branchiostegal rays 12–18, 3–9 on ceratohyal and nine on epihyal. A 6/9 or 8/9 pattern is most common.
2. Submandibular pores 10–13, very large and V-shaped in large adults.

**Similar Species**

1. Redfin pickerel have a suborbital dark bar that tiger muskellunge lack. Redfin pickerel have fewer submandibular pores (8) than tiger muskellunge (10–13).
2. Adult northern pike have rows of light colored spots that resemble chainmail. However, juvenile northern pike more closely resembles adult tiger muskellunge than adult northern pike. Although total branchiostegal ray counts between pike and muskellunge overlap, tiger muskellunge always have nine branchiostegal rays (northern pike have eight or fewer) arising on the epihyal.

**Etymology**

_Esox:_ An old European vernacular name for pike.

_lucius:_ Latin vernacular name for pike, from Lucifer ‘the devil.’

_masquinongy:_ French phonetic spelling of a Chippewa, Ojibway, or Cree name given to this fish.

**Common Name(s)**

Tiger muskellunge (AFS name), tiger muskie.
**Distribution**

Tiger muskellunge are a F₁ hybrid between northern pike and muskellunge parents. In North America, northern pike were widely distributed across the northern United States (north of the Ohio River Valley) and all of Canada east of the Rocky Mountains. They also occurred in northeastern British Columbia, and all of the Yukon and Alaska. Muskellunge occurred over a much narrower range centered around the Ohio River and Great Lakes. Natural hybrids (tiger muskellunge) were reported wherever the two species occurred in sympatry. Because the hybrid grows fast and has a voracious appetite, many state fisheries management agencies began programs to artificially produce sterile tiger muskellunge which are used for the dual purpose of controlling rough fish populations and establishing trophy sport fisheries. WDFW began a program of tiger muskellunge introduction as an alternative to lake rehabilitation to control populations of unwanted fish in some lakes where poisoning with rotenone had become unpopular with the public (e.g., Silver Lake, Spokane Co.). Tiger muskellunge have been introduced in five lakes in eastern Washington: Newman and Silver lakes (Spokane Co.), Curlew Lake (Ferry Co.), and Evergreen and Red Rock lakes (Grant Co.). Stocking in Evergreen Reservoir was discontinued in 1999, when tiger muskellunge escaped past a water control structure at the lake’s outlet and was caught by an angler in the Hanford Reach at the Columbia River. In western Washington, tiger muskellunge were introduced in Merwin Reservoir (Cowlitz Co.), Mayfield Reservoir (Lewis Co., Idaho), Tapps Reservoir (Pierce Co.), Green Lake (King Co.), and Fazon Lake (Whatcom Co.).
Chapter 12
Family Salmonidae: Salmon, Trout, Whitefish, Grayling

The Family Salmonidae, in the order Salmoniformes, is composed of freshwater and anadromous fishes distributed across the northern hemisphere (Nelson 1984; Behnke 1979, 1992, 2002). Anadromous fish are hatched in freshwater, migrate to foraging areas in the ocean, then back into freshwater (usually back to their parent stream) to reproduce. Behnke (1979, 1992, 2002), Smith and Stearley (1989), and Stearley and Smith (1993) have reviewed various aspects of the complicated taxonomy of Salmonid fishes. Salmonids prefer habitats with coldwater and plenty of oxygen.

Salmonids are considered to be primitive (ancestral) bony fishes because they have physostomous swim bladders, cycloid scales, a single (soft-rayed) dorsal fin, and pectoral and pelvic fins separated by a long distance on the belly. Their pelvic fins are in the abdominal position. They are distinguished from many other families of primitive fishes, like Cyprinidae and Catostomidae, by the presence of an adipose fin, and, usually, teeth in their jaws, and on the roof and floor of the mouth. Their bodies are fusiform, the shape that best reduces energy expenditures while swimming.

Salmonids are noted for their long distance, energetically taxing migrations, and reproductive homing. For example, some Chinook salmon in the Gulf of Alaska historically traveled about 4,300 km (2,700 mi) to spawn at their birthplace in the headwaters of the Columbia River, British Columbia. This migration encompassed about 1,500 mi (2,400 km) in the ocean and 1,200 mi (1,900 km) in the Columbia River over two falls (Celilo and Kettle falls) and dozens of major rapids.

The Family Salmonidae is subdivided into three subfamilies: Coregoninae (whitefishes), Salmoninae (salmon, trout, and charr), and Thymallinae (grayling). Members of all three subfamilies are characterized by the presence of: 1) an adipose fin, and 2) an axillary process at the anterior base of the pelvic fins. The Salmoninae have small scales (> 110 in a row along the lateral line), large upper jaws, teeth on the maxillary bone, and a short dorsal fin (< 16 rays). The Coregoninae and Thymallinae both have large scales (fewer than 110 in the lateral line row). The two subfamilies are differentiated by the size of the dorsal fin and the presence/absence of teeth on their maxillary bone. The Coregoninae have relatively short dorsal fins (≤ 15 rays) and no teeth in the maxillaries. The Thymallinae have long, sail-like dorsal fins (≥ 16 rays) and teeth in their maxillaries.

Three species of Coregoninae occur in eastern Washington. The lake whitefish Coregonus clupeaformis is characterized by two narial flaps between the anterior and posterior nares, relatively long, numerous (19–37, usually > 22) gill rakers, and a concave nape (Figure 12.1A). The mountain whitefish Prosopium williamsoni is characterized by one narial flap between the anterior and posterior nares, shorter, less numerous (9–25, usually ≤ 22) gill rakers, 71–110 lateral line scales and a convex nape (Figure 12.1B). The pygmy whitefish Prosopium coulteri is characterized by one narial flap, shorter, less numerous (9–25, usually ≤ 22) gill rakers, ≤ 70 lateral line scales, and blunt snout (Figure 12.1C). The mountain and pygmy whitefish are native to the northern Rockies and Pacific Northwest. The lake whitefish, native to the Great Lakes region, was introduced at several locations in eastern Washington, north Idaho, and western Montana by federal and state fisheries agencies.

The Subfamily Salmoninae in eastern Washington is comprised of 3 genera: Oncorhynchus (Pacific salmon and trout), Salmo (Atlantic salmon and trout), and Salvelinus (charr).
Subfamily Coregoninae. A) Lake whitefish *Coregonus clupeiformis* is characterized by two narial flaps, long gill rakers, and concave nape; B) Mountain whitefish *Prosopium williamsoni* is characterized by one narial flap, short gill rakers, and convex nape; C) Pygmy whitefish, *Prosopium coulteri* is characterized by one narial flap and blunt snout. Original drawings by Carolyn Connelly, Color enhancement by Judy McMillan, EWU University Graphics.

Members of the subfamily Salmoninae are subdivided into genera by color pattern. *Oncorhynchus* and *Salmo* have black spots on a light background whereas *Salvelinus* has light colored spots on a dark background. Additionally, the vomer (a bone in the center of the roof of the mouth) of *Oncorhynchus* and *Salmo* bears teeth along the entire length whereas in *Salvelinus* the teeth are restricted to the anterior end.
Oncorhynchus species and Salmo species overlap in morphological features, in counts of most meristic characters, and measurements of morphometric characters. The two genera are distinguished primarily by distinctive bones (Regan 1914; Stearley and Smith 1993). One external difference that separates the two groups is that Oncorhynchus species have spots that are either irregular or round in outline. Salmo species have spots that are often × or + - shaped, in addition to round spots, and their spots are often surrounded by pale haloes. Salmo also often possess maroon, red or orange spots in addition to black spots while Oncorhynchus has black spots only.

Members of Oncorhynchus are separated into Pacific salmon (subgenus Oncorhynchus) and Pacific trout (subgenus Rhabdofario for rainbow and subgenus Fario for cutthroat) based on distinctive traits. In Pacific salmon, (pink, chum, coho, sockeye/kokanee, and Chinook salmon), the anal fin has 13 or more rays (its width is greater than its height), the interior of the mouth is black, and a kype (hooked snout) develops on the upper jaw of spawning males. In Pacific trout, (rainbow and cutthroat), the anal fin has 12 or fewer rays (its width is equal to its height), the interior of the mouth is white, and the spawning kype develops on the lower jaw. Atlantic salmon and trout share these traits with the Pacific trout, so far many years (until 1993) the Pacific trout were classified in the genus Salmo (Jordan and Evermann 1896; Jordan et al. 1930; Chute et al. 1948; Bailey et al. 1960, 1970; Robins et al. 1980) until Stearley and Smith (1993) placed them with the Pacific salmon. Stearly and Smith conducted a cladistic analysis based on 119 morphological and meristic characters. They found that when a large number of characters were compared, Pacific trout were more similar to Pacific salmon than to Atlantic salmon or trout. Also, molecular genetics investigations determined that allozymes and mtDNA of Pacific trout had diverged less from that of Pacific salmon than that of Atlantic salmon and trout (Okazaki 1984; Berg and Ferris 1984; Thomas et al. 1986, McVeigh and Davidson 1991; Osinov and Lebedev 2000).

Five species of Pacific salmon Oncorhynchus, including pink O. gorbuscha, chum, O. keta, coho O. kisutch, sockeye (kokanee) O. nerka and Chinook O. tshawytscha (Figure 12.2) occur in the Pacific Northwest. Coho, sockeye and Chinook salmon occur in both eastern and western Washington, whereas pink and chum salmon are usually confined to coastal drainages. However, both of the latter species occasionally migrate up the Columbia River and ascend above Bonneville Dam. Pacific salmon almost invariably exhibit an anadromous life history although some populations of sockeye, called kokanee Oncorhynchus nerka var. kennerlyi, are land-locked for their entire lives. Kokanee make adfluvial migrations between their home tributary and a nursery lake where they forage and grow to maturity before returning to spawn in their home tributary.

The Pacific salmon are distinguished by the presence or absence of spots on the back and sides (Figure 12.2). Two species (chum and sockeye/kokanee) have no or few spots, and are further separated by gill raker counts: 16–26 in chum salmon; 28–44 in sockeye/kokanee salmon. Spawning males of these two species are easily identified because chum usually lack humps and their coloration resembles streaky paint. Spawning sockeye/kokanee usually have a hump in front of their dorsal fin and their color is uniformly bright orange or red above and below the lateral line. Three species (pink, coho and Chinook) have numerous spots and are further separated by the details of the spot pattern and other characters. Pink salmon have large, oblong black spots on the back and sides above the lateral line and in linear arrays on both lobes of the caudal fin. They also have 24–35 gill rakers on the first gill arch. Spawning males have a pronounced hump in front of the dorsal fin and their sides are tinted in a dull rosy blush. Coho salmon have a few spots on the dorsal and posterior margins of their caudal fins. They have 18–25 gill rakers. Their tongue and gums are black, but flesh along the gumline of the teeth is lighter colored. Spawning males do not develop a hump, and have bright pink to dull red color on the sides of the body below the lateral line.
Figure 12.2  Pacific salmon *Onorhynchus* (*Oncorhynchus*) fresh from the ocean. A) Pink salmon *O. gubuscha* with black marks and long oblong black spots on tail; B) Chum salmon *O. keta* no spots on tail; C) Coho salmon *O. kisuta* with white gums and black jaws and tongue and a few spots confined to dorsal caudal fin; D) Sockeye *O. nera* with uniformly dark jaws, gums and tongue and no or few spots on tail; F) Chinook salmon *O. tshawytcha* with uniformly black jaws, gums and tongue and medium-sized spots (in linear arrays) on tail; F) Chinook salmon (spawning coloration); G) Sockeye (kokanee) salmon (spawning coloration). Both F and G from Lake Roosevelt. A–E adapted from WDFW internet website.
Chinook salmon have medium-sized, irregular shaped spots on the back and side above the lateral line and on both lobes of the caudal fin. Chinook salmon have 16–26 gill rakers. The interior of their mouth is uniformly black. Spawning males have purple-black spawning coloration.

The Pacific trout are separated into cutthroat and rainbow series based on 1) the presence or absence of basibranchial teeth on the hyoid bone, located at the base of the tongue on the floor of the pharynx between the gill arches, and 2) presence or absence of yellow, orange or red slash marks in the membranous folds beneath the lower jaw. Cutthroat have both traits, rainbow usually don’t. However, some populations of O. mykiss gairdneri in northeastern Washington, particularly in the Spokane River and Upper Crab Creek drainages, may possess vestigial basibranchial teeth and rudimentary cutthroat marks.

Coastal cutthroat O. clarkii clarkii, westslope cutthroat O. clarkii lewisi, Yellowstone cutthroat O. clarkii bouvier, and Lahontan cutthroat O. clarkii henshawi, form the cutthroat trout series (Figure 12.3). Coastal and Lahontan cutthroat trout have spots on the top of the head. Spots are also more or less evenly distributed over the sides of their bodies and caudal fin above and below the lateral line. Coastal cutthroat trout usually have numerous spots all over the body and 17–19 gill rakers (range 15–21) on the first gill arch. Lahontan cutthroat have few, medium-sized spots, round in outline, none on the anal fin. They usually have 23–26 gill rakers (range 21–28) on the first gill arch. Westslope and Yellowstone cutthroat trout have spots unequally distributed over the sides of the body and caudal fin. Both species have more black spots on the posterior as compared to the anterior of the body. On the anterior of the body, both species have a few black spots above the lateral line. A few black spots are also present below the lateral line in Yellowstone cutthroat trout but absent (or nearly so) in the westslope cutthroat trout. Also, the spots on the westslope variety are irregular in outline whereas those on the Yellowstone variety are rounded or oval. Additionally, although both varieties have a similar number of gill rakers on the first gill arch (range = 17–21 in westslope and 17–23 in Yellowstone), the number usually present is different between them (18–19 in westslope and 20–22 in Yellowstone). The number of posterior gill rakers on the first arch also varies between the two varieties (5–15, well developed, in westslope and 0–3, weakly developed, in Yellowstone).

Coastal and westslope cutthroat are indigenous to Washington. The coastal variety generally occurs in the Puget Sound and Olympic Peninsula west of the Cascade Mountains. In the Columbia Basin they are confined to tributaries below Bonneville Dam. The westslope variety occurs east of the Cascade mountain range. Westslope cutthroat trout range across the Continental Divide in the mainstem and tributaries of the Upper Missouri River. They were first recorded from below the Great Falls of the Missouri by Captain Meriweather Lewis in a journal entry of June 13, 1805. In 1853, Dr. George Suckley collected another specimen there and attached the scientific name Salar lewisi (Suckley 1862). Suckley (1862) noted that the specimens he collected in the Upper Missouri were identical to specimens that he had previously collected from the Pend Oreille/Clark Fork/Flathead/Bitterroot river drainages (Upper Columbia River Basin) in western Montana and Idaho Panhandle. The common name of the latter populations came to be called “westslope” cutthroat trout because they were found west of the Continental Divide. This name clearly does not adequately capture the original distribution of the subspecies both east and west of the Divide. WDFW Fisheries biologist Don Earnest suggested that the name ‘intermontane cutthroat trout’ was more descriptive as it occurs from the east side of the Cascades to the east side of the Rockies (Crawford 1979). We believe that Earnest’s suggestion is a more appropriate common name for this species. Interestingly, the cutthroat trout of the Upper Missouri River Basin are genetically more similar to the cutthroat of the Upper Columbia Basin than they are to the cutthroat of the Yellowstone River, a major Missouri tributary (Behnke 2002).
Yellowstone cutthroat trout, native to Yellowstone Lake, Wyoming and Henry’s Lake, Idaho, were widely introduced in eastern Washington and north Idaho between 1892 and 1940, often under the common name Montana blackspotted trout. Lahontan cutthroat trout, native to the Lahontan and Truckee River basins of California and Nevada, evolved to become adapted to highly alkaline waters as pluvial Lake Lahontan underwent dessication.
They have been introduced in many alkaline lakes in eastern Washington. Coastal cutthroat trout may exhibit anadromous or stream resident life history strategies. Westslope cutthroat trout usually do not migrate to saltwater, but have resident fluvial or adfluvial life history. Yellowstone cutthroat and Lahontan cutthroat are usually adfluvial.

Coastal rainbow *O. mykiss iredeus*, interior (redband) rainbow *O. mykiss gairdneri*, and golden trout *O. mykiss aguabonita* form the rainbow series (Figure 12.4). The morphological, morphometric, and meristic characters of golden trout overlap almost completely with rainbow trout and they can successfully hybridize with them. Until 2004, golden trout were classified as a distinct species, *Oncorhynchus aguabonita*, from rainbow trout. Behnke (1992, 2002) and Stearley and Smith (1993) suggested that golden trout might be better classified as a subspecies of rainbow trout *Oncorhynchus mykiss aguabonita*. In 2004, the AFS Committee for Names of Fishes abandoned *O. aguabonita* as a valid scientific name, but did not recognize the subspecies. We agree with Behnke, and Stearly and Smith, that the golden trout is properly classified as a subspecies *aguabonita* of *O. mykiss*. The primary feature distinguishing golden trout from most rainbow trout was brilliant yellow, copper, or golden hues on the side of the body and orange or red hues on the belly.

The coastal variety of rainbow trout has rounded parr marks in the row along the lateral line. Supplementary rows above and below this main row are absent or faint. The interior (or redband) variety of rainbow trout has elliptical parr marks in the row along the lateral line and supplementary rows above and below this main row. Coastal rainbow usually have 125–127 (range 111–143), scales in the lateral row compared to 135–160 (range 131–170) in the redband trout. Coastal rainbow usually have weakly developed teeth on the tongue while those of redband trout are well developed. Coastal rainbow trout lack basibranchial teeth and cutthroat markings, but interior redband rainbow may have vestigial basibranchial teeth and faint cutthroat marks. Tips of dorsal, anal, and pelvic fins are not pigmented in coastal rainbow trout but are white, yellow, or orange in redband trout.

The interior or redband rainbow/steelhead trout were indigenous to the Columbia River Basin of eastern Washington above Celilo Falls. Some strains (called redband steelhead) had an anadromous life cycle and grew to large size in the ocean; others were non-anadromous (called redband rainbow trout) that did not migrate to the sea and grew to smaller sizes. The non-anadromous redband rainbow exhibited several life history strategies: fluvial, adfluvial, or resident. Those that make round trip adfluvial migrations from tributary streams into lakes often attain large size because they fed on small fishes (especially kokanee) in the lakes. The Kamloops trout is a large adfluvial life history variant of redband rainbow trout that resembles the redband steelhead.

The coastal rainbow was indigenous to the lower Columbia River below Celilo Falls and in coastal rivers from California to British Columbia. Most strains of rainbow trout at hatcheries throughout the United States, including those of the WDFW hatchery in Spokane, were derived from a stock of primarily coastal steelhead (but with some California redband strain mixed in) obtained from the McCloud River, California (Crawford 1979). These rainbow have been widely stocked throughout most of eastern Washington. At the present time they greatly outnumber the native redband trout because they have been stocked in many lowland lakes that did not have native trout populations.

Many lowland lakes throughout eastern Washington counties originally contained only native minnows, suckers, and sculpins or were devoid of fish. Initially, these lakes were stocked with warmwater sportfishes such as largemouth bass, black crappie, pumpkinseed, bluegill and yellow perch. Some of these lakes were managed as warmwater sport fisheries. Others also received annual plants of kokanee, rainbow or cutthroat trout and were managed as mixed species waters. Because anglers preferred catching salmonids over warmwater species, the WDFW, commencing in 1938, began treating many of the mixed species waters with rotenone.
Figure 12.4  Rainbow trout *Oncorhynchus* (*Rhabdofario*) *mykiss*; A) Golden trout *O. m. aguabonita* (from a lake in Okanogan County); B) Interior (redband) rainbow trout *O.m. gairdneri* from California Creek (Spokane River Drainage); C) Coastal rainbow trout *O. m. irideus*; D) Closeup of white mouth; E) Small to medium spots (in linear arrays) on tail of this species; F) Spokane hatchery coastal rainbow in Lake Roosevelt; G) Interior (redband) Kamloops rainbow trout Boundary Reservoir, Pend Oreille River.
Chapter 12

Rotenone is a poison made from the pulverized roots of tropical rainforest plants. It was the invention of South American Indians who used it for fishing. Rotenone is a metabolic poison that works like cyanide by blocking transfer of electrons to oxygen in the electron transport chain, thereby shutting down ATP production. Emulsified rotenone powder in water is first picked up by the gills of the fish during respiration and kills the cells in the gills, causing the fish to suffocate before it absorbs any rotenone into its muscle. Rotenone treatment, called “rehabilitation,” was followed by stocking desired salmonids. Good growth of salmonids occurred for several years after rehabilitation, then gradually became reduced after warm-water fishes reinvaded the lakes (either by illegal stocking or because an incomplete kill was achieved). Thus, lakes began to be rehabilitated on schedules at intervals of about six years (range 2–14 years). A history of WDFW’s rotenone rehabilitation program was compiled by Bradbury (1986). Rainbow trout became the preferred fish for stocking because they were easier to raise than cutthroat trout or kokanee and consequently cost less to produce. Many of the fish used for this program were offspring of WDFW Spokane Hatchery broodstock raised at either Spokane or Ford hatcheries. Thus, most rainbow trout stocked in eastern Washington waters are actually coastal steelhead.

Golden trout, native to the Sacramento River Basin of California, were introduced to Washington in 1959 (Crawford 1979). Most were stocked in shallow, alpine lakes on both slopes of the Cascade Mountains. They have been stocked intermittently since 1959 whenever WDFW could obtain them from sources in California or Wyoming.

Atlantic salmon *Salmo salar* overlap with brown trout *Salmo trutta* in most morphological, morphometric and meristic traits (Figure 12.5). Atlantic salmon have a narrow, streamlined caudal peduncle. Brown trout have a thicker, stouter caudal peduncle. The caudal fin of Atlantic salmon is slightly v-shaped or emarginate. The caudal fin of brown trout is truncate (square). The body of Atlantic salmon is tinted in hues of silvery blue or blue-green, sometimes with maroon spots whereas the body of brown trout is tinted in hues of yellow or brown, although ocean or lake-dwelling individuals of both species may be predominately silver owing to guanine deposition. Brown trout often have a few orange or red spots. Some of the black spots in both species are × or + - shaped and may be surrounded by pale haloes.

Both Atlantic salmon and brown trout were introduced into several lakes, rivers, and reservoirs in eastern Washington either to enhance sport fisheries or for commercial net pen operations. Two varieties of brown trout were imported from Europe into the United States by the USFC in the late 1800’s: the German brown trout (*Salmo trutta* var. *fario*) from Germany and the Loch Leven brown trout (*Salmo trutta* var. *laevis*) from Scotland. Both varieties have been stocked in eastern Washington at numerous locations. Fisheries agencies also interbred German brown trout and Loch Leven brown trout until they could no longer be distinguished.

Brown trout *Salmo trutta* have been genetically crossed with brook trout *Salvelinus fontinalis* to produce a sterile hybrid called the tiger trout (Figure 12.5 C). Tiger trout are so called because they possess vermiculations (wave-like markings) that resemble either tiger stripes or a giraffe’s spots. Tiger trout were bred in an attempt to combine the fighting characteristics of a brown trout with the disease resistance of a brook trout.

Four species of charr, bull trout *Salvelinus confluentus*, brook trout *Salvelinus fontinalis*, Dolly Varden trout, *Salvelinus malma*, and lake trout *Salvelinus namaycush*, occur in Washington (Figure 12.6). Among *Salvelinus*, brook trout are distinguished by vermiculations (conspicuous wavy markings) on the back. Their pectoral, pelvic and anal fins have white leading edges, with a contrasting black bar interior to the white fin margin that is distinctive and striking. They often contain light colored spots in hues of red, orange, yellow, in haloes of white and pale blue (Figure 12.6B, E, F).
Bull trout lack vermiculations on their back. Their pectoral, pelvic, and anal fins have a white leading edge, but they lack the interior black bar. They have white, creamy orange and/or red spots. Their caudal fin is not deeply forked (i.e., the shortest caudal ray is greater than half the length of the longest caudal ray) (Figure 12.6A). Dolly varden are virtually identical to bull trout in external appearance. Both species were classified together under the common name Dolly Varden and scientific name *Salvelinus malma* until Cavender
(1978) determined that their cranial bones were different. Later, additional morphological and genetic analysis confirmed that bull trout and Dolly Varden were two distinct species (Morton 1980; Haas and McPhail 1991, 2001; Crane et al. 1994; Leary and Allendorf 1997; Baxter et al. 1997). The single best external characteristic used to distinguish between the two species is the number of branchiostegal rays. The mean number (and range) of branchiostegal rays was 27 (26–31) in bull trout (95% of specimens examined had 26–28) compared to 22 (17–23) in Dolly Varden (Haas and McPhail 1991).

Lake trout *Salvelinus namaycush* lack vermiculations on the back. Their pectoral, pelvic, and anal fins have a colorless or faint (transparent) white leading edge and no interior black bar. Their bodies are covered by irregular sized light (white) spots. They have a deeply forked caudal fin (i.e., the shortest ray is less than half the length of the longest ray) (Figure 12.6C).

The bull trout is indigenous to the interior waters of the upper Columbia and Snake River Basins and closely resembles the Dolly Varden trout. Both species occurred in the coastal drainages of western Washington and lower Columbia River, but usually only the bull trout occurred above Celilo Falls (now The Dalles Dam).

Brook trout and lake trout were both introduced into eastern Washington. Brook trout were transported from the East Coast by the USFC’s fleet of aquarium railroad cars. After arriving at destinations in the western states, the fish were offloaded into metal milk containers on buckboard wagons for transport to stocking sites. Others were carried by pack mule trains to the headwaters of national forest streams. It was hoped that fish distributed by this type of “headwater seeding” would disperse throughout the tributary. Thus, brook trout came to be widely distributed throughout the national forests in eastern Washington and north Idaho where they competed with westslope cutthroat and bull trout for food and habitat. Lake trout, from the Great Lakes region, were introduced into a limited number of lakes in eastern Washington and north Idaho by federal and state fisheries agencies in both states.

The Subfamily Thymallinae, is comprised of one species that occurs in North America, the Arctic grayling, *Thymallus arcticus* (Figure 12.7). It is characterized by a long sail-like, dorsal fin with ≥ 16 rays, and relatively large scales in comparison to the Salmoninae. The number of scales in the lateral line row varies from 54–97 in the Coregoninae, 70–103 in the Thymallinae, and 105–229 in the Salmoninae.

Arctic grayling have a holarctic distribution above 60°N latitude. Disjunct populations occurred in Montana and Michigan. Michigan populations suffered extinction in 1936, but Montana populations have survived to present. Arctic grayling from Montana were introduced into several high elevation lakes in eastern Washington, but successfully established a naturally reproducing, self-sustaining population at only one location.

Salmonids return to the stream of their birth to spawn. This behavior is termed natal homing. Populations that exhibit precise natal homing to one tributary generation after generation are called stocks. Because stocks are reproductively isolated from one another by virtue of their precise homing, they accumulate genetic differences that can be detected by examination of the nucleotide base sequence of their DNA or the amino acid sequence of their proteins.

Eventually, each stock develops its own stable genetic structure where the frequency of alleles and genotypes is constant from generation to generation, or what geneticists call Hardy-Weinberg Equilibrium. Each stock is thus characterized by a unique frequency of alleles and genotypes that is in Hardy-Weinberg Equilibrium.
Species of charr, Genus *Salvelinus* all have light spots on dark background. A) Bull trout *S. confluentus*; B) Brook trout *S. fontinalis*; C) Lake trout *S. namycush*; D) 889 mm (35 in.), 10.4 kg (25 lb) lake trout collected in Bead Lake, Pend Oreille Co. in May 2004. Unique features of brook trout include; E) Vermiculations on back, and F) pectoral, pelvic, and anal fins with white leading edges and contrasting interior black bar. No figure was provided of Dolly Varden because they theoretically do not occur in eastern Washington. Dolly Varden are virtually identical to bull trout.
The reason why genotypes remain in Hardy-Weinberg equilibrium is that, when acted upon by the force of natural selection, the phenotypic traits they control have survival value. Those individuals possessing a suite of phenotypic traits that are well matched to their local environment conditions survive to pass their alleles to the next generation, whereas individuals that lack these traits do not. Thus, each stock is locally adapted to its home river. Because natural selection is responsible for the genetic structure of each stock, stocks are adapted to their local environments. One example of local adaptation is that salmonids are coldwater fish that usually do not survive in warmwater. Their DNA produces proteins that work best over a narrow range of temperatures. However, some stocks of rainbow trout live in warm desert streams. In warm streams, individuals with DNA variations (produced by random mutation) manufactured proteins that worked at higher temperatures. These fish survived and passed on their genes. Those individuals that possessed coldwater genes only manufactured proteins that worked at lower optimal temperature. Not so many of those fish survived to pass on their genes. Individuals whose DNA (genes) produced proteins that worked in warmwater passed through the filter of natural selection, whereas individuals whose DNA (genes) produced proteins that only worked in coldwater did not. As a result, the frequency of genes that produced the warmwater protein gradually increased in the population. Thus, the stock became adapted to its local environment. If human activities, such as a pollutant entering the stream and killing the native population were to occur, it is unlikely that the problem could be corrected by stocking hatchery fish as replacements because they do not have the genes that allow individuals to survive in warmwater. Therefore, there is value in preserving the genetic variation in each locally adapted stock.

Salmon usually bury their eggs in gravel. In some species, (e.g. pink salmon and chum salmon) juveniles begin to swim to the ocean within hours, days or weeks after emerging from their spawning gravels. In other species, (e.g. coho salmon, Chinook salmon, steelhead trout, cutthroat trout, Atlantic salmon, and brown trout) juveniles remain in their home tributary for months to years before migrating to sea. The most common time for emigration is in the spring at age six or 18 months. In another variation of the anadromous life cycle, sockeye salmon migrate out of their home tributary into a nursery lake soon after emerging from their spawning gravel. They reside in the nursery lake until they are 1.5 years old (or older in unproductive lakes), then emigrate to sea.

Figure 12.7 Subfamily Thymallinae, Arctic grayling. Fish is shown in spawning coloration. Drawing by Carolyn Conelly. Color enhancement by Judy McMillan, EWU University Graphics.
Female salmonids typically dig depressions, termed redds, in streams that flow rapidly over gravel or cobble bottoms. After she has selected a site, the adult female turns on her side and displaces the substrate by powerful thrusts of her tail. This behavior, called “digging” or “cutting,” results in a concavity in the streambed that is surrounded on the rim by loose gravel and cobble. Finer sediments, such as silt and sand, that were embedded in the substrate, are carried downstream away from the redd by current flow. After a ritualized mating dance with her breeding partner, the female and male hover together over the depression. With their mouths agape, and using intense muscular contractions while remaining stationary over the center of the redd, they express their eggs and sperm. After eggs are laid the female displaces the loose gravel or cobble from the rim of the redd over the top of the eggs. Females may construct several egg pockets within each redd and spawn with multiple partners in this manner. Exhausted by their efforts, the parent fish usually die.

In many species of salmonids, adult fish spawn only once during their lifetime. This is called semelparous reproduction. Other species may survive to spawn two or more times. This is called iteroparous reproduction. Hendry and Sterns (2004) provided an excellent summary of which species of salmonids are semelparous and which are iteroparous, including the maximum numbers of spawning episodes in the life of iteroparous species. In general, Pacific salmon (pink, chum, coho, sockeye and Chinook), which make extensive anadromous migrations are invariably semelparous. All other species are iteroparous. However, rainbow/steelhead trout, cutthroat trout, Atlantic salmon, and brown trout that make extensive anadromous migrations exhibit high levels of semelparity. For example, survival of anadromous steelhead trout in the Columbia River to spawn a second time has been estimated at about 2–4% for stocks above Bonneville Dam and 18% for stocks below Bonneville Dam. Spawned out iteroparous fish are called kelts. Kelts are easily recognized by their emaciated appearance.

Incubation of the eggs and embryonic development occurs under the gravel. Eggs absorb water and become water-hardened within a few hours after fertilization. Eyes become visible after about two weeks and hatch about 1–2 months later into alevins or sac fry. Alevins are nourished by a yolk sac which contains a balanced diet of minerals, nutrients, amino acids, and energy stores (fats and carbohydrates) that allow them to complete their embryonic development under the gravel. The alevins remain buried for an additional 1–3 months (depending upon water temperature), which protects them from predators. Warm temperatures hasten embryonic development. Cold temperatures retard embryonic development. During the entire period of residence in the gravel, a flow of clean, well-oxygenated water is critical to the survival of eggs and alevins. Water percolates down to the egg pocket through the spaces between the gravel and cobble. If silt covers the redd, these spaces become clogged and the alevins suffocate. This is why increased sedimentation, resulting from accelerated erosion caused by poor land management practices associated with grazing cattle, logging, and mining poses a threat to salmonids.

Alevins are initially rotund owing to their yolk sac. After their yolk sacs are absorbed, they become slimmer and eventually are able to wriggle their way up through the narrow interstices of the gravel and cobble. They swim to the surface, inflate their swim bladders by gulping air and begin to feed. This is termed emergence or the swim-up fry stage.

Fry are small salmonids that have completely absorbed their yolk sac. The fry of some salmonid species migrate immediately to the ocean or a nursery lake. The fry of other species remain in their natal tributary for varying lengths of time before migration. The fry develop dark vertical bars (parr marks) that helps them to blend in with stream vegetation and affords them protective coloration. Fry are called fingerlings when they attain a size of about 75–100 mm. Juvenile salmon from the fry to fingerling stage are termed parr because of their parr marks.
The parr marks are the result of black pigments manufactured by specialized cells called chromatophores (melanophores) that are embedded subcutaneously underneath the surface of the skin. Juvenile salmon can be identified to species based on their distinctive pattern of parr marks (McConnell and Snyder 1972; Phillips 1977; Pollard et al. 1997).

Parr are solitary, and oriented upstream into the current. They display territorial behavior and defend their feeding territory against encroachment by chasing and nipping at intruders. Stationing themselves underneath an overhanging bank, with their heads pointed upstream, they wait for their prey (aquatic insects) to drift downstream with the water current.

Parr are typical freshwater fish that cannot tolerate saltwater and will usually die within 12–48 hours if placed in seawater. Blood serum concentration is measured in units of milliosmols/liter (mosmols/L). Distilled water (DW) has an osmotic concentration of 0 mosmols/L and full strength seawater (SW) has an osmotic concentration of 1000 mosmols per liter. These osmotic concentrations correspond to salinities of 0 and 35 ppt (parts per thousand, denoted by the symbol ‰) for DW and SW respectively. Both freshwater (FW) and SW fish maintain their blood serum (internal osmotic concentration) at about 300 mosmols/L. Salmon parr are stenohaline freshwater regulators. Parr can regulate their blood serum concentration at 300 mosmols/L, which is optimal for their enzymes to work properly, and survive in water with salinities of 0.30 to 10 ‰ (30–300 mosmols/L) but when placed in seawater with salinities > 10–35 ‰ (> 300–1000 mosmols/L) they begin to accumulate salt ions in their blood serum. When the concentration reaches levels of about 15–18 ‰ (400–500 mosmols/L), the fish's enzymes stop functioning properly and it dies.

Body fluids of freshwater fish and salmon parr are more concentrated than the water surrounding them; so they tend to gain water from, and loose ions to the environment. Permeable tissues such as the skin and gills act as a wick to suck up water by osmosis. Parr take in so much water across the gills and skin and with the food they eat, they do not have to drink. Thus, there is a real danger that their body fluids will become too dilute. They counter this by using their kidneys to pump out the excess water. Unlike mammalian nephrons which have a Loop of Henle (functions as a counter-current multiplier to produce a concentrated urine), fish nephrons lack this structure and so produce a dilute rather than concentrated urine. Freshwater fish and salmon parr rapidly flush dilute body fluids through the glomerulus and into Bowman’s capsule (i.e., have high glomerular filtration rate). After entering Bowman’s capsule the dilute fluids are passed into the renal tubules and thence into the collecting ducts and ureter to the outside of the body.

Prolactin, produced by the adenohypophysis (anterior pituitary gland) is an osmoregulatory hormone involved in the maintenance of water balance in freshwater (reviewed by Johnson 1973; Bern 1975; Hasler and Scholz 1983). Hypophysectomy (removal of the pituitary gland) of freshwater adapted fish caused death. The fish suffered from edema and swelled up with excess water until they became bloated and died. Prolactin injection replacement therapy enabled hypophysectomized fish to survive, whereas injections of other anterior pituitary hormones were ineffective. Thus, prolactin appears to be necessary for survival in freshwater. Prolactin possibly plays a role either in altering the permeability of the kidney tubules so they flush more water or increasing the rate of glomular filtration.

When they are about 1.5 years old, coho, sockeye, and Chinook parr transform into silvery smolts. Parr-smolt transformation is a metamorphic event that involves morphological, physiological, and behavioral changes associated with entry of juvenile salmonids into saltwater (reviewed by Hoar 1976, 1988; Folmar and Dickhoff 1980; Hasler and Scholz 1983; Clarke and Hirano 1995). During the smolt stage their parr marks disappear and they turn silver; their osmoregulatory mechanisms begin making adjustments that will enable survival in saltwater; they cease territorial behavior, form schools numbering in hundreds to thousands of individuals, and embark en
masse on their seaward journey. Most notably, smolts become euryhaline osmoregulators [i.e., they were able to regulate serum osmotic concentration at 300 mosmols per liter over a wide range of environmental osmotic concentrations (25–1000 mosmols/liter)].

Smolt transformation is stimulated by an endogenous rhythm in the fishes genes that causes the fish to smolt in about July. The annual photocycle resynchronizes this endogenous rhythm so that the fish begin to smolt in about mid-April, coincident with the spring freshet that will carry them swiftly down the river to the sea. Smolts experience elevated levels of thyroid hormone, growth hormone, cortisol, and several other hormones, and reduced levels of prolactin, that stimulate the smolt transitions (reviewed by Folmer and Dickhardt 1980; Hasler and Scholz 1983; Hoar 1976, 1988; Scholz and McLellan 2009).

The silvery coloration of smolts is imparted by activation of a second type of pigment cell, called iridocytes, by thyroid hormones. Iridocytes are goblet cells, embedded in the integument, that manufacture silvery guanine crystals. Guanine crystals are deposited subcutaneously over the melanophores, masking parr marks (Robertson 1948, 1949; Johnston and Eales 1967, 1968, 1970; Hasler and Scholz 1983). The crystals overlap and interlock, forming a surface that acts like a reflecting mirror. This arrangement affords protective camouflage in the ocean, where wave action causes spectral points of light to dance along the surface. The guanine mirror helps the smolt to blend in with the sea surface because the surface light bounces off them. Thus, they blend in with the dazzling spectral points of light and are less visible to predators below them in the water column and looking up. The backs of salmon smolts are dark olive green and iridescent blue. These colors blend in with deep water and afford protection from predators that are above them in the water column and looking down. Iridocytes are activated to produce and secrete guanine crystals by the action of thyroid hormones. Administration of exogenous thyroid hormones into presmolt rainbow/steelhead trout and coho salmon was soon followed by subcutaneous deposition of guanine crystals and development of silver color (Robertson 1949; Hasler and Scholz 1983).

Atlantic salmon, coho salmon, and steelhead trout presmolts that were given injections of either thyroid stimulating hormone or thyroid hormones in a solvent at time when the thyroid gland was inactive, showed increased downstream migratory activity compared to control fish injected with solvent alone (Godin et al. 1974; Scholz 1980; Hasler and Scholz 1983; Muzi 1984; Scholz et al. 1985).

Salinity tolerance and osmoregulatory capability develop in smolts. Smolts are able to survive for > 96 hours (usually indefinitely) in salinity challenge tests where they are abruptly transferred from freshwater (> 1 ‰) to full strength seawater (35 ‰) (Huntsman and Hoar 1939). Smolts actually develop a behavioral preference of seawater and will seek 35 ‰ SW when put in a tank that offers them a choice of compartments where salinity varies from freshwater to full strength seawater (Baggerman 1960b; McInerny 1964). Unlike parr, smolts can osmoregulate in seawater. When smolts are transferred abruptly from freshwater (< 1 ‰) to seawater as varying salinity (say 10, 20, and 30 ‰, which corresponds to blood osmotic concentration of about 280, 560, 857 mosmol/L) they are able to maintain a stable blood osmotic concentration of approximately 300 mosmol/L in each of the tanks. Smolts begin to drink seawater and absorb Na+ ions across the wall of their intestines into their blood. Water follows by osmosis. They get rid of the excess sodium ions by pumping them back into seawater across the gills. Embedded in the gills are chloride cells that contain the enzyme Na+/K+ ATPase, which uses energy (ATP) to pump Na+ ions out of the fish. Na+/K+ ATPase is activated by increased levels of cortisol, growth hormones, and thyroid hormones at the time of smolt transformation (reviewed by Folmar and Dickhoff 1980; Hasler and Scholz 1983; Scholz and McLellan 2009).
The smolt stage is also the critical period for olfactory imprinting, when the salmon learns (or becomes imprinted) to the odor of its homestream, this odor, embedded in the memory of the fish, later provides adults with a cue to relocate its homestream (Scholz et al. 1976; Hasler et al. 1978; reviewed by Hasler and Scholz 1983 and Scholz and McLellan 2009). The imprinted odor acts as a sign stimulus to release a stereotyped behavior. The fish swim upstream when the odor is present and downstream when it is absent (Johnsen and Hasler 1980). Olfactory imprinting in smolts is activated by thyroid hormones (Scholz 1980; Hasler and Scholz 1983), which appears to cause neuron circuits to develop that store the long term olfactory memory.

Thyroid induced differentiation of brain neurons was observed in steelhead trout undergoing smolt transformation (Lanier 1987; Scholz et al. 1992). Golgi silver stain impregnation techniques were used to render the axons and dendrites of individual neurons visible. Individual neurons were traced using a camera lucida while focusing through several focal planes of a phase contrast microscope, so that the 3-dimensional neuron could be converted into a two dimensional drawing. Lanier (1987) found that, coinciding with the thyroid surge in smolt stage steelhead, the diameter of the nerve cell bodies increased, the number of axons increased, the number of dendrites increased, the lengths of the axons increased, the lengths of the dendrites increased, and the number of synapses increased.

Each of these variables was significantly greater during the smolt stage in late April or early May (when the thyroid hormone surge occurred) as compared to presmolts in February (when thyroid hormones were at basal levels) (Lanier 1987). Presmolts injected with TSH in February, in doses sufficient to elevate thyroid hormones concentrations to levels found in natural smolts, displayed proliferation of axons, dendrites, and synapses that resembled the pattern observed in natural smolts (Lanier 1987; Scholz et al. 1992). In contrast, control fish injected with saline placebo in February did not experience increased thyroid hormone concentration or undergo neuron proliferation.

While olfactory cues guide the fish in its migration up the Columbia River to the home tributary, their migration in the open ocean appears to be guided by geomagnetic cues. Quinn (1982, 1984) and Lohmann et al. (2008a, 2008b) proposed a model for adult salmon migration on the high seas that involved either a genetically inherited map sense that identified the location of their home river or geomagnetic imprint of the mouth of their home river as they entered the ocean. “Two magnetic elements (including angle and intensity) vary predictably across the globe, and endow different geographic areas with unique magnetic signatures. The magnetic field of the earth resembles that of a bar magnet. Field lines leave the southern hemisphere and reenter in the northern hemisphere. At each location on the globe, the magnetic field lines intersect at the Earth’s surface at a specific angle of inclination. Hence, inclination angle varies predictably at a given latitude” (Lohmann et al. 2008b). Salmon could determine their location relative to home based on inclination (or dip) and declination (angle between the geographic and magnetic poles) of the earth’s magnetic field, then use a compass heading (based on geomagnetic cues) to maintain their course towards home.

Chinook, chum, sockeye salmon, and rainbow trout have an organ in the dermoethmoid cartilage that contains crystals of the ferromagnetic mineral magnetite (Fe₃O₄) (Kirschvink et al. 1985, 2001; Walker et al. 1988; Mann et al. 1988; Ogura et al. 1992). In rainbow trout, receptor cells containing magnetite have been found in the olfactory lamellae (Diebel et al. 2000). In each case, bundles (chains) of magnetite are associated with neural dendrites. It is thought that the magnetite interacts with these neurons to depolarize them, sending an electrical signal into the brain. Magnetite, which has magnetic properties, appears to respond to the earth’s magnetic field, giving the fish the ability to navigate the ocean. Thus, if the fish has either a genetic memory, or an imprinted (learned) memory, of where home
is, it may also be able to compare its current map position to the position of where home is and migrate in an appropriate compass direction to get there.

Lake whitefish are usually lake residents that spawn in shoreline gravels. They live for 9–10 years and usually become sexually mature at age 3–5. They are iteroparous. They attain a maximum total length of about 701 mm (27.6 in.) in eastern Washington. Fecundity ranged from about 15,000–70,000 eggs/female.

Pygmy whitefish can be stream residents, lake residents or make adfluvial migration between their natal tributary and a lake. They live for 5–9 years and become sexually mature at age 1–3. They are iteroparous. They attain a maximum total length of 289 mm (11.4 in.) but few grow larger than 150 mm (5.9 in.). Fecundity ranged from 156–2,271 eggs/female.

Mountain whitefish exhibit resident, fluvial, and adfluvial life histories. They have a maximum lifespan of 8–16 years and become sexually mature at age 3 or 4. They attain a maximum total length of 686 mm (27.0 in.). Fecundity ranges from 1,426–24,143 eggs/female.

Coastal cutthroat trout exhibit anadromous, fluvial, or resident life histories. Anadromous populations live a maximum of 10–11 years, migrate to saltwater at age 1–3, and become sexually mature at age 3 or 4. They typically grow to a maximum total length of about 475 mm (18.7 in.). They spawn in the spring and are iteroparous (Trotter 1989). Some individuals were documented to spawn each year for five consecutive years. Resident populations are usually isolated above barrier falls, live a maximum of about 4 years, become sexually mature at age 2 and seldom grow larger than 200 mm TL (Trotter 1989). Fecundity of coastal cutthroat trout ranged from 300–2,700 eggs/female.

Westslope (intermontane) cutthroat trout exhibit resident, fluvial, or adfluvial life histories. Maximum lifespan was about 7 or 8 for fluvial and adfluvial variants. They migrate out of their natal tributary at age 1–4 (most at age 2–3), and attain sexual maturity at age 3–5. About 1–25% of the individuals in a (spawning population) are iteroparous. Maximum lifespan was 12–13 for resident variants. They are iteroparous and spawn either annually or in alternate years beginning at age 3–5. Maximum total length was about 250–300 mm TL for resident variants, 350–450 mm TL for fluvial variants, and 450–550 mm TL for adfluvial variants. Fecundity of westslope cutthroat trout in Lake Chelan averaged (ranged) 917 (667–1,027) eggs/female in females that averaged (ranged) 266 (221–363) mm TL (Brown 1984).

Yellowstone cutthroat trout exhibit resident, fluvial, and afluvial life history strategies (Gresswell et al. 1994), adfluvial being most common. They have a maximum life expectancy of 6–11 years, migrate out of their natal tributary at age 1–3, and become sexually mature at age 2–4. They spawn during spring and summer with about 15–26% of being iteroparous. Their maximum size is about 525 mm (20.7 in.) and fecundity normally ranged from about 1,577–2,930 eggs/female.

Lahontan cutthroat trout usually exhibit an adfluvial life history strategy. They have a maximum life expectancy of 6–9 years, migrate out of their natal tributary at age < 1–3 years, and become sexually mature at age 2–4. They spawn during summer and are iteroparous. Their maximum size is about 990 mm (39 in.) in Pyramid Lake Nevada, and 787 mm (31 in.) in eastern Washington (Omak Lake). Fecundity ranged from about 1,000–4,000 eggs/female.

Pink salmon live 2 years and migrate to the ocean soon after they fry emerge from their redds at age 0 (Heard 1991). After reaching the ocean, pink salmon swim into the Gulf of Alaska. They almost invariably return to spawn at age 2 (Heard 1991). They are fall spawners and semelparous. Pink salmon spawn close to saltwater rarely traveling more than 50 km inland. Some spawn in estuaries. Sexually mature pink salmon average (range) 508
Chum salmon migrate to the ocean at age 0 after spending a few (up to six) months in freshwater (Salo 1991). They remain at sea for 3–5 years, with most fish returning at age 4 (Salo 1991). They are fall spawners and semelparous. Maximum total length of chum salmon is 1,088 mm (42.8 in.). Fecundity averaged (ranged) 2,241 (2,028–2,534) eggs/female for chum salmon returning to Columbia River hatcheries. Most chum salmon in the Columbia River Basin spawn in the tributaries below Bonneville Dam. At Ives and Pierce Islands (in the main channel of the Columbia River below Bonneville Dam) chum salmon spawned in upwelling water that was significantly warmer than surrounding river water (Geist et al. 2002). Mean river temperatures were 5.7°C and mean redd temperature was 8.3°C. Salo (1991) also reported that many stocks of chum salmon in both Asia and North America selected spawning areas with warmwater discharge. After reaching the ocean chum salmon swim into the Gulf of Alaska.

Coho salmon usually migrate to the ocean from March–June at age 1.5 (Sandercock 1991). They almost invariably return after spending 1.5 years in the ocean to spawn at age 3, although some (about 15%) are precocious fish called jacks (males) or jills (females) return to spawn after spending 6 months at sea at age 2 (Sandercock 1991). The ratio of jacks to jills is about 25:1. Coho spawn in fall and are semelparous. Maximum total lengths of coho is about 850 mm (33.5 in.). Fecundity in the Columbia Basin ranges from about 2,200–2,948 eggs/female. After reaching the ocean coho usually remain off the coast of Washington and Oregon.

Golden trout are usually stream residents in their native habitats. However, they have been successfully established in high mountain lakes with inlets or outlets where they develop an adfluvial life history, growing in the lake and spawning in the tributaries (Moyle 2002). Maximum lifespan was 7–9 years and both sexes became sexually mature at age 3 or 4. They spawn in fall and are iteroparous. Maximum total length is 711 mm (28 in.), although few individuals are more than 350–400 mm (13.8–15.7 in.).

Coastal and interior (redband) rainbow/steelhead trout. Steelhead are anadromous and rainbow trout are landlocked life history variants or Oncorhynchus mykiss. Fisheries scientists recognize two major evolutionary lineages in North America that differ genetically enough to warrant subdivision into subspecies: O. m. irideus (coastal steelhead/rainbow trout) and O. m. gairdneri (interior (redband) steelhead/rainbow trout) (Behnke 1992). The distribution of coastal steelhead (anadromous) and rainbow (resident) is usually allopatric, separated by a barrier falls. Below the falls is the province of steelhead. Above the falls is the province of rainbow trout. The distribution of interior (redband trout) is usually sympatric. In very cold headwater streams, juvenile steelhead had difficulty in attaining the size needed to undergo smolt transformation and were thus "thermally fated" to become resident redband rainbow trout as opposed to redband steelhead trout (Mullan et al. 1992). The Kamloops trout is a redband trout with an adfluvial life history.

Steelhead are subdivided into a stream-maturing type (called summer steelhead) and an ocean-maturing type (called winter steelhead). Summer steelhead return to the Columbia River from March through October, and spawn in tributaries from February to June in the calendar year following their return (WDFW/ODFW 2002). Winter steelhead return to the Columbia River from December through April. They spawn from February to June in the same year of their return (WDFW/ODFW 2002). Most hatchery raised summer and winter steelhead migrate to the ocean at age 1, while most wild summer and winter steelhead migrate to the ocean at age 2 or 3. This difference is a reflection of hatchery steelhead growing to smolt size faster than wild steelhead. Summer steelhead spend 1, 2 or 3 years at sea. Most winter steelhead spend two years at sea. Most winter steelhead return to tributaries.
below Bonneville Dam and none return to tributaries above The Dalles Dam. In Bonneville Reservoir, the Klickitat and Wind rivers and a few minor tributaries support winter steelhead runs. In contrast, summer steelhead return to tributaries below and above Bonneville Dam. They formerly ascended the Columbia upstream as far as the Spokane (RKM 1,029) and Pend Oreille (RKM 1,194 km) rivers, and the Snake River to Shoshore Falls (about 952 km above the confluence of the Snake and Columbia rivers, or 1,472 km from the sea) (Fulton 1970).

In the Columbia/Snake River Basins the upriver run of summer steelhead are further subdivided into A-run or B-run fish. A-run fish enter the Columbia River in June–August (pass Bonneville Dam before August 25). B-run steelhead enter the Columbia River from late August to October (pass Bonneville Dam after August 25). A-run steelhead usually return after one year in the ocean, whereas B–run steelhead usually return after two years in the ocean. A-run steelhead return to tributaries in both the Columbia and Snake rivers whereas B-run steelhead are limited to only the Clearwater and Salmon River drainages, tributaries of the Snake River in Idaho. Maximum lifespan of rainbow/steelhead trout is 9–12 years, but they more commonly live from 4–6 years. Most freshwater rainbows become sexually mature at age 3. Most steelhead become sexually mature at age 4 or 5. Steelhead and rainbow are iteroparous, i.e., some steelhead and most rainbow survive to spawn a second or third time. Steelhead worn out after their arduous migration become kelts, and spawning kelts, which can be recognized by their emaciated appearance, descend the river along with smolts. Rates of iteropary in steelhead ranges from 1.6 to 17% with higher rates in tributaries below Bonneville Dam and lower rates in tributaries above Bonneville Dam.

Maximum fork length is about 890 mm (35.0 in.) in steelhead population, 750 mm (30 in.) in adfluvial rainbow populations, 650 mm (25.6 in.) in fluvial rainbows and 450 mm (17.5 in.) in resident rainbow populations. Fecundity of anadromous steelhead in the Columbia Basin ranged from about 3,412–7,571 eggs/female (reviewed by Scholz and McLellan 2009). Fecundity of potamodromous or resident rainbow trout in the Columbia Basin ranged from 76 eggs in a 159 mm FL female to 3,102 eggs in a 465 mm FL female.

Sockeye salmon migrate out of the natal tributary to a nursery lake soon after emergence from the gravel. They remain in their nursery lake until they migrate to the ocean at age 1.5 or 2.5. They usually spend 1.5 to 3.5 years at sea before returning to spawn at ages 3 to 5 (Burgner 1991). They are fall spawners and semelparous. After reaching the ocean, sockeye from the Columbia River migrate to the Gulf of Alaska. Kokanee are land-locked sockeye that migrate into a nursery lake immediately after emergence and return to their home streams at age 2, 3, or 4. Sockeye typically grow to a maximum fork length of about 575 mm (22.6 in.). Kokanee grow to an average length of 331 mm TL (13.0 in.) at age 4 in nine eastern Washington lakes (Scholz and McLellan 2009). Kokanee grew best in Lake Roosevelt where 4 year olds averaged 438 mm (17.2 in.). The largest kokanee in Lake Roosevelt measured 591 mm (23.3 in.). Fecundity of 958 sockeye from Lake Wenatchee and Okanogan Lake ranged from 1,305–2,677 eggs/female (Chapman et al. 1995). Fecundity of kokanee in Lake Roosevelt (n = 102) averaged 1,000 eggs/female in age 2 females (263 mm TL), 1,376 eggs/female in age 3 females (356 mm TL) and 1,683 eggs/female in age 4 females (467 mm TL) (Peone et al. 1990). Age 3 and 4 kokanee (n = 170) at Sullivan Lake that averaged 240 mm TL contained an average of 364 eggs/female (McLellan 2004, 2005, 2006; King and McLellan 2007). Age 3 and 4 kokanee (n = 3,563) in Rimrock Lake (233 mm TL) averaged 156 eggs/female (Eric Anderson, WDFW, pers. comm.).

Chinook salmon are anadromous and semelparous. Chinook salmon have two major life history variations (Healey 1991; Myers et al. 1998). One form, called “stream-type” Chinook, typically reside in freshwater for more than one year before emigrating to the ocean as smolts at age 1+ (Gilbert 1912; Healy 1983; 1991; Chapman et al. 1994). Their downstream
migration in the Columbia River takes about a month to complete. The age at time of return to freshwater is 2 to 6. Adults usually return to freshwater several months before spawning. Typically they enter freshwater from March to May and spawn from August to October. The second form, called “ocean-type” Chinook, reside in freshwater for less than a year, typically 1–4 months, before emigrating to the ocean as smolts at age 0 (Mullan 1987; Healey 1991; Chapman et al. 1994). They begin to migrate soon after emerging from their redd. Their downstream migration may take 3–4 months to complete. They feed along the way and reach the ocean by the end of the summer of the year they were born. The age at time of return is 2–7.

In the Columbia River, Chinook salmon are also divided into spring, summer, and fall runs. Spring run Chinook return to freshwater primarily in March to May and spawn from August to October (WDFW/ODFW 2002). Almost all spring runs are stream-type Chinook. Summer run Chinook enter the river during June and July, with the majority passing Bonneville Dam in early July (WDFW/ODFW 2002). They spawn from late September through November. Fall run Chinook enter the river in August to November (WDFW/ODFW 2002). Spawning occurs in autumn. Almost all fall run fish are ocean-type Chinook.

There are two distinctive components of summer Chinook runs. One group spawns in tributaries of the upper Columbia River. Juveniles migrate to saltwater in their first year of life and are therefore considered to be ocean-type Chinook (Mullan 1987; Chapman et al. 1991, 1994; Taylor 1990a, 1990b, 1991; Myers et al. 1998). The other group spawns in tributaries of the Snake River, Idaho. They spend a full year in freshwater before migrating to the oceans and are thus considered to be stream-type Chinook (Taylor 1990a, 1990b, 1991; Chapman 1991, 1994; Myers et al. 1998).

Adults return in the summer and autumn, and spawn soon after entering freshwater. Typically they enter freshwater from August to October and spawn from mid-August to November. Spring and summer Chinook return to spawn and rear in the upper reaches of the major tributaries of the Columbia and Snake rivers. In contrast, fall Chinook spawn in the mainstems of the Columbia and Snake rivers and in the lower reaches of the major tributaries.

Two types of fall Chinook enter the Columbia River. Some called “Tules” enter the river in an advanced state of sexual maturation. Their gonads are ripe and they have dark spawning coloration. They enter the river and spawn immediately. “Tules” historically spawned in the mainstem from the mouth of the Columbia to the Klickitat river (near the Cascade Crest). Others, called “upriver brights” entered the river 1–3 months before spawning, in slivery coloration and gradually matured. Upriver brights (URB) historically spawned in the mainstem of the Columbia River above the Cascade Crest, in the regions now occupied by the four lower Columbia reservoirs and in the Hanford Reach. Wild spawning of upriver brights now occurs primarily in the Hanford Reach, the last remaining free-flowing section of the Columbia River above Bonneville Dam in the United States. Snake River brights (SRB) are upriver brights that spawn in the Snake River.

Maximum fork lengths are about 950 mm (37.4 in.) for a 6 year old stream-type Chinook and 1,000 mm (39.4 in.) for a 6 year old ocean-type Chinook. Fecundity ranged from 2,148–7,750 eggs/female in a sample of 462 Chinook females collected in the Columbia and Snake rivers that ranged from 493–840 mm FL (summarized by Scholz and McLellan 2009).

Chinook salmon have the largest eggs of all salmon species, about 6–7 mm in diameter (Rounsefell 1957). Consequently their eggs have a small surface to volume ratio, which means they will have more difficulty extracting oxygen within the redd. Hence, Chinook
prefer areas with high sub gravel flow. For example, in the Hanford Reach of the Columbia River, adult fall (ocean-type) Chinook constructed redds in clusters (Geist et al. 2000a). These clusters were associated with areas where hyporeic water discharged into the river channel. This upwelling water had a specific conductance similar to the river water and was thought to have entered the highly permeable river bed substrate upstream from the spawning area. It then percolated through the redd by sub-gravel flow and upwelled through the redds. This type of area is apparently highly attractive to egg laying Chinook. Areas where little or no upwelling occurred, or areas where hyporeic discharge was composed of undiluted ground water, low in oxygen, failed to attract spawning females. Areas selected by salmon had rates of upwelling that averaged (± 95% CI) 1,200 (784–1665) l • m² • day⁻¹ that had dissolved oxygen content of 9 ± 0.4 mg/l. Areas not selected by salmon had rates of upwelling that averaged (± 95% CI) 500 (303–1,159) l • m² • day⁻¹ and had a dissolved oxygen content of 7 (± 0.9) mg/l (Geist et al. 2000a). Repeated use of the same cluster areas was made by Chinook during the 1994 and 1995 spawning seasons. Chinook were spaced uniformly within a cluster, which suggested that redds were evenly spaced so not to interfere with oxygen levels in neighboring redds (Geist et al. 2000a).

Stream-type Chinook salmon tagged in the Columbia River were recovered off the coasts of northern British Columbia and Alaska or on the high seas as far west as 175°W longitude. Ocean-type Chinook remained within 250 km of the coast.

Atlantic salmon usually migrate to sea at age 1.5–2.5. They usually remain at sea for 2–3 years and return to spawn for the first time at age 3–5. They live a maximum of 8–9 years. They are fall spawners and iteroparous. Sebago salmon are a land-locked variety of Atlantic salmon with adfluvial life history, that migrate to a lake at age 1.5 and spawn at age 3 or 4. Maximum fork length was 1,351 mm (53.2 in.) in anadromous Atlantic salmon and 640 mm (25.2 in.) in land-locked Atlantic salmon (Scott and Crossman 1973). Fecundity varies from about 2,000–15,000 eggs/female.

Brown trout (sea run or adfluvial variations) usually migrate to the sea or lake at age 1.5. Most males become sexually mature at age 3–4 and most females at age 4–5, after spending 1.5–2.5 or 2.5–3.5 years at sea or in the lake respectively. Maximum lifespan of resident and adfluvial brown trout in eastern Washington was 10–11 years in eastern Washington. They become sexually mature at age 1–5, they are fall spawning and iteroparous. Maximum total length in eastern Washington was 914 mm (36 in.) TL. Fecundity ranged from 144 eggs in a 178 mm (7 in.) female to 20,865 in an 826 mm (32.5 in.) female (Wydoski and Whitney 2003).

Tiger trout are produced by crossing a female brown trout with a male brook trout. The hybrid is sterile. Tiger trout grow rather quickly since they don't have to put any energy into gamete production but instead put it all into somatic cell growth. In Fish Lake, Spokane Co., they grow to 227 mm TL by age 1, 358 mm TL by age 2 and 514 mm TL by age 4. At Black Lake, Stevens Co., they grow to 225 mm TL by age 1, 292 mm by age 2, 371 mm by age 3 and 467 mm by age 4 (reviewed by Scholz and McLellan 2009).

Bull trout exhibit fluvial, adfluvial, and resident life histories in eastern Washington. Bull trout typically live 9–11 years. Fluvial and adfluvial bull trout usually leave their natal tributary at age 2–3 and become sexually mature at age 5–6. Fluvial adults attain maximum total length of 400–600 mm (Scholz and McLellan 2009). Adfluvial adults attain maximum total length at 700–1,000 mm. Resident bull trout become sexually mature at age 3 or 4 and attain maximum lengths of 200–300 mm. Fecundity ranged from 380–7,382 eggs/female in bull trout that ranged from 270–723 mm TL. Bull trout generally spawn in gravel substrate in proximity to areas of cold (9°C) upwelling spring or tributary and presence of cover. These requirements restrict the number of bull trout spawning sites within a stream. For example, in the Flathead basin Montana only about 27% of the basin had hyporeic discharge and cover and this is where all of the bull trout spawned (Fraleyn and Shepard 1989).
Chapter 12

Brook trout are rarely anadromous. Most populations in eastern Washington are stream residents. Maximum lifespan is 8 years, but they seldom live longer than 5 years. They become sexually mature in 2–3 years, are fall spawners, and iteroparous. The largest brook trout we have collected in eastern Washington was a 533 mm TL specimen from Deer Lake, Stevens Co. (Scholz et al. 1988b). At most locations brook trout did not attain such large size. McLellan (2002, 2003, 2005) sampled 291 sites in the Little Spokane River Basin (Pend Orielle, Spokane and Stevens Cos.) and collected 6,655 brook trout ranging from 32–296 mm TL. Ashe and Scholz (1992) sampled 1,287 brook trout from 5 tributaries at the Pend Oreille River ranging from 41–234 mm TL. Over a 25 year period from 1980–2004, EWU examined 9,250 brook trout in Marshall Creek, tributary of Latah Creek, Spokane Co. The largest fish measured 371 mm (14.6 in.) TL and only 10 of them exceeded 254 mm (10.0 in.) TL. Fecundity varied from 100 eggs in a 144 mm (5.7 in) female to 6,811 eggs in a 565 mm (20.5 in) female (reviewed by Scholz and McLellan 2009).

Lake trout are usually lake dwelling and spawn either along the shoreline or over offshore reefs. Maximum lifespan is about 12-23 years. Lake trout become sexually mature at ages 5–7. They do not dig redds but instead broadcast spawn over cobble substrate. They usually spawn in late fall and are iteroparous. Maximum total length in eastern Washington is about 1,000 mm (39.4 in.). Fecundity ranged from 2,476–17,119 eggs in females ranging from 638–965 mm.

Arctic grayling spawn in spring at about the time of ice break-up. Unlike most salmonids females do not dig redds. Instead they broadcast spawn and the eggs, which are demersal and adhesive, sink into spaces between the gravel and cobble. Arctic grayling have a maximum lifespan of 6–10 years, and become sexually mature at age 2–3, attain a maximum total length of 531 mm (20.9 in.), and are iteroparous.

Salmonid fishes are omnivores that prey opportunistically on whatever organisms are numerically abundant in the environment. Salmonids are equipped with many different kinds of teeth that are used to capture and subdue prey. Not only do they have teeth in their lower jaws (mandibular teeth) and upper jaws (maxillary teeth), but also on the palatine bones (palatine teeth) and vomer (vomerine teeth) on the roof of the mouth, on the tongue (lingual teeth) and, in some species, on the hyoid bone (hyoid or basibranchial teeth) at the base of (i.e., behind and underneath) the tongue, between the anterior gill arches.

Many species of salmonids have gill rakers (in addition to gill filaments) on the gill arches that act as ‘filter baskets’ to strain zooplankton out of the water that is being pumped through the gills. The spacing between the gill rakers dictates the size of the organisms that are filtered. For example, brown trout, which have relatively short, stubby gill rakers spaced far apart (n = 14−17 gill rakers on 1st gill arch; gap > 1 mm) are not effective at cropping zooplankton (Figure 12.8). In contrast, rainbow trout which have relatively long gill rakers spaced closer together (n = 16–22 gill rakers on 1st gill arch gap; ~1.0 mm) can effectively crop large sized cladocerans (e.g. Daphnia) that are ≥ 1.0 mm (Figure 12.8). Small-sized cladoceran species (e.g. Bosmina, Ceriodaphnia, Chydorus) and copepods that are typically < 1.0 mm pass through the spaces between the gill rakers. Kokanee salmon, which have gill rakers that are even longer and more closely spaced together (n = 31–44 gill rakers on 1st gill arch; gap < 1.0 mm) than rainbow trout can crop small-sized cladocerans and copepods more effectively than rainbow trout (Figure 12.8).

Small, stream-dwelling salmonids tend to prey on benthic macroinvertebrates, especially the larval or pupal stages of aquatic insects. They may feed off the bottom (where many insects are attached to rocks) or on the drift (which includes aquatic insects that have become detached from their substrate or terrestrial insects blown into the water). Small, lake-
Figure 12.8  Comparison of gill rakers in three species of salmon. A) Brown trout with short stubby, gill rakers are not well adapted for feeding in zooplankton; B) Rainbow trout have longer gill rakers spaced about 1 mm apart that are adapted for feeding on large size cladocera such as *Daphnia*; C) Kokanee salmon have long gill rakers spaced < 1 mm apart that are adapted for feeding on Cladocera or smaller-sized copepods; D) Cladocera (*Daphnia* spp.); E) Rainbow trout showing how gill rakers act as a sieve to trap *Daphnia*. All of the orange blobs are *Daphnia*; F) A copepod.

dwelling salmonids tend to prey on zooplankton. As they become older, the large-sized individuals in both streams and lakes often begin to consume fish.
Lake whitefish in Lake Roosevelt are facultative planktivores because benthic production in the lake is limited by extreme drawdown. Barlow (2000) and Black et al. (2003) conducted stable isotope assessment of the Lake Roosevelt food web. They found that Lake whitefish in Lake Roosevelt obtain almost 100% of their carbon from limnetic rather than benthic sources, suggesting that they feed predominantly on zooplankton living in the water column rather than aquatic insects living on the bottom. Prey organisms in the diet of 171 lake whitefish at Banks Lake included 77% zooplankton (87% of which were *Daphnia*), 15% insects, 2% snails, and 6% sculpins (Polacek et al. 2003a, 2003b).

Lake whitefish, pygmy whitefish, and mountain whitefish consume crustaceans, aquatic insects, molluscs (snails and fingernail clams), water mites, and occasionally ostracods, amphipods and fish eggs (Scholz and McLellan 2009). Chironomid (midges) comprised about 50% of the diet of most populations of all three species. Caddisfly larvae and pupae were also prominent prey in the diets of mountain whitefish.

Coastal cutthroat diets in freshwater were comprised of about 50% aquatic insects (mayflies, caddisflies, stoneflies) and crayfish, and 50% fish. Coastal cutthroat exhibited a greater degree of piscivory than interior cutthroat trout. In marine waters, coastal cutthroat consumed mainly fish (about 89% of the diet by weight), krill (*Euphausiidae*) and crab megalops larvae (Loch and Miller 1988). Almost half the fish were northern anchovy *Engraulis mordax*.

Interior (westslope and Yellowstone) cutthroat trout ate a smorgasbord of aquatic insects (Diptera, beetles, mayflies, caddisflies, stoneflies, flying ants), grasshoppers, water mites, orb snails, and rarely fish (mainly sculpins). In five tributaries of the Pend Oreille River, westslope cutthroat ate a mixed diet of aquatic insect larvae and terrestries adults (Ashe and Scholz 1992). They fed more heavily on larval and adult insects that were drifting on water currels as opposed to those anchored in the substrate because the compositions of insects in their diet more closely approximated that of insects caught in drift net samples than that of insects caught in Hess substrate samplers. Also, in a study that compared the diets of Yellowstone cutthroat trout, rainbow trout, and mountain whitefish captured in the same location, the two trout species were surface orientated, whereas the whitefish fed mainly on prey that were crawling along the bottom or attached to substrate (Laakso 1951). Thus, the behavior of whitefish and trout resulted in partitioning of food resources that allowed them to avoid direct competition.

Lahontan cutthroat trout in their native habitats initially eat zooplankton and aquatic insects, especially midges *Chironomous* and phantom midges *Chaoborus*. As they grew older they gradually became more piscivorous. In Washington, older Lahontan cutthroat (> 300 mm TL) did not switch to fish because they were typically stocked into high alkalinity lakes e.g., Omak (Okanogan Co.), Lenore (Grant Co.) and Granite (Spokane Co.), that contained no or few fish (Kucera et al. 1985; Chess et al. 1993). For example, Granite Lake, Spokane Co. is a highly alkaline (pH 9–10) lake that was historically fishless prior to introduction of the Lahontan cutthroat. Here they ate neotonic siger salamanders *Ambystoma tigrinum*.

Pink salmon do not usually feed in freshwater (Heard 1991). After entering the estuary they fed mainly on copepods. As they move offshore they consume euphausiids (krill), mysids, ostracods, amphipods, crab zoea and megalops larvae, barnacle larvae and pteropods (flapping snails). Pink salmon also consumed fish, particularly sandlance *Ammodytes hexapterus* and pacific herring *Clupea pallasi* (Heard 1991).

Chum salmon initially prey on copepods, chironomids, krill, amphipods, and tunicate larvae upon entering seawater (Salo 1991). In the open ocean they consumed 36% gelatinous zooplankton (jellyfish, ctenopheres, and siphonophores), 30% krill, 15% pteropods, 9% fish,
6% amphipods, 4% arrow worms, 3% squid, 2% polychaetes and 21% copepods and decapod crustaceans larvae (Myers et al. 1995). Herrings, sandlances, greenlings, cods, rockfish, and lantern fishes were the predominate types of fish consumed.

Juvenile coho salmon are voracious predators during their period of stream residence. After staking out a feeding territory, they orient upstream and devour almost any organism that drifts over the surface or crawls along the bottom of their territory. Aquatic insect larvae and pupae, or terrestrial insects that have fallen or were blown into the water, form the mainstay of their diet. Types of prey consumed in freshwater included chironomid larvae, caddisfly larvae, stonefly larvae, may fly larvae, beetles, water mites, and worms (Foerster and Ricker 1953; Roos 1960; Mason 1974). Small fishes, including some species of salmonids, are also frequently found in their stomach contents. In the ocean coho were piscivores that consumed Pacific herring, northern anchovy and Pacific sand lance and at least 17 other species of fish (Sandercock 1991). Additionally, at times they eat substantial numbers of squid, krill, cancer crab megalops larvae, and goose barnacles.

Rainbow trout diets were comprised of large amounts of zooplankton (predominantly *Daphnia* sp. and *Leptodora kindtii*), and chironomid larvae and pupae. *Daphnia* usually account for about 75% of their diet by number but chironimids are the dominant food by weight. Rainbow trout also consumed smaller amounts of crustaceans (amphipods and crayfish), mayflies, caddisflies, damsel flies, stoneflies, flying ants, grasshoppers, butterflies, ostracods, aphids, cicadens, clams, snails, Dipterans (e.g., mosquitos, crane flies, black flies), bugs (e.g., water boatman, water striders, backswimmers), dragon flies, wasps, and several kinds of beetles. Rainbow trout occasionally consume fish, predominantly sculpin. Large adfluvial kamloops trout often consumed kokanee. Fish and squid dominated the diet of anadromous amphipods, pteropods, krill, and crab and barnacle larvae constituted the remainder of the stomach contents (reviewed by Scholz and McLellan 2009). Goldent trout consumed almost exclusively aquatic and terrestrial insects (McAfee 1966; Moyle 1976a).

Anadromous sockeye salmon in freshwater nursery lakes are mainly plantivores as are adfluvial kokanee in their lake dwelling phase (Burgner 1991). In lakes where *Daphnia* are available their diet is composed almost exclusively of *Daphnia*. For example, in Lake Roosevelt, where 564 kokanee stomachs were examined from 1988–2000, the dominant item in the diet for all years was *Daphnia*, which comprised 99% by number and 90% by weight of all food items found in their stomachs. Additionally, they consumed trace amounts of copepods and chironomid larvae and pupae. In oligotrophic alpine lakes (e.g., Lake Chelan) where *Daphnia* is less available in the zooplankton community, sockeye and kokanee shift to copepods (Brown 1984). They are one of the few freshwater fish species that can eat copepods because the space between their gill rakers is fine enough to trap the smaller sized copepods. At sea, sockeye consumed 27% krill, 23% squid, 13% copepods, 6% pteropods, 4% fish, 2% gelatinous zooplankton (cnideriams, ctenophores, siphonophores), 1% crab larvae, 1% arrow worms, and 1% polychaete worms (Myers et al. 1995).

Chinook salmon juveniles in Columbia River consume mostly larvae, pupae and adult midges, mayflies, caddisflies, amphipods *Corophium salmonis*, mysid shrimp *Neomysis mercedis*. In the Columbia River estuary, *C. salmonis* dominated the diet, which included a variety of aquatic insects, crab megalops larvae, and fish (especially smelt and Pacific sand lance) (Healey 1991). At sea Chinook consumed 75% fish by weight (herring, smolt, northern anchovy, and rockfish). Adfluvial Chinook that occupy lakes, prey on fish, especially kokanee and cutthroat trout (reviewed by Scholz and McLellan 2009).

Atlantic salmon juveniles in freshwater eat a variety of aquatic and terrestrial insects especially mayflies, beetles, midge larvae and pupae, damselflies, and caddisfly larvae. At sea, Atlantic salmon predominantly eat crustaceans (amphipods, euphausiids, decapods), and fishes (sand lance, smelt, herrings, and cod).
Stream-dwelling resident brown trout are sedentary and defend a feeding territory, seldom moving more than a few meters from that territory except during spawning migrations to their natal breeding site (Becker 1983). After the reproductive season they return to the same feeding territory previously occupied. Feeding territories are the result of aggressive encounters that establish dominance hierarchies among individual brown trout in the population. Usually the largest, most aggressive individual establishes the largest territory in the best area of the stream for catching drifting insects and where hiding cover (e.g. large woody debris, undercut banks) is available. Juvenile brown trout consume zooplankton, freshwater shrimp, snails, fingernail clams, midges and mayflies, stoneflies, caddisflies, and beetles. Feeding is most intense at dusk and dawn, but can occur any time during the day or night. Adult brown trout have a reputation for being more piscivorous than other trout species (Scott and Crossman 1973).

Food habits of 521 tiger trout were recently determined in 10 eastern Washington lakes (Miller 2009). Tiger trout in eastern Washington ate mainly *Daphnia* spp. and a variety of aquatic insects (Miller 2009). Molluscs (snails and fingernail clams), and amphipod crustaceans were also consumed. Adults switched to whichever fish species was relatively abundant (redside shiner, pumpkinseed, salmonids, and crayfish) (Miller 2009).

Resident and juvenile fluvial/adfluvial bull trout fed on aquatic insects, especially midges and mayflies (Martin 1992; Underwood 1996). Fluvial and adfluvial bull trout switched to fish, amphibians, and small mammals once they attained a larger size. Types of fish prey included sculpins and salmonids. Kokanee were a favorite prey of lake dwelling adfluvial bull trout (James 2002).

Brook trout in tributaries of Box Canyon Reservoir (Pend Oreille River) ate a mixed diet of aquatic and terrestrial insects, and large-sized zooplankton. Midges, blackflies, mayflies, caddisflies dominated their diets (Ashe and Scholz 1992). Flying ants were seasonally important. Stoneflies, beetles, amphipods, and snails were also found in their diets.

Lake trout are adapted for piscivory. Their large mouth gape (long jaws) enables them to capture large-sized prey. Sharp teeth on the head of the vomer, palatines, two rows on the tongue, and hyoid (basibranchial) teeth made them adept at subduing and ingesting fish prey. Adult lake trout eat whatever kind of fish happen to be available. Fish prey consumed by lake trout in Bead Lake included kokanee, largescale suckers, northern pikeminnow, burbot, sculpins, and yellow perch. Juvenile lake trout ate aquatic insects and zooplankton (Rader 2006).

Arctic grayling fed mainly on surface prey, especially during the summer, when they ate ovipositing adult flies of various types of aquatic insects that were alighting on the surface to lay their eggs or pupae that were emerging at the surface (Scott and Crossman 1973; Brown 1971). Like most salmonids, grayling appeared to be opportunistic predators, with stream dwellers consuming aquatic insect larvae, crustaceans (amphipods) and mollusks (snails) off the bottom and lake dwellers consuming crustacean zooplankton (Cladocera and copepods) in the water column at times when the supply of surface prey was low.

Anadromous salmon play a pivotal role in the ecosystems of the Pacific Northwest because they link oceanic to freshwater, and aquatic to terrestrial, food webs. In Washington, 137 species of wildlife in Washington are dependent upon salmon to some degree (Cedarholm et al. 2000). Salmon are a component in biogeochemical nitrogen, phosphorous, and carbon cycles. There is a constant loss of nutrients (nitrogen, phosphorous) from salmon rivers to the ocean. Nutrients converted into salmon flesh during their residence in the ocean are carried back upstream and recycled through decomposition of their carcasses. Nutrients released by this process fuel primary and secondary production in freshwater and terrestrial habitats.

Carbon skeletons that were manufactured by primary producers in the ocean are also converted into salmon flesh. Some of this carbon is consumed by predators, like grizzly bear
and bald eagles, that eat adult salmon or their carcasses. Thus, salmon are a key component in the biogeochemical cycles of many elements. Because salmon are prey for so many species of fish and wildlife, link oceans to freshwater, and freshwater to terrestrial ecosystems, and play a central role in the biogeochemical recycling of essential nutrients, they are considered to be a keystone species. Therefore, reduction in the numbers of salmon has potential to cause cascading trophic interactions with many ecological consequences.

Bilby et al. (1996) and Larkin and Slaney (1997) recognized that decreased productivity in salmon ecosystems may be self-perpetuating if the capacity of a watershed to produce future generations of salmon is progressively diminished because fewer and fewer adults return. Along with the loss of adult fish is the loss of nutrients recycled from the ocean, which creates a negative feedback loop that prevents future recovery because freshwaters are not sufficiently fertilized to increase primary and secondary production, and, hence, survival of the juvenile offspring.

In support of this idea, Cedarholm et al. (1999) estimated that before European settlement of the Columbia River Basin, when anadromous salmon and steelhead runs totaled 9.6–16.3 million adult fish at an average weight of 6.8 kg (NPPC 1986), harvest by the region’s Indian tribes was about 18,960 metric tons and spawning escapement back to home tributaries was about 45,150 metric tons. In comparison, the 1997 run size totaled about 2 million adult fish, most of which (about 1.5 million) were produced in hatcheries and either caught in fisheries or returned to their hatchery of origin, leaving only about 0.5 million fish, that totaled 3,400 metric tons (Cedarholm et al. 1999), that escaped to fuel the salmonid ecosystem of the Columbia Basin. This represented an astonishing 92% loss of the pre-settlement salmonid biomass (and corresponding loss of recycled marine nutrients). Gresh et al. (2000) concluded; “only 7% of the marine-derived nitrogen and phosphorus once delivered to rivers in the Pacific Northwest is currently reaching them. This nutrient deficit has likely contributed to the downward spiral of salmonid abundance making it impossible to recover salmon to self-sustaining levels.”

**KEY TO FAMILY SALMONIDAE**

**General Family Characters**

Confirm the specimen has these characters before keying to species.

1. Adipose fin present. Axillary process present at front base of pelvic fins.
2. One soft-rayed dorsal fin; other fins only with soft rays.
3. Pelvic and pectoral fins inserted near ventral midline.
4. Pelvic fins in abdominal position, inserted underneath dorsal fin.
5. Jaws with teeth. Other teeth present on floor and roof of mouth
6. Cycloid scales.
7. No barbels.

**Key to the Species of the Salmonidae of Eastern Washington**

1. A. Long sail-like dorsal fin with ≥ 17 rays *(Subfamily Thymallinae).*  
   *Arctic grayling*  
   *Thymallus arcticus*  
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   B. Short dorsal fin with ≤ 16 rays.  
   Go to 2
2. A. Large scales (<100 in lateral line row); short upper jaw (Maxillary bone not reaching point below center of eye); teeth absent or weakly developed on jaws; mouth slightly sub-terminal (Subfamily Coregoninae).

B. Small scales (>100 in lateral line row); long upper jaw (Maxillary bone extends beyond point below center of eye); teeth well developed on jaws and vomer; mouth terminal (Subfamily Salmoninae).

3. A. Two flaps between anterior and posterior nares; gill rakers long with 19–33 (usually > 22) on first arch; head concave between nape and snout (Genus Coregonus).

B. One flap between anterior and posterior nares; gill rakers stubby and stout with 9–25 (usually < 22) on first arch (Genus Prosopium).

4. A. Snout blunt (head round between nape and snout); <70 lateral line scales.

B. Snout pointed (head convex between nape and snout); >70 lateral line scales.

5. A. Light spots on dark background; teeth absent on shaft of vomer (Genus Salvelinus).
Family Salmonidae

B. Dark spots on light background; teeth present on shaft of vomer (Genus *Oncorhynchus* or *Salmo*).

6. A. Vermiculations (worm-like markings) present on back; leading edges of pectoral, pelvic and anal fins white with interior black bar.

   Brook trout  
   *Salvelinus fontinalis*  
   Page 201

   Go to 8

   B. Vermiculations absent on back; leading edges of pectoral, pelvic and anal fins white or translucent without interior black bar.

   Go to 7

7. A. Red, orange, or yellow spots present on sides on body (white spots may also be present); caudal fin not deeply forked (length of shortest caudal ray more than half the longest); prominent crest absent on front of vomer.

   Bull trout  
   *Salvelinus confluentus*  
   Page 199

   Lake trout  
   *Salvelinus namaycush*  
   Page 203

   B. Only white spots present on sides of body; caudal fin deeply forked (length of shortest caudal ray less than half the longest); prominent crest present on front of vomer.

8. A. Anal fin rays ≥ 13. Mouth with black or gray pigment on tongue and gums (*Pacific salmon*).

   Go to 9

   B. Anal fin rays ≤ 12. Mouth unpigmented, usually white (*Pacific trout, Atlantic salmon and trout*).

   Go to 13
9. A. Black spots absent on sides, and caudal fin (but fine black speckling may be present).

   B. Black spots present on back, sides and caudal fin.

Go to 10

10. A. Gill rakers on first arch 16–26, short and stout. Breeding males with streaky black, gray, white and red markings on sides that resembles paint that has run.

   B. Gill rakers on first arch 28–44, long and slender. Breeding males with brilliant orange or red color on back and sides, with pronounced kype and often a hump on their back.

Go to 11

Chum salmon
Oncorhynchus keta
Page 179

Sockeye salmon/kokanee
Oncorhynchus nerka
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11. A. Large oblong black spots on back and sides above the lateral line and on both lobes of caudal fin. Distinct hump present in front of dorsal fin in adult males.

   B. Small to medium-sized spots, rounded or irregular shaped in outline, present on back, sides and caudal fin. Hump in front of dorsal fin absent in adult males.

Go to 12

Pink salmon
Oncorhynchus gorbuscha
Page 177

12. A. Small spots on caudal fin confined to superior and posterior margins of dorsal lobe; interior of mouth has black pigment on tongue and jaws but gumlines along base of teeth are white.

Go to 12

Coho salmon
Oncorhynchus kisutch
Page 181
Family Salmonidae

B. Medium-sized spots present on both dorsal and ventral lobes of caudal fin; interior of mouth (tongue, jaws, gumline at base of teeth) is uniformly pigmented black.

Chinook salmon
Oncorhynchus tshawytscha
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13. A. Round or irregular shaped black spots on body; not in haloes (Pacific trout).

B. + or ×-shaped black spots or tiger stripes, in addition to rounded or irregular shaped black spots. Spots often surrounded by often surrounded by pale haloes. Red spots sometimes present; caudal fin usually without spots or with few irregularly spaced spots; large spots present on operculum (Atlantic salmon and trout, tiger trout).

14. A. Red, orange or yellow slash marks present in membranous folds under lower jaw (may be distinct or faint); basibranchial teeth present on hyoid bone (at back of throat between the gill arches) (Cutthroat trout group).

B. Red, orange, or yellow slash marks usually absent in membranous folds under lower jaw (except redband trout may have faint orange or yellow marks); basibranchial teeth absent on hyoid bone (except redband trout may have vestigial hyoid teeth) (Rainbow trout group).

Cutthroat trout
Oncorhynchus clarkii
Go to step 15 for key to varieties.

Rainbow trout
Oncorhynchus mykiss
Go to step 18 for key to varieties.
15. A. Spots present on top of head and distributed more or less uniformly over entire body (front and back, above and below lateral line).

B. Spots absent on top of head and distributed unevenly, with few in the anterior field and almost none below the lateral line in the anterior field.

16. A. Spots numerous over entire body, irregular (not rounded) outline; posterior edges of pelvic, anal, and caudal fins not fringed in white.

B. Sparse medium-sized spots with rounded outline; posterior edge of pelvic, anal, and caudal fins fringed with white markings.

17. A. Outline of spots rounded or oval; gill rakers 17–23 (usually 20–22). Posterior gill rakers on first arch weakly developed (0–3).

B. Outline of spots irregular (not rounded); gill rakers 17–21 (usually 18–19). Posterior gill rakers on first arch strongly developed (5–15).

18. A. Sides yellow, copper or gold, with contrasting red or orange belly; > 170 scales in lateral line row (usually more than 200).

B. Sides not yellow, copper or gold; < 170 scales in lateral line row (usually < 160).

19. A. Parr marks rounded, supplementary rows above and below the row along lateral line absent or reduced; tips of dorsal, anal and pelvic fin not colored different from rest of fin; no vestiges of basibranchial teeth or cutthroat marks under lower jaw; teeth on tongue weakly developed.

B. Parr marks elliptical, supplementary rows present above and below the row along lateral line; tips of dorsal, anal and pelvic fins different from rest of fin (in white, yellow, or orange pastels); basibranchial teeth and faint traces of cutthroat marks under jaw present in some individuals; teeth on tongue well developed.
20. A. Dark color tiger stripes or giraffe-like marking on a light background.

B. + or ×-shaped dark spots in addition to round spots on a light background.

21. A. Caudal peduncle narrow and streamlined. Width at narrowest point about equal to length of base of anal fin. Spots usually present on both dorsal and ventral lobes of caudal fin. Caudal fin forked.

   Tiger trout
   Salmo trutta (female) × Salvelinus fontinalis (male)
   Page 197

   Go to 21

B. Caudal peduncle thick and short. Width at narrowest point longer than length of base of anal fin. Spots usually absent on spots caudal fin and, if present, usually confined to upper lobe. Caudal fin square.

   Atlantic salmon
   Salmo salar
   Page 193

   Brown trout
   Salmo trutta
   Page 195
LAKE WHITEFISH

*Coregonus clupeaformis* (Mitchill, 1818)

Figure 12.9 Lake whitefish, Lake Roosevelt, Ferry/Lincoln/Stevens Cos., WA. Photograph courtesy of Casey Badwin, WDFW.

**Primary Identification**

1. Adipose fin present. Axillary process present at front base of pelvic fins.
2. Silvery color with large scales (70–97 in lateral line row).
3. Head slightly concave between nape and snout.

**Confirming Characters**

1. Two flaps between anterior and posterior nares. (Figure 13.10, p. 130).
2. Mouth slightly sub-terminal.

**Similar Species**

1. Pygmy whitefish have a distinctly blunt snout, and one flap between anterior and posterior nares.
2. Mountain whitefish have a head that is slightly convex between the nape and snout, and one flap between the anterior and posterior nares.
3. Arctic grayling have large scales like whitefish, but have a long, sail-like dorsal fin (16–25 rays).

**Etymology**

*Coregonus*: (G.) *core* the pupil of the eye; *-gon* -i, *-us*, an angle, i.e., angle-eye.

*clupeaformis*: (L.) *clupea-* ancient Latin name for herring; (L.) *-form* (is) shape, i.e., herring shaped.

**Common Name(s)**

Lake whitefish (AFS name), Great Lakes whitefish, common whitefish.
Figure 12.10  Lake whitefish distribution in eastern Washington.

Distribution

The lake whitefish has a wide distribution in North America, but was not a native of the Columbia River Basin. Lake whitefish were introduced in Idaho in 1889 when the USFC planted 1.3 million fry into in Pend Oreille Lake, 1.93 million fry into Coeur d’Alene Lake, and 200,000 fry into Hayden Lake. They failed to establish naturally reproducing populations in Coeur d’Alene or Hayden lakes, but they did become established in Pend Oreille Lake. In 1909, 500,000 lake whitefish were stocked in Flathead Lake, Montana and became established there (Brown 1971). They gradually expanded their range by migrating down the Flathead, Clark Fork, and Pend Oreille rivers into the Columbia River (Lake Roosevelt).

Whitefish are present in most mainstem reservoirs of the Columbia River and in irrigation storage reservoirs associated with the Columbia Basin irrigation project. We believe that their distribution in eastern Washington is owing to immigration into Lake Roosevelt from Pend Oreille Lake and/or Flathead Lake. Water from Lake Roosevelt is pumped though large diameter pipes, into Banks Lake, which serves as the main distribution reservoir for the Columbia Basin Project (Stober et al. 1976). Abundance of lake whitefish in Lake Roosevelt was estimated at 81,822 in 1999/2000 (Baldwin et al. 1999, 2005). The population appears sufficiently large to act as a reservoir for dispersal of lake whitefish throughout the Columbia mainstem and Columbia Basin Project area. In Banks Lake the lake whitefish population was estimated at 94,151 in 2000 (Polacek et al. 2003).
PYGMY WHITEFISH

*Prosopium coulterii* (Eigenmann and Eigenmann, 1892)

**Figure 12.11** Pygmy whitefish, Lake Chester Morse, King Co., WA.

**Primary Identification**

1. Adipose fin present. Axillary process present at front base of pelvic fins.
2. Silvery color with large scales (54–70 in lateral line row).
4. Blunt snout (head distinctly rounded in between nape and tip of snout).

**Confirming Characters**

1. One flap between anterior and posterior nares. (Figure 12.1C, p. 130).
2. Mouth slightly subterminal.
3. Dorsal rays: 9–12; anal rays: 8–10; pyloric caeca: 13–33.

**Similar Species**

1. Mountain whitefish have a head that is slightly convex between the nape and snout, and one flap between the anterior and posterior nares.
2. Lake whitefish have a head that is slightly concave between the nape and snout, and two flaps between the anterior and posterior nares.
3. Arctic grayling have large scales like whitefish but have a long, sail-like dorsal fin (16–25 rays).

**Etymology**

*Prosopium*: (G.) *Prosop* = face or mask, *-ium* = small, i.e., small face or mask. Large orbital bones in front of the eyes vaguely resemble a mask.

*coulterii*: (L.) Latinized name in honor of Dr. J.M. Coulter, a botanist of the Rocky Mountains.

**Common Name(s)**

Pygmy whitefish (AFS name), Coulter’s whitefish, brownbacked whitefish.

In Washington, pygmy whitefish were historically distributed in 19 lakes, but have apparently been extirpated from nine of them (Hallock and Mongillo 1998). It occurs in Lake Chelan (Chelan Co.), Bead and Sullivan lakes and Mill pond (Pend Oreille Co.), Cle Elum, Kachess and Keechelus lakes (Kittitas Co.), Lake Osoyoos (Okanagon Co.), Lake Chester Morse (King Co.), and Crescent Lake (Clallam Co.). The species has been extirpated in Twin Lakes (Ferry Co.), Buffalo lake (Okanogan Co.), Diamond, Horseshoe, and Marshall lakes (Pend Oreille Co.), and Gillette, Leo, Sherry, and Thomas lakes (Pend Oreille/Stevens Counties). Pygmy whitefish in Gillette, Leo, Sherry Thomas, Marshall, and Buffalo lakes were killed when WDFW rehabilitated these lakes with rotenone (Hallock and Mongillo 1998). Pygmy whitefish disappeared from Diamond and North Twin lakes shortly after largemouth bass were introduced (Hallock and Mongillo 1998). During a hydroacoustic survey conducted at Bead Lake in 1999, the pygmy whitefish population (± 95% confidence intervals) was estimated at 6,344 ± 2,436 (Polacek et al. 2003).
MOUNTAIN WHITEFISH
*Prosopium williamsoni* (Girard, 1856)

**Figure 12.13** Mountain whitefish, Long Lake, Spokane River, Spokane/Stevens Cos., WA. Inset shows detail of sub-terminal mouth.

**Primary Identification**

1. Adipose fin present. Axillary process present at front base of pelvic fins.
2. Silvery color with large scales (74–90 in lateral line row).
3. Head is slightly convex between nape and snout.

**Confirming Characters**

1. One flap between anterior and posterior nares. (Figure 12.1B, p. 130).
2. Mouth slightly sub-terminal.

**Similar Species**

1. Pygmy whitefish have distinctly blunted snout, one flap between anterior and posterior nares, and 54–70 scales in the lateral line row.
2. Lake whitefish have a head that is slightly concave between the nape and snout, and two flaps between anterior and posterior nares.
3. Arctic grayling have large scales like whitefish but have a long, sail-like dorsal fin (16–25 rays).

**Etymology**

*Prosopium*: (G.) Prosop = face, -ium = small. The name means small face or mask in reference to large preorbital bones in front of the eye.

*williamsoni*: Latinized name to honor Army Lieut. R.S. Williamson, who obtained the first specimen.

**Common Name(s)**

Mountain whitefish (AFS name), Rocky Mountain whitefish, Williamson’s whitefish.
Figure 12.14  Mountain whitefish distribution in eastern Washington.

**Distribution**

Mountain whitefish were native to the northern Rockies, Pacific Northwest, and parts of the Great Basin. In the United States, mountain whitefish were recorded from Washington, Idaho, Montana, Wyoming, and northern parts of Colorado, Utah, Nevada and California (Lee et al. 1980). In Canada, it occurs in Alberta and British Columbia (Lee et al. 1980). The mountain whitefish was naturally distributed throughout the state of Washington (Lee et al. 1980). In eastern Washington, the mountain whitefish occurs throughout the Columbia and Snake river mainstems and in the following tributaries of the Columbia (Rock Creek, White salmon, Klickitat, Walla Walla/Touchet, Yakima/Natches, Wenatchee, Entiat, Chelan, Methow, Okanogan, Nespelem, Sanpoil, Spokane/Little Spokane, Colville, Kettle and Pend Oreille rivers), and Snake (Tucannon, Palouse (~below Palouse Falls, Asotin and Grand Ronde rivers). The mountain whitefish is absent from the Columbia Plateau. Major drainages within this area include the Palouse river above Palouse Falls, Crab Creek and Douglas Creeks. None were found in any tributary of the Palouse River (Cow, Willow, Union Flat, Rock/Pine/Cottonwood, or Rebel Flat creeks) (Havens 1996, 1997; Glover 2004; Fox 2005; Porter 2006). None were found in any tributary of Crab Creek (Bluestem, Cannawai, Coal, Lake, Rock, Sheep, or Wilson creeks) (Scholz 2002, 2003).
Yellowstone Cutthroat Trout

*Salmo clarkii* var. *bouvieri* (Bendire, 1882)

**Figure 12.15** Yellowstone cutthroat trout, Big Fork State Fish Hatchery, MT.

**Primary Identification**

1. Adipose fin present. Axillary process at front base of pelvic fins.
3. Red or orange slash marks present in membranous folds under lower jaw.
4. Basibranchial teeth present on hyoid bone (on floor of pharynx underneath and behind the tongue and between the gill arches). Two rows of prominent teeth on tongue.

**Confirming Characters**

1. Few spots above and below lateral line in front of dorsal fin, becoming larger and more numerous in caudal peduncle region. Dorsal, adipose, and anal fins spotted. Spots absent on head, pelvic, and anal fins. Outline of spots rounded or oval.
2. Gill rakers 17–23 (usually 20–22); pyloric caeca 25–50 (usually 35–43); lateral line scales 150–200 (usually 165–180).

**Similar Species**

1. Coastal cutthroat have many irregularly shaped spots over entire body above and below the lateral line.
2. Westslope cutthroat spots are similar to Yellowstone cutthroat trout. Lahontan cutthroat have rounded spots sparsely distributed over entire body.
3. Rainbow trout usually lack red or orange mark below the jaw and hyoid teeth.
4. Golden trout have more scales in the lateral line row (170–210), usually > 200.

**Etymology**

*Oncorhynchus*: (G.) *Onco-* = hooked, *-rhynchus* = snout: hooked snout. Refers to the spawning kype that develops on the jaws of males as a secondary sex character in this species.

*clarkii*: Named to honor Captain William Clark of the Lewis and Clark Expedition.

*bouvieri*: Named to honor Captain Bouvier, United States Army.

**Common Name(s)**

Cutthroat trout (AFS name), Yellowstone cutthroat trout.
Figure 12.16  Yellowstone cutthroat trout distribution in eastern Washington.

Distribution

Yellowstone cutthroat trout were indigenous to the Yellowstone River drainage of Montana and Wyoming and to the Upper Snake River drainage in Wyoming and Idaho. Yellowstone Lake, Wyoming and Henry’s Lake, Idaho were in about the geographic center of their range. The Yellowstone cutthroat trout was also native to Waha Lake, Idaho (Behnke 1992).

Yellowstone cutthroat (called Montana black spotted trout) from Bozeman National Fish Hatchery, Montana were stocked in eastern Washington counties between 1900 and 1923, including Adams (3,000), Asotin (2,000), Chelan (17,500), Columbia (7,000) Ferry (199,250), Grant (10,000), Kittitas (458,060), Lincoln (10,800), Okanogan (194,950), Pend Oreille (143,675), Skamia (386,350), Spokane (582,999), Stevens (307,925), Walla Walla (14,675), Whitman (67,221), and Yakima (255,000). Summarized by Scholz and McLellan (2009).

A total of 6,176,588 eggs were shipped to Washington counties from a hatchery in Yellowstone National Park from 1914–1951 (Varley 1979), including: Chelan (1,200,729 in 1930, 1932, 1936 1938, 1941 and 1951); Ferry (300,000 in 1930, 1931 and 1932), Grant (50,200 in 1938), Kittitas (375,000 in 1916, 1917, 1930, 1932, 1935), Klickitat (100,000 in 1932); Okanogan (200,000 in 1930 and 1932), Pend Oreille (500,000 in 1931, 1932,1935, 1936, and 1938), Skamania (100,000 in 1930), Spokane (1,700,000 in 1929, 1930, 1931, 1932, 1935, 1936, and 1938), Stevens (500,000 in 1917, 1921, 1931,1932, 1936, and 1938), Walla Walla (350,000 in 1914 and 1930), and Yakima (800, 129 in 1930, 1932, 1938 and 1950).
COASTAL CUTTHROAT TROUT

*Oncorhynchus* var. *clarkii clarkii* (Richardson, 1836)

Figure 12.17 Coastal cutthroat trout, Cowlitz River, Cowlitz Co., WA.

**Primary Identification**

1. Adipose fin present. Axillary process at front base of pelvic fins.
3. Red or orange slash marks present in membranous folds under lower jaw.
4. Basibranchial teeth present on hyoid bone (on floor of pharynx underneath and behind the tongue and between the gill arches). Two rows of prominent teeth on tongue.

**Confirming Characters**

1. Profusion of large irregularly shaped spots on head, back and sides of body above and below the lateral line. Spots present on dorsal, anal adipose and caudal fins.
2. Gill rakers 15–21 (usually 17–19); pyloric caeca 25–55 (usually 30–40); lateral line 125–180 (usually 155–160 in sea run coastal cutthroat trout).

**Similar Species**

1. Other subspecies of cutthroat trout (westslope, Yellowstone, and Lahontan) are not so heavily spotted as the coastal cutthroat.
2. Rainbow trout usually lack the red or orange cutthroat marks and hyoid (basibranchial) teeth.

**Etymology**

*Oncorhynchus*: (G.) *Onco-* = hooked, *-rhynchus* = snout: hooked snout. Refers to the kype that develops on the jaws of males as a secondary sex character in this species.

*clarkii*: Named to honor Captain William Clark of the Lewis and Clark Expedition.

**Common Name(s)**

Cutthroat trout (AFS name), coastal cutthroat trout, sea-run cutthroat trout.
Coastal cutthroat trout occur in coastal streams from northern California to southeastern Alaska. In Washington coastal cutthroat occurs in tributaries of Puget Sound, the Olympic Peninsula, and lower Columbia River. In the Columbia Basin, their distribution was confined to below Bonneville Dam. Genetically discrete stocks were found in the following Washington tributaries of the Columbia River: Abernathy and Salmon Creeks and Elochoman, Cowlitz, Coweeman, Toutle, Kalama, Lewis, and Washougal rivers (Blakley et al. 2000). In the Columbia River, most coastal cutthroat exhibit an andromalous life history and they are iteroparous (spawn more than once). Tagging studies have revealed that coastal cutthroat from the Columbia River remain in the estuary during their first migration (Wydoski and Whitney 2003). In subsequent migrations they move into the ocean, traveling from about 11–110 km (5–50 mi) off the coasts of Washington and Oregon.
LAHONTAN CUTTHROAT TROUT

Oncorhynchus clarkii var. henshawi (Gill and Jordan, 1878)

Figure 12.19  Lahontan cutthroat trout, Lake Lenore, Grant Co., WA.

Primary Identification

1. Adipose fin present. Axillary process present at front base of pelvic fin.
2. Anal fin with < 12 rays. Interior of mouth white.
3. Red or orange slash marks in membranous folds under lower jaw.
4. Basibranchial teeth present on hyoid bone (on floor of pharynx underneath and behind the tongue and between the gill arches). Two rows of prominent tongue teeth.

Confirming Characters

1. Rounded spots, sparsely distributed over top of head, entire body, dorsal, adipose and caudal fins.

Similar Species

1. Coastal, westslope, and yellowstone cutthroat have fewer gill rakers (usually 17–21) and fewer pyloric caeca (usually 30–43) than Lahontan cutthroat trout.
2. Rainbow trout usually lack the red or orange marks below the jaws and hyoid (basibranchial) teeth.

Etymology

Oncorhynchus: (G.) Onco- = hooked, -rhynchus = snout: hooked snout. Refers to the kype that develops on the jaws of males as a secondary sex character in this species.

clarkii: Named to honor Captain William Clark of the Lewis and Clark Expedition.

henshawi: Named for Henry W. Henshaw, naturalist who discovered the subspecies.

Common Name(s)

Cutthroat trout (AFS name), Lahontan cutthroat trout, Pyramid Lake trout.
**Figure 12.20** Lahontan cutthroat trout distribution in eastern Washington.

**Distribution**

Lahontan were native to the Lahontan Basin of Nevada, California, and Oregon. Because they are tolerant of alkaline water, they have been introduced at several alkali lakes in eastern Washington. From 1968 to 1970, the USFWS stocked a total of 76,750 Lahontans from California into Omak Lake, Okanogan Co. (Kucera et al. 1985). Commencing in 1971, eggs have been collected annually in Omak Lake, raised in a hatchery and stocked back into the lake. From 1968 to 2003, a total of 2,583,758 Lahontan cutthroat trout were planted in Omak Lake.

Lahontan were planted in Lake Lenore, Grant Co., by WDFW in 1979. Since 1987, WDFW had collected eggs from Lahontan spawners returning to a trap in the inlet stream of Lake Lenore and reared them in a fish hatchery. The fry were planted in the following counties: Adams (Halfmoon, Hayes, Hutchinson-Shiner, MacManaman, Morgan, and Sprague lakes); Douglas (Grimes Lake); Grant (Alkali, Lenore, Lower Goose, Upper Goose, Para Juvenile lakes); Okanogan (Big Twin Lake, Blue, Emerald, Horseshoe, Palmer and Reflection lakes); Spokane (Granite Lake); and Yakima (Fenner Lake).
Westslope cutthroat trout, Anaconda State Hatchery, MT. Inset shows details of white mouth.

**Primary Identification**

2. Interior of mouth white. Red or orange slash marks present in membranous folds under lower jaw. Basibranchial teeth present on hyoid bone (on floor of pharynx underneath and behind the tongue and between the gill arches). Two rows of prominent teeth on tongue.

**Confirming Characters**

1. Few spots, irregular in outline, above lateral line in front of the dorsal fin; becoming larger, more numerous, both above and below the lateral line above anal fin. Dorsal, adipose and caudal fins, spotted. Spots absent on head, pelvic fins, anal fin.
2. Gill rakers 17–21 (usually 18–19); pyloric caeca 25–55 (usually 30–40); lateral line scales 150–200 (usually 165–180).

**Similar Species**

1. Coastal cutthroat have many irregularly shaped spots over entire body above and below the lateral line. Lahontan cutthroat have fewest and smallest spots distributed over entire body. Yellowstone cutthroat spots are similar to westslope cutthroat, except they have a few spots above and below the lateral line, in front of the dorsal fin.
2. Rainbow trout usually lack the red or orange cutthroat marks below the jaws and hyoid (basibranchial) teeth.

**Etymology**

*Oncorhynchus*: (G.) *Onco-* = hooked, *-rhynchus* = snout: hooked snout. Refers to the spawning kype that develops on the jaws of males as a secondary sex character in this species.

*clarkii*: Named to honor Captain William Clark of the Lewis & Clark Expedition.

*lewisi*: Named to honor Captain Meriwether Lewis of the Lewis & Clark Expedition.

**Common Name(s)**

Cutthroat trout (AFS name), westslope cutthroat trout, intermontane trout, Montana black spotted trout, Rocky mountain trout, Missouri River trout.
Figure 12.22 Westslope cutthroat trout distribution in eastern Washington.

Distribution

The westslope cutthroat is the most widely distributed of all cutthroat subspecies found in eastern Washington. Historically, it was distributed in three major drainages: the Columbia, which drains to the Pacific Ocean, the Missouri, which joins the Mississippi River and drains into the Gulf of Mexico (Atlantic Ocean), and the South Saskatchewan River, which drains into Hudson's Bay (Arctic Ocean).

Westslope cutthroat trout occurred in the Columbia River from Grand Coulee Dam to its head waters, and in the Klickitat, Yakima, Wenatchee, Entiat, Chelan, Spokane, Pend Oreille, and Kootenai drainages. They also occurred in the Snake River.

Between 1907 and 1922, the WDFW stocked at least 18,530,323 westslope cutthroats at 255 locations in 21 eastern Washington counties. Nearly 46% (n = 8,478,173) of them were planted at 69 locations in Chelan, Co. Adams, Asotin, Benton, Columbia, Douglas, Ferry, Garfield, Grant, Kittitas, Klickitat Lincoln, Okanogan, Pend Oreille, Skamania, Spokane, Stevens, Walla Walla, Whitman and Yakima counties also received plants. Between 1933 and 2007, the WDFW stocked 56,403,604 westslope cutthroat trout at 864 locations in 15 of 21 eastern Washington counties (Adams, Columbia, Douglas, Ferry, Grant, Kittitas, Klickitat, Lincoln, Okanogan, Pend Oreille, Skamania, Spokane, Stevens, Walla Walla, and Yakima).
Primary Identification

1. Adipose fin present. Axillary process present at front base of pelvic fins.
2. Dark spots on light background.
4. Large, oblong black spots on back above lateral line and on both lobes of caudal fin (some spots as large as diameter of eye).

Confirming Characters

1. Lateral line scales 169–229 (very small scales); gill rakers 24–35; pyloric caeca 95–225.
2. Large hump on back in front of dorsal fin and pronounced kype on upper jaws of spawning males.

Similar Species

1. No other Pacific salmon (Chinook, chum, coho, sockeye) has such large spots.
2. Cutthroat, rainbow, and brown trout, Atlantic salmon, have ≤ 12 anal rays.
3. Charr (brook, bull and lake trout) have light spots on a dark background.

Etymology

*Oncorhynchus*: (G.) *Onco-* = hooked, *-rhynchus* = snout. Hooked snout. Refers to the kype that develops on the upper jaw of males as secondary sex characteristics in this species.

gorbuschca: The Kamchatkan native word for the pink salmon.

Common Name(s)

Pink Salmon (AFS name), humpback salmon.
Figure 12.24  Pink salmon distribution in eastern Washington.

Distribution

Pink salmon have a circum-North Pacific distribution. They occur from Peter the Great Bay in the Sea of Japan, north to the Sea of Okhotsk and Bering Sea. They also occur in Bristol Bay, Alaska south to the Sacramento River, California, but established populations occur only as far south as Puget Sound (Heard 1991). In the Sacramento, Columbia, Fraser, and Skeena rivers, pink salmon seldom penetrate more than 160 km inland (McPhail and Lindsey 1970).

In the Columbia River, counts of pink salmon in the fish ladders at Bonneville Dam between 1938 and 2006 have totaled 3,008 fish, averaged 44 fish/year and ranged from 0- 637/ year during the interval. The farthest up the Columbia they have ascended is to the reservoir behind McNary Dam. The farthest up the Snake River they have ascended is to Lower Granite Dam, which is located 625 km from the ocean (Basham and Gilbert 1978). Relatively large numbers of pink salmon ascended in 2003 (n = 637). In 2003, counts of pink salmon at Columbia River dams were 127 at the Dallas, 18 at John Day, 51 at McNary. None were counted at Columbia River dams above McNary. Counts at Snake River dams were 12 at Ice Harbor, three at Lower Monumental, four at Little Goose, and one at Lower Granite. In 1975, five spawned out pink salmon carcasses (four female, one male) were recovered in the lower Tucannon River (Basham and Gilbreath 1978). The Tucannon River joins the Snake River below Little Goose Dam.
CHUM SALMON

*Oncorhynchus keta* (Walbaum, 1792)

**Figure 12.25** Chum salmon in spawning coloration, Ives Island, Columbia River, Skamania Co., WA. Inset shows coloration of a chum salmon fresh from the ocean.

**Primary Identification**

1. Adipose fin present. Axillary process present at front base of pelvic fins.
2. None or few spots on back and caudal fin.
4. The mouth and gums are white but the tongue is black.

**Confirming Characters**

1. Lateral line scales 124–153; gill rakers 19–26; pyloric caeca 140–186.
2. Conspicuous (gnarly) canine teeth in kypes on upper jaw of spawning males. Gray, green, red, purple, and white spawning colors that resembles streaky paint.

**Similar Species**

1. Other Pacific salmon (Chinook, coho, and pink) have spots on back and dorsal fin. Chum and sockeye salmon usually lack spots. Gill rakers 19–26 short, and widely spaced in chum; 30–40 long spaced close together in sockeye.
2. Cutthroat and brown trout, Atlantic salmon, brown trout have ≤ 12 anal rays.
3. Charr (brook, bull, and lake trout) have light spots on a dark background.

**Etymology**

*Oncorhynchus*: *Onco-* = hooked and *-rhynchus* = snout. Hooked snout. Refers to the kype that develops on the upper jaw of males as a secondary sex character in this species.

*keta*: The Kamchatkan native name for the chum salmon.

**Common Name(s)**

Chum salmon (AFS name), dog salmon, calico salmon (refers to spawning coloration).
Distribution

In northeast Asia, chum salmon range from the Naktong River, South Korea to the Arctic Ocean, and west along the Arctic coast to the Lena River, Siberia. In western North America, chum salmon range from the Sacramento River, California to the Arctic coast and east along the arctic coast to the Mackenzie River (Dymond 1940; McPhail and Lindsey 1970). It ascends the Yukon River to its headwaters and the McKenzie River to Great Bear and Great Slave Lakes about 1,600 km from the sea (McPhail and Lindsey 1970).

Fulton (1970) described the spawning areas of chum salmon in the Columbia River Basin. Of the 25 areas described only three were above Bonneville Dam (RKM 234); Rock Creek (RKM 240), Herman Creek (RKM 242) and Little White Salmon River (RKM 259). The average (range) in chum salmon counted at Bonneville Dam from 1938 to 2000 was 595 (4–5,369). Chum salmon spawn in the Columbia mainstem at Ives and Pierce Islands below Bonneville Dam and in two nearby creeks (Hardy and Hamilton creeks). Chum redd counts and spawning populations at Ives and Pierce Island have averaged (ranged) 205 (129–776), 852 (40–4,232) respectively, between 1998 and 2005, (Mueller 2006; Van Der Naald et al. 2006; and Tomaro et al. 2007). Craig and Soumela (1941) noted that nearly 3.8 million chum eggs from tributaries of the lower Columbia were shipped to the Methow River in 1916 and 1920. These plants failed to establish chum in the Methow because no adults were subsequently captured there.
COHO SALMON

Oncorhynchus kisutch (Walbaum, 1792)

Figure 12.27  Coho salmon in spawning coloration, Lyons Ferry State Fish Hatchery, Franklin Co., WA. Insets shows a non-spawning fish and close-up of mouth.

Primary Identification

1. Adipose fin present. Axillary process present at front base of pelvic fins.
2. Dark spots on light background.
3. Anal fin with $\geq 13$ rays.
4. Interior of mouth, tongue black. Sides of mouth black. White gum lines.

Confirming Characters

1. Small to mid-sized black dots on back and dorsal lobe of caudal fin. Caudal spots restricted to top and posterior margins of dorsal lobe.
3. Breeding males develop spawning kype on upper jaw and both sexes develop red spawning coloration.

Similar Species

1. Spots are present on both lobes of caudal fin in Chinook and pink, and absent on the caudal fins of chum and sockeye.
2. Cutthroat and brown trout, Atlantic salmon have white mouths and $\leq 12$ anal rays.
3. Charr (brook, bull and lake trout) have light spots on dark background.

Etymology

Oncorhynchus: (G.) Onco- = hooked, -rhynchus = snout: hooked snout. Refers to the kype that develops on the upper jaw of males as a secondary sex characteristic in this species.

kisutch: Kamchatkan native name for coho salmon.

Common Name(s)

Coho salmon (AFS name), silver salmon.
Coho salmon have a circum-North Pacific distribution, from Chongjin, North Korea in the Sea of Japan, north to the Chukchi Sea in the Arctic Ocean, and south to the San Lorenzo River California (Sandercock 1991; Kaczynski and Alvarado 2006; Adams et al. 2007). The furthest upstream that coho salmon historically spawned in the Columbia River was in the Spokane and Little Spokane rivers (Fulton 1970). All coho stocks spawning above Bonneville Dam are now extinct (Nehlsen et al. 1991). At the present time production of coho salmon in the Columbia Basin comes almost entirely from hatcheries (WDFW/ODFW 2002).

The Yakama Tribe is currently attempting to restore coho salmon to the Yakima, Wenatchee, and Methow rivers, WA. Limited numbers of coho are currently naturally reproducing in some of these rivers. The Nez Perce Tribe is currently attempting to restore coho salmon in the Clearwater River, ID. Some of the fish planted in the Clearwater River strayed as adults to the Tucannon River, Columbia Co., where coho redds were counted: five in 2001, 11 in 2002, 11 in 2003, and 16 in 2004 (Milks et al. 2005, 2006). Coho smolts, captured in a downstream migration trap in the Tucannon River (135 in 2003 and 224 in 2004), indicated that coho are naturally reproducing in the Tucannon River (Milks et al. 2005, 2006).
GOLDEN TROUT
_Oncorhynchus mykiss aguabonita_ (Jordan, 1892)

![Golden Trout Image](image)

**Figure 12.29** Golden trout, Washburn Lake, Okanogan Co., WA.

**Primary Identification**

1. Adipose fin present. Axillary process present at front base of pelvic fin.
2. Dark spots on light background; anal fin with ≤12 rays; interior of mouth white.
3. Brassy or copper color above and golden yellow color below lateral line; belly red; intense red stripe runs through parr marks, which are oblong and colored dark purple. White tips with interior dark borders on dorsal, anal, and pelvic fins.

**Confirming Characters**

1. Large round black spots on caudal peduncle; caudal fin with oblong black spots.
2. Lateral line scales: 170–200; pyloric caeca: 30–32.
3. Some individuals (roughly ⅓) have basibranchial teeth.

**Similar Species**

1. Rainbow trout are not so brightly colored as the golden trout.
2. Cutthroat trout: have red/orange marks on throat; in golden trout the entire throat is red.
3. Lake, bull, and brook charr: have light spots on a dark background.

**Etymology**

_Oncorhynchus:_ **Onco** = hooked and **-rhynchus** = snout. Hooked snout.

_mykiss:_ Kamchatkan native name for the rainbow trout.

_aguabonita:_ **agua**- = water, **-bonita** = good, pretty, beautiful. Pretty water, from Aguabonita Falls, Volcano Creek, tributary of Kern River, California, where this fish abounds.

**Common Name(s)**

Golden trout (AFS name), California golden trout, Kern River trout, Volcano Creek trout.
Figure 12.30  Golden trout distribution in eastern Washington.

Distribution
Golden trout are endemic to the Kern River Basin, California, near Mount Whitney and Sequoia National Park (Behnke 1979, 1992, 2002). Golden trout were first introduced in Washington in 1936, into alpine lakes of the Cascade Mountains (Chapman 1942).

Currently (2006), WDFW obtains eggs from California in some years when they are available and stocks them into small high mountain lakes in the Cascade Mountains. From 1993–2006, WDFW has stocked golden trout into 34 lakes east of and 24 lakes west of the Cascade Crest. Waters stocked in eastern Washington included; Augusta, Choral, Clear, Cradle, Crystal, Edna, Elsey, Enchantment #8, Enchantment #9, Enchantment #10, Grace, Josephine, Rock, Tamarack, unnamed (Cara), unnamed (Clear), unnamed (Windy), and two unnamed lakes (Chelan Co.); Baker (Thetis), Firewood #1, Glacier, Lorna, Park (lower), Park (upper), Summit Chief, and Three Queens lakes (Kittitas Co.); Beaner, Schoelite, Washburn and one unnamed lake (Okanogan Co.); Bernice and Island lakes (Skamia Co.), and one unnamed (Bauer) lake (Yakima Co.).

In the Idaho Panhandle, IDFG has planted golden trout into Long Mountain and Parker lakes in the Selkirk Mountain Range and Forage Lake in the St. Joe drainage.
Chapter 12

INTERIOR (REDBAND) RAINBOW/STEELHEAD TROUT

Oncorhynchus mykiss gairdneri (Walbaum, 1792).

Figure 12.31 Columbia River redband trout, Crab Creek, Lincoln, Co., WA. Inset shows white mouth and nonspawning anadromous steelhead (Lyons Ferry Fish Hatchery, Franklin Co., WA).

Primary Identification

1. Adipose fin present. Axillary process present at front base of pelvic fin.
3. Irregular shaped, small to medium-sized spots present on head and body above and below lateral line. Those on caudal fin in well defined linear arrays. Tips of dorsal anal pelvic fin light colored (white, yellow, or orange). Red stripe along lateral line.

Confirming Characters

1. Basibranchial (hyoid) teeth weakly developed or absent. Teeth on tongue well developed. Faint red or orange ‘cutthroat marks’ may be present under jaws.
3. Parr marks elliptical, supplementary rows usually present. Obscured by silvery guanine deposits in anadromous or adfluvial individuals.

Similar Species

1. Golden trout have copper or gold color not matched by rainbow trout. Cutthroat have distinctive red/orange cutthroat marks under jaws and hyoid teeth. Pacific salmon have ≥ 13 rays. Charr (brook, bull, and lake trout) have light spots on dark background.

Etymology

Oncorhynchus: (G.) Onco- = hooked, -rhynchus = snout; hooked snout.

mykiss: From "mikizha" or "mykyz", the Kamchatkan native word for rainbow trout.

gairdneri: Named to honor British naturalist Meridith Gairdner.

Common Name(s)

Rainbow trout (AFS name), steelhead trout, interior rainbow trout, redband trout, salmon trout (name used by residents of the Upper Columbia Basin) (Jordan and Gilbert 1883).
Distribution

Interior steelhead historically spawned in the Columbia mainstem between RKM 635 and 1,194, and in the following rivers (tributaries); Wind, Little White Salmon, White Salmon, Walla Walla (Touchet River and Mill Creek), Yakima (Naches River, Satus and Toppenish Creeks), Wenatchee (Little Wenatchee, Chiwawa and White rivers; Chiwaukum, Icicle, Mission, Nason and Peshastin Creeks), Entiat (Mad rivers), Methow (Chewack and Twisp rivers), Okanagan (Similkameen River, Omak Creek), Sanpoil, Spokane (Little Spokane River, Chamokane and Latah Creeks), and Pend Oreille River (Fulton 1970). In the Snake River, redband steelhead historically spawned in the mainstem from its confluence with the Columbia to Shoshone Falls (Snake RKM 952) and in the following Washington tributaries: Tucannon River, Asotin Creek, and Grande Ronde River (Fulton 1970). Their access to the Upper Columbia, Sanpoil, Spokane, and Pend Oreille River was blocked by Grand Coulee Dam (RKM 961) in 1939 and later by Chief Joseph Dam (RKM 877) in 1955. Their access to the Snake River was blocked by Hells Canyon Dam (Snake RKM 398) in 1964. Populations of interior (redband) rainbow trout occurred in the same rivers that steelhead were found in, including remnant populations throughout the area above Grand Coulee/Chief Joseph dams (Small et al. 2007). Interior (redband) trout were also found throughout the Upper Crab Creek Basin, Grant, Lincoln, and Spokane Cos. Genetic analysis of rainbow populations in Upper Crab Creek revealed their redband ancestry (Bettles 2004).
Figure 12.33  Coastal rainbow/steelhead trout, Lake Roosevelt, Ferry/Lincoln/Stevens Cos., WA.

Primary Identification
1. Adipose fin present. Axillary process present at front end of pelvic fins.
3. Irregular-shaped, small to medium-sized spots present on head and body above and below lateral line. Those on caudal fin in well defined linear arrays.

Confirming Characters
1. Red stripe usually present along lateral line.
2. No basibranchial (hyoid) teeth or cutthroat marks under jaw. Teeth on tongue weakly developed.
4. Parr marks rounded. Supplementary rows of parr marks absent or reduced. (Obscured by silver and guanine deposits in anadromous or adfluvial individuals).

Similar Species
1. Golden trout have copper or gold color not matched by rainbow trout.
2. Cutthroat trout have distinctive red/orange cutthroat marks under jaws and hyoid (basibranchial) teeth.
3. Pacific salmon have ≥ 13 anal rays and black pigment in mouth.
4. Charr (brook, bull and lake trout) have light spots on dark background.

Etymology
Oncorhynchus: (G.) Onco- = hooked, -rhynchus = snout: hooked snout.
mykiss: From "mikizha" or "mykyz," the Kamchatkan native word for trout.
irideus: (G.) Rainbow-like.

Common Name(s)
Rainbow trout (AFS name), steelhead trout, coastal rainbow (steelhead).
The ancestry of most hatchery stocks of rainbow trout in Washington can be traced to the McCloud River, California (Crawford 1979). The fish, spawned there by the USFC, were composed of about 95% coastal Sacramento River steelhead *Oncorhynchus mykiss irideus* and 5% interior (redband) rainbow trout *Oncorhynchus mykiss stonei* (Needham and Behnke 1962; Behnke 1992). Fertilized eggs from these matings were shipped to hatcheries in the eastern United States. The broodstock for the WDFW hatchery in Spokane was obtained from the Cape Cod Trout Company (Crawford 1979). Thus, most of the rainbows stocked in eastern Washington are coastal rainbow trout. From 1933–2007, WFDW has stocked 557,274,690 rainbow trout into 21 eastern Washington counties, including; 6,366,974 at 40 locations in Adams; 2,409,881 at 18 locations in Asotin; 4,500 at one location in Benton; 43,857,988 at 25 locations in Chelan; 8,774,624 at 48 locations in Columbia; 16,228 at 36 locations in Douglas; 43,836,477 at 66 locations in Ferry; 3,182,802 at 27 locations in Franklin; 1,457,732 at 23 locations in Garfield; 87,747,936 at 219 locations in Grant; 20,349,929 at 181 locations in Kittitas; 14,143,748 at 145 locations in Klickitat; 9,175,622 at 54 locations in Lincoln; 68,458,520 at 273 locations in Okanogan; 21,642,207 at 90 locations in Pend Oreille; 59,758,976 at 174 locations in Skamania; 68,004,349 at 59 locations in Spokane; 34,089,057 at 136 locations in Stevens; 4,745,477 at 35 locations in Walla Walla; 2,836,103 at 37 locations in Whitman; and 40,174,478 at 225 locations in Yakima counties.
SOCKEYE/KOKANEE SALMON

*Oncorhynchus nerka* (Walbaum, 1792)

![Figure 12.35](image)

**Figure 12.35** Sockeye/kokanee salmon, Lake Roosevelt, Ferry/Lincoln/Stevens Cos., WA. Insets show details of black mouth, and blue back and silver sides of non-spawning fish.

### Primary Identification


2. Tongue black, gums and flesh at base of teeth dark gray to black color.

### Confirming Characters

1. Lateral line scales 120–150; gill rakers 28–44; pyloric caeca 45–115. No distinct spots on back, sides, and caudal fin.


### Similar Species

1. Chinook, chum and coho respectively have maximum counts of 20, 26, and 25 gill rakers on their first arch. Pink salmon are heavily spotted with large oblong spots.

2. Cutthroat and brown trout, Atlantic salmon have white mouths and ≤12 anal rays.

3. Charr (brook, bull, and lake trout) have light spots on a dark background.

### Etymology

*Oncorhynchus*: *Onco-* = hooked and *-rhynchus* = snout. Hooked snout. Refers to the kype that develops on the upper jaw of males as a secondary sex character in this species.

*nerka*: The Kamchatkan native name for sockeye salmon.

### Common Name(s)

Sockeye salmon (AFS name), red salmon, red fish, blueback, kokanee salmon, little red fish, silver trout, silvers.
Figure 12.36  Sockeye/kokanee salmon distribution in eastern Washington.

**Distribution**

Anadromous sockeye were originally distributed from the Klamath River, California, north to the Yukon River in Alaska and northern Hokkaido, Japan, north to the Nadir River, Siberia. Their original distribution in the Columbia Basin was confined to spawning areas with suitable nursery lakes (Fulton 1970). These included: Upper and Lower Arrow, Whatson, Slocan, Skaha, and Okanogan lakes, BC; Osoyoos (Okanogan River), Wenatchee (Wenatchee River), Chain (Spokane River), Bumping, Kachess, Kechelus, Cle Elum lakes (Yakima River), WA; Suttle (Metolius River), and Wallawa lakes (Grand Ronde River), OR; Redfish, Alturus, Pettit, Yellow Belly, Stanley Lake (Salmon River), and Payette, Little Payette and Upper Payette lakes (Payette River), ID. By 1970, anadromous sockeye were extirpated at all of these locations, except for Wenatchee, Osoyoos, and Redfish lakes (Fulton 1970). However, kokanee still persisted in many of these lakes. Between 1908–1929 and 1933–2007 the WDFW stocked at least 415,269,693 kokanee, into 309 lakes or streams in 19 eastern Washington counties (Riseland 1909, 1911; Darwin 1916a, 1916b 1917, 1919, 1920, 1921a, 1921b; Dibble and Kinney 1923; WDFW fish stocking data base). Naturally reproducing kokanee occur in Lake Wenatchee, Chelan Co.; Lake Roosevelt, Ferry, Lincoln, and Stevens, counties; Banks Lake, Grant Co.; Palmer Lake, Okanogan Co.; Bead, Chain, Davis, Horseshoe, and Sullivan lakes, Pend Oreille Co.; Deer, and Loon lakes, Stevens Co., and Rimrock Lake, Yakima Co. Some of these lakes are supplemented annually with hatchery kokanee.
CHINOOK SALMON

*Oncorhynchus tshawytscha* (Walbaum, 1792)

![Chinook salmon image](image)

**Figure 12.37** Chinook salmon, Lake Roosevelt, Ferry/Lincoln/Stevens Cos., WA. Inset shows details of black mouth and medium size black spots in linear arrays on tail.

### Primary Identification

1. Adipose fin present. Axillary process present at front base of pelvic fins.
3. Interior of mouth (tongue, sides, gum, and flesh at base of teeth) uniformly black.
4. Small to medium-sized, irregular-shaped spots on back and sides above lateral line and in linear arrays on dorsal and ventral lobes of caudal fin.

### Confirming Characters

2. Breeding males develop kypes on upper jaw. Purple black spawning colors (both sexes).

### Similar Species

1. Sockeye and chum usually not spotted. Pink have relatively large spots on back, sides, and both lobes of caudal fin. Coho have fewer spots than Chinook and those on caudal fin are confined to the top of the posterior margins of the dorsal lobe.
2. Cutthroat, rainbow, brown trout, Atlantic salmon have white mouths, ≤ 12 anal rays. Charr (brook, bull, and lake trout) have light spots on dark background.

### Etymology

*Oncorhynchus*: (G.) *Onco-* = hooked, *-rhynchus* = snout. Hooked snout. Refers to the kype that develops on the upper jaw of males as a secondary sex characteristic in this species.

*tshawytscha*: The Kamchatkan native name for Chinook salmon.

### Common Name(s)

Chinook salmon (AFS name), king, tyee, quinnat.
Chinook salmon ascend spawning rivers between the Ventura River, California, and Hokkaido, Japan. In the Bering Sea they ascend the Yukon River (3200 km) to its headwaters (Major et al. 1978; McLeod and O’Niel 1983). Chinook ascend the McKenzie and Laird rivers in the Yukon. On the West Coast of North America there were probably over 1,000 genetically isolated spawning populations. Fulton (1968) identified approximately 135 stocks of Chinook salmon that formerly spawned in the Columbia Basin alone. Chinook occurred in the Columbia River mainstem to its headwaters (RKM 1,947) and in the following tributaries: Big and Little White Salmon, Klickitat, Walla Walla/Toucet, Yakima, Wenatchee, Entiat, Methow, Okanogan, Sanpoil, Spokane Colville, Kettle, Pend Oreille, and Kootenay rivers (Fulton 1968). They also ascended the Snake River to Shoshone Falls (Snake RKM 976) and the Tucannon, and Grande Ronde rivers (Fulton 1968). Grand Coulee Dam (RKM 955) and Hells Canyon Dam (Snake RKM 395) blocked runs above these points. From 1974–1978 and 1991–2006, WDFW introduced 1,711,876 Chinook salmon into Lake Chelan, Chelan Co., that subsequently began to spawn in tributaries of the lake (Fielder 1998). IDFG stocked Chinook into Coeur d’Alene Lake. Some of them migrated down the Spokane River into Lake Roosevelt. In the autumn they migrated up the Spokane River to Little Falls Dam. Others occupied Little Falls Reservoir (Spokane River) and entered Chamokane Creek during spawning season, where they constructed redds.
Figure 12.39  Atlantic salmon.

Primary Identification

1. Adipose fin present. Axillary process present at front base of pelvic fins.
3. Black spots irregularly outlined, often + or ×-shaped and surrounded by pale haloes. Maroon spots sometimes present. Note: Spots may be obliterated by silvery guanine deposits in anadromous and lake-dwelling individuals. Body tinted a silvery blue color.

Confirming Characters

1. Caudal fin with slight V-shape or emarginate.
2. Lateral line scales 109–121; gill rakers 14–17; pyloric caeca 30–60.

Similar Species

1. Brown trout have a thicker, stouter caudal peduncle than Atlantic salmon.
2. Dark spots of Pacific trout (cutthroat, rainbow) not surrounded by haloes.
3. Chinook chum, coho, pink, and sockeye/kokanee salmon have longer anal fin (≥ 13 rays).
4. Charrs (brook, bull, and lake trout) have light spots on dark background.

Etymology

Salmo: Ancient Latin name for the Atlantic salmon (means “to leap”).

salar: From (L.) Salien (to leap), means “the leaper.” Refers to its ability to jump over waterfalls.

Common Name(s)

Atlantic salmon (AFS name), Sebago salmon (after a lake in Maine where they were native), landlocked salmon (A name used in many USFC and USBF publications). Although Pacific Northwest Fisheries biologists automatically think of kokanee when the term landlocked salmon is used, USFC and USBF used this term exclusively to describe Sebago salmon.
Figure 12.40  Atlantic salmon distribution in eastern Washington.

Distribution

The Atlantic salmon is indigenous to the North Atlantic, north of 40°N latitude (MacCrimmon and Gotts 1979; Mills 1991). In the eastern Atlantic it occurs from Spain and Portugal, north to the North, Baltic, Barents and White seas. In the western Atlantic it occurs from the Connecticut River, north to Ungava Bay, Greenland, and Iceland. Landlocked populations occur in Maine, eastern Canada, and Europe.


Atlantic salmon were also raised in net pens in eastern Washington for commercial sale for eight years (1991–1998) at Rufus Wood Reservoir, the impoundment between Chief Joseph and Grand Coulee dams. Farmed fish periodically escaped and were observed downstream at Wells, Rocky Reach, Rock Island, and McNary dams (Wydoski and Whitney 2003). Atlantic salmon were also reared in a private hatchery on Rocky Ford Creek between Moses Lake and Ephrata, Grant Co. (Waknitz 2000).
**BROWN TROUT**

*Salmo trutta* (Linnaeus, 1758)

![Image of Brown Trout](image)

**Figure 12.41** Brown trout, Chamokoke Creek, Stevens Co., WA. Insets show detail of white mouth and square tail.

**Primary identification**

1. Adipose fin present. Axillary process present at front base of pelvic fins.
3. Spots, rounded in outline, often + or ×-shaped and surrounded by haloes. A few orange spots are often present. Spots obscured by silvery guanine deposits in anadromous and lake-dwelling individuals. Body color tinted in yellows and browns (fluvial habitats) or silvery (lacustrine and ocean habitats).

**Confirming Characters**


**Similar Species**

1. Atlantic salmon have a slender caudal peduncle.
2. Cutthroat/rainbow trout have dark spots not surrounded by haloes.
3. Pacific salmon (Chinook, chum, coho, pink, and sockeye) have large anal fins (≥ 13 rays).
4. Charrs (brook, bull and lake trout) have light spots on dark background.

**Etymology**

*Salmo*: (L.) Ancient Latin name for Atlantic salmon (means “to leap”).

*trutta*: (L.) Ancient Latin name for brown trout.

**Common Name(s)**

Brown trout (AFS name), German brown trout, Loch Leven trout.
Brown trout are indigenous to Europe and Eurasia (MacCrimmon and Marshall 1968; MacCrimmon et al. 1970; Courtenay et al. 1984, 1986, 1991). From 1932–1937, 2,449,070 brown trout were planted in Washington waters by the federal government (Leach 1933, 1934; Leach and James 1935, 1936, 1937, 1938). Also from 1933–2005, WDFW stocked a total of 7,910,967 brown trout into eastern Washington lakes and streams. Numbers of brown trout stocked by county during this interval were: Adams (125,362), Asotin (0), Benton (83,180), Chelan (506,675), Columbia (161,582), Douglas (3,884), Ferry (37,775), Franklin (403), Garfield (0), Grant (534,607), Kittitas (392,595), Klickitat (92,023), Lincoln (188,987), Okanogan (249,059), Pend Oreille (21,255), Skamania (323,742), Spokane (2,766,342), Stevens (887,226), Walla Walla (39,631), Whitman (1,018,202), and Yakima (478,437).

Strongholds for brown trout include many tributaries of the Pend Oreille and Kettle rivers, Chamokane Creek (tributary of the Spokane River), Cooper Creek (tributary of Cle Elum and Yakima rivers) and Touchet River (tributary of the Walla Walla River) where naturally reproducing populations are present. Nearly all of the brown trout programmed for Whitman Co. were stocked in Rock Lake. Over a 29 year period (1978–2007), Rock Lake received plants totaling 1,111,581 brown trout (Fox 2006). Rock Lake is the state's premiere brown trout fishery producing fish that weigh up to 3.4 kg (7.5 lbs). In 1999, McLellan (2000) estimated that 19,237 anglers fished a total of 70,681 hours to catch 33,938 fish including 19,206 brown trout.
**TIGER TROUT**

*Salvelinus fontinalis* (Mitchell, 1814) × *Salmo trutta* (Linnaeus, 1758)

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**Primary Identification**

1. Adipose fin present. Axillary process present at front base of pelvic fin.
2. Square anal fin with ≤ 12 rays.
3. Wavy markings (vermiculations) present on back and sides (over most of body), resembles a tiger (in adults > 25 cm) or giraffe (in juveniles < 25 cm).

**Confirming Characters**

1. Anterior margins of pectoral, pelvic and anal fin white with faint (narrow) interior black bar. Black spots on operculum, nape, dorsal, adipose, and caudal fins.
2. Lateral line scales 106–133; gill rakers 12–20; pyloric caeca 18–52.

**Similar Species**

1. Brook trout have wavy markings (vermiculations) confined to back, light spots on a dark background, red spots in blue haloes. Anterior margin of pectoral, pelvic and anal fins white with a distinct (broad) black interior bar.
2. Brown trout have dark spots on light background, some × or + shaped, in haloes, a few maroon/orange. Anterior edge of pectoral, pelvic and anal fins not tipped in white.

**Etymology**

*Salvelinus*: An old Scandanavian name for charr.

*fontinalis*: Living in springs.

*Salmo*: An ancient Latin name for Atlantic salmon, means “the leaper.”

*trutta*: An ancient Latin name for the brown trout.

**Common Name(s)**

Tiger trout (No official AFS name).
Figure 12.44  Tiger trout distribution in eastern Washington.

Distribution

Tiger trout are a recent addition to the waters of eastern Washington. Owing to their sterility, they are now the preferred alternative for planting many waters formerly stocked with brown trout. Since 2003, tiger trout have been stocked at the following locations in Eastern Washington: Quail Lake (Adams Co.), and Buckwheat Lake (Douglas Co.). Grant Co. locations included: Beda, Blue, Brookies, Dry Falls, Dune, Harris, Homestead, Index #1, Index #2, Lenice, Magpie, Mansfield, March, Merry, Nunnally, Sage (East), Sage (West), Sanddock, Shay, Vic Meyer, and Warden lakes. Upper Crab Creek and Gloyd Seeps (on upper Crab Creek), Homestead Creek, and Drains 239/645. Okanogan Co. locations include: Big Twin Lake (Methow Valley), and Connor, Forde, Little Reflection and Washburn lakes (Sinlahekin Valley). Pend Oreille Co. locations included: Leo Lake (Little Pend Oreille Lake Chain, Colville River Drainage), Sacheen Lake (Little Spokane River drainage), and Sullivan Lake (Pend Oreille River drainage). Spokane Co. locations include: Clear, Fish, Medical, North Silver, and Silver lakes. Stevens Co. locations included: Black, Gillette, Heritage, Sherry and Thomas lakes (Little Pend Oreille River/Colville River drainage). At most of these locations the number of tiger trout stocked ranged from a few hundred to a few thousand. Larger numbers were stocked at Black (n = 7000), Clear (n = 16,300), Fish (n = 15,000), and Sacheen (n = 6,000), and Thomas (n = 8,000) lakes. Tiger trout were recently collected in Moses Lake (Grant Co.) by WDFW and in Lake Roosevelt Lincoln Co. by EWU. Natural hybrids between brook trout and brown trout have been reported in Montana (Brown 1971) and Alberta (Nelson and Paetz 1992).
**BULL TROUT**  
*Salvelinus confluentus* (Suckley, 1859)

**Figure 12.45**  Bull trout, Pend Oreille River, Pend Oreille Co., WA.

**Primary Identification**

1. Adipose fin present. Axillary process present at front base of pelvic fin.
2. Light spots (white, yellow, orange, or red), usually orange or red, on dark background.
3. Leading edge of pectoral, pelvic, and anal fins with white margin.

**Confirming Characters**

1. Posterior margin of caudal fin square or nearly so. (Shortest caudal ray > \(\frac{3}{4}\) length of longest caudal ray).

**Similar Species**

1. Lake trout have deeply forked caudal fins (shortest caudal ray < \(\frac{1}{2}\) length of longest caudal ray).
2. Brook trout have vermiculations (worm-like markings) in back.
3. Members of genus *Salmo* and *Oncorhynchus* have black spots on a light background.

**Etymology**

*Salvelinus*: An old European name for charr (i.e., salmonid fishes with light spots on a dark background).

*confluentus*: (L.) con- = together, -fluent- = flowing, -us- = Latin diminutive suffix. Flowing together or 'where two waters meet'.

**Common Name(s)**

Bull trout (AFS name), bull charr or char, interior Dolly Varden, salmon-trout, red spotted salmon-trout.
Figure 12.46  Bull trout distribution in eastern Washington.

Distribution

The bull trout is a native to northwestern North America. Its distribution was centered in the Columbia Basin. Bull trout occur throughout the Columbia mainstem, being relatively common between Wanapum and Chief Joseph dams, and rare above and below them. Bull trout are relatively abundant in the Yakima (average redd count = 328, Anderson 2005), Wenatchee (average redd count = 486, USFWS 2002), Entiat (average redd count = 26, USFWS 2002), and Methow (average redd count = 134, USFWS 2002) rivers. Bull trout are rare in tributaries that enter the Columbia above Chief Joseph Dam, e.g., Spokane and Pend Oreille rivers, although they are more abundant in Idaho reaches of both rivers.


Few fluvial bull trout occur in the mainstem reservoirs of the Snake River (Ice Harbor, Lower Monumental, Little Goose and Lower Granite). However, resident populations do occur in the tributaries of the Snake River: Tucannon River (average redd count = 149), Asotin Creek (average redd count = 23), and Grande Ronde River (average redd count in Washington tributaries of the Grande Ronde = 181, Mendel et al. 2006). Bull trout are absent in the Upper Crab Creek and Palouse River drainages.
BROOK TROUT
*Salvelinus fontinalis* (Mitchell, 1814)

**Figure 12.47**  Brook trout, Marshal Creek, Spokane Co., WA.

**Primary Identification**

1. Adipose fin present. Axillary process present at front base of pelvic fin.
2. Light spots (yellow, orange, red, sometimes in blue haloes) on dark background.
3. Leading edge of pectoral, pelvic and anal fins with contrasting white margin and interior black bar. See Figure 12.6F, page 140.

**Confirming Characters**

1. Vermiculations (worm-like markings) on back. See Figure 12.6E, page 140.
2. Tail square or nearly so (i.e., shortest caudal ray > ¾ length of longest caudal ray).

**Similar Species**

1. Lake trout have deeply forked tails (i.e., shortest caudal ray < ½ length of longest caudal ray).
2. Bull trout and Dolly Varden trout lack vermiculations on backs.
3. Members of genus *Salmo* and *Oncorhynchus* have black spots on a light background.

**Etymology**

*Salvelinus*: Latinized version of an old Scandinavian name for charr.

*fontinalis*: (L.) *font-* = a fountain or spring. *-in-* = in. *-alis* = pertaining to. Translates as “found in springs” or “living in springs.” Refers to the preferred habitat being coldwater springs, or streams with hyporeic discharge of upwelling groundwater.

**Common Name(s)**

Brook trout (AFS name), brook charr or charr, eastern brook trout, char or charr.
Figure 12.48  Brook trout distribution in eastern Washington.

Distribution

The native and introduced distributions of brook trout were described by MacCrimmon and Campbell (1969) MacCrimmon et al. (1975), and Fuller et al. (1999). From 1896 to 1920, the USFC and its successor, the USBF, made 113 plants totaling 468,897 brook trout into 16 eastern Washington counties (Ravenel 1896, 1898a, 1898b, 1899, 1900, 1901, 1902; Bowers 1900, 1907; Titcomb 1904, 1905; USBF 1905, 1906, 1907, 1909, 1913; O’Malley 1917, 1919; Leach 1920, 1922).

From 1907–2004, WDFW stocked 92,721,029 brook trout in eastern Washington counties, including: Adams (989,920), Asotin (498,000), Benton (32,090), Chelan (3,863,599), Columbia (866,403), Douglas (959,503), Ferry (9,512,834), Franklin (12,505), Garfield (819,982), Grant (1,822,063), Kittitas (7,707,728), Klickitat (1,470,682), Lincoln (1,935,183), Okanogan (21,219,659), Pend Oreille (14,807,326), Skamia (4,952,540), Spokane (5,170,074), Stevens (7,748,067), Walla Walla (675,852), Whitman (573,510), and Yakima (6,220,261).

LAKE TROUT
*Salvelinus namaycush* (Walbaum, 1792)

Figure 12.49  Lake trout, Bead Lake, Pend Oreille Co., WA.

**Primary Identification**
1. Adipose fin present. Axillary process present at front base of pelvic fins.
2. Light (white) spots on dark background. Back and sides covered in white spots.
3. Caudal fin deeply forked (i.e., shortest caudal ray < ½ length of longest caudal ray).

**Confirming Characters**
1. Pectoral, pelvic, and anal fins not usually tipped with leading white edge; (may be translucent).

**Similar Species**
1. Brook trout have vermiculations on back.
2. Bull trout have orange/red colored spots and caudal fin is not deeply forked (i.e., Shortest ray > ¾ length of longest ray).

**Etymology**
*Salvelinus*: Latinized version of an ancient Scandinavian name (Salvelin) for charr.

*namaycush*: A vernacular name used by Cree Indians in the Hudson Bay region where the type specimen was collected. The Cree name "namekos" means “dweller of the deep” (Behnke 2002).

**Common Name(s)**
Lake trout (AFS name), mackinaw, siscowet or “fat trout” refers to race of lake trout in Lake Superior that are stunted, stouter with a higher fat content than typical lake trout.
Lake trout are native only to North America. They are distributed widely across Canada from the Atlantic Ocean to the Pacific Ocean, from the U.S. border to the Arctic. However, they were not native to the Columbia River Basin (Lee et al. 1980), but were stocked into Pend Oreille and Coeur d’Alene Lake, Idaho in 1911 and 1912 respectively by USBF. In Washington, we have stocking records for 3,044,881 lake trout planted in 31 different lakes by USBF and WDFW in eastern Washington between 1904 and 2004, including 1,027,241 stocked into Lake Chelan, Chelan Co. by WDFW between 1980 and 2000. These plants resulted in the establishment of a self-perpetuating lake trout population in the lake. From 1915 to 1938, USBF and WDFW stocked 64,823 lake trout into Deer Lake, Stevens Co. Lake trout have been naturally reproducing in the lake since that time. From 1900 to 1938 and 1981 to 1995, 489,482 lake trout were stocked in Loon Lake, Stevens Co. By 1911 lake trout became established as a result of the plants made in 1900 (Kemmerer et al. 1923).

Lake trout failed to become established in most of the 31 lakes where they were stocked. In addition to Chelan, Deer and Loon lakes, the only other lakes in eastern Washington where lake trout established self-sustaining populations were Eight Mile (Chelan Co.), Cle Elum (Kittitas Co.), Bonaparte (Okanogan Co.), and Bead and Horseshoe lakes (Pend Oreille Co.). Bead Lake was last stocked with lake trout in 1965, but lake trout were recorded in a fish surveys conducted 2004 (Rader et al. 2006).
ARCTIC GRAYLING

*Thymallus acticus* (Pallas, 1776)

Figure 12.51  Arctic grayling, Bozeman National Fish Hatchery, MT.

**Primary Identification**

1. Adipose fin present. Axillary process present at front base of pelvic fins.
2. Long sail-like dorsal fin (16–25, rays, distal margin $\geq 1\frac{1}{2}$ times insertion).

**Confirming Characters**

1. Large scales (70–103 in lateral row)
2. Mouth terminal, with intermediate-sized gape. Short maxillary bones with weakly developed teeth.
4. Specimens from small streams and rivers often strikingly colored with olive green head and lavender to iridescent blue flanks. About 8–15 black spots confined to front half of body behind operculum. Flesh has bluish-green hue.

**Similar Species**

1. Lake, pygmy, and mountain whitefishes all have relatively big scales (54–90 in lateral line row), but they all have short dorsal fins ($\leq 15$ rays).
2. Salmon, trout, and charr have small scales (105–230 in lateral line row), and short dorsal fins ($\leq 15$ rays).

**Etymology**

*Thymallus*: (G.) *thymallus*- fish that smells like thyme. We could not detect it in Arctic grayling from either Montana or McKenzie River, Northwest Territories.

*Arcticus*: (G.) *Arctic*- Northern or Arctic

**Common Name(s)**

Artic grayling (AFS name), Montana grayling, Michigan grayling.
Figure 12.52  Arctic grayling distribution in eastern Washington

Distribution

In North America, native populations of Arctic grayling were widely distributed in Arctic drainages from the western side of Hudson Bay to Alaska. Abundant in the McKenzie and Yukon River drainages. Disjunct indigenous populations also occurred in Michigan and Montana. Millions of Montana grayling eggs and fry obtained from streams in Yellowstone Park were shipped to 23 states outside their native range, including Idaho and Washington (Varley 1981; Varley and Schullery 1998; Fuller et al. 1999).

Arctic grayling were not indigenous to Washington. They were introduced in 1921 at several locations in the Yakima Basin, Kittitas, and Yakima Cos., including: Bumping, Cle Elum, Fish, Kachess, Keachelus lakes, the North, Middle, and South forks of the Teanaway River, and the Yakima River (Dibble and Kinney 1923). The plants did not result in any naturally reproducing grayling and none occur in the Yakima Basin at the present time (2009). In 1936, the USBF sent another shipment of Arctic grayling from Yellowstone National Park to Spokane, WA (Leach and James 1937). About 125,000 were planted in Little Pend Oreille Lake chain, Colville River Basin, Stevens Co. These plants also did not result in the establishment of any naturally reproducing populations. Arctic grayling were also stocked in Lake Chelan (12,000), Cougar Lake, Okanogan Co. (25,000), Granite Lake, Skagit Co. (55,000), Kings Lake, Pend Oreille Co. (22,358), and McDowell Lake, Stevens Co. (6,443). Artic grayling established a small self-sustaining population that has persisted to the present only at Granite Lake (Crawford 1979; Wydoski and Whitney 2003).
Two species of trout-perches occur in North America. *Percopsis transmontana*, the sandroller, is endemic to the Columbia River Basin. *P. omiscomaycus* (Walbaum), the trout-perch, is distributed east of the Continental Divide, except in Alaska where it crosses into the Yukon River drainage.

An Eocene (55–34 MYBP) fossil percopsid *Libotonius pearsoni* was discovered in the Klondike Mountain Formation near Republic, Washington and Allenby Formation near Kelowna, British Columbia (Wilson 1977a, 1979). Both locations are within the Columbia River Basin. It is not known if *L. pearsoni* was an ancestor of modern *P. transmontana* because the Percopsidae are not present in the fossil record anywhere west of the Continental Divide after the Eocene.

Trout-perches, as their name implies, have characteristics of both the salmonids and percids. Like salmonids, they possess an adipose fin and have a single dorsal fin. They are also about the size of a juvenile salmonid and fresh caught specimens often possess one or two rows of spots reminiscent of the parr marks of juvenile salmon, whitefish, or trout. However, this resemblance is superficial because other characters are definitely not trout-like, including: 1) dorsal and anal fins with spines; 2) pelvic fins are in the thoracic position (like perch and other types of advanced fishes) rather than in the abdominal position (like primitive fishes); and 3) scales are ctenoid (like perch) rather than cycloid (like salmonids).

The only species with which the sandroller can be confused is the trout-perch, but their distribution is allopatric (no geographic overlap). The two species closely resemble each other, but trout-perch have 1–4 weak spines on their dorsal and anal fins, whereas sandrollers have 1–2 stout spines. Sandroller are also smaller (max. length 127 mm) than the trout-perch (max. length 200 mm). In the Columbia Basin the sandroller is distinctive and unique.

Gray and Dauble (1979) described the biology of sandroller. Maximum lifespan was 6 years, but few (3 of 51) survived beyond age 3. Three year old fish averaged 3 in. (77 mm) in total length. Maximum length recorded was 127 mm. Gravid females were collected from June to mid-July and recently hatched fry (15–16 mm) were collected in mid-August, suggesting that spawning commences in mid-summer when water temperatures reach 14–16°C. Fecundity of eight females ranged from 1,106–3,369 eggs. In John Day Reservoir, Columbia River, sandroller spawning extended from approximately early June through late July, based on the presence of ripe individuals in May and June, and appearance of prolarvae from early July to early August (Hjort et al. 1981).

Chironomidae (midge) and Trichoptera (caddisfly) larvae and pupae were the dominant items in the diet of 66 sandrollers from the Hanford Reach. Other prey included: copepods, cladocera, amphipods, and Emphelemoptera (mayfly) pupae (Gray and Dauble 1979a).

Sandrollers are frequently found over sandy substrates, but preferred habitat is unknown. They have been collected in backwater sloughs in association with cover provided by undercut banks and large woody debris. They have also been collected in the deeper waters of lower Columbia River reservoirs in bottom trawls. They may make annual movements, associated with reproduction, from more open waters into shallow embayments or tributaries.

Sandrollers were consumed by northern pikeminnow, smallmouth bass, and walleye in the Lower Columbia River from John Day Reservoir to below Bonneville Dam (Poe et al. 1991;
Zimmerman 1999). Sandrollers accounted for 14 and 25% of the diet of walleye, 1.4 and 3.3% of the diet of smallmouth bass, and 0.1 and 0.3% of the diet of northern pikeminnow collected respectively above and below Bonneville Dam.

**KEY TO FAMILY PERCOPSIDAE**

**General Family Characters**

Confirm these characters before keying to species.

1. Adipose fin present.
2. No barbels.
3. One dorsal fin with one or two spiny rays in front of soft rays.
4. Pelvic fins thoracic, inserted below and slightly behind pectoral fins.
5. Anal fin with shorter base than dorsal fin and 1–2 spiny rays.
6. Head large in relation to body (20–25% of total length).
7. Ctenoid scales.

![Sandroller](Image)

**Figure 13.1** Sandroller (Figure in C.H. Eigenmann, 1895. Bulletin of the USFC (1894). P. 107 plate 6d. Figure in public domain. Color enhancement by Judy McMillan, EWU University Graphics.

**Key to the Species of the Percopsidae of Eastern Washington**

This family is represented by a single species (*Percopsis transmontana*) in eastern Washington, so the general family characteristics also serve to identify the species (go to page 209).
**SANDROLLER**

*Percopsis transmontana* (Eigenmann and Eigenmann, 1892)

![Sandroller](image)

**Figure 13.2**  Sandroller, McNary Reservoir, Benton/Walla Walla, Cos., WA.

**Primary Identification**

1. Adipose fin present.
2. Single dorsal fin with 1–2 (usually two) stout spines.
3. Pelvic fins in thoracic position, posterior tip of the pectoral fin extends behind the anal fin base. This trait, in combination with an adipose fin, is diagnostic.
4. No axillary process on pelvic fins.

**Confirming Characters**

1. Anal fin with 1–2 (usually two) stout spines.
2. Tail forked with spots in linear arrays, which is similar to the spot pattern on the caudal fin of a rainbow trout.
3. Ctenoid scales. Teeth or cteni at edge of scale feel rough to touch. Can be seen with magnifying lens or field microscope.
4. Teeth small, in brush-like bands (difficult to see without magnification).

**Similar Species**

1. Salmon, trout, whitefish: Sandrollers resemble salmonids because they have an adipose fin and markings similar to the parr marks of salmonids. However, pelvic fins are in the thoracic position in sandrollers and in the abdominal position in salmonids. All salmonids also have a pelvic axillary process. In sandrollers, the dorsal and anal fins contain 1–2 spiny rays and scales are ctenoid. In salmonids, the dorsal and anal fins contain only soft rays and scales are cycloid.

**Etymology**

*Percopsis*: (L.) Perch-like.


**Common Name(s)**

Sandroller (AFS name), Columbia River trout-perch.
Distribution

The sandroller, endemic to the Columbia River, is found from RKM 40 above the mouth to Wanapum Reservoir RKM 715 above the mouth (Wydoski and Whitney 1979, 2003). It is most abundant in the lower Columbia River and its tributaries (Gray and Dauble 1979a; Scheerer and Jacobs 2006). Fair numbers were captured in Bonneville, The Dalles, and John Day reservoirs and also in the lower river between the confluence with the Cowlitz River and tailrace of Bonneville Dam by USFWS personnel while bottom trawling for juvenile sturgeon (Mongillo and Hallock 1995). Sandrollers (n = 103) were captured in Priest Rapids and Wanapum reservoirs (Dell et al. 1975). Sandroller were collected in the tailraces below Priest Rapids (n = 126) and Wanapum dams (n = 465) (Pfeifer et al. 2001). A few specimens have been collected in the Hanford Reach (Gray and Dauble 1976), Yakima (Patten et al. 1970; Wydoski and Whitney 2003), Snake, and Tucannon rivers (Mongillo and Hallock 1995). Two sandrollers were collected in the lower Yakima River (RKM 10-19) in 1997 (Pearsons et al. 1999). Sandrollers have periodically been collected in a WDFW trap on the Tucannon River, Columbia Co., most recently in 2005 (Gallinat and Ross 2005). In Idaho, there are historical records of sandrollers in the Snake and Clearwater rivers near Lewiston (Pratt and Whitt 1952; Simpson and Wallace 1982), but Maughan (1976) failed to collect any in that vicinity.
Chapter 14
Family Gadidae: Cods

The Gadidae are predominantly bottom-dwelling marine fishes with circumpolar distribution above 40°N latitude. Fifty-four of the 55 known species occur in saltwater and are sold commercially as cod, haddock, hake, and pollack. The burbot *Lota lota* (Linnaeus), occurs in cold, freshwaters of the northern hemisphere. It has a circumpolar distribution above 42°N latitude (McPhail and Lindsey 1970; Scott and Crossman 1973; Howes 1991). The burbot is the only member of this family that occurs in eastern Washington.

Burbot characters are intermediate between those possessed by primitive (ancestral) and advanced (derived) fishes. They have a physoclist swim bladder and two dorsal fins similar to advanced fishes, but their fins contain no spines and they have cycloid scales like primitive fishes. In other advanced fishes that possess two dorsal fins, such as the Centrachidae (basses and sunfishes) and Percidae (perches), the first dorsal fin contains spiny rays and they have ctenoid scales. Also the burbot is unique because its pelvic fins are in the jugular position (situated below and in front of the pectoral fins). In other families with two dorsal fins the pelvic fins are in the thoracic position (below and behind the pectoral fins). Burbot have long eel-like bodies and their long second dorsal and anal fins are reminiscent of an eel or lamprey. However, these two fins are not confluent with the caudal fins as is the case with eels and lampreys.


Burbot have pads of teeth on the bones of the jaw and roof of their mouth that are used to subdue and reposition their prey so that they can be swallowed whole (Figure 14.1). The initial prey of burbot were phytoplankton, rotifers, and copepod nauplii (McPhail and Paragamian 2000). As they grew to about 15–20 mm burbot larvae gradually switched to a diet of Cladocera and Chironomidae. Small burbot (under 130 mm) ate benthic invertebrates such as amphipods and mayfly nymphs. Medium-sized burbot (130–460 mm) ate a mix of benthic invertebrates and fish. Adult burbot (> 460 mm) ate fish almost exclusively. Prey fishes reported in diets of burbot collected in Washington and Idaho included: kokanee, rainbow trout, whitefish, peamouth, small-
Family Gadidae

Figure 14.1 Burbot have pads of fine teeth in the skull (maxilla) (left) and jaw (mandible) (right).

mouth bass, walleye, and sculpin (Bonar et al. 1997). One individual burbot had 179 small fish in its digestive tract (Scott and Crossman 1973). We observed a 660 mm burbot in Lake Roosevelt that had swallowed a 279 mm kokanee salmon whole.

Fish and isopod crustaceans (aquatic sow bugs) accounted for 75% of the diet of 196 burbot, 121–610 mm TL, collected in Lake Roosevelt between 1998 and 2001 (Polacek et al. 2006). Both types of prey were present in about equal proportions (38% fish and 37% isopods). Types of fish consumed included Cottidae (sculpin), which accounted for about 40% of all the fish eaten, Catostomidae (suckers), Centrarchidae (bass and sunfishes), Cyprinidae (minnows), Ictaluridae (bullhead catfishes), Percidae (yellow perch and walleye), and Salmonidae (salmon, trout, and whitefish) (Polacek et al. 2006). Other prey consumed by burbot in Lake Roosevelt included: segmented worms, leeches, amphipods, crayfish, opos-
sum shrimp, beetles, flies and midges, mayflies, true bugs, damselflies/dragonflies, stone-
flies, caddisflies, clams, amphibian tadpoles, and fish eggs (Polacek et al. 2006). In Sullivan
Lake, Pend Oreille Co., juvenile burbot (n = 16) consumed amphipods, zooplankton, may-
flies midges and snails and adult (n = 69) consumed mainly fish (kokanee, redside shiner,
slimy sculpin) (Nine 2005; Nine and Scholz 2005). In Bead Lake, Pend Oreille Co., bur-
bot (n = 19) consumed crayfish, chironomids, kokanee, northern pikeminnow, amphipods,
damsel flies, water mides and earthworms (Rader 2006; Rader et al. 2006).

Burbot prefer the bottom of large rivers, reservoirs, and deep lakes, although they move
into shallow water at night to feed. Paragamian and Whitman (1997, 1998) tracked burbot
in the Kootenai River, Idaho using ultrasonic telemetry. Only one of 11 sonic tagged burbot
tracked over four spawning seasons had a non-spawning or rest year. The others spawned
annually. One returned after each of three consecutive spawning seasons to the same pool
in the Kootenai mainstem. Five of eight burbot that were highly mobile repeatedly spawned
in a home pool in the Goat River (Paragamian 2005).

Burbot are poor swimmers, with low swimming endurance. Even large burbot are unable
to swim upstream against current velocities greater than 24 cm/s for more than ten minutes
(Jones et al. 1974). This may be one reason why burbot spawn in winter. Winter spawning
may be an adaptation associated with reducing energy costs for migration. In natural sys-
tems, stream discharge is usually lower during the winter than either fall (owing to autumn
rains) or spring (owing to snowmelt runoff). Burbot probably do not have the physical
stamina to negotiate turbulent flows of large western rivers during the spring freshet.

McPhail (1994) noted that the collapse of burbot population below dams was a common-
place phenomenon in the Pacific Northwest. Hydropower development has reversed the
natural flow regimen in many western rivers. In regulated rivers, peak flows occur in the
winter instead of the spring. Water, captured in storage reservoirs during the spring season
and stored over the summer months, is released during the fall and winter to produce
electricity for heating homes and workplaces. This alteration may be contributing to the
demise of burbot in some systems. For example, adfluvial burbot in the Kooteney/Kootenai
Lake and River system, British Columbia and Idaho, no longer migrate to spawning sites
in the river 50–120 km above the lake, apparently because they lack stamina needed to
stem the high flows that are now prevalent in the Kootenai River during the winter months
(Paragamian et al. 2000b).

**KEY TO FAMILY GADIDAE**

**General Family Characters**

Confirm these characters before keying to species.

1. Two soft-rayed dorsal fins, first short (8–16 rays), second long (60–79 rays).
2. Long anal fin (59–76 rays).
4. Single barbel present on tip of chin.
5. Body with mottled coloration, like camouflage clothing.
7. Tiny teeth, arranged in pads along roof and floor of mouth.
8. Teeth on lower or upper jaws few or absent.
9. Small sensory barbel projecting from each nostril (nare).
Figure 14.2  (Top) Line drawing of burbot made by USFC published in Jordan and Evermann (1896–1900). Figure in public domain. Color enhancement by EWU University Graphics. (Bottom) Photograph of head of burbot showing pelvic fins in jugular position (underneath and in front of pectoral fins) and single chin barbel.

Key to the Species of the Gadidae of Eastern Washington

This family is represented by a single species in eastern Washington, the native burbot, *Lota lota* (Linnaeus, 1758), so the family characters serve to identify the species (go to page 215).
BURBOT
*Lota lota* (Linnaeus, 1758)

Figure 14.3  Burbot, Lake Roosevelt, Lincoln/Stevens Cos., WA.

Primary Identification
1. Long eel-like body.
2. Two dorsal fins: first short (8–16 rays), second long (55–78 rays), both soft.
3. Insertion of pelvic fins jugular (in front of pectoral fins).
4. One chin barbel.

Confirming Characters
1. Large head in proportion to body (about 19–20% of total length).
2. Blotchy brown, gray, green, and yellow color that resembles camouflage clothing.
3. Tiny cycloid scales, deeply embedded in skin, make this fish appear scaleless, feels slimy to the touch.

Similar Species
1. No similar species. The burbot is distinctive because the position of its pelvic fins is in front of the pectoral fins and single, large barbel at the tip of chin.

Etymology
*Lota*: From the French lotte, which was a common name employed for burbot in medieval France.

Common Name(s)
Burbot (AFS name), ling, freshwater ling, lawyer (Great Lakes region), lake lawyer (Washington state), loche, methy or mathameg (Cree Indian name about Hudson Bay, means ‘ugly fish’), land cod (English fur trade name). The names ling or freshwater ling refers to the morphological similarity between burbot and a saltwater fish called lingcod *Ophidon elongatus*. However, the two species are unrelated since the lingcod (Family Hexagrammidae-Greenlings) is not a member of the Cod Family (Gadidae). Burbot are also called ‘loche’ (Alaska), and maria (Saskatchewan).
Distribution

In the western United States burbot occur in the Columbia River Basin Washington, Idaho, Montana, Oregon, and Wyoming but are absent in coastal drainages. In Washington, native populations occur in Lake Roosevelt (Ferry, Lincoln, and Stevens Cos.), Rufus Woods Lake (Okanogan and Douglas Co.), Osoyoos Lake (Okanogan Co.), Lake Chelan (Chelan Co.), and Cle Elum, Kachess, and Kechelus lakes (Kittitas Co.) and Palmer Lake (Okanogan Co.) (Bonar et al. 2000). Burbot were also collected in Wells and Rocky Reach reservoirs in 1993 (Douglas, Chelan, and Okanogan Cos.) (Bonar et al. 2000). Burbot were collected in the Spokane River below Little Falls Dam (RKM 45), but not above Little Falls Dam.

Banks Lake became populated with burbot after construction of Grand Coulee Dam in 1941, when power produced by the dam was used to pump water from Lake Roosevelt into Banks Lake, which is the main water supply for the Columbia Basin Irrigation Project. Burbot are occasionally collected in other Columbia Basin Project waters. For example, burbot were recently collected in Moses Lake and Potholes reservoirs (WDFW-FWIN 2004, 2005). McLellan (2001) collected four burbot in Boundary Reservoir, Pend Oreille River. Burbot were also introduced into Sullivan and Bead lakes, Pend Oreille Co. (Bonar et al. 2000; Nine and Scholz 2005; Radar et al. 2006). A burbot was killed during the first rehabilitation of Diamond Lake (yellow dot on Figure 14.4), but none have been reported since that time.
Chapter 15
Poecilidae: Livebearers

The Family Poecilidae belongs to the order Cyprinodontiformes, which includes pupfishes, top minnows, killifishes, and mosquitofishes. The family is composed of about 150 species with worldwide equatorial distribution between about 40°N and 40°S latitude (Wischnath 1993). Many members of this family are popular aquarium fish such as guppies, mollies, platys, and swordtails that have morphological specializations for capturing insects on the surface. Twenty-one species occur in North America, none indigenous to the Pacific Northwest (Nelson 1994). One species, the western mosquitofish *Gambusia affinis*, was introduced into many locations in eastern Washington for mosquito control.

Cyprinodontiform fishes are intermediate between those with primitive (ancestral) and advanced (derived) body plans. They have a single, soft dorsal fin (similar to primitive fishes). The anterior insertion of the dorsal fin usually arises posterior to the anterior insertion of the anal fin, and both fins are positioned slightly behind the midpoint of the body (whereas the soft dorsal fin of most primitive fishes is centered over the midpoint of the body). The pectoral fins are elevated to a more lateral position (similar to advanced fishes) instead of having a ventral insertion characteristic of primitive fishes. The base of the pectoral fin is oriented vertically, similar to advanced fishes rather than horizontally like primitive fishes. Additionally, the pelvic fins are more anteriorly inserted than those of a primitive fish, but not as far forward as those of an advanced fish, i.e., the pelvic fins are intermediate between the abdominal and thoracic positions. Cyprinodonts are small and easily confused with cypriniform fishes (minnows and suckers). The two orders are separated by the presence or absence of teeth in the jaws. Cyprinodonts have them, Cypriniforms don’t (the name Cyprinodont means “toothed carp”).

Two families of Cyprinodontiform fishes occur in eastern Washington the Fundulidae, which includes killifishes and topminnows, and the Poecilidae, which includes the mosquitofish. The Poecilidae are livebearers with anal fins of males modified into a gonopodium, which functions as a copulatory organ. The Fundulidae are egg layers with anal fins of males not so modified. Many members of this order have oblique mouths. The premaxillary bones alone form the upper jaw. These characters enable cyprinodontiform fishes to hover at an angle near the surface, where they prey on insect pupae emerging on the surface, or aquatic and terrestrial adult insects that live on the surface. Cyprinodontiforme fishes are often called “top minnows” on account of this trait. Their caudal fin is usually rounded and symmetrical. Their lower jaw often projects beyond the upper jaw. They are small, short-lived and incredibly prolific.

Mosquitofish have short lifespans and seldom live longer than 15 months. Both sexes become sexually mature in 4–6 weeks after birth. Males and females grow to sizes of about 35 mm and 60 mm respectively. Internal fertilization is accomplished by males transferring sperm to the reproductive tract of females via the gonopodium. The gonopodium is an elongation of anal rays 3, 4, and 5, which can rotate forward or sideways to facilitate copulation. Males produce sperm in “sperm packets.” Sperm packets slide down the grooved surface of the gonopodium. The tip of the gonopodium is barbed with sharp spines that prevents it from pulling out when inserted into the female’s genital pore (Rosen and Gordon 1953). Live sperm are stored in the cloaca of the female. Mosquitofish give birth to live young from eggs that hatch inside the female’s body. Eggs ripen in the ovaries. Some of the stored sperm ascends up the oviduct and fertilizes the eggs. The normal gestation period is 3–4 weeks. This type of live birth differs from that of most mammals, because, in mammals, female parents nourish the embryo which is attached via a placenta. In contrast, developing mosquitofish embryos are nourished only from the yolk contained in the egg. This type of vivipary is termed ovoviviparous. A single female produces an average (range) of 50 (2–315) offspring per fertilization event and may bear 3–4 broods in one season (Krumholtz 1948; Brown 1996).
Chesser et al. (1984) found that the high genetic variation in mosquitofish populations was the result of multiple insemination of a female by several males. Biochemical genetic testing of all the offspring produced by one female revealed that they were sired by sperm from multiple males. Females can use sperm collected during their first summer and carried over the winter in their cloaca to fertilize eggs in the spring of their second year (Meffe and Snelson 1989; Haynes 1993). Overwinter sperm retention may be one factor that allows for reestablishment of populations that have suffered mortality due to harsh winter conditions.

The diet of mosquitofish is composed of zooplankton and insect larvae and pupae, especially *Anopheles* mosquitoes, the type that carry malarial parasites. In one experiment replicated lots of 100 mosquitofish were stocked in each of five ponds and five additional were left barren as controls (Krumholtz 1943). After two months, counts of *Anopheles* larvae and pupae were made in each pond prior to the peak emergence of mosquitoes. Counts of *Anopheles* averaged (ranged) 17 (13–31) larvae in the experimental ponds and 301 (108–609) larvae in the control ponds, indicating that *Anopheles* mosquito production was reduced about 94% in ponds stocked with mosquitofish.

Mosquitofish, through predation, competitive interactions, and disruption of food chains, can cause harm to indigenous fishes, including some species that are also effective biological control agents for mosquitos (Myers 1965; Minkley and Deacon 1986; Ono et al. 1983). Mosquitofish are pugacious and shred the fins of, or kill, native fish, resulting in displacement of native species (Meffe 1983; Fuller et al. 1999).

In Washington, mosquitofish stock ponds are maintained by Mosquito Control Boards (MCB) in Adams, Benton, and Grant Cos. MCBs deliver mosquitofish to applicants who request them for stock ponds, golf course water hazards, water troughs, and private lakes that cannot be connected to the Columbia River or any of its tributaries. Despite this precaution mosquitofish have escaped their confinement and entered the Yakima and Columbia rivers. Mosquitofish grow and reproduce best in warmwater. They are tolerant of temperatures between 4–38°C and rarely survive at locations where water temperature drops below 4°C. They usually must be reintroduced each year at those locations. However, Krumholtz (1944) reported strains in Illinois and Michigan that survived winters under ice cover 25–66 cm thick.

**KEY TO FAMILY POECILIIDAE**

**General Family Characteristics**

Confirm these characters before keying to species.

1. One soft dorsal fin with origin arising posterior to the origin of the anal fin.
2. Pelvic fins intermediate between abdominal and thoracic positions (origin of pelvic fins in front of anterior origin of dorsal fin).
3. Lateral line absent on sides of body (present on head only).
4. Pronounced sexual dimorphism. Males possess gonopodium (copulatory organ). Females larger (to 60 mm TL) and more robust than males (to 35 mm TL). Females with distinct belly and males more streamlined.
5. Mouth distinctly oblique (upturned at 45° angle).

**Key to the Species of the Poeciliidae of Eastern Washington**

Represented by a single species, the western mosquitofish, in eastern Washington, so the general family characters also serve to identify the species (go to page 219).
WESTERN MOSQUITOFISH

*Gambusia affinis* (Baird and Girard, 1859)

**Figure 15.1** Western mosquitofish, Benton Co. Mosquito Control Board, Tricities, WA.

**Primary Identification**

1. One soft dorsal fin, situated behind the midpoint of the body. Origin posterior to origin of anal fin.

2. Pelvic fins intermediate between abdominal and thoracic positions (origin of pelvic fins in front of posterior tip of pectoral fins).


**Confirming Characters**

1. Mouth oblique (upturned).

2. Lateral line not evident externally on sides of body. (May be present on head only).

**Similar Species**

1. Similar to banded killifish (*Cyprinodontiformes: Cyprinodontidae: Fundulus diaphanus*). See page on page 286. Banded killifish are distinguished by a series of alternating light and dark bands along the sides of the body which mosquitofish lack.

2. Similar in size to minnows (*Cyprinidae*). Mosquitofish have teeth in their jaws; minnows don’t.

**Etymology**

*Gambusia*: The generic name coined by Poey (1854) was derived from the Cuban word *gambusino*, meaning insignificant or unimportant, a jib at the small size of this fish.

*affinis*: (L.) *affini* = Allied or related, i.e., it was nearly identical to eastern mosquitofish, *G. holbrooki*.

**Common Name(s)**

Western mosquitofish (AFS name), viviparous topminnow.
Figure 15.2 Western mosquitofish distribution in eastern Washington.

Distribution

The western mosquitofish is native to the Gulf Coast from Alabama to Mexico, and to the Mississippi Valley north to southern Illinois. Because they are voracious predators of mosquitoes, they have been introduced throughout the world in tropical, subtropical, and even some temperate regions for mosquito and malaria control.

Western mosquitofish were illegally introduced in Washington in 1958 by a State Health Department employee who planted them in eight ponds in Adams, Benton, and Grant Cos. (Dees 1961a; Mongillo 1984). They were later legally introduced by MCBs in those counties during the 1960’s. Stockings occurred in Rodeo Lake (Adams Co.), several desert lakes west of Potholes Reservoir (Grant Co.) and in two ponds at Sacajawea State Park (Benton Co.). They were also introduced into four broodstock ponds in Richland, Kennewick, and Benton cities (Benton Co.) in 1970. Fish from all these facilities, which are still (2003) maintained by the MCBs, were distributed primarily to backyard ponds, water troughs, and water hazards at golf courses. For example, in 2002, the Benton Co. MCB transported 4,612 mosquitofish from their brood ponds in the Tri-Cities to 62 applicants (average 72 fish per applicant). Recently, western mosquitofish were collected in backwaters along the Yakima River (Benton Co.). Their presence in John Day Reservoir, Columbia River, was documented by Hjort et al. (1981).
Chapter 16

Gasterosteidae: Sticklebacks

The Gasterosteidae (sticklebacks) are composed of five genera and seven species that occur in marine, brackish, and freshwaters of the northern hemisphere (Wootton 1976, 1984; Nelson 1994). Two species occur in Washington; the native threespine stickleback *Gasterosteus aculeatus*, and introduced brook stickleback *Culaea inconstans*.

Sticklebacks are distinctive from all other families of fishes found in eastern Washington because they have a variable number of isolated spines that precede the soft dorsal fin. Each spine has an individual membrane. Additionally, stout spines are present at the bases of the pelvic and anal fins. The pelvic fins are highly modified so that they are composed of just the spine plus one or a few inconspicuous soft rays. Specializations of the skeleton and musculature supporting all these spines allow them to be erected and locked rigidly into place for an extended period of time, in a predator’s throat, which prevents the stickleback from being swallowed.

Sticklebacks are also distinguished by the presence of bony lateral plates instead of scales, which form shield-like body armor along the sides of the body. The degree to which the lateral plates are developed is highly variable among species and even within populations of one species. Sticklebacks are one of the few families that lack swim bladders.

Threespine stickleback from marine environments exhibit little morphological or life history variation across their holarctic range (Baker 1994; Foster 1995; Foster et al. 1998, 2003). They generally have substantial armorment, including three predorsal spines, a complete pelvic skeleton with well developed pelvic spines, and are fully plated with shield-like lateral plates running along the sides of the entire body (Figure 16.1 top). In contrast, freshwater forms are morphologically variable in their armorment, often showing a reduction in predorsal spines to one or two (sometimes none), a reduction in the pelvic skeleton and spines (sometimes absent), and a reduction in lateral plates on the posterior of the body (some have lateral plates confined to the front and others have none) (Hagen 1967; Wootton 1976; Kynard 1979a; Bell 2001; McKinnon and Rundle 2002; Foster et al. 2003) (Figure 16.1 bottom). Freshwater threespine sticklebacks also show considerable life history variation, with some adapted to near shore benthic environments and others to offshore limnetic environments; in each case with specialized morphology for each niche (Wootton 1976; McPhail 1984, 1994; Bell and Foster 1994a; McKinnon and Rundle 2002; Foster et al. 2003).

Biology of stickleback has been described in four books (Wootton 1976, 1984; Bell and Foster 1994; Ostlund-Nilson et al. 2006). Publications on stickleback in eastern Washington include papers on populations of threespine sticklebacks in Wapato, Roses, and Chelan lakes, Chelan Co. (Hagen and Gilbertsen 1972, 1973a, 1973b; Kynard 1972, 1978, 1979a, 1979b), a paper on temperature tolerance of threespine stickleback in the Columbia River (Blahm and Snyder 1975), and a paper describing the introduction of brook stickleback in Spokane Co. (Scholz et al. 2003).

Threespine stickleback spawn from April to July. Males construct tunnel nests either out of twigs and debris (Scott and Crossman 1973) or strands of algae and aquatic plants (Moyle 1976; Wydoski and Whitney 1979). The male cements the nest material together using a sticky fluid secreted by his kidneys. The nest is open at each end. After the nest is completed the male defends the territory around it from encroachment by other males and tries to entice females into it.

Threespine stickelback breeding males develop vivid spawning coloration: bright red bellies, blue flanks, and iridescent blue eyes (Figure 16.2). Male spawning colors are usually muted
in inland populations. Breeding females are not so vividly colored, but their abdomens become distended with developing eggs. These color patterns and morphological shapes act as sign stimuli (signals) that elicit stereotyped behavior (fixed action patterns) by the males and females during their elaborate breeding ritual (Tinbergen 1952). During their mating dance, the females follow the male, who conducts her on a zig-zag path to the entrance of his nest.

Males spawn with several females, collecting several clutches of eggs. Each female typically deposits 50–150 eggs. Up to 600 eggs have been collected from one nest, which were spawned by several females. After the nest has a full complement of eggs, the male assumes a head stand posture at the nest entrance and circulates oxygenated water over the eggs by fanning his pectoral fins. The male also pugnaciously defends the eggs and larvae from potential predators for several weeks after hatching. Most threespine stickleback complete their lifecycle in one year, although a small percentage of individuals may live 2–3 years (Wydoski and Whitney 1979). Stickleback are semelparous; adults die soon after spawning once. They attain maximum total lengths of about 75 mm.

Good descriptions of the nest building and spawning behavior of brook stickleback were presented by Jacobs (1948), Winn (1960), Thomas (1962), Reisman and Cade (1967), McKenzie (1974), and McLennan (1993, 1995). In general, both types of activities are similar to that already described for threespine stickleback except that the nest is usually round instead of tube-like and it usually has only one entrance instead of two. They grow rapidly and reach sexual maturity in one year. Maximum size is about 70 mm.

Both threespine and brook stickleback fed on aquatic insect larvae (midges, blackflies, stonefly and caddisflies), zooplankton, ostracods, snails, worms, fish eggs, and fry. Threespine stickleback are known to cannibalize eggs of other threespine stickleback.
Figure 16.2  (Top) Female and (Bottom) male threespine stickleback in breeding coloration. Note distended belly of female and blue eye and red belly of male. Their shallow water habits bring stickleback into contact with, and their small size makes them vulnerable to, a variety of fish, reptile, bird, and mammal predators. Their spines and armor-like lateral plates are thought to have evolved to make them less ideal prey (Hoagland et al. 1956; Hagen 1967; Hagen and Gilbertson 1972).

Hoogland et al. (1956) demonstrated that when erected, the spines of threespine stickleback increased its effective diameter, making its more difficult to swallow by pike and perch predators. Additionally, the spines punctured the mouth parts of the predators.

In an experiment where 1,581 threespine stickleback were introduced into a net enclosure in a natural lake (Roses Lake, Chelan Co.) that contained cutthroat trout predators, 380 escaped pursuit by trout and 1,201 were captured (Reimchen 1991). Of those captured 491 (40.9%) were not swallowed during the subduction phase, including 369 individuals (75.1%) that were rejected by the trout and 122 (24.9%) that actively escaped. Most juvenile stickleback handled by the trout, were eaten, whereas about 80% of the adult stickleback handled by the trout were rejected. Reimchen (1991) estimated that when their dorsal, pelvic, and anal spines were fully erected, adult stickleback had a cross-sectional diameter that was 230% greater than the original body diameter, making them difficult to swallow. Reimchen (1991) concluded that adult stickleback in the lake were largely immune from successful predation by trout. Analysis of stomach contents indicated that few adult stickleback were present in the diets of wild trout captured in the same lake (Reimchen 1980).

**KEY TO FAMILY GASTEROSTEIDAE**

**General Family Characters**

Confirm these characters before keying to species.

1. Isolated dorsal spines 2–7, preceding soft dorsal fin. Each spine stout, with a posterior triangular membrane.
2. Pelvic fins modified into one spine and one soft ray.
3. Stout spine present at anterior insertion of anal fin, slightly separated from fin.
4. Body smooth, scaleless, but covered to varying degrees with bony lateral plates. (Lateral plates of brook stickleback very small, almost invisible).
5. Pectoral fins inserted above ventral midline.
6. Pelvic fins thoracic, inserted below and slightly behind pectoral fins.
7. Mouth upturned at oblique angle.

**Key to the Species of the Gasterosteidae of Eastern Washington**

1. A. Isolated predorsal spines 4–7, no distinct bony lateral plates on sides.  
   - **Brook stickleback**  
     - *Culaea inconstans*  
     - Page 225

   B. Isolated predorsal spines 2–3, distinct bony lateral plates usually present on sides.  
   - **Threespine stickleback**  
     - *Gasterosteus aculeatus*  
     - Page 227
BROOK STICKLEBACK
*Culaea inconstans* (Kirtland, 1841)

Figure 16.3  Brook stickleback, Rock Creek (Palouse River Drainage), Spokane Co., WA.

**Primary Identification**

1. Isolated backward-curved spines, 4–7, usually 5–6, in front of soft dorsal fin. Each with triangular membrane. Spines depressible into a cartilaginous ridge along base.

2. Pelvic fins composed of one long, stout spine and one soft ray. Some populations in Alberta lack pelvic skeletons (Nelson and Paetz 1992), but we have not observed this in any population we have examined in eastern Washington.

3. Anal fins with one short (but stout) spine followed by 9–11 soft rays.

4. Body without scales or lateral plates, but with careful examination the fish actually has about 30–33 tiny lateral plates along the lateral line. (Requires magnifying lens to see).

**Confirming Characters**

1. Body laterally compressed. Narrow caudal peduncle, not keeled. Dorsal and anal fins both about the same size and inserted opposite each other, look like mirror images.

2. Mouth oblique; upturned at 45° angle.

3. Posterior margins of caudal and pectoral fins rounded.

**Similar Species**

1. Threespine stickleback: Differentiated by the number of isolated predorsal spines (2–3 in threespine and 4–7 in brook stickleback), presence/absence of lateral plates (brook stickleback have tiny lateral plates whereas threespine stickleback usually have large lateral plates), and the relative size of the dorsal and anal fins (in brook stickleback about equal, in threespine stickleback dorsal fin is larger than the anal fin).

**Etymology**

*Culaea*: (L.) Cula = little.

*inconstans*: (L.) Variable, referring to the number (4–7) of isolated pre-dorsal spines. A sample of 2,316 brook sticklebacks collected on Turnbull National Wildlife Refugee, near Cheney, Washington contained 16 individuals with four spines (< 1%), 2,052 with five spines (89%), 247 with six spines (10%), and one with seven spines (< 1%).

**Common Name(s)**
Brook stickleback (AFS name), five-spined stickleback, six-spined stickleback.
Distribution

The natural distribution of brook stickleback in North America was centered east of the Rocky Mountains, in the Midwest between the Ohio Valley and Great Lakes, extending north and west to the upper Missouri/Mississippi River, Peace/McKenzie River, and Hudson Bay drainages (Nelson 1969; Wootton 1976, 1984; Lee et al. 1980), including the eastern slopes of the Rocky Mountains in British Columbia (Dymond 1936; Scott and Crossman 1973), Alberta (Nelson and Paetz 1992), Northwest Territories (McPhail and Lindsey 1970), and Montana (Brown 1971; Holton and Johnson 1996), but not Wyoming (Baxter and Stone 1995). They were introduced to Washington in the late 1990’s.

First reports in Washington occurred in 1999 at Turnbull National Wildlife Refuge, and upper Rock Creek, a tributary of the Palouse River (Spokane/Whitman Co.) (McLellan 2000; Scholz et al. 2003). From 2003–2005, specimens were collected in the Pine, Cottonwood, and Pleasant Valley and Imbler Creek drainages (Glover 2004; Fox 2005; Porter 2006), and all tributaries of Rock Creek. The BLM collected brook stickleback in isolated ponds on their property south of Sprague Lake in 2002 and on the Escure Ranch (adjacent to Rock Creek) in 1999. Scholz et al. (2003) determined that the brook stickleback in the Rock Creek drainage originated from the midwestern United States. Brook stickleback were also collected in the upper Cow creek (Palouse River drainage) in 2003 and in California Creek, a tributary of Latah (Hangman) Creek, Spokane River drainage in 2005.

Figure 16.4  Brook stickleback distribution in eastern Washington.
THREESPINE STICKLEBACK

*Gasterosteus aculeatus* (Linnaeus, 1758)

**Figure 16.5** Three-spine stickleback, Walla Walla River, Walla Walla Co., WA.

**Primary Identification**

1. Isolated spines, 2–3, usually 3, in front of soft dorsal fin. First two spines long and stout, third short but also stout. Each spine with triangular membrane.
2. Pelvic fins composed of one stout spine and one soft ray.
3. Anal fin with one short (but stout) spine followed by 8–10 soft rays.

**Confirming Characters**

2. Caudal peduncle usually strongly keeled in marine populations but the keel is weak or absent in freshwater populations.
3. Posterior margins of caudal and pectoral fins square.
4. Single ventral bony plate between and behind pelvic fins.

**Similar Species**

1. Brook stickleback: Threespine stickleback have 2–3 isolated pre-dorsal spines, whereas brook stickleback have 4–7. Threespine stickleback usually have at least some lateral plates whereas brook stickleback appear naked. Dorsal and anal fins of unequal length in three spine stickleback and about equal length in brook stickleback.

**Etymology**

*Gasterosteus*: (G.) *Gaster-* (belly) and *-osteus* (bone), a reference to the bony plate, with posterior extension along the ventral midline between the pelvic fins.

*aculeatus*: (G.) Spined.

**Common Name(s)**

Threespine stickleback (AFS name), twospine stickleback, common stickleback.
In Washington the threespine stickleback is abundant in coastal streams and associated wetlands west of the Cascade Mountains. It also occurs in the Columbia Basin upstream as far as Lake Chelan (RKM 805.3) (Wydoski and Whitney 1979; Kynard 1979a). It occurs in the Walla Walla (Gilbert and Evermann 1894; Mendel et al. 2000, 2001a, 2001c, 2002), Yakima (Patten et al. 1970) and Wenatchee (Miller and Schonning 2005) rivers, and Hanford Reach (Gray and Dauble 1977) of the Columbia River. It is abundant in Chelan, Wapato and Roses lakes in the Chelan River drainage, but is not widespread or commonly found in eastern Washington (Wydoski and Whitney 1979, 2003). WDFW records indicate that when McCoy Lake on the Spokane Indian Reservation, Stevens Co., was rehabilitated in 1971, thousands of threespine stickleback were eradicated. McCoy Lake is located near the confluence of the Spokane and Columbia rivers (RKM 1022.2) and is completely isolated from both rivers. To our knowledge this is the farthest upstream that threespine stickleback have been reported in the Columbia Basin (Figure 16.6, yellow dot on distribution map).

Threespine stickleback are popular aquarium fish that have been illegally introduced into natural waters where it is not indigenous, including locations in the Columbia Basin. Threespine stickleback were introduced into central Oregon in the 1980's and are presently found in the Deschutes River from Crane Prairie Reservoir downstream to Lake Billy Chinook and in two of its tributaries (Fuller et al. 1999).
Chapter 17

Family Cottidae: Sculpins

The Family Cottidae belongs to the Order Scorpaeniformes and is composed of about 70 genera and 300 species of marine and freshwater fishes that occur mainly in the Northern Hemisphere (Nelson 1984). Thirty-four genera and 123 species occur in North America (Nelson et al. 2004). Members of this family are characterized by being somewhat dorso-ventrally flattened, having swim bladders with reduced volume or absent, large fan-like pectoral fins, eyes close together on the top of the head, and body usually appearing naked (ctenoid scales, if present, are weak and embedded deep within the skin). Sculpins often contain prickles (bony dermal elements) that occur in small patches or (rarely) cover the entire body.

The Cottidae are similar to other “advanced” (derived) fishes like the Centrarchidae and Percidae by having two dorsal fins (the first spiny-rayed), and pelvic fins shifted forward into the thoracic position. Unlike sculpins, these families have eyes on the sides of their head, swim bladders, and normal-sized pectoral fins.

Sculpins flattened shape, negative buoyancy, and large fins are adaptations for occupying turbulent waters in riffles of streams, wave zones of lakes, or intertidal zones of oceans. For example, the mottled sculpin \textit{Cottus bairdii}, a freshwater stream-dwelling species, holds position in currents by sinking to the bottom and hiding in crevices or behind cover in rocky substrate. When their flattened heads are oriented into the current and pectoral fins are spread, the current presses down against their large surface area, and pins them to the substrate, helping the sculpin to maintain position in fast currents.

The genus \textit{Cottus} is composed of freshwater sculpins. In North America 28 species of \textit{Cottus} are recognized (Nelson et al. 2004), including seven species that occur in eastern Washington (Mongillo and Hallock 1995; Wydoski and Whitney 1979, 2003). Of these, prickly \textit{C. asper}, shorthead \textit{C. confuses}, and torrent sculpin \textit{C. rhotheus} are distributed throughout the state on both sides of the Cascade Mountains. The mottled sculpin \textit{C. bairdii} is distributed widely throughout eastern Washington and the Paiute sculpin \textit{C. beldingi} is distributed predominantly in the Walla Walla, Tucannon, and Yakima basins. Margined sculpin \textit{C. marginatus} is distributed in the Umatilla, Walla Walla/Touchet, and Tucannon basins, and slimy sculpin \textit{C. cognatus} is distributed predominantly in the mid-Columbia River drainages (Yakima, Wentachee, Entiat, Methow, and Okanogan rivers), the upper Columbia River drainages (Spokane, Kettle, and Pend Oreille rivers), and in Lake Chelan (Mongillo and Hallock 1995; Wydoski and Whitney 2003).

Molly Hallock, WDFW, Olympia, WA has identified several characters that are particularly useful for separating the seven sculpin species that occur in eastern Washington, including:

1. Median chin pores on the ventral surface of the jaw at the anterior midpoint where the two jaws come together, (there are either one or two pores);
2. Palatine teeth in the roof of the mouth either (present or absent);
3. Lateral line either complete (extends to posterior margin of caudal peduncle) or incomplete (terminates under second dorsal fin);
4. Number of pelvic fin rays (either three or four); some species that usually have three have a fourth ray that is about \(\frac{1}{2}\) to \(\frac{2}{3}\) the size of the other rays;
5. Dorsal fins (either united or separated to base); and
6. Length of anal fin base (about equal or distinctly shorter than dorsal fin base).
Table 17.1  Comparison of sculpin characters.

<table>
<thead>
<tr>
<th>Character</th>
<th>Prickly C. asper</th>
<th>Mottled C. bairdi</th>
<th>Paiute C. beldingi</th>
<th>Slimy C. cognatus</th>
<th>Shorthead C. confusus</th>
<th>Margined C. marginatus</th>
<th>Torrent C. rotheus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chin pores</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Palatine teeth</td>
<td>P</td>
<td>P</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>P</td>
</tr>
<tr>
<td>Lateral line</td>
<td>C</td>
<td>C (few I)</td>
<td>I</td>
<td>I</td>
<td>C (few I)</td>
<td>I</td>
<td>C</td>
</tr>
<tr>
<td>No. pelvic rays</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Dorsal fins</td>
<td>united</td>
<td>separated</td>
<td>separated</td>
<td>separated</td>
<td>separated</td>
<td>united</td>
<td>separated</td>
</tr>
<tr>
<td>Anal fin base</td>
<td>= dorsal</td>
<td>&lt; dorsal</td>
<td>&lt; dorsal</td>
<td>&lt; dorsal</td>
<td>&lt; dorsal</td>
<td>&lt; dorsal</td>
<td>&lt; dorsal</td>
</tr>
</tbody>
</table>

1. Lateral line is incomplete in many mottled and shorthead sculpin; 2. About 25% of specimens in the southeast corner of Washington (Blue Mountains south of the Snake River) have only three pelvic rays; 3. Some individuals have four pelvic rays; if four, the innermost ray is less than 2/5 the length of the other rays; 4. United condition of dorsal fins implies that they are connected greater than 1/5 of the height of the first ray of second dorsal fin; separated conditions indicates two fins are separated to base or connected less than 1/5 of height of first ray in second dorsal fin.

Table 17.1 compares the characters in the seven species of sculpin found in eastern Washington. Unfortunately, none of these characters are as clear cut as indicated by the comparison chart. For example, McAllister and Lindsey reported that 400 of 405 (99%) prickly sculpin examined from throughout their range had one median chin pore, but five (1%) had two. Paiute sculpin and margined sculpin occur in sympatry in the Walla Walla and Tucannon River Basins (Lonzarich 1993). Paiute sculpin always have two median chin pores and usually four pelvic fin rays, but 25% of the specimens collected from these drainages had three pelvic rays (Lonzarich 1993). Margined sculpin usually have one chin pore and three pelvic rays, but in these drainages 6% of the specimens had two chin pores and 25% had four pelvic fin rays. In specimens where a fourth ray was present, the innermost ray was shorter than the other three (Lonzarich 1993). Thus, identification of these two species in southeastern Washington is somewhat problematic and is better described in terms of probability rather than certainty. The two species can be identified with a high degree of certainty only about 75% of the time. By comparing additional characters this probability is elevated to about 90–95%.

Adding to the headaches of sculpin taxonomy was the discovery that some characters exhibit environmental and ontogenetic plasticity. For example, the completeness of the lateral line in mottled sculpin has been positively correlated to total length (Janssen et al. 1987). Although it is presently not possible to positively identify sculpin 100% of the time, genetic analysis has revealed that, at a particular location, placement of sculpins into species based on morphological characters is reasonably accurate. Genetic analyses have generally confirmed that when sympatric populations of different species of sculpin from the same geographic area were compared, they were usually genetically distinctive. For example, fish identified as slimy sculpin or shorthead sculpin based on morphological characters were also separable genetically because they had different (diagnostic) alleles at six out of 33 gene loci examined (Zimmerman and Wooten 1991).

All seven species of sculpin found in eastern Washington exhibit similar spawning behavior. All spawn in the spring. Males construct nests underneath rock overhangs, cavities of submerged logs or in man-made debris (e.g., coffee cans, car bodies, mufflers, and tail pipes). Males cement a sticky mucus to the ceilings of these structures. Eggs, ovulated in a jelly-like cluster, adhere to the mucus. Females are courted by males who lead them to the nest. After spawning, males chase the females away from the nest and guard eggs until they hatch. Males also use their fan-like pectoral fins and sometimes their caudal fins to circulate oxygenated water through the nest. Males usually spawn with multiple partners as evidenced by the fact that nests often contain 2–10 times more eggs than the maximum fecundity recorded for a species.

Prickly sculpin have maximum lifespan of 7–8 years, but seldom live more than 2–3 years. Prickly sculpin attain sexual maturity between age 1 and 4, usually by age 2 (Bond 1963;
Krejsa 1967a, 1967b; Patten 1971a; Rickard 1980). Prickly sculpin attained a maximum of 305 mm TL but seldom exceeded 150 mm (Carl et al. 1967a). Fecundity ranged from 584–10,980 eggs in females 60–195 mm SL (Bond 1963; Millikn 1968; Patten 1971a). Males typically spawn with 2–10 females and their nursery chambers usually contain 25,000–30,000 eggs (Krejsa 1967a; McLarney 1968).

Maximum life expectancy of mottled sculpin is about 5 or 6 years. Both males and females become sexually mature at age 2 (Patten 1971a). Fecundity ranged from 46–275 eggs in females 46–91 mm TL collected from the Yakima River (Patten 1971a). Bailey (1952) often observed up to 1,200–1,800 eggs in nest chambers under different rocks, indicating that the species is polygamous. Brown and Downhewer (1982a) reported that the mean number of female spawning partners per male during a single season ranged from 1–14 and was usually 2–4.

Paiute sculpin have a maximum lifespan of 5 years and usually attain sexual maturity at age 2 (Moyle 1976). Their maximum total length was about 127 mm. Fecundity of Paiute sculpin ranged from 37–181 eggs in females 43–76 mm TL from the Yakima River (Patten 1971a). Slimy sculpin have a maximum lifespan of about six years. Both sexes become sexually mature at age 2. Slimy sculpin attain maximum total lengths of about 120 mm (McPhail and Lindsey 1970), although specimens this large are uncommon. Most sexually mature adults range from about 51–80 mm (Wydoski and Whitney 2003). Females 38–80 mm TL contained 84–653 eggs (Foltz 1976).

Lifespan of the shorthead sculpin is 4–6 years (Wydoski and Whitney 1979, 2003). Sexual maturity was attained at age 2 (Patten 1971a). Maximum size reported in Washington was 132 mm (Wydoski and Whitney 2003), but 55–80 mm is a more typical adult size. Fecundity ranged from 47–690 eggs in females 61–91 mm TL (Patten 1971a; Gasser et al. 1981).

Little is known about the age, growth, or reproduction of margined sculpin. Total lengths of 397 specimens in the UW Fish Collection ranged from 22–85 mm TL, with only three fish exceeding 75 mm TL. No information is available about the fecundity of margined sculpin.

Torrent sculpin have a lifespan of 6 years and become sexually mature at age 2 (Northcote 1954). The maximum size reported in the literature was a 152 mm TL specimen collected in the Arrow Lakes, British Columbia, but we collected a specimen in Hawk Creek, a tributary of Lake Roosevelt, that was 156 mm TL. Fecundity ranged from about 156–370 eggs/female (Patten 1971a).

The food habits of all species of sculpins found in eastern Washington are similar. Juvenile sculpins fed on zooplankton and a few types of aquatic insect larvae (e.g., chironomids). Adult sculpins ate predominately many kinds of aquatic insect larvae, especially chironomids (midges) and caddisflies. They also ate crustaceans, such as amphipods, tiny juvenile crayfish, mayflies, mollusks (snails and fingernail clams), and occasionally the eggs or larvae of fishes. The mouths of torrent sculpin have a larger gape than other sculpins so they tended to eat larger prey and consume more fish and crayfish than other sculpin species (Northcote 1954).

Although sculpin sometimes eat the eggs or fry of salmonid species they are not considered important predators of salmonids. Sculpins evolved in sympatry with Pacific salmon and trout, which spawn at relatively cold temperatures when sculpin metabolism and, consequently, their rate of food intake will be reduced. Although trout and sculpins may compete for aquatic insects, they partition this resource with sculpin feeding primarily off the bottom and trout feeding on drifting insects.

Because sculpins are favorite prey for many predators, they tend to be nocturnal. Mottled
sculpin hunt at twilight by using their lateral line sense to detect differences in water pressure that occur along the length of their bodies as potential prey swim by (Hoekstra and Janssen 1985, 1986). Detailed behavior and neurophysiology of their response was described by Coombs and Conley (1997a, 1997b, 1998). Janssen (1990) reported that mottled sculpin placed their submandibular pores in contact with the stream bottom and used them to detect vibrations of prey burrowing into or crawling on top of the substrate.

Jones and Janssen (1992) described the ontogenetic development of lateral line system in the mottled sculpin. In early development, neuromasts developed along the sides of the body, surrounding the orbit of the eye, and on the pre-operculum and mandible. At hatching, the neuromasts were superficial, but by day 25 those along the side became enclosed in canals. Those surrounding the eyes, on the operculum and underneath the mandible, became recessed in pits connected to the outside by pores. (See Jones and Janssen 1992) for an excellent series of photographs that illustrates this). Jones and Janssen (1992) suggested that mottled sculpin may use neuromasts primarily as a predator avoidance system in the larval stage before developing into prey detection system in adults. The placement of neuromasts at different locations on the body is thought to provide both horizontal and vertical position of the prey in a three-dimensional aquatic environment (Janssen and Corceran 1998).

Sculpin are, in turn, a key forage species for many piscivorous fishes. Sculpin in streams are consumed by salmonids, especially brown trout, cutthroat trout, rainbow trout, and bull trout. Sculpins that occupy lakes, reservoirs, and big rivers are one of the most important prey items in the diet of walleye, smallmouth bass, northern pikeminnow, burbot, and white sturgeon.

Sculpin are sedentary and spend most of their time hidden under rocks or stones on the stream bottom. McCleave (1964) captured and marked (by fin clips) 1,847 mottled sculpin in a 5.6 km long segment of a Montana stream that was subdivided into ten sections. A total of 441 marked fish were subsequently recaptured, 80% of them in the same section where they were originally marked or an adjacent section. Home range was estimated at 46 m. The longest upstream movement was 180 m and the longest downstream movement was 153 m.

Brown and Downhower (1982b) marked 384 mottled sculpin with a fluorescent polymer and released them under tiles placed on the stream bottom. Of 102 fish subsequently recaptured within two months of release, 88% were recaptured within 2 m of their release point, most under the tile where released. The maximum distance moved was 14 m. Hill and Grossman (1987) marked 180 mottled sculpin in a small stream and recaptured 50 of them (some on multiple occasions) up to 458 days later: 92% of the recoveries were in the same tributary section where they were originally marked. The average (± SD) distance moved between capture and recapture was 12.9 (± 2.4) m and maximum distance moved was 55 m.

**KEY TO THE FAMILY COTTIDAE**

**General Family Characters**

Confirm these characters before keying to species.

1. Two dorsal fins (1st spiny, 2nd soft).
2. Pelvic fins thoracic, insertion underneath and slightly behind pectoral fin.
3. Eyes close together on top of head in dorsal position instead of on opposite sides of body.
4. Large pectoral fins.
5. Body moderately dorso-ventrally flattened.
6. Head and opercular region armed with spiny projections or prickles. (Sometimes difficult to see).
7. Anal fin with no spiny rays.
8. Caudal fin truncate (square) or convex.

**Key to the Species of the Cottidae of Eastern Washington**

1. A. One median chin pore; dorsal fins connected.
   B. Two median chin pores; dorsal fins separated.

2. A. Palatine teeth absent; lateral line incomplete.
   B. Palatine teeth present; lateral line complete.

- **Prickly sculpin**
  *Cottus asper*
  Page 235

  ![lateral line terminates under dorsal fin]

- **Margined sculpin**
  *Cottus marginatus*
  Page 245

  ![lateral line extends to tail]
3. A. Palatine teeth (on roof of mouth) absent (weakly developed) in small patches. **Go to 4**
   B. Palatine teeth (on roof of mouth) present (strongly developed) in large patches. **Go to 6**

4. A. Pelvic fins usually with three rays (if 4th ray present, the innermost is about 2/3 or less the length of outer rays). **Slimy sculpin** *Cottus marginatus*
   Page 241
   B. Pelvic fins usually with four rays (See note in couplet 4A). **Go to 5**

5. A. Patch of prickles absent on body underneath or behind pectoral fin. Lateral line incomplete. **Paiute sculpin** *Cottus beldingi*
   Page 239
   B. Patch of prickles present on body underneath or behind pectoral fins; lateral line complete (extends to posterior of caudal peduncle). **Shorthead sculpin** *Cottus confusus*
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6. A. Palatine teeth usually not in contact with vomer; usually three dark saddle-like marks, slanted forward, under 2nd dorsal fin; head usually convex. **Mottled sculpin** *Cottus bairdii*
   Page 237
   B. Palatine teeth usually in contact with vomer; usually two dark saddle-like marks, angled forward, under 2nd dorsal fin; head usually broad and flattened. **Torrent sculpin** *Cottus rhotheus*
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PRICKLY SCULPIN

*Cottus asper* (Richardson, 1936)

**Figure 17.1** Prickly sculpin, Yakima River, Kittitas Co., WA.

**Primary Identification**

1. One median chin pore. Over their range, 400 of 405 (99%) specimens examined by McAllister and Lindsey (1961) had one and five (1%) had two.

2. Dorsal fins connected. Posterior membrane of anterior fin joined to first ray of second dorsal fin greater than $\frac{1}{5}$ of its height.

3. Palatine teeth present.

4. Lateral line complete, extends to caudal peduncle.

5. Entire body usually covered by prickles in eastern Washington specimens.

**Confirming Characters**

1. Caudal peduncle narrow, width less than interorbital width.

2. Four pelvic fin rays.


4. Anal fin base about same length as base of second dorsal fin.

**Similar Species**

1. Margined sculpin. Both species have one median chin pore and connected dorsal fins. Margined sculpin lack palatine teeth and have an incomplete lateral line that terminates below the second dorsal fin.

2. Other sculpins have two median chin pores and dorsal fins separated to the base.

**Etymology**


*asper*: (L.) Rough or prickly, a reference to the prickles that cover the body in inland species.

**Common Name(s)**

Prickly sculpin (AFS name), prickly bullhead (Schultz 1936), bullhead.
Prickly sculpin are distributed along the west coast of North America from Ventura, California to the Kenai Peninsula of Alaska in both fresh and brackish waters. In the Columbia River Basin, prickly sculpin occur in the mainstem between the mouth and Revelstoke Dam, British Columbia (Northcote 1964; Gray and Dauble 1977b, 1977c). Prickly sculpin occur in the Snake River reservoirs above Ice Harbor, Lower Monumental, and Little Goose dams (Bennett et al. 1983), but have not been reported from the Snake River above Lower Granite Dam (Simpson and Wallace 1982). They were collected in the Yakima River between Toppenish and Ellensberg (Patten et al. 1970; Mongillo and Hallock 1995) and throughout the Crab Creek Basin (Mongillo and Hallock 1995; Scholz 2002).

Prickly sculpin occur in the Wenatchee (Mongillo and Hallock 1995), Methow (Wydoski and Whitney 2003), Okanogan (Dymond 1936; Clemens et al. 1939; Mongillo and Hallock 1995), Sanpoil (Peden 1987; Barton Evermann in 1894 USNM 00231959), and Kettle (Scholz 2001) rivers. Prickly sculpin were recorded in Pend Oreille River from the mouth upstream to Boundary Dam, but are apparently absent above this point, in Boundary (McLellan 2001) or Box Canyon reservoirs (Ashe and Scholz 1992; Bennett and Liter 1991). Prickly sculpin were present in the Kootenay River system below Bonnington Falls but absent above the Falls (Carl et al. 1967).
MOTTLED SCULPIN

Cottus bairdii (Girard, 1850)

Figure 17.3  Mottled sculpin, Spokane River, Spokane Co., WA.

Primary Identification

1. Two median chin pores in all specimens examined (McAllister and Lindsey 1961).
2. Dorsal fins separated to base or nearly so. If joined, the connection is less than $\frac{1}{5}$ the height of first ray of second dorsal fin.
3. Palatine teeth strongly developed but not in contact with vomer.
4. Lateral line variable, usually complete (extending to base of caudal peduncle) but sometimes incomplete (terminating below second dorsal fin). Head relatively large (> 26% of total length).

Confirming Characters

1. Four pelvic fin rays. Base of anal fin distinctly shorter than base of second dorsal fin.
2. Prickles variable. Some have a patch near pectoral fins. Others lack prickles.
3. One preopercular spine pointed backward and 1–3 smaller spines pointed downward.

Similar Species

1. Similar to torrent sculpin. The width of the caudal peduncle is less than the interorbital width in torrent sculpin and greater than the interorbital width in mottled sculpin. Palatine teeth of the torrent sculpin contact the vomer.
2. Other sculpin have shorter heads in proportion to total length: < 22% in shorthead sculpin and 23–25% in Paiute, slimy, prickly, and margined sculpins. Prickly and margined sculpins have one chin pore. Slimy and margined usually have three pelvic rays.

Etymology

Cottus: (G.) Cott, -us. A kind of fish. An old European name for freshwater sculpin.

bairdii: (L.) Named for Spencer Fullerton Baird, Secretary of the Smithsonian Institute, (United States National Museum) and first United States Fish Commissioner.

Common Name(s)

Mottled sculpin (AFS name), Malheur mottled sculpin (Markle et al. 1996), Bonneville mottled sculpin (Sigler and Miller 1963), Rocky Mountain bullhead (Jordan et al. 1930; Schultz 1936), Miller’s thumb, muddler minnow, blob, gudgeon.
**Distribution**

Mottled sculpin range widely throughout North America, but their distribution is discontinuous particularly in the intermountain west. Western populations occur in the Columbia/Snake River drainage (Montana, Wyoming, Idaho, Washington, and Oregon), Harney Basin (Oregon), Bonneville Basin (Utah and Nevada), Upper Colorado River Basin (Wyoming, Colorado, and Utah). The native range of this species in the northern Rockies is difficult to determine because during the middle part of the 20th century they were commonly used for baitfish and are thought to have been introduced by bait bucket transfer at several locations (Fuller et al. 1999). In eastern Washington, mottled sculpin have been collected in McNary Reservoir; Snake River above Ice Harbor, Lower Monumental, and Little Goose dams (Bennett et al. 1983); Palouse River (Maughan et al. 1980; Havens 1996), Walla Walla; and Touchet rivers, (Michaelis 1972; Jackson 1975; Knecht 1976; Pearman 1977); Yakima and Naches rivers (Bailey and Dimick 1949); and Hanford Reach of the Columbia River (Gray and Dauble 1977b 1977c).

Mottled sculpin occur in the Columbia mainstem between Priest Rapids Dam and the International border (Wydoski and Whitney 2003), and in the Crab Creek, Spokane, Colville, and Kettle basins (Gilbert and Evermann 1894; Schultz and DeLacy 1935/1936; Mongillo and Hallock 1995; McLellan 2003).
PAIUTE SCULPIN

*Cottus beldingi* (Eigenmann and Eigenmann, 1891)

**Figure 17.5** Paiute sculpin, Touchet River, Columbia Co., WA.

**Primary Identification**

1. Two median chin pores.
2. Dorsal fins separated to base or nearly so. If joined, the connection is less than \( \frac{1}{5} \) the height of first ray of second dorsal fin.
3. Palatine teeth absent or weakly developed.
4. Lateral line incomplete, terminates under second dorsal fin.
5. Prickles absent under or behind pectoral fin.

**Confirming Characters**

1. Pelvic fin usually with four rays. About 25% of specimens from Blue Mountains in southeastern Washington had only three rays (Lonzarich 1993).
2. Usually have one preopercular spine pointed backward.
3. Anal fin base slightly shorter than second dorsal fin base.

**Similar Species**

1. Similar to margined sculpin which has only one median chin pore.

**Etymology**


*beldingi*: Named after Linus Belding who collected the first specimens of this species.

**Common Name(s)**

Paiute sculpin (AFS name), Belding’s sculpin, smooth bullhead (Schultz 1936), rifflefish (Schultz 1931), Lahontan sculpin (La Rivers 1962), Snake River sculpin (Simon 1946).
Figure 17.6  Paiute sculpin distribution in eastern Washington.

**Distribution**

The Paiute sculpin occurs in the Columbia and Snake River Basins in Idaho, Oregon, Washington, Wyoming, the Bonneville Basin in Utah, the Lahontan Basin in Nevada and California and the Humbolt Sink region of northeastern Nevada. Their distribution is discontinuous throughout this range. Wydoski and Whitney (2003) noted that Paiute sculpin had not been reported in the Columbia Basin above the Wenatchee River. In the Columbia River they were collected in the Hanford Reach (Gray and Dauble 1977a) and near Rock Island Dam (Mongillo and Hallock 1995). In the Walla Walla Basin, they occur in the Touchet River, in the North, South, Wolf, Robinson forks of the Touchet, Coppei Creek; and Mill Creek (Lonzarich 1993; Mongillo and Hallock 1995; Mendel et al. 1999). In the Yakima Basin, Paiute sculpin occurred in the Yakima mainstem between Rkm 69–305 (Patten et al. 1970; Mongillo and Hallock 1995), and in the Naches River and several tributaries (Mongillo and Mallock 1995). Paiute sculpin were collected in Crab Creek, Grant Co., (USNM 00104625) and in the Wenatchee River in 1932 (Wydoski and Whitney 2003).

In the Snake River Basin, Washington, Paiute sculpin occurred in the mainstem reservoirs above Ice Harbor, Lower Monumental, and Little Goose dams (Bennett et al. 1983), and in the North and South forks of Asotin Creek (Lonzarich 1993; Mongillo and Hallock 1995), and Grande Ronde River drainage (Lonzarich 1993).
SLIMY SCULPIN
*Cottus cognatus* (Richardson, 1836)

**Primary Identification**
1. Two median chin pores.
2. Dorsal fins separated to base or nearly so. If joined, connection is less than one fifth the height of first ray of second dorsal fin.
3. Palatine teeth absent.
4. Lateral line incomplete; terminates under second dorsal fin.
5. Body prickles usually absent.

**Confirming Characters**
1. Caudal peduncle relatively wide, width greater than interorbital width.
2. Three pelvic fin rays. If four rays are present, the innermost is less than \( \frac{2}{3} \) the length of the other rays.
3. One large preopercular spine directed upward and posteriorly, 1–2 smaller spines directed downward.
4. Anal fin base is noticeably shorter than length of second dorsal fin base.

**Similar Species**
1. Similar to margined sculpin; both usually have three pelvic fin rays. All other species have four pelvic fin rays. Margined sculpin usually have one chin pore (94%) whereas slimy sculpin usually have two.

**Etymology**

*cognatus*: (G.) related. (Refers to its similarity to the European species *Cottus gobio*).

**Common Name(s)**
Slimy sculpin (AFS name), Miller’s thumb, muddler minnow, slimy muddler, stargazer, Bear Lake bullhead, cockatouch (a commercial name for slimy sculpin used as a bait fish).
Distribution

The slimy sculpin has a wide distribution across most of Canada from the United States boundary to the Arctic Ocean and the entire state of Alaska. It occurs in the upper Columbia River Basin in northern Idaho, Montana, Washington, and British Columbia. In Washington, distribution of the slimy sculpin is restricted to the northeastern corner of the state. Slimy sculpin have been collected in Crab Creek (Scholz 2002), Lake Chelan (UW 018501; UW 020451; Mongillo and Hallock 1995; Wydoski and Whitney 2003), Okanogan River (UW 020209 by J.D. McPhail on 10 June 1964), Spokane River below Little Falls Dam (Scholz 2002), Little Spokane River drainage in Buck Creek (Scholz 2001; McLellan 2002), Bear Creek (McLellan 2002), Griffin Springs Creek (Bailey and Dimick 1949), Diamond Lake, Sacheen Lake, Horseshoe Lake (Mongillo and Hallock 1995), Sherman Creek, a tributary of the Columbia that enters Lake Roosevelt near Kettle Falls (Scholz 2001), Kettle River (UW 019953 by J.D. McPhail 1 October 1991), Pend Oreille River in Boundary (Peden 1987; McLellan 2001), and Box Canyon (Geist et al. 2004) reservoirs and Sullivan Lake in Pend Oreille Co. (Nine 2005). Slimy sculpin is the only sculpin species we have observed in the Pend Oreille River. One anomalous record of slimy sculpin distribution was reported at Snoqualmie Falls (Gilbert and Evermann 1894). This is the only record of slimy sculpin from the western slopes of the Cascade Range.
SHORTHEAD SCULPIN
*Cottus confusus* (Bailey and Bond, 1963)

![Shorthead sculpin, Yakima River, Yakima Co., WA.](image)

**Figure 17.9**  Shorthead sculpin, Yakima River, Yakima Co., WA.

**Primary Identification**
1. Two median chin pores.
2. Dorsal fins separated to base or nearly so. If joined, the connection is less than $\frac{1}{5}$ the height of first ray of second dorsal fin.
3. Palatine teeth absent or weakly developed.
4. Lateral line variable, usually incomplete, but many specimens have complete lateral line.
5. Small patch of prickles usually present under or behind dorsal fin in specimens from Washington but reduced (absent) in specimens from Montana and British Columbia.
6. Head short and compact ($\leq 22\%$ of total length).

**Confirming Characteristics**
1. Caudal peduncle relatively wide, width greater than interorbital width.
2. Pelvic fin with four rays.
3. Two or three weakly developed preopercular spines.

**Similar Species**
1. Other sculpins. Shorthead sculpin have shorter heads (head $\leq 22\%$ of TL) compared to prickly, Paiute, slimy, and margined sculpin (heads $\geq 22-25 \%$ of TL) or torrent and mottled sculpin (heads $\geq 26\%$ of TL). Palatine teeth strongly developed in prickly, mottled, and torrent sculpin; absent in Paiute, slimy, and margined sculpin; and present (but weakly developed) in shorthead sculpin.

**Etymology**
*Cottus*: (G.) *Cott, -us*. A kind of fish. An ancient European name for freshwater sculpin.

*confusus*: (L.) Clouded, refers to irregular and indistinct body pigmentation.

**Common Name(s)**
Shorthead sculpin (AFS name).
Figure 17.10  Shorthead sculpin distribution in eastern Washington.

Distribution

The shorthead sculpin is distributed in parts of Washington, Oregon, Idaho, Montana, and British Columbia almost exclusively in the Columbia River and Puget Sound drainages. In eastern Washington, the shorthead sculpin is rare in the mainstem of the Columbia River and more common in tributaries entering the Columbia along the eastern slopes of the Cascade range. It has been collected in the Columbia River at Rock Island Dam (UW 015880). It occurs between RKM 69 and 305 in the Yakima River, its tributaries and in Rimrock, Cle Elum, Kachess, and Keechelus Lakes (UMMZ 180653; Bailey and Dimick 1963; Patten et al. 1970; Mongillo and Hallock 1995). Shorthead sculpin found at in the Wenatchee River Basin at Icicle Creek (UW 020560), Nason Creek (UMMZ 180353 and UMMZ 98636-37), White River (OSU 1289), Little Wenatchee River, Chiwawa Creek and Lake Wenatchee (Bailey and Bond 1963; Mongillo and Hallock 1995). Shorthead sculpin occurred at three locations in the Entiat River, Lake Chelan, and four locations in the Methow River Basin, including the Methow, Twisp, and Chewak rivers, and Robinson Creek (Bailey and Bond 1963; Mongillo and Hallock 1995; Wydoski and Whitney 2003). We have collected specimens in tributaries that enter Lake Roosevelt. Specimens were also collected in the Kettle River (Peden 1987) and Latah (Hangman) Creek, a tributary of the Spokane River (Peden 1987; RBCM 986-00219-2). One specimen was collected in the Tucannon River, Snake River Basin, near Margeno in southeastern Washington (UW 017770).
MARGINED SCULPIN

*Cottus marginatus* (Bean, 1881)

**Figure 17.11**  Margined sculpin, Robinson Fork Touchet River, Columbia Co., WA.

**Primary Identification**

1. One median chin pore. Lonzarich (1993) reported that 94% of 300 specimens had one and 6% had two.
2. Dorsal fins connected. Posterior membrane of anterior fin joined to first ray of second dorsal fin greater than $\frac{1}{5}$ of its height.
3. Palatine teeth absent.
4. Lateral line incomplete, terminates under the second dorsal fin.
5. Prickles often present in a patch under or behind the pectoral fins.

**Confirming Characters**

1. Pelvic fin usually with three rays (in about 75% of specimens). If four rays are present, the innermost is less than $\frac{2}{3}$ the length of the other rays.
2. Anal fin base slightly shorter than base of second dorsal fin.

**Similar Species**

1. Both prickly and margined sculpin have one median chin pore and connected dorsal fins. Prickly sculpin have palatine teeth and a complete lateral line that extends to the base of the caudal peduncle.
2. Most margined and Paiute sculpin usually have three pelvic fin rays, whereas all the other sculpins in eastern Washington usually have four. Paiute sculpin has two median chin pores.

**Etymology**

*Cottus*: (G.) *Cott, -us*. A kind of fish. An ancient European name for freshwater sculpin.

*marginatus*: (L.) *marg, in -atus*. A border or edge. Refers to the first dorsal fin being dark (darker than the body) with a distinct white margin.

**Common Name(s)**

Margined sculpin (AFS name).
Distribution

The margined sculpin is endemic to two tributaries of the Columbia River (Umatilla and Walla Walla River drainages) and one tributary of the lower Snake River (Tucannon River drainage) in the Blue Mountains of southeastern Washington and northeastern Oregon. Mongillo and Hallock (1995, 1998) collected native non-game fishes at over 1,000 different locations in Washington, but did not find margined sculpin other than in these drainages. Lonzarich (1993, 1996) specifically looked for margined sculpin in two nearby drainages (Asotin Creek and Grande Ronde River) but did not find any.

In the Walla Walla Basin, Washington and Oregon, margined sculpin were collected in the Walla Walla mainstem (Lonzarich 1993, 1996; Mongillo and Hallock 1998), and in the North, South, Wolf, and Robinson Forks of the Touchet River, Coppei Creek, Dry, Garrison, Mill, Cayuse, Cottonwood, and Yellowhawk creeks (Gilbert and Evermann 1894; Michaelis 1972; Knecht 1976; Pearman 1977; Lonzarich 1993, 1996; Mongillo and Hallock 1998; Mendle et al. 1999). In the Tucannon Basin, margined sculpin were collected in the mainstem and tributaries (D.W. Kelly and Associates 1982). Mainstem locations included sites 8 km below Margeno, Washington (UW 022716, UW 017808), at Margeno (UW 017769), and at Tucannon hatchery (UW 022737, UW 022738). Tributary locations included Little Tucannon River (UW 022700, UW 022710, UW 022772) and Panjab Creek (UW 022774) (Lonzarich 1993).
TORRENT SCULPIN

*Cottus rhotheus* (Smith, 1882)

**Figure 17.13**  Torrent sculpin, Spokane River, Spokane Co., WA.

**Primary Identification**

1. Two median chin pores.

2. Dorsal fins separated to base or nearly so. If joined, the connection is less than $\frac{1}{5}$ the height of first ray of second dorsal fin.

3. Palatine teeth strongly developed, usually in contact with vomer.

4. Lateral line complete. Large head, broad and flattened (length of head ≥ 26% of total length), wide mouth. Entire body usually covered with prickles.

**Confirming Characters**

1. Caudal peduncle narrow, less than interorbital width (i.e., distance between eyes).

2. Pelvic fin with four rays. Black splotch at posterior base of 1st dorsal fin.

3. One spine at angle of preopercle, directed upward and backward. Usually two blunt spines below and one spine directed forward at inferior angle of opercle.


**Similar Species**

1. Mottled sculpin. Palatine teeth contact the vomer in torrent sculpin, but don’t in mottled sculpin.

2. Other sculpins have shorter heads in proportion to total length: ≤ 22% in shorthead sculpin and 23–25% in Paiute, slimy, prickly, and margined sculpin.

**Etymology**

*Cottus*: (G.) *Cott, -us*. A kind of fish. An ancient European name for freshwater sculpin.

*rhotheus*: (L.) A rushing river or torrent.

**Common Name(s)**

Torrent sculpin (AFS name), bullhead (Schultz 1936). The common name torrent sculpin reflects its original capture location below the falls at Spokane, Washington.
Figure 17.14  Torrent sculpin distribution in eastern Washington.

Distribution

The torrent sculpin occurs in the Columbia River Basin of British Columbia, Idaho, Oregon, Montana, and Washington, the upper Fraser River Basin, British Columbia, and along the Pacific Coast and Puget Sound west of the Cascade Mountains from Tillamook, Oregon to near Arlington, Washington in the Columbia Basin. They occur in the mainstem in the Hanford Reach (Gray and Dauble 1977b, 1977c; Mongillo and Hallock 1995), at Rock Island Dam and at the mouths of most tributaries entering Lake Roosevelt above Grand Coulee Dam. Torrent sculpin occur in the Yakima, Entiat, Methow, Wenatchee, Okanogan, Similkamen, Sanpoil, Spokane, Colville, Kettle, Palouse, and Walla Walla drainages. Torrent sculpin are abundant in the Spokane River Basin, in Washington and Idaho, above and below Spokane Falls.

In the Little Spokane River, torrent sculpin were collected at Dartford (Gilbert and Evermann 1895; Schultz and Delacy 1935/1936 ~ UW 002388, UMMZ 98671; UW002391) and at Chatteroy and Elk, (R.M. Bailey 20 July 1955 UMMZ 179442). They occurred in Dragoon, West Branch Dragoon and Dry creeks and in the West Branch Little Spokane River near Horseshoe Lake (McLellan 2002, 2003). Torrent sculpin occurred in the Touchet River near Waitsburg (Mongillo and Hallock 1995). Mendel et al. (1999) found torrent sculpin in the lower and upper reaches of the Walla Walla River, and the middle and upper reaches of the Touchet River.
Chapter 18
Centrarchidae: Sunfishes

The Centrarchidae are a family of eight genera and 32 species indigenous only to North America. Of these, seven genera and 31 species were originally distributed east of the Continental Divide throughout the eastern and midwestern United States and southern Canada along the international border. They inhabit warm lakes, ponds, reservoirs, backwater sloughs, and sluggish rivers. These species include several popular sportfishes including black bass (genus *Micropterus*), sunfishes (genus *Lepomis*), and crappies (genus *Pomoxis*). Because of their popularity with anglers they have been widely introduced in the western states and throughout the world. Declines in native species have frequently followed their establishment in novel waters both in North America and around the world (Moyle and Cech 2004). One notable example was the near disappearance of the only native species of Centrarchid, the Sacramento perch *Archoplities interruptus*, that occurred naturally west of the Rocky Mountains. The Sacramento perch disappeared over much of its native range in California’s Central Valley following the introduction of various species of Centrarchids from the eastern United States (Moyle 1976a).

Several species, including green sunfish *Lepomis cyanellus*, pumpkinseed *L. gibbosus*, warmouth *L. gulosus*, bluegill *L. macrochirus*, smallmouth bass *Micropterus dolomieui*, largemouth bass *M. salmoides*, white crappie *Pomoxis annularis*, and black crappie *P. nigromaculatus*, were introduced at a limited number of locations in eastern Washington by the USFC between 1890 and 1895. After they became established at the initial sites of introduction, some of their progeny were seined out and disbursed to additional waters through the efforts of county game commissions or private individuals. Warmouth did not become established by these introductions, but the remaining species did. From about 1910–1922, millions of smallmouth bass, largemouth bass, and black crappie raised in WDFW or county fish commission hatcheries were distributed at many locations throughout eastern Washington. For example, in 1921 and 1922, a total of 217,500 smallmouth bass, 644,100 largemouth bass, 200,932 crappie, and 5,200 sunfish (genus *Lepomis*) raised at WDFW hatcheries were stocked in Washington lakes (Dibble and Kinney 1923).

Centrarchids are “advanced” (derived) fishes with two dorsal fins (spiny and soft-rayed), pectoral fins in the lateral position, pelvic fins in the thoracic position (lying underneath and slightly behind the pectorals), and physoclist swim bladder. They superficially resemble the other advanced fishes that occur in North America. Besides the centrarchids only two of these families occur in eastern Washington (Percidae and Cottidae).

Centrarchids are distinguished from percids by their dorsal fins and number of dorsal and anal spines. Centrarchids have two dorsal fins that are slightly or broadly united (Figure 18.1A). In many species, the last ray of the spiny dorsal and first ray of the soft dorsal fin are so broadly joined that they appear as a single fin. Centrarchids have 7–11 dorsal spines and 3–7 (usually three or six) anal spines. In contrast, percids have two dorsal fins that are separated by a notch or gap (Figure 18.1B). They have 12–16 (usually 14) dorsal spines and 1–2 anal spines. Sculpins have two dorsal fins, but are easily distinguished by their large pectoral fins and their eyes which lie close together on top of their head.

Three genera of Centrarchids became established in eastern Washington. *Lepomis* is characterized by having: 1) spiny and soft-rayed dorsal fins broadly united (appear as single fin), 2) an anal fin base that is approximately half the length of the dorsal fin base, i.e., about the same length as soft-rayed portion of the dorsal fin, 3) three anal spines, and 4) the posterior of operculum terminates in an earlike flap. *Micropterus* is characterized by having:
Figure 18.1  Comparison of Centrarchidae and Percidae. Note that dorsal fins are joined in A) Centrarchidae and separated by a notch in B) Percidae.

1) spiny and soft-rayed dorsal fins slightly united (appear as two fins), 2) an anal fin base that is less than half the length of the dorsal fin base (often shorter than the soft dorsal base), and 3) three anal spines. *Pomoxis* is characterized by having: 1) spiny and soft-rayed fins broadly united (appear as single fin), 2) an anal fin base that is approximately the same length as the dorsal fin base, and 3) six to seven anal spines.

Species of *Lepomis* overlap in most meristic characters. Green sunfish and warmouth have a larger mouth gape than either pumpkinseed or bluegill. The maxillaries of green sunfish and warmouth extend to the midpoint of the eye. In contrast, the maxillaries of pumpkinseed and bluegill don’t extend to the front of the eye. The posterior edge of the operculum in all four species terminates in an ear-like flap with a distinctive blue or black spot. Pumpkinseed have an orange, red, yellow, or white spot posterior to the blue or black spot, which the other three species lack.

Species of *Micropterus* are distinguished by the length of the maxillary bone. In smallmouth bass, the maxillary extends to the middle of the eye, whereas in largemouth bass, it extends beyond the posterior edge of the eye. Largemouth also have a distinct black stripe along the lateral line, especially in juvenile specimens.

Species of *Pomoxis* are distinguished by the number of spiny rays in the dorsal fin. White crappie have 5–6, whereas black crappie have 7–8. The base of the anal fin is noticeably longer than the base of the dorsal fin in white crappie, but about the same length as the base of the dorsal fin in black crappie.

Reproductive habits of all species of Centrarchidae are remarkably uniform. Reproductive behavior of the green sunfish, pumpkinseed, bluegill, smallmouth bass, largemouth bass, white crappie, black crappie and other species in the family were described by Breder (1936) and Breder and Rosen (1966). All species are iteroparous.
In general, members of this family are temperature sensitive spawners that move inshore in late spring or early summer to spawn in warm, shallow waters (0.1–0.6 m deep) near the shoreline. Spawning occurs when both daylength and temperature are elevated above certain critical levels. For example, the critical photoperiod for both male and female green sunfish was 10–15 hours and the critical temperature was 10–15°C for males and 15–20°C for females (Kaya and Hasler 1972; Kaya 1973).

Males construct “nests,” in gravel, sand, or mud bottoms by fanning the substrate to create a saucer or oval shaped depression about 150–1000 mm in diameter. Nests are often constructed in areas with aquatic macrophytes and the depression exposes rootlets. Nest diameter and water depth at which the nest is constructed vary dependent upon species and size of individual males. Some species nest in colonies while others are more solitary.

Centrarchids display elaborate courtship and mating rituals, often involving a circular “dance,” butting and nipping. The spawning partners then assume stereotyped spawning positions with the male upright and the female at a 45° angle, with their ventral openings close together. Eggs are demersal and adhesive.

Males aggressively defend nests and guard their offspring until the fry become free-swimming. Eggs usually hatch within a few (1–5) days and larvae remain in the nest for an additional 3–14 days before completing their development. Male centrarchids guard their nest during day and night (Hinch and Collins 1991; Popiel et al. 1996). The nest guarding activities of male centrarchids is critical to survival of their offspring. When guarding male smallmouth bass or largemouth bass were removed from their nest, survival of eggs or larvae to young-of-the-year fry stage was zero (Kramer and Smith 1962; Neves 1975).

Centrarchids nest in shallow water, so wind-generated water turbulence can cause significant nest destruction and is an important factor regulating year class strength (Goff 1985, 1986; Popiel et al. 1996). Overwinter survival during the first year of life is a major regulator of year class strength in both smallmouth and largemouth bass. Bass must attain a critical size by the end of their first growing season to gain sufficient energy reserves to survive the winter season (Aggus and Elliot 1975; Shuter et al. 1980). In eastern Washington and northern Idaho, the critical size for largemouth bass appears to be about 50–75 mm (Bennett and Bowles 1985; Bennett and Hatch 1991; Ashe and Scholz 1992).

Relatively low water temperatures in many water bodies in eastern Washington reduce the length of the growing season and contributes to the inability of young-of-the-year bass to achieve the critical size needed to survive the first winter. For example, in Box Canyon Reservoir, Pend Oreille River, water temperatures were above 15°C, the minimum temperature required for positive growth of bass fry, for only four months (early June–late September) (Ashe and Scholz 1992).

Maximum lifespan of green sunfish is 7–9 years, but most do not live past age 6. Sexual maturity usually occurs at age 2–3 year. Maximum size attained by green sunfish in the United States was 305 mm and 964 g (the United States angling record from Missouri). In Washington, the state angling record taken from Bailey Lake, Spokane Co. in 1994, measured 254 mm and weighed 357 g. Female greenfish produced about 15,000 to 50,000 eggs (Carlander 1977).

Maximum lifespan of pumpkinseed is about 9–10 years, but in eastern Washington pumpkinseed attained this age in only 3 of 43 water bodies where age has been determined. In most of these lakes pumpkinseed attained maximum ages of 5–7. Sexual maturity occurs in both sexes at age 2–3. Maximum size attained by pumpkinseed in the United States was 329 mm and 482 g (Carlander 1977). Maximum total length of pumpkinseed in 43 eastern Washington lakes (n = 1,706 pumpkinseed examined) was 285 mm.
Fecundity of female pumpkinseed ranged from about 600 to 3,000 eggs (Carlander 1977; Wydoski and Whitney 2003).

Maximum lifespan of bluegill is 9–11 years, but fish of this age were found in only 3 of 29 lakes, reservoirs, and ponds in eastern Washington where bluegill ages were determined. In most of these lakes the oldest bluegill were age 5–7. Bluegills usually become sexually mature at age 2–3 (males) or 3–4 (females). The largest bluegill reported in the United States measured 384 mm TL and the heaviest weighed 2.15 kg (Carlander 1977). The largest bluegill caught by an angler in Washington, in Tampico Pond (Yakima Co.) measured 305 mm TL and weighed 1.06 kg, but fish this large are rare. The largest bluegill found during fish surveys in 29 lakes in eastern Washington was 335 mm. Fecundity of female bluegill ranged from about 2,000–81,000 eggs. Males spawn with more than one female throughout the spawning season, so their nests often contain several broods of eggs. As many as 68,815 to 224,900 fry have been collected from one nest (Scott and Crossman 1973; Wydoski and Whitney 1979, 2003).

Maximum life expectancy of smallmouth bass is about 15 years, but they rarely live past age 8–10. A smallmouth in its 14th year was collected during a fish survey at Little Goose Reservoir (Bennett et al. 1983), which was the maximum age recorded from 31 water bodies in eastern Washington where smallmouth bass have been aged. In four other lakes, smallmouth lived up to 11 years, but in most the maximum age ranged from 8–10. Smallmouth bass become sexually mature at age 3–4 or total length of about 190–240 mm. The maximum size of smallmouth bass collected during fish surveys of 31 lakes in eastern Washington was 680 mm from Banks Lake (Grant Co.). Palmer Lake (Okanogan Co.) produced a smallmouth bass 590 mm in total length. The Washington state angling record for smallmouth bass (629 mm TL and 4.0 kg) was taken in 1966 from the Hanford Reach of the Columbia River (Yakima Co.). Female smallmouth bass produce about 15,400 eggs/kg (7,000 eggs/lb) of body weight (Scott and Crossman 1973), and fecundity typically ranges from about 2,000 to 20,825 eggs/female (Scott and Crossman 1973; Carlander 1977; Wydoski and Whitney 2003).

Maximum age of largemouth bass in 73 water bodies in eastern Washington was 18 years, but only five waters contained individuals over 13 years old. At most locations (n = 45) they lived a maximum of ten years. Largemouth bass usually become sexually mature at age 3 or 4 or at a total length of about 200–220 mm. The Washington state angling record for largemouth bass was a 584 mm, 5.25 kg specimen harvested in 1977 at Banks Lake. The maximum size of largemouth bass collected during fisheries surveys in 73 water bodies in eastern Washington was 566 mm (Eloika Lake, Spokane Co.). Other water bodies with big largemouth bass included: Palmer Lake (Okanogan Co.) 565 mm, Whitestone Lake (Okanogan Co.) 562 mm, Long Lake (Spokane Co.) 550 mm, Red Rock Lake (Grant Co.) 545 mm, Bonnie Lake (Spokane Co.) 541 mm, Potholes Reservoir (Grant Co.) 536 mm, and Newman Lake (Spokane Co.) 528 mm. Fecundity ranged from 2,000–109,314 eggs/female depending upon her size and body weight.

When guarding their nests, male smallmouth and largemouth bass strike at anything that comes near it. Their aggressive defense of their nests make them vulnerable to angling (Suski 2004). Of 214 smallmouth bass that were guarding a nest, 149 (70%) struck at a lure that was cast of their direction within six casts (including 43% hooked on the first cast). Of 90 largemouth bass that were guarding a nest, 45 (50%) struck at the lure within the first six casts (including 34% hooked on the first cast).

Nest abandonment after capture and release of nesting male smallmouth and largemouth bass has been documented (Ridgway and Friesen 1992; Ridgway and Shuter 1997). In one study, about 6% of smallmouth bass nests were naturally abandoned by males (Philipp
et al. 1997). In contrast, when males were caught and released by an angler near the nest, nest abandonment increased dramatically. Playing the fish for 2, 5, and 10 minutes resulted in 24%, 53%, and 93% nest abandonment respectively (Phillip et al. 1997). During the interval the fish were being played, handled, and released, SCUBA divers watched the nest. When males were absent for 2, 5, or 10 minutes respectively 49%, 72%, and 92% of the undefended nests were attacked by predators and some of the eggs were removed (Philipp et al. 1997).

Mortality of adult largemouth bass caught and released by anglers during bass tournaments was reported to be as high as 98% (May 1973; Pelzman 1978; Gustaveson et al. 1991). Capture and handling stress altered their osmoregulatory physiology to a point that caused mortality. Owing to these discoveries, most bass tournaments are now held at times when bass are not defending nest sites. Additionally, strict guidelines, such as required use of aerated livewells for transportation of fish to weighing sites, and adding electrolytes are usually followed by tournament organizers.

Maximum lifespan of white crappie is 9 years, but in eastern Washington few live past 7. Sexual maturity is attained at age 2–4 or a total length of about 147–201 mm. The largest white crappie recorded in Washington was a 401 mm, 1.27 kg specimen caught in the Columbia River (Walla Walla Co.). Fecundity ranged from 970–213,000 eggs in females 147–330 mm TL (Wydoski and Whitney 2003).

Black crappie live 8–10 years. In 50 eastern Washington lakes 8 year old fish were found in ten, 9 year old fish were found in 12 and 10 year old fish were found in three. In the majority of populations, the oldest fish were aged at 5 or 6 years. Black crappie attain sexual maturity at age 2-4 or sizes of 175-225 mm. The largest black crappie caught by an angler in Washington weighed 2 kg and measured 432 mm. The fish was taken in Seattle’s Lake Washington (King Co.). The largest black crappie observed in 50 eastern Washington Lakes measured 406 mm (from Little Goose Reservoir on the Snake River). Black crappie in excess of 350 mm were found in only six lakes. Minimum and maximum egg counts were 11,000–188,000 eggs/female (Wydoski and Whitney 2003).

The diet of all three species of Lepomis (green sunfish, pumpkinseed, bluegill) consists of zooplankton, aquatic insects, fish larvae, and other invertebrates. Each species has morphological adaptations in their feeding apparatus that allow them to effectively partition, rather than compete for, resources where they occur in sympatry. For example, green sunfish have a larger mouth gape than either pumpkinseed or bluegill and can eat larger prey. Consequently, they tend to eat fish larvae, fish fry, and small crayfish more frequently than either pumpkinseed or bluegill. Green sunfish also have long, slender gill rakers that enable them to effectively filter large bodied zooplankton. Chironomid larvae and snails were the dominant item in the diet of pumpkinseed from several locations in eastern Washington, including Pend Oreille River (Skillingstad 1993), Deer and Loon lakes, Stevens Co., (Scholz et al. 1988) and Moses Lake, Grant Co. (Burgess 2003).

Adult pumpkinseed tend to forage in vegetated littoral zones where snails adhere to macrophytic vegetation. Snails are often a significant component of their diet. Juvenile pumpkinseed usually do not eat snails because their pharyngeal jaw apparatus is too weakly developed to crush snails until they attain a total length of about 75 mm (Wainwright et al. 1991). Adult pumpkinseed have specializations that enable them to crush snails. These include: 1) enlarged muscles and bones of the pharyngeal jaw apparatus that generates a powerful bite and 2) motor neurons that generate a pattern of action potentials that result in prolonged muscle contractions conducive to crushing snails (Lauder 1983, Mittelbach 1984; Wainwright and Lauder 1986, 1992; Osenberg et al. 1988; Wainwright 1986). Beside snails, chironomids (midges), and larvae usually figure
predominantly in pumpkinseed diets. Pumpkinseed have short, stubby gill rakers which are poorly adapted for filtering zooplankton.

Bluegill lack the specialized morphological and physiological adaptations for crushing snails and instead must swallow them whole. Consequently, they rarely eat snails, and instead feed primarily on zooplankton in the limnetic zone. Bluegill have long, slender gill rakers that form a ‘filter basket’ that traps large zooplankton. They are the zooplankton specialist among *Lepomis*. Adult bluegill are most often found in the open waters of the limnetic zone where large zooplankton are abundant. Bluegill search for moving prey such as *Daphnia* in the limnetic zone while stopped (hovering). Often they feed along the edge of weed beds because moving prey are detected more easily when swimming against a background (Janssen 1982). They pick off their prey one at a time. Bluegill are size selective predators on cladoceran zooplankton, such as *Daphnia* spp. and *Bosmina longirostris* (Werner and Hall 1974; O’Brien et al. 1976; O’Brien 1979; Bartell 1982). When zooplankton abundance was low, bluegill were not very picky and consumed a range of sizes, but as zooplankton abundance increased, they became more selective and consumed primarily large-sized individuals. Bluegill in eastern Washington lakes also consumed chironomid larvae, amphipods, segmented worms, leeches, water mites, tiny crayfish, calanoid and cyclopoid copepods, beetles, mosquito larvae, craneflies, mayflies, water boatmen, and damselflies.

Larval smallmouth bass eat zooplankton, predominantly water fleas (Cladocera: *Daphnidae*). Juveniles eat aquatic insects, larval fishes, and tiny crayfish. Adults continue to eat insects, but gradually shift their diet so that fish and crayfish become more prevalent. Wydoski and Whitney (2003) noted that crayfish ranked particularly high in the diet of smallmouth bass in Washington.

Crayfish was the most important item in the diets of smallmouth bass collected in Little Goose (*n* = 484), Lower Granite (*n* = 54) and Lower Monumental (*n* = 18) reservoirs, accounting respectively for about 60%, 43%, and 47% of the diet in those reservoirs. This was followed by fish, cladocerans, and aquatic insects (Bennett et al. 1983). In Ice Harbor Reservoir, fish was the dominant food (59%), followed by crayfish (37%) (Bennett et al. 1983).

Largemouth bass fry (< 80 mm TL) subsisted on zooplankton, primarily large cladocerans such as *Daphnia*, and aquatic insects. Juveniles, 80–100 mm TL, typically resided in littoral habitats and consume mainly invertebrates. At about 80 mm, they began to eat fish, and by 150 mm, their primary food was fish. Intermediate-sized bass, 250–300 mm TL, usually occupy open water habitats, frequently occurred in aggregations and preyed on fish. Big largemouth bass, > 380 mm TL, were usually solitary ambush predations hiding near submerged structures such as stumps, pilings, large woody debris, or vegetation at the edge of the littoral zone. They also hid in macrophyte cover next to leads through dense macrophyte beds. Adult largemouth bass eat fish, crayfish, tadpoles, frogs, and a variety of invertebrates.

Habitat shifts were apparently related to allometric growth. Intermediate-sized largemouth bass were fusiform, whereas larger bass added more weight than length, which made them bulky. The fusiform shape allowed intermediate-sized bass to efficiently chase down prey in open water. The larger, bulkier bass must expend more energy to move in open water, so they have adopted the tactic of hiding and waiting for prey to swim by them before making a burst attack. Often, they are more cryptically colored than intermediate-sized bass in open water because their dark lateral stripes deepens in color and becomes more blotchy which helps them to blend in better with vegetation. The lateral stripe is usually not so pronounced in intermediate-sized largemouth that dwell in open water.
The feeding mechanisms of white and black crappie are uniform. Both species have long, finely spaced gill rakers, 25–29 on first gill arch, ideal for straining small-bodied zooplankton and chironomid larvae. This may give black crappie an advantage over other centrarchids which have 8–12 gill rakers on their first arch (Keast 1968). Crappie also have a rather large, protrusible mouths for ingesting large prey such as larval and juvenile fishes or large aquatic insects larvae (Keast 1968; Mathur and Robbins 1971; Mathur 1972). Thus, they feed on zooplankton, many types of small planktivorous fishes, and many types of aquatic insects. Until they attain a size of about 160 mm, black and white crappie eat zooplankton and chironomid larvae almost exclusively. At 160 mm, they begin to eat fish and aquatic invertebrates.

Black crappie occupy the littoral zone by day where but exhibit diel migrations to forage in the limnetic zone at dusk and dawn. Their crepuscular migration to open water at these times brings them into contact with zooplankton and dipteran larvae that are migrating vertically from the bottom of the lake up to the surface to graze on phytoplankton in the euphotic zone. The zooplankton and chironomid larvae spend the day in dark bottom waters presumably to reduce encounters with visual predators.

Centrarchids are warmwater species that can tolerate temperature as high as 36°C for several days. Their optimal temperatures that maximizes their scope for growth and activity ranged from about 27°–32°C, which corresponded to their preferred temperature in behavioral tests.

Green sunfish, pumpkinseed, bluegill, black crappie, white crappie, and largemouth bass all prefer habitat in bays of lakes or backwater sloughs along river with submergent/emergent macrophytes and large woody debris. For example, Ashe and Scholz (1992) reported that of 11,683 pumpkinseed captured in the Pend Oreille River, 11,599 of them (99.3%) were captured macrophyte-choked sloughs compared to 83 (.07%) caught in the main channel. Smallmouth bass preferred habitat composed of large cobble, boulder, or rocky talus substrates.

Most species of Centrarchids occupy a summer home range or feeding territory within a lake. Green sunfish returned to the site where they were captured after displacement to a different location (Hasler and Widby 1958; Parker and Hasler 1959).

In their native range (upper Midwest and northeast) smallmouth bass annually migrate between three habitats: spawning grounds, summer home ranges, and overwintering areas. Three distinctive types of homing behavior (Gerking 1953) have been documented in smallmouth bass, associated with their occupation of each of these habitats:

1. Reproductive homing to nest sites. During the spawning season, male smallmouth bass return with great fidelity (76–85%) to within 50 m of the nest site they occupied in previous spawning seasons (Ridgway et al. 1991). DNA “fingerprints” (i.e., nucleotide base sequences of DNA fragments made by cutting DNA with restriction enzymes) of individuals from 15 nests were consistent with the hypothesis that smallmouth bass return repeatedly to the same nest site and, perhaps, to their birthplace to spawn, i.e., natal homing (Gross et al. 1994). The mechanism(s) used by smallmouth bass to relocate the spawning site remain undetermined.

2. Displacement homing to summer home ranges. After spawning, smallmouth bass established summer home ranges that may be near or far away from the nest site (Ridgway et al. 1991). Summer home ranges are usually at locations that provide good foraging opportunities as fish reside there for most of the growing season while temperatures are optimal for growth. The fish make excursions within this home range presumably to search for food. Fajen (1962) documented that smallmouth bass, marked and displaced about 2 km from their home pool in a river, returned to the original pool.
Smallmouth bass in a large lake implanted with ultrasonic transmitters and displaced varying distances up to 14 km away from their summer home range, left the release site and returned to the home range within 1–9 days (Ridgeway and Shutter 1996).

3. Fidelity to overwintering sites. In autumn, smallmouth bass leave their summer home ranges and migrate to overwintering sites (Webster 1954; Langhurst and Schoenike 1990). Apparently, smallmouth bass utilize the same overwinter areas year after year (Webster 1954). One study conducted in the Embarrass and Wolf rivers, Wisconsin showed that smallmouth bass returned from wintering areas to summer ranges previously used. Smallmouth bass captured in a 5 km segment of the Embarrass River and monitored by a combination of conventional tagging (n = 651 marked) and radio-telemetry, remained near their capture site throughout the summer (Langhurst and Schoenike 1990). In the fall, as water temperatures dropped below 16°C, they migrated 109 km downstream to overwinter in the Wolf River. In April and May of the following year, most individuals returned to the same 5 km segment of the Embarrass River where they were originally marked.

Largemouth bass behavior is similar to that of smallmouth bass with respect to repeat spawning at previously utilized spawning sites and establishment of summer home ranges in their native lakes.

Largemouth bass homed back to the same spawning site that they had used the previous year. In Box Canyon Reservoir, Pend Oreille River 10 largemouth bass captured in 7 sloughs during the spawning season: Tiger Slough (RKM 72, west bank), Gardiner Slough (RKM 100, west bank), Campbell Slough (RKM 100.5, east bank), Dike Slough (RKM 109) and Ashenfelder Bay (RKM 145 west bank), Pow Wow Slough (RKM 112, east bank) Indian Island Slough (RKM 130, west bank), were surgically implanted with either radio or ultrasonic transmitter (Ashe and Scholz 1992). The transmitters in ten of these (one each from Gardiner and Indian Island sloughs and two each from Campbell, Dike, Pow Wow, and Ashenfelder sloughs) continued broadcasting until the subsequent spawning season. After spawning, each of these ten fish migrated out of their slough and into the main channel of the Pend Oreille River. Throughout the following year they remained in the main channel of the Pend Oreille River at varying distances ranging from 0.8–26 km away from the slough where they had spawned and established summer home ranges. During the subsequent spawning season eight of these fish returned to spawn in the same slough where they were originally captured. One fish tagged in the Pow Wow Slough (RKM 112, east bank) was recaptured in Cusick Slough which is located at RKM 112 on the west bank across from Pow Wow Slough. The last fish originally caught in Dike Slough (RKM 109, east bank) spawned in Pow Wow Slough (RKM 112, east bank) the following year. Thus it appeared that largemouth bass exhibited fidelity to previously used spawning areas.

In eastern Washington, waterbodies where smallmouth bass and largemouth bass occur together, usually one species predominates. Because smallmouth and largemouth bass exhibit such a high degree of overlap in their diets of both juvenile (= 90%) and adult (= 89%) life stages (Willms et al. 1989), when both species are added simultaneously to a water body, one of the two eventually outcompetes the other and becomes the dominant species.

Smallmouth bass tend to outperform largemouth bass in lakes and reservoirs with rocky shoreline habitat that drops off quickly into deep water. Largemouth bass tend to outperform smallmouth bass in shallow lakes and reservoirs surrounded by marshy sloughs or embayments with mud or silt bottoms. Smallmouth bass appear more adaptable to swift current conditions than largemouth bass, which prefer sluggish water. Smallmouth bass also seem to better tolerate fluctuating reservoir elevations better than largemouth bass, but largemouth seem to tolerate macrophytes better than smallmouth bass.
KEY TO FAMILY CENTRARCHIDAE

General Family Characters

Confirm these characters before keying to species.

1. Two dorsal fins (1st spiny, 2nd soft) united (may be almost separated or broadly joined). This character is used to distinguish genera within the family.

2. Pectoral fin insertion is vertical rather than horizontal.

3. Pelvic fins in thoracic position (below and slightly behind pectoral fins).

4. All fins (except caudal) contain some spines.

5. Anal fin with three or more spiny rays.

Key to the Species of the Centrarchidae of Eastern Washington

1. A. Anal fin smaller than spiny plus soft dorsal fins. Origin of anal fin distinctly posterior to origin of spiny dorsal fin, at about point where spiny and soft dorsal fins are united. Dorsal spines 9–11. Anal spines three.  
   

2. A. Spiny and soft-rayed dorsal fins broadly joined (appear as single fin). Operculum with ear-like flap, tip colored black or blue (Genus Lepomis).

   B. Spiny and soft-rayed dorsal fins slightly joined appear almost divided into two distinctive fins. Operculum without ear-like flap, tip not colored blue. (Genus Micropterus).

Go to 4

B. Opercular flap flexible. Mouth slightly oblique with small gape. Maxillary bone does not extend to eye.

4. A. Operculum with red, orange, yellow or white spot at edge of flap.  

Pumpkinseed  
*Lepomis gibbosus*  
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B. Operculum without red, orange, yellow or white spot at edge of flap. Instead black or blue tip extends to edge of flap (usually red or orange).


Smallmouth bass  
*Micropterus dolomieu*  
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B. Maxillary bone extends past the posterior edge of the eye. Horizontal black stripe below lateral line extends from front of eye to caudal peduncle. Green and black colors predominate.


White crappie  
*Pomoxis annularis*  
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B. Dorsal spines 7–8. Base of anal fin about equal in length to base of spiny plus soft dorsal fin.  

Black crappie  
*Pomoxis nigromaculatus*  
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Chapter 18

GREEN SUNFISH

*Lepomis cyanellus* (Rafinesque, 1819)

Figure 18.2  Green sunfish, Horseshoe Lake, Pend Oreille Co., WA.

**Primary Identification**

1. Two dorsal fins united (like one fin). Anal fin shorter than base of dorsal fin.
2. Height of spiny dorsal fin shorter than height of soft dorsal fin. Length of spiny dorsal base about equal to length of soft dorsal base.
3. Maxillary bone extends to midpoint of eye, terminal mouth with large gape.
4. Operculum with stiff ear-like flap with blue-black splotch on flap.

**Confirming Characters**

2. Pectoral fins, short and rounded.

**Similar Species**

1. Warmouth have tiny teeth on the front of the tongue.
2. Pumpkinseed/bluegill have slightly oblique mouths (maxillary does not extend to front of eye).
3. Largemouth/smallmouth bass dorsal fins are almost divided into two fins.
4. White crappie/black crappie have more anal spines (6–7).

**Etymology**


cyanellus: (G.) *cyan* = blue. (L.) *ellus* = small. Small blue fish.

**Common Name(s)**

Green sunfish (AFS name)
Figure 18.3  Green sunfish distribution in eastern Washington.

Distribution

The native distribution of green sunfish included most of the eastern and central United States, from the Appalachian Mountains to the Great Plains. Green sunfish were first introduced into eastern Washington by the USFC in 1890 and 1891 (Smith 1896; Doane 1902a 1902b; Chapman 1941; Lampman 1946). They were introduced, in mixed lots along with bluegill and possibly pumpkinseed, under the title “sunfish” to Sprague Lake (Adams and Lincoln Cos.) and Loon and Deer lakes (Stevens Co.). WDFW also reared “sunfishes” (species not identified) in state hatcheries from 1908 and 1922 and stocked them at unspecified locations throughout the state. Green sunfish were apparently distributed to a limited number of lakes (or, if they were widely distributed, they didn’t become established at most locations) because naturally reproducing populations of this species now occur in only a few lakes.

At the present time, distribution of green sunfish in Washington appears to be confined to northeastern counties (Pend Oreille and Spokane) where they have been collected during recent surveys by WDFW personnel. They occur in Diamond (Phillips and Divens 2000b), Fan (Nielsen 1975; Jackson 1990; Divens et al. 2002a), Horseshoe (Mongillo 1995; McLellan et al. 2005), Sacheen (Divens et al. 2002b), and Trout lakes (Pend Oreille Co.) (Mongillo 1993) in the West Branch Little Spokane River Drainage. Green sunfish was also found in Deer (Divens 2002; McLellan et al. 2006) and Pierre (Osborne and Divens 2004) lakes, Stevens Co. and in Eloika Lake (Spokane Co. (Zook 1978; Divens et al. 2001).
PUMPKINSEED

*Lepomis gibbosus* (Linnaeus, 1758)

**Figure 18.4** Pumpkinseed, Rock Lake, Whitman Co., WA.

**Primary Identification**

1. Two dorsal fins united (like one fin). Base of anal fin shorter than base of dorsal fin.
2. Height of spiny dorsal fin about equal to height of soft dorsal fin. Length of spiny dorsal base greater than the length of soft dorsal base.
4. Operculum with flexible ear-like flap, with orange or red spot at posterior edge.

**Confirming Characters**

2. Vaguely worm-like bluish-white markings often present on head and operculum.

**Similar Species**

1. Bluegill/green sunfish lack orange or red spot at posterior end of opercular.
2. Largemouth/smallmouth bass have dorsal fins almost divided into two fins.
3. White crappie/black crappie have more anal spines (6–7)

**Etyomology**


*gibbosus*: (L.) *gibb* = humped. Refers to humped shape.

**Common Name(s)**

Pumpkinseed (AFS name), common sunfish, bream.
Figure 18.5 Pumpkinseed distribution in eastern Washington.

Distribution

Native distribution of pumpkinseed was the United States and Southern Canada between the Atlantic Ocean and the prairies. In Washington and Oregon there is no record of introduction of pumpkinseed. In its official records of fish distribution, the USFC acknowledged only bluegill and green sunfish as species stocked under the name “sunfish.” Nevertheless, pumpkinseed may have been included in these shipments. The WDFW reared “sunfishes” (species not identified) in state hatcheries from 1908–1922 and stocked them at unspecified locations.

Pumpkinseed had become established in numerous lowland lakes on both sides of the Cascades in Washington and Oregon (Chapman 1941). They accounted for 0.8% of the sport fish observed in creel checks made by the WDFW in 1938 and 1939 (Chapman 1941). The species was particularly abundant in Kahlotus Lake (Franklin Co.) where they grew to 0.7 kg (1.5 lbs). During the late 1930’s and early 1940’s, the Kahlotus Lake pumpkinseed fishery was one of the most popular in the state. On weekends and holidays, automobiles and pickup trucks, parked bumper to bumper, lined State Highway 260 for miles adjacent to the lake. Kahlotus Lake is now dry, owing to a combination of several successive years of drought between 1985 and 1992 and overpumping of the aquifer that supplies it to irrigate surrounding croplands. It never refilled after the drought. Pumpkinseed is now widely distributed throughout eastern Washington. It is the most common sunfish in the state.
BLUEGILL

*Lepomis macrochirus* (Rafinesque, 1819)

![Figure 18.6 Bluegill, Rock Lake, Whitman Co., WA.](image)

**Primary Identification**

1. Two dorsal fins united (like one fin). Base of anal fin shorter than base of dorsal fin.
2. Height of spiny dorsal fin about equal to height of soft dorsal fin. Length of spiny dorsal fin base about equal to length of soft dorsal fin base.
4. Operculum with flexible, ear-like flap with blue-black splotch on flap.

**Confirming Characters**

2. Pectoral fins long and pointed.

**Similar Species**

1. Green sunfish have 18–19 gill rakers; pumpkinseed have 12.
2. Largemouth/smallmouth bass have dorsal fins almost divided into two fins.
3. White crappie and black crappie have more anal spines (6–7).

**Etymology**


*macrochirus*: (G.) *macro-* = large, *-chirus* = hand. Refers to shape.

**Common Name(s)**

Bluegill (AFS name), bluegill sunfish, bream, roach.
Figure 18.7  Bluegill distribution in Eastern Washington.

Distribution

The native range of bluegill was centered in the eastern and central United States, from the Canadian border south to the Gulf of Mexico, from the Appalachian Mountains west to the Great Plains. Bluegill were first introduced in eastern Washington together with green sunfish from 1890 to 1892 at Deer and Loon Lakes (Stevens Co.) and Sprague Lake (Adams and Lincoln Cos.) (Smith 1896; Chapman 1942; Lampman 1946). The WDFW and county fish commissions also reared "sunfishes" (species not identified) in state and county hatcheries from about 1908 to 1922 and stocked them at numerous locations in Washington, but did not keep detailed records about their distribution. In 1936 and 1937, the WDFW transplanted bluegill from Moses Lake (Grant Co.) to Wapato Lake (Chelan Co.) (Foster et al. 1997).

In recent years, the WDFW Warmwater Fish Program has reared bluegill at the Columbia Basin hatchery in Ephrata, or transplanted bluegill from lakes where they are established, and stocked them into several lakes in eastern Washington: Sprague Lake (Adams/Lincoln Cos.), Columbia Park Pond (Benton Co.), Kahlotus Lake (Franklin Co.), and Alkali, Ancient, Hutchinson-Shiner, Lower Goose, Moses, and Stan Coffin lakes (Grant Co.).

At present, bluegill have been documented from many locations in eastern Washington and are established at many of them.
SMALLMOUTH BASS
Micropterus dolomieu (Lacepede, 1802)

Figure 18.8  Smallmouth bass, Little Goose Reservoir (Snake River), Columbia/Garfield/Whitman Cos., WA.

**Primary Identification**
1. Two dorsal fins, slightly united, appear as two fins.
2. Height of spiny dorsal about equal to height of soft dorsal. Length of spiny dorsal about equal to length of soft dorsal.
3. Maxillary bone extends to midpoint of eye; mouth terminal with large gape.
4. Operculum with bony pointed edge (no ear-like flap).

**Confirming Characters**
1. Eye usually red or orange; 3–5 brown bars slanted back and down from eyes. Color: brown, green, and yellow predominate.
2. First dorsal fin with ten spiny rays. Anal fin with three spiny and 10–12 soft rays.
3. Pectoral fins, posterior edge rounded.
4. Fusiform body with slight lateral compression.

**Similar Species**
1. Largemouth bass maxillary bone extends beyond the posterior edge of eye.
2. Green sunfish, pumpkinseed, warmouth, and bluegill have spiny and soft dorsal fins broadly united (appear as a single fin).
3. White crappie/black crappie have more anal spines (6–7).

**Etymology**
*Micropterus*: (L.) *Micro-* = short, and *opterus* = fin.

dolomieu: Named in honor of geologist M. Dolomieu, who also had a rock (dolomite) named after him.

**Common Name(s)**
Smallmouth bass (AFS name), smallmouth black bass.
Smallmouth bass were native to the eastern and central United States, from the Atlantic Seaboard to the Great Plains, from the Canadian border to about 32°N latitude. Smallmouth and largemouth bass (called black bass) were introduced to Washington by the USFC commencing in the 1890s. In the 1980s WDFW began to plant smallmouth bass into many lakes and reservoirs in eastern Washington (Fletcher 1986), where they intentionally tried to create smallmouth bass fisheries. WDFW captured a few adult fish from an area where they were established and transplanted them to a different site. As an example, in 1992, 156 smallmouth bass, caught by members of local bass clubs who assisted WDFW, were transferred from Lower Monumental Reservoir on the Snake River to Long Lake Reservoir (Peck 1993; Peck and Vail 1994). In 1993, an additional 250 fish were planted. In 1995, 144 smallmouth bass were caught in the Columbia River at Lake Roosevelt and transplanted into Long Lake (Duff et al. 1996, 1997). These smallmouth bass were the first documented in Long Lake. In 2001, smallmouth bass ranked fourth in abundance of species captured (399 or 6.9% of 5,791 total fish caught) during electrofishing, gillnet and fyke net surveys conducted by WDFW in Long Lake (Osborne et al. 2003c).

Numerous illegal introductions have also occurred. At present, smallmouth bass are particularly abundant throughout the Columbia River and Snake River mainstems, and in the Yakima, Sanpoil, Spokane, and Pend Oreille rivers (Zimmerman and Parker 1995).
LARGEMOUTH BASS
*Micropterus salmoides* (Lacepede, 1802)

**Figure 18.10** Largemouth bass, Medical Lake, Spokane Co., WA.

**Primary Identification**
1. Two dorsal fins, slightly united, appear as two fins.
2. Height of spiny dorsal about equal to height of soft dorsal; length of spiny dorsal about equal to length of soft dorsal.
3. Maxillary bone extends beyond posterior edge of eye. Mouth terminal with large gape.
4. Operculum with bony, pointed, or rounded edge (no flexible ear-like flap).

**Confirming Characters**
1. Wide dark lateral band running along lateral line usually present. Color: green and black predominate.
2. Dorsal fin with ten spiny rays. Anal fin with three spiny and 10–12 soft rays.
3. Pectoral fins, posterior edge rounded.
4. Fusiform body with slight lateral compression.

**Similar Species**
1. Smallmouth bass maxillary bone extends only to center of eye.
2. Green sunfish, pumpkinseed, warmouth, and bluegill have spiny and soft-rayed dorsal fins broadly united (appear as a single fin).
3. White crappie/black crappie have more anal spines (6–7).

**Etymology**
*salmoides*: (L.) *salmo* = salmon or trout-like.

**Common Name(s)**
Largemouth bass (AFS name), black bass.
Figure 18.11  Largemouth bass distribution in eastern Washington.

Distribution
Largemouth bass were originally distributed in the eastern and central United States, from the Canadian border to the Gulf of Mexico, from the Atlantic seaboard to the Great Plains (Scott and Crossman 1973; Lee et al. 1980). Largemouth bass were widely transplanted around the world (MacCrimmon and Robins 1975). Originally native to 25 states, it now occurs in 49 (Fuller et al. 1999). The first documented plants in Washington occurred in 1890 when the USFC stocked 1,220 in Loon Lake (Stevens Co.), Sprague Lake (Adams/Lincoln Co.), and Lake Washington (King Co.) (Smith 1896). The USFC stocked largemouth at Liberty (Spokane Co.) and Loon lakes (Stevens Co.) in 1891; at Clear, Silver, and Liberty lakes (Spokane Co.), and Deer and Loon lakes (Stevens Co.) in 1892 (Smith 1896). From 1908 to 1922, the WDFW and county fish commissions raised largemouth bass at state or county fish hatcheries and stocked tens to hundreds of thousands annually in lakes and ponds throughout the state. Additionally numerous illegal introductions of largemouth bass have been made by anglers desirous of spiny-ray angling opportunities in eastern Washington lakes. At present, largemouth bass are well established throughout eastern Washington. In 1936 and 1937, largemouth bass were transplanted from Moses Lake (Grant Co.) to Wapato Lake (Chelan Co.) (Foster et al. 1997). In subsequent years, WDFW transplanted largemouth bass from lakes that were rehabilitated with rotenone to a different lake (Nielsen 1976; Duff et al. 1978; Foster et al. 1997)
WHITE CRAPPIE
*Pomoxis annularis* (Rafinesque, 1818)

Figure 18.12 White crappie, Lower Granite Reservoir (Snake River), Asotin/Garfield/Whitman Cos., WA.

**Primary Identification**
1. Two dorsal fins united (like one fin). Base of anal fin longer than base of dorsal fin.
2. Height and length of spiny dorsal fin less than height and length of soft dorsal fin.
3. Maxillary bone extends past middle of eye (to posterior edge of pupil).
4. Mouth terminal, slightly oblique, gape extends to posterior nostril.
5. Body thin and distinctly laterally compressed.

**Confirming Characters**
2. Operculum with pointed posterior edge.
3. Head and sides with light pigmentation, few irregular shaped black blotches.

**Similar Species**
1. Black crappie have 7–8 dorsal spines. Irregular black blotches on head and sides.
2. Green sunfish, pumpkinseed, warmouth, bluegill, smallmouth bass, and largemouth bass have three anal spines.

**Etymology**
*Pomoxis*: (L.) Sharp cover. The posterior end of the operculum is pointed instead of being rounded or terminating in an ear-like flap.

*annularis*: (L.) Annular mark. Refers to a series of faint half-circular bars along the side of the body.

**Common Name(s)**
White crappie (AFS name), crappie, crappy.
Figure 18.13  White crappie distribution in eastern Washington.

**Distribution**

White crappie were originally distributed in the eastern and central United States, from the Canadian border to the Gulf of Mexico, from the Atlantic Coast to the Great Plains. Mixed lots of black and white crappie were introduced to eastern Washington in 1891 and 1892 (Smith 1896), when the USFC planted 50 in Liberty Lake (Spokane Co.), 220 in Loon Lake (Stevens Co.), 25 in Deer Lake (Stevens Co.), and 18 in Shepard Lake (Spokane Co.). White crappie were introduced (Smith 1896) but apparently they did not survive as well as the black crappie because the latter species currently resides in these lakes, whereas the former does not.

WDFW planted white crappie in Cow (Adams Co.) and Sprague lakes (Adams/Lincoln Cos.) in the late 1970s, but these failed to become established. In May 1997, 853 adult white crappie collected in the Snake River were transplanted into Moses Lake (Foster et al. 1997), but none were seen in a sample of 5,136 fish collected by electrofishing and netting in 1998–1999 (Burgess 2000). In general, the white crappie has a less robust distribution in the waters of eastern Washington than black crappie. This is probably due to the fact that black crappie thrive in cool waters, whereas white crappie does not. White crappie, at present, are established at only a few locations in eastern Washington, primarily in the Snake River reservoirs and Columbia River reservoirs below the confluence of the Snake River (Bennett et al. 1983). Small numbers occur elsewhere mainly because of recent stocking.
BLACK CRAPPIE

Pomoxis nigromaculatus (Lesueur, 1892)

Figure 18.14  Black crappie, Sprague Lake, Adams/Lincoln Cos., WA.

Primary Identification

1. Two dorsal fins united (like one fin). Base of anal fin about the same size or slightly longer than base of dorsal fin.
2. Length and height of spiny dorsal fin less than length and height of soft dorsal fin.
3. Maxillary bone extends past middle of eye (to posterior edge of pupil). Mouth terminal, oblique, gape extends to posterior nostril.
4. Body thin and distinctly laterally compressed.

Confirming Characters

2. Operculum with pointed posterior edge.
3. Head and sides with irregular mosaic of black blotches on silvery background.

Similar Species

1. White crappie have 5–6 dorsal spines, head and sides with light pigmentation.
2. Green sunfish, pumpkinseed, warmouth, bluegill, smallmouth bass, and largemouth bass have three anal spines.

Etymology

Pomoxis: (L.) Sharp cover. (Posterior end of the operculum is pointed).

nigromaculatus: (L.) nigro- = black, (L.) -maculatus = spotted.

Common Name(s)

Black crappie (AFS name), calico bass, strawberry bass.
Family Centrarchidae

Black crappie distribution in eastern Washington.

Distribution

Black crappie originally occurred in the eastern and central United States, from the Canadian border to the Gulf of Mexico, from the Atlantic coast to the Great Plains. Crappie were introduced to eastern Washington in 1891 and 1892 when the USFC stocked 220 black and white crappie into Loon Lake, 25 into Deer Lake (Stevens Co.), 18 into Shepard Lake (Spokane Co.), and 50 into Liberty Lake (Spokane Co.) (Smith 1896). Black crappie were widely distributed across eastern Washington by the WDFW and/or county fish commissions from 1908 to 1922. For example, in 1921/1922, the WDFW distributed 200,932 “crappies” raised at state or county hatcheries into the Washington waters (Dibble and Kinney 1923). In 1936 and 1937, the WDFW transferred black crappies from Moses Lake (Grant Co.) to Wapato Lake (Chelan Co.) (Foster et al. 1997).

Since 1996, WDFW has stocked black crappie in Hutchinson and Shiner Lakes (Adams Co.), Columbia Park Pond and I-82 Pond 2 (Benton Co.), Roses Lake (Chelan Co.), Alkali, Lower Goose, Moses and Stan Coffin lakes and Potholes Reservoir (Grant Co.), and Palmer and Whitestone lakes and Washburn Island Ponds (Okanogan Co.). One of the premier black crappie waters in the state of Washington is Sprague Lake (Adams/Lincoln Cos.). Black crappie apparently colonized Sprague Lake after it was rehabilitated by WDFW in 1985 by emigrating downstream from Fishtrap Lake (Lincoln/Spokane Cos.).
Chapter 19

Family Percidae: Perch

The Family Percidae belongs to the Order Perciformes which contains 149 families, 1,367 genera and 9,200 of the 23,250 known species of fishes, making the Perciformes the largest order of vertebrates (Nelson 1994; Moyle and Cech 2004). Members of this order form the core of the “advanced” (derived) fishes. They are distinguished from the more primitive (ancestral) fishes by the presence of two dorsal fins, the first composed of spiny rays, the second primarily of soft rays (although a few of the anterior most rays of the second fin may also be spiny). Additionally, the anal, pectoral, and pelvic fins contain spines. The pelvic fins are in the thoracic position (advanced condition) rather than in the abdominal position (primitive condition). The pectoral fins are positioned on the sides of the body (lateral position) with a vertical insertion (advanced condition) rather than on the belly (ventral position) with horizontal insertion (primitive condition). The swim bladder is physoclist (advanced condition without pneumatic duct) instead of physostome (primitive condition with pneumatic duct connecting the swim bladder to the esophagus). Beyond these similarities, members of this order are morphologically diverse and probably represent several evolutionary lines. Two families of perciforme fishes predominate in freshwaters of eastern Washington: the Percidae (yellow perch and walleye) and Centrarchidae (sunfishes and basses).

In North America, the Family Percidae is represented by six genera and 142 species (Nelson et al. 2003), but none were historically present west of the Rocky Mountains. The family is characterized by a notch (space) between the spiny and soft-rayed dorsal fins (Figure 18.1). Two species, the yellow perch *Perca flavescens* and walleye *Sander vitreus*, were introduced to eastern Washington. Yellow perch are characterized by the absence of canine teeth in the jaws, prominent anal spine(s), and 6–8 anal fin rays. Walleye are characterized by the presence of canine teeth, weak anal spine(s), and 11–14 anal fin rays. Both species inhabit large rivers, reservoirs and lakes. They have large mouths and are piscivorous.

Yellow perch and walleye are important commercial and sport fishes, so the natural history of both species has received extensive scrutiny. Ney (1978) published a systematic review of walleye and yellow perch and Colby et al. (1979) reviewed the biological data on walleye. Addison and Ryder (1970) and Ebbers et al. (1988) published annotated bibliographies containing 3,116 references on walleye and Craig (1987) published a book on the biology of perch.

Yellow perch have a maximum lifespan of 9–11 years. They usually become sexually mature at age of 2–3 and are iteroparous. Maximum length attained in Washington is about 375 mm (Wydoski and Whitney 2003). Fecundity ranged from 20,000–109,00 eggs/female.

In eastern Washington, yellow perch spawn from about 1 April–1 May at water temperatures of 4–12°C. Yellow perch move into shallow vegetated bays of lakes or sloughs of rivers, and spawn around submerged brush. Eggs are laid in a gelatinous tube with accordion-like folds. Eggs are embedded in the gelatin. Females extrude a portion of the egg tube and swim through brush until it becomes attached to a submerged branch. They then swim away, pulling or tugging, until the egg tube is extruded. One or more males weave in and out around the egg tube releasing milt. Water circulates through a central canal in the egg tube to oxygenate eggs.

Maximum lifespan of walleye is 24 years but few fish live past age 10–13. Walleye became sexually mature at ages 2–3 (males) and 3–4 (females). Carlander (1997) summarized the age and growth of 69,898 walleye collected by fisheries scientists throughout the United States and Canada. The oldest fish in the sample was 24 years old, but few fish lived past age
10. Only 967 fish (1.8%) were age 10–13 and 159 (0.2%) were age 14–24. The longest fish was a 16 year old that measured 947 mm TL. The heaviest fish was a 19 year old that weighed 9.64 kg. Walleye fecundity in John Day Reservoir (Columbia River) averaged (ranged) 83,000 (5,600–123,000) in females 520–764 mm TL and 1.72–5.91 kg (Maule and Horton 1985). Twenty-one females collected in Moses Lake averaged 84,394 eggs/female (Foster et al. 1997).

Yellow perch eat cladoceran zooplankton, especially *Daphnia* spp., chironomid (midge) larvae, mayfly larvae, a variety aquatic insects, ostracods, molluscs (snails and fingernail clams), small crayfish, and many kinds of small fish (Carlander 1997). Yellow perch became increasingly piscivorous as they aged (Carlander 1997). Yellow perch ate minnows, suckers, salmonids, sculpins, centrarchids, and cannibalized other yellow perch.

Walleye eat predominately zooplankton (cladocerans and copepods). However, walleye become piscivorous immediately after hatching, so it is not unusual for larval fishes to comprise 10–40% of the diet of larval walleye. Larval catostomids, cyprinids, yellow perch and walleye are commonly found in the stomachs of larval walleye. Larval walleye are naturally cannibalsitic; so much so that they have proven difficult to raise in captivity. Walleye eggs were successfully incubated and hatched in our lab, but the larvae began to devour each other as soon as their yolk sacs were absorbed. Walleye remain cannibalsitic through their juvenile life stages, but adult walleye are less so (Carlander 1997).

Fish are the predominant food of adult walleye. Fish reported in walleye diets in Washington included: speckled dace, chiselmouth, northern pikeminnow, redside shiner, carp, suckers, Chinook salmon, coho salmon, sockeye/kokanee salmon, rainbow and cutthroat trout, whitefish, shad, burbot, sandroller, smallmouth bass, largemouth bass, pumpkinseed, bluegill, black crappie, stickleback, sculpins, and walleye (reviewed by Scholz and McLellan 2009). Adult walleye also eat aquatic insects and crayfish.

Bioenergetics modeling has also been used to determine the impact of walleye predation on kokanee and rainbow trout in Lake Roosevelt (Baldwin et al. 2003). The objective of this study was to determine the number of kokanee and rainbow trout released from Sherman Creek hatchery that were consumed by walleye. In 1999, a population of 16,610 walleyes consumed 54,073 kokanee or about 15% of 360,487 kokanee released from the Sherman Creek hatchery within 41 days of release (Baldwin et al. 2003). In 2000, a population of 12,223 walleye consumed 34,076 kokanee, or about 9.4% of 362,521 kokanee, and 4,839 rainbow trout, or about 7.3% of 66,288 rainbow trout, released from the Sherman Creek hatchery within 41 days of release (Baldwin et al. 2003).

After Grand Coulee Reservoir filled, native Cyprinid fishes (northern pikeminnow, pumpeaumouth, redside shiner) were the dominant members of the Lake Roosevelt fish community, constituting about 70% of the relative abundance between 1949 and 1963 (Gangmark and Fulton 1949; Earnest et al. 1966). After walleye were introduced the relative abundance of Cyprinids declined to 4% by 1988–1989 (Beckman et al. 1985; Peone et al. 1990). As the cyprinids declined, walleye switched to preying predominately upon yellow perch, suckers, sculpins and salmonids. From 1997 to 2001, we examined 10,612 adult kokanee collected in Lake Roosevelt. Of these 1,689 (16%) had characteristic walleye bite marks i.e., multiple slashes on the belly that ripped through the skin deep into the muscle layer and occasionally penetrated into the body cavity. Walleye also preyed on salmon smolts in Lower Columbia reservoirs (Zimmerman 1999).

Yellow perch prefer temperatures of 21–26.5°C. They are capable of anaerobic respiration for extended periods at low temperatures. They can tolerate a wide range of pH. These traits enable yellow perch to occupy small naturally acidic bog lakes of the upper Midwest and
naturally alkaline pothole lakes of the northern Great Plains, Canadian Prairie provinces and eastern Washington scablands. These lakes are often pond size (i.e., shallow) with very warm summer temperatures. After ice forms in winter, oxygen is unable to diffuse into the lake across the air-water interface and is not replenished until the ice cover breaks up in spring. Organisms and organic decay gradually deplete the oxygen over the course of the winter. Because these lakes are typically shallow, they have a low volume, so it is not usual for them to become devoid of oxygen before the ice cover melts, which results in the death of many members of the fish community. This condition is termed “winter kill.” Because yellow perch are tolerant of low dissolved oxygen and capable of anaerobic respiration, they can survive in winter kill lakes.

Walleye migrate offshore into deep water during the day and on shore at twilight. Their eyes are silvery and luminous. At night, when a flashlight is shined on them, their eyes appear to glow in the dark. Walleye have a reflective layer of silver guanine crystals behind their retina, called a tapetum lucidum, that functions like a mirror to reflect light back through the retina. The light sensitive rods and cones of the retina are thus activated twice, by the incoming light and reflected light, instead of just once. The visual pigment in the rods and cones are also more sensitive to low light intensity compared to those of other fish (Ali et al. 1977). These adaptations enable walleye to see especially well during twilight, when other species lacking tapetum lucidum have trouble seeing. Hence, walleye are highly effective at locating prey in twilight when their prey can't see them well enough from a distance to take evasive action. In yellow perch, for example, the photoreceptors and visual pigments are suited for daylight (Ali et al. 1977). Both walleye and yellow perch migrate onshore into shoal areas at night which sets up a classic predator-prey interaction between these two species (Ali et al. 1977).

Tagging and radiotracking studies have shown that: (1) walleye generally home back to the same previously used spawning ground during subsequent spawning events, and (2) some walleye migrate to summer feeding areas that may be remote from their spawning sites where they establish rather narrow summer home ranges while others may wander extensively (reviewed by Scholz and McLellan 2009). For example, two walleye tagged on spawning grounds located on the Spokane arm of Lake Roosevelt in May 1981, subsequently travelled upstream 224 km to the tailrace of Hugh Keenlyside Dam in British Columbia where they were recaptured in July and August (Beckman et al. 1985). Also, several walleye tagged on their spawning grounds in the Spokane River were subsequently recovered on the same spawning grounds during the spawning season one or two years later.

The introduction of walleye into the Columbia River Basin is uncertain. One possibility is that walleye migrated downstream from the Clark Fork River, Montana, into Pend Oreille Lake, Idaho in the early 1950’s. Walleye documented in Pend Oreille Lake in 1951 supports this theory (Linder 1963). Pend Oreille Lake is connected to Lake Roosevelt by the Pend Oreille River. A second possibility is that walleye gained access into Banks Lake when it inundated Devil’s Lake where walleye were supposedly stocked in the 1930’s (Lennox 1977; Beamesderfer and Nigro 1989) although we could find no official records of this stocking. In support of this theory, the first walleye documented in Washington was captured in Banks Lake on 6 December 1959 and placed in the UW Fish Collection. However, it is also possible that walleye could have been pumped into Banks Lake from Lake Roosevelt. Pumps lift water out of Lake Roosevelt into Banks Lake to supply irrigation water for the Columbia Basin project. In 1976, the USFWS stocked 250,000 walleye (1.5 in. TL) in Little Falls Reservoir, RKM 45–51 of the Spokane River, immediately upstream from the Spokane Arm of Lake Roosevelt (USFWS plant record dated 17 November 1976 signed by F.L. Halfmoon). It is probable that the stocked walleye were entrained at Little Falls Dam and contributed to the establishment of the spawning population below the dam. Populations became established in Lake Roosevelt by the mid-1960’s. They gradually spread down the Columbia River, establishing populations in the reservoirs between Bonneville and McNary dams during the 1970’s, and in the lower Columbia
River below Bonneville Dam and the Willamette River below Willamette Falls by 1982. Sport fishing for walleye occurs in reservoirs throughout the Columbia mainstem.

KEY TO FAMILY PERCIDAE

General Family Characters

Confirm these characters before keying to species.

1. Two dorsal fins, anterior spiny-rayed, posterior soft-rayed.
2. Dorsal fins well separated by notch or space.
3. Dorsal fins about equal in size or anterior fin slightly larger than posterior fin.
4. Anal fin with one or two spiny rays (spines flexible and sometimes difficult to distinguish from soft ray elements).
5. Pectoral fins inserted on sides, fin base vertical. Pelvic fins in thoracic position (below and slightly behind pectoral fins). Both sets of paired fins about equal in size.
7. Caudal fin forked.
8. Eyes on sides of body (lateral position).

Key to the Species of the Percidae of Eastern Washington

1. A. Canine teeth absent in jaws. Anal fin with 6–8 rays. Yellow perch
   Perca flavescens
   Page 277

   B. Canine teeth present in jaws. Anal fin with 11–14 rays. Walleye
   Sander vitreus
   Page 279

Figure 19.1 A) Photo of a juvenile yellow perch showing canine teeth absent (left) and juvenile walleye showing canine teeth present (right); B) Yellow perch anal fin; C) Walleye anal fin.
YELLOW PERCH

*Perca flavescens* (Mitchill, 1814)

Figure 19.2  Yellow perch, Pend Oreille River, Pend Oreille Co., WA.

**Primary Identification**
1. Two dorsal fins separated by a notch.
2. Anal fin with 6–8 rays.
3. Canine teeth absent.

**Confirming Characters**
1. Six to eight dark vertical bars on sides against a yellow background.
3. Caudal fin with shallow fork.
4. Maxillary extends to middle of eye.

**Similar Species**
1. Walleye have anal fins with 11–14 rays and canine teeth present in jaws.
2. Centrarchidae (bass and sunfishes) dorsal fins are slightly or broadly connected.
3. Cottidae (sculpins) have dorsal fins that are separated or only slightly joined but they have very large fan-like pectoral fins (much bigger than pelvic fins) and their eyes are positioned on top of the head.

**Etymology**

*Perca*: Ancient Greek name for the perch. Derived from *percno* = dusky, in reference the dark and bars on the sides.

*flavescens*: (L.) *flav-* = tawny or reddish yellow, and (L.) *-escens* = becoming.

**Common Name(s)**

Yellow perch (AFS name), perch (ancient common name for Eurasian perch), American perch, lake perch (Great Lakes region), ringed perch (in Idaho, Keil 1928).
Figure 19.3  Yellow perch distribution in eastern Washington.

Distribution

The natural distribution of yellow perch was east of the Continental Divide in the northern United States and Canada. Yellow perch were introduced to eastern Washington in 1890 by the USFS (Smith 1896). From about 1910 to 1922, yellow perch were raised at state and county fish hatcheries and were widely distributed in lakes throughout eastern Washington. For example, in 1921 and 1922, 125,400 yellow perch were distributed into ten lakes by the WDFW (Dibble and Kinney 1923).

By the 1930’s, yellow perch was distributed widely throughout eastern Washington. In 1938 and 1939, yellow perch comprised 22.5% of all fish creeled statewide in angler surveys conducted by the WDFW (Chapman 1942). Some lakes in eastern Washington were described as “tremendously productive.” In Fish Lake, Chelan Co., 2,631 anglers checked by WDFW had harvested 30,610 yellow perch (Chapman 1942). In 1939, 2,768 anglers caught 40,295 yellow perch there (Chapman 1942). WDFW biologists had surveyed only about one third of the anglers, so the total harvest at Fish Lake was probably about 90,000 to 120,000 yellow perch annually.

The WDFW Angler Education Program has issued a pamphlet (report # FM93-9) that lists 127 productive yellow perch waters in 20 eastern Washington counties.
WALLEYE
*Sander vitreus* (Mitchill, 1818)

Figure 19.4  Walleye, Lake Roosevelt, Ferry/Lincoln/Stevens Cos., WA.

**Primary Identification**
1. Two dorsal fins, separated by a notch.
3. Canine teeth present.

**Confirming Characters**
1. Anal and caudal (lower lobe) fins tipped in white. Black spot at posterior base of first dorsal fin.
2. First dorsal fin with 12–16 spiny rays. Second dorsal fin with 1–2 spiny and 18–22 soft rays.
3. Caudal fin distinctly forked.
4. Maxillary extends to posterior edge of eye.

**Similar Species**
1. Yellow perch have 6–8 rays in anal fin and no canine teeth in jaw.
2. Bass and sunfish have two dorsal fins that are slightly or broadly connected.
3. Sculpins have very large, fan-like pectoral fins and eyes positioned on top of head.

**Etymology**
*Sander*: From Zander, an old European (Slavic) vernacular name to describe the pike-perch of eastern Europe and Eurasia.

*vitreus*: (L.) glassy, a reference to the large silvery eyes.

**Common Name(s)**
Walleye (AFS name), pike-perch, pickerel.
Walleye originally occurred east of the Continental Divide from the Gulf Coast to about 60°N latitude, being relatively more abundant in the northern compared to the southern portion of their range. Native walleye populations also occurred in the Peace River and McKenzie River, Northwest Territories and Yukon (Scott and Crossman 1973; Lee et al. 1980). Because of its popularity as a sport fish, walleye have been widely introduced in the United States. Originally native to 23 states, it now occurs in 48 (Fuller et al. 1999).

Walleye occur in Lake Roosevelt and in all of the Columbia River mainstem reservoirs downstream from Grand Coulee Dam. Walleye also occur throughout the Columbia Basin Irrigation Project Area in Banks Lake, Billy Clapp Reservoir, Moses Lake, Potholes Reservoir, and Scooteny Reservoir. Walleye are present in the Snake River in the reservoirs above Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams. Walleye are also present in Sprague Lake (Adams and Lincoln Cos.), Liberty, Clear, and Silver lakes (Spokane Co.), Palmer Lake (Okanogan Co.), and Curlew Lake (Ferry Co.).
Chapter 20
Species with Rare or Uncertain Status

Species described in this chapter have been reported by fisheries scientists in eastern Washington but were not included in our keys or life history accounts because it is uncertain if natural spawning populations have become established. The fishes included: grass carp, white sucker, white catfish, blue catfish, flathead catfish, banded killifish, warmouth, and saugeye.

GRASS CARP

*Ctenopharyngodon idella* (Valenciennes, 1844)
(Cypriniformes: Cyprinidae)

![Grass carp. Inset shows details of pharyngeal teeth. Photographs courtesy of University of Michigan Museum of Zoology, Ann Arbor, Michigan. Used with permission.](image)

**Figure 20.1** Grass carp. Inset shows details of pharyngeal teeth. Photographs courtesy of University of Michigan Museum of Zoology, Ann Arbor, Michigan. Used with permission.

**Identification**

1. Typical cyprinid (minnow) body plan. Distinguished from most cyprinids by its large scales and robust (thick) caudal peduncle.

2. Teeth absent in jaws. Pharyngeal teeth have a distinctive, serrated grinding surfaces. Pharyngeal tooth formula 2,5–4,2.

**Life History/Distribution**

Lifespan 15 years. Maximum length 1,500 mm TL. Maximum weight 36 kg. Grass carp graze readily on pondweed and water milfoil. Bonar et al. (1996) described the efficacy of using triploid (sterile) grass carp for management of aquatic plants, particularly invasive Eurasian water milfoil, in heavily vegetated lakes of Washington State.

Grass carp inhabit large rivers from northern Thailand to the Amur River, China, and Siberia (native range). Grass carp were imported to the United States in 1962 by aquaculture facilities in Alabama and Arkansas (Fuller et al. 1999). Since then triploid (sterile) grass carp have been stocked in 45 states primarily as a biological control agent to crop nuisance aquatic macrophytes (Fuller et al. 1999). Since 1994, triploid grass carp were stocked at about 40 locations in 16 eastern Washington counties.
WHITE SUCKER

*Catostomus commersonii* (Lacépède, 1803)
(Cypriniformes: Catostomidae)

![Figure 20.2](image)

White sucker.

**Identification**

1. Mouth toothless, sub-terminal, overhung by snout. Fleshy lips with papillae. Lower lip cleft into two lobes, 0–1 rows of papillae cross midline.


**Life History/Distribution**

Maximum lifespan, lengths and weight were respectively 17 years, 635 mm (25 in.), and 3.2 kg (7 lb) (McPhail and Lindsey 1970; Scott and Crossman 1973). The natural distribution of white sucker is from about 40°N latitude to 60°N latitude, east of the Continental Divide to the Atlantic Ocean. In British Columbia, they occurred naturally west of the Continental Divide in the Fraser, Skeena, Peace, and Laird river drainages (Scott and Crossman 1973). There are no historical records documenting the presence of white sucker in the Columbia River Basin, British Columbia, Idaho, Montana, Oregon, Washington, or Wyoming (Schultz and DeLacy 1935/1936; Simon 1946, 1951; Carl et al. 1967; Baxter and Simon 1970; Brown 1971; Bond 1973, 1994; Scott and Crossman 1973; Wydoski and Whitney 1979, 2003; Simpson and Wallace 1982; Baxter and Stone 1995).

Two white suckers were recorded in a sample of 559 total fish collected at seven sites in the Little Spokane River, Spokane Co. by Hartung and Meier (1995). Subsequent to this collection, WDFW surveyed 249 sites in the Little Spokane River drainage from 2001 to 2003 (McLellan 2002, 2003, 2004). Among 33,864 total fish collected during these surveys, no white suckers were observed. Our results were consistent with those collected by WDFW, with no white suckers among 1,131 fish sampled at 22 sites in the Little Spokane drainage, including most of the sites sampled by Hartung and Meier (Scholz 2000, 2001, 2002). We infer that white sucker either are not established in the Little Spokane River or that Hartung and Meier’s (1995) specimens were misidentified.
WHITE CATFISH

*Ameiurus catus* (Linnaeus, 1758)
(Siluriformes: Ictaluridae)

Figure 20.3  White catfish.

**Identification**

1. White catfish resemble bullhead except their tail is forked rather than truncated or rounded. The fork is not as deep as those of channel catfish or blue catfish. The shortest caudal rays are about half the length of the longest caudal rays in white catfish compared to less than a fourth the length of the longest caudal ray in channel catfish and one third the length of the longest caudal ray in blue catfish.

2. Posterior edge of pectoral spine serrated with 11–15 saw-toothed teeth (rough to touch).


**Life History/Distribution**

White catfish typically live eight years and grow to 272–404 mm FL and 2–3 kg in weight (Moyle 2003). The Washington State angling record, from the Walla Walla River in 2002, weighed 9.0 kg (19.9 lb) (WDFW 2008). White catfish had a limited native distribution along the Atlantic and Gulf of Mexico coastlines. White catfish were introduced into Silver Lake, Cowlitz River drainage in western Washington in 1888 by the USFC (Smith 1896; Lampman 1946). White catfish have been reported from locations in eastern Washington. One 576 mm TL specimen, in the UW Fish Collection (UW 022279), was caught in Banks Lake near Coulee City, Grant Co. on 27 October 1991. The second was the aforementioned state angling record from the Walla Walla River. We were unable to discover how white catfish came to be at these locations. The species does not appear to be established in eastern Washington.
BLUE CATFISH

*Ictalurus furcatus* (Lesueur, 1840)
(Siluriformes: Ictaluridae)

Figure 20.4 Blue catfish.

**Identification**

1. Dorsal fin positioned near nape. Anal fin long (30–35 rays). Caudal fin distinctly forked, similar to channel and white catfish, but unlike the rounded or truncated posterior margin of the caudal fin of bullheads and flathead catfish.


3. Coloration: Usually slate blue on head and back. Sides tinted blue, fading to white belly in front of anterior insertion (origin) of pelvic fins.

**Life History/Distribution**

The Washington state angling record for blue catfish, caught in the Columbia River, McNary Reservoir (Lake Wallula), Benton Co. in 1975 measured 813 mm TL (32 in.) and weighed 8.0 kg (17.7 lbs). Native to the Gulf Coast and the Mississippi River Basin. Blue catfish (*n* = 1,250) were introduced to Moses Lake, Grant Co., by the U.S. Bureau of Fisheries in 1934 (Groves 1951). This introduction was apparently unsuccessful in establishing naturally reproducing populations because gill net and beach seine sampling at Moses Lake in 1950 failed to capture any blue catfish (Groves 1951). None have been reported in recent surveys of Moses Lake conducted by WDFW (Burgess 2000, 2003a, 2003b, 2003c).

Blue catfish are occasionally reported from reservoirs of the Columbia and Snake rivers, Washington. Blue catfish (*n* = 150) were introduced into the Snake River, Idaho by the USFWS and IDFG in 1945 (Simpson and Wallace 1982). Self-perpetuating populations of blue catfish are present in the Snake River above and below Shoshone Falls, Twin Falls Co., Idaho (IDFG 1990). We suspect that the blue catfish found in the Snake and Columbia rivers, Washington were displaced downstream from locations where they are established in the Snake River, Idaho. There is no indication that they have become established in eastern Washington.
FLATHEAD CATFISH

_Pylodictis olivaris_ (Rafinesque, 1818)
(Siluriformes: Ictaluridae)

Figure 20.5  Flathead catfish.

Identification


2. Posterior margin of caudal fin truncated (square) or rounded in flathead catfish, similar to bullheads. In contrast, the caudal fin is deeply forked in both blue and channel catfish and moderately forked in white catfish.

3. Cardiform plate (with many small teeth arranged in pads) on premaxillary bones U-shaped. In other species cardiform plate on premaxillary bones is oval-shaped.

Life History/Distribution

Maximum lifespan 19–20 years. Maximum length in native range is about 1,400 mm (55.1 in.) and maximum weight is about 60 kg (132 lbs). The Washington state angling record, caught in the Snake River, Walla Walla Co., 1981, weighed 10.2 kg (22.8 lbs). The Idaho record from Brownlee Reservoir, Snake River in 1994 weighed 26.6 kg (58.5 lbs).

The flathead catfish was native to the Mississippi, Ohio, and Missouri river drainages, from the Gulf Coast to Canadian border. Also native to Rio Grande drainage (New Mexico and Texas) and rivers flowing into the Gulf of Mexico between Mobile, Alabama and northeastern Mexico. There is no record of intentional introduction in the Columbia River Basin. Linder (1963), in his review of alien fishes of Idaho, found no record of introduction of flathead catfish, but noted they were first reported from the Snake River in 1956. They later became established in the Snake River (Simpson and Wallace 1982).

In Washington, we found no records of introduction of flathead catfish but their presence was intermittently recorded in the four lower Snake reservoirs (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite reservoirs) and in the Columbia River at its confluence with the Snake River from the mid 1970’s to early 1980’s (Wydoski and Whitney 2003). For example, 2 flathead catfish were among 3,869 total fish sampled in Ice Harbor Reservoir, and none were among 4,702 fish from Lower Monumental Reservoir, 40,598 fish from Little Goose Reservoir or 3,090 fish from Lower Granite Reservoir in 1979–1980 (Bennett et al. 1993). Thus, we found no indication that flathead catfish were established in eastern Washington.
BANDED KILLIFISH

_Fundulus diaphanus_ (Lesueur, 1817)
(Cyprinodontiformes: Fundulidae)

**Figure 20.6** Banded killifish.

**Identification**

1. All paired and median fins rounded. Alternating dark and light vertical bands (13–20 dark bands) along their flanks between the head and base of the caudal fin.

2. Similar in size to minnows, but have teeth in jaws whereas minnow do not.

3. Intermediate between fishes with primitive (ancestral) and advanced (derived) traits; cycloid scales (primitive) and physoclist swim bladder (advanced).

**Life History/Distribution**

Referred to as topminnows because they live in flooded vegetation and frequently are observed feeding on emergent insect pupae. Have the typical adaptations of a fish with a surface feeding life style: oblique (upturned) mouth; large eyes near the top of the head; dorsal and anal fins inserted about \( \frac{2}{3} \) of distance between mouth and caudal fin, which aids in orienting at a 45 degree angle with head up and tail down, enabling them to survey the surface.

Native along the Atlantic Coast from South Carolina to Newfoundland, and in the U.S. states and Canadian provinces bordering the St. Lawrence River/Great Lakes. Also native to the prairies in Missouri and Yellowstone River Basins.

In the Pacific Northwest, banded killifish were first recorded from tributaries of the Willamette River in the mid 1980’s (Farr and Ward 1993). Their sudden appearance was thought to be due to release of aquarium fish. In Washington, banded killifish were first recorded from the Kalama River, Cowlitz Co. in 1989 (Wydoski and Whitney 2003). By 2003, their population had expanded to cover a 234 km reach of the Columbia River from its mouth to Bonneville Dam. They were recently recorded from Lower Granite Reservoir, Snake River, in southeastern Washington, where 331 were collected (Bennett and Seybold 2004).
WARMOUTH

*Lepomis gulosus* (Cuvier, 1829)
(Perciformes: Centrarchidae)

![Figure 20.7  Warmouth.](image)

**Identification**


2. Usually have 3–5 alternating dark and light bands on cheek radiating backward from eye.

3. Numerous tiny teeth present on tip of tongue. Teeth difficult to see but when a probe is used to explore the tip of the tongue, it feels rough (bumpy) to touch.

4. Resemble green sunfish (wide gape, maxillary extends beyond edge of eye). Pumpkinseed and bluegill have small gapes (maxillary does not extend beyond edge of eye).

**Life History/Distribution**

Live a maximum of 9 years, but lifespan is typically 7 or 8 years. The Washington state angling record warmouth, measured 330 mm and weighed 0.24 kg. Native to the Great Lakes region and Mississippi River Basin.

It was first introduced into Washington in 1892, when the USFC planted 29 yearlings in Loon Lake, Stevens Co. (Worth 1895; Smith 1896; Doane 1902a, 1902b; Chapman 1941; Lampman 1946). In eastern Washington, Spence and Earnest (1961) collected one warmouth, 254 mm TL, among 119 fish in a gill net survey at Eloika Lake, Spokane Co. In subsequent surveys of Eloika Lake, no warmouth were collected in 1978 and 2000 (Zook 1978; Divens et al. 2001).

Warmouth were collected in reservoirs on the Snake River between 1979 and 2002 (Bennett et al. 1983; Bennett and Seybold 2004, 2005). In 1979–1980, 13 were collected in Little Goose Reservoir (Bennett et al. 1983). In 1986, two were collected at Lower Granite Reservoir, and in 2002, one was collected there (Bennett and Shrier 1986; Bennett and Seybold 2004).
SAUGEYE

*Sander vitreus* (Mitchill, 1818) × *Sander canadensis* (Griffith and Smith, 1834) (Perciformes: Percidae)

**Figure 20.8** Saugeye.

**Identification**

1. Spiny and soft dorsal fins separated by distinct notch. Anal fin with 2 spines and 12–13 soft rays. Canine teeth present. Cheeks with scales (rough) in saugeye, fewer scales (rough) in sauger and few or no scales (smooth) in walleye.

2. Spiny dorsal fins with 1 or 2 rows of spots along base and dark blotches at base on posterior (intermediate between walleye and sauger).

3. Distinct dark blotches on sides extending below lateral line (similar to sauger).

4. Distinct alternating light and dark bands on soft dorsal and caudal fins (similar to sauger which have the same banding pattern but fainter). White blotch absent at posterior edge of ventral caudal fin in saugeye and sauger; present in walleye.

**Life History/Distribution**

Walleye hybridize with sauger in nature to produce saugeye (Stroud 1948; Nelson 1968b; Becker 1983). The F₁ hybrids and backcrosses between the F₁ offspring with either parent are fertile (Hearn 1986). Natural hybrids occur where walleye and sauger occur in sympatry, but the hybrid is apparently uncommon in nature. Saugeye were stocked in Liberty Lake, as an alternative to walleye because it was originally thought to be a sterile hybrid. Saugeye stocking was curtailed when it was discovered that the hybrid was fertile (C. Donley, WDFW, Spokane, pers. comm.).

Saugeye were stocked at Liberty Lake in 2000 (n = 2,300 fingerlings) and 2001 (n = 630,000 sac fry). A total of 72 saugeye from these fingerling plants were collected by WDFW during annual Fall Walleye Index Netting surveys in Liberty Lake from 2003–2006, but no saugeye from the sac fry plans have been collected to date. No natural reproduction has been documented to date. Walleye and saugeye planted in Liberty Lake were not uniquely marked to identify species, cohorts or hatchery-v-wild fish, so it was not possible to determine if saugeye were established in Liberty Lake or even if all the fish listed above were saugeye (R. Osborne, WDFW, Spokane, WA, pers. comm.).
LITERATURE CITED


Addison, W.D., and R.A. Ryder. 1970. An indexed bibliogra-

phy of North American Zostestes (Pisces, Percidae) spe-


Baldwin, C., H. Woller, and M. Polacek. 2005. Limnetic sur-


00000118-2: 60 pp.

Barlow, G.W. 2000. Investigating the utilization of ben-


Bennett, D.H., and E.C. Shrier. 1986. Effects of sediment dredging and in-water disposal on fishes in Lower Granite Reservoir,
Literature Cited

Bowers, G.M. 1907. The distribution of food fishes during the fis-
cal year 1906. Report of the United States Bureau of Fisheries


Burg, W.L., and S.D. Ferris. 1984. Restriction endonuclease analy-
sis of salmonid mitochondrial DNA. Canadian Journal of Fisheries and Aquatic Sciences 41:1041-1047.

Bennett, D.H., and F.C. Shrier. 1987. Monitoring sediment dredg-

Bennett, D.H., and F.C. Shrier. 1987. Monitoring sediment dredg-

Bond, C.E., and L.E. Bisbee. 1955. Records of the tadpole mad-
tom, Schilbeodes mollis, and the black bullhead, Amieturus me-


Bond, C.E., and L.E. Bisbee. 1955. Records of the tadpole mad-
tom, Schilbeodes mollis, and the black bullhead, Amieturus me-

Bond, C.E. 1904. Preliminary assessment of genetic populat-


Bond, C.E., and L.E. Bisbee. 1955. Records of the tadpole mad-
tom, Schilbeodes mollis, and the black bullhead, Amieturus me-


Literature Cited


Oncorhynchus, Alosa, Gasterosteus – (Rafinesque) from northern Idaho. Brain, 297


Literature Cited


Mueller, R. 2006. Deepwater spawning of fall Chinnook salmon (Oncorhynchus tshawytscha) near Ives and Pierce Island


Literature Cited


DOFV/WDFW 2001a. Joint staff report concerning commercial season for spring Chinook, summer Chinook steelhead, sturgeon, shad, smolt and other species and miscellaneous

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ODFW/WDFW 2002b. Joint staff report concerning the 2002 in-river commercial harvest of Columbia River fall Chinook salmon, summer steelhead, coho salmon, chum salmon and sturgeon. Joint Columbia River Management Staff, Oregon Department of Fish and Wildlife (ODFW)/Washington Department of Fish and Wildlife (WDFW), (ODFW)/Washington Department of Fish and Wildlife (WDFW), Portland, Oregon and Olympia, Washington. 74 pp.


Peden, A.E., and G.W. Hughes. 1988. Sympathy in four species of Rhinichthys (Pisces), including the first documented


Poey, F. 1851-1854. *Memorias sobre la historia natural de la isla de Cuba, acompañadas de sumarios latinos y extractos en revisa*.


Poe, F. 1851-1854. Memorias sobre la historia natural de la isla de Cuba, acompañadas de sumarios latinos y extractos en revisa.


Literature Cited


Washington University Printing Services, Cheney, Washington. (approximately 700 pp.).


Literature Cited


WDFW. 1979. Gill net survey (4-25-79) of Billy Clapp Lake, Grant County, Washington. File data at Washington Department of Fish and Wildlife, Region 2 Office, Ephrata Washington. [Data summary: 5 net sets collected 49 fish, comprised of 3 Kokanee (265-292 mm TL), 1 lake whitefish (390 mm TL), 1 mountain whitefish (280 mm TL), 3 bridgelip sucker (220-247 mm TL), 1 carp (495 mm TL), and 40 yellow perch (101-108 mm TL)].


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Dr. Allan T. Scholz received B.S., M.S., and Ph.D degrees in zoology from the University of Wisconsin in Madison in 1976, 1977 and 1980 respectively. Since 1980 he has been employed as a professor in the Biology Department at Eastern Washington University, Cheney, Washington where he teaches classes in Ichthyology, Fisheries Management, Marine Biology, an Introduction to Biology series for majors, History of Biology, and The Growth of Biological Thought. He is the author (or co-author) of 137 books, publications, and technical reports, most of them about fishes in eastern Washington. He is best known for work on olfactory imprinting and homing in salmon. (Young salmon form a permanent memory to the odor of their homestream, at a time when they experience a surge of thyroid hormone, which serves as a cue to guide the adults back there during their spawning migration). He has been awarded 132 research grants, contracts, and donations of equipment totaling approximately $9.2 million to support his research. Perhaps his most significant accomplishment has been in training fisheries scientists, at least 103 of which have been employed by federal state, and tribal fisheries management agencies, public utility districts, or private consulting firms. Dr. Scholz still maintains professional contacts with most of his former students.

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In addition to this field guide, Dr. Scholz and Ms. McLellan have collaborated in producing a 700+ page *Fishes of the Columbia and Snake River Basins in Eastern Washington* (2009), which provides detailed information about the ecology, behavior, growth, reproduction, food habits and distribution of each species in eastern Washington and a 1,500+ page *Fishes of Eastern Washington: A Natural History* (forthcoming in 2010), which describes the history of fisheries exploration of eastern Washington, the past and current distribution and stock status of each species. It also describes the methods used to collect life history information on fishes and provides a more detailed account of the life history, taxonomy, and nomenclature of each species. It discusses the fossil fishes found in eastern Washington and how distribution of modern fish is related to geological events, including tectonism, ice ages, and the Glacial Lake Missoula flood.