



The American Eel (*Anguilla rostrata*) – An Under-Appreciated Resident and Important Link to the Health of the Delaware River

The Journeys of the American Eel

American eel are the only freshwater eel species in the Western hemisphere. The free-flowing Delaware River - with no dams its entire mainstem length, makes the Delaware River home to the most abundant population of American eel in Pennsylvania and one of the largest populations of eels in the Nation. In fact, American eels are distributed widely throughout the Delaware River Basin -- wherever dam impediments do not stop them from accessing needed habitat. This makes the Delaware River a very important home for these unique fish that in other areas have been vastly diminished or extirpated entirely, often because of dams.



Juvenile American Eels (*Anguilla rostrata*),
Photo by Uwe Kils via Wikimedia Commons.

American eel are the only fish in North America that are catadromous - meaning they are born in salt water and return as adults to spawn in salt water, but travel to freshwater streams as young adults where they mature and spend most of their lives. When ready, the American eel return to the Sargasso Sea to spawn.

American eel are slow to mature and are a long-lived species that spend 8-30 years in estuary and freshwater streams, before they return to the warm waters of the Sargasso Sea¹ to spawn as “silver eels” in the late summer and fall. While females produce millions of eggs, American eel reproduce only once in their lifetime and die after they spawn. Young American eel return to their estuaries in a stage when they are referred to as glass eels – as glass eels they are small and transparent. As they mature, the young eels become elvers; in this stage they are pigmented. As Yellow eels, they can remain in freshwater and brackish water systems for up to 30 years, only then maturing into silver eels at which point they return to the Sea to spawn.

See 12 seconds of an American Eel on you tube:

http://www.youtube.com/v/buRdRjLpE_Y&hl=en_US&feature=player_embedded&version=3

¹ Western North Atlantic Ocean east of the Bahamas and south of Bermuda

The small glass eels journey great distances to undammed freshwaters to live out their lives. In the case of the Delaware River, the journey from the Sargasso Sea is about a thousand mile journey at least (measured using google ruler tool). How the juveniles know which river to go to is still unknown but scientists hypothesize temperature and salinity may be important determining factors. Female eels arriving in the river where they will grow and mature swim far upstream, including to headwater areas. Males stay in the lower reaches in the brackish tidewaters.

American eel can absorb oxygen through their skin as well as their gills, making it possible for them to travel over land, particularly in wet grass or mud, which may help them move around barriers located in streams. While American eel, because of their unique body structure, do have the ability to overcome a variety of barriers that other migratory fish cannot, such as spillways, low dams, falls and rapids, dams have had a big impact and remain a large concern for their survival. This is one reason why the Delaware River boasts the largest population of the American eel, because it is the longest un-dammed river in the United States east of the Mississippi, extending 330 miles from the confluence of its East and West branches at Hancock, N.Y. to the mouth of the Delaware Bay where it meets the Atlantic Ocean.

The Lives and Perils of the Eels

American eel feed on insects, worms, mollusks, crustaceans and other fish. A favorite food for the American Eel is the horseshoe crab. In fact, Eels are often harvested using horseshoe crab as bait – this is some of the bait harvest that has contributed to the steep population decline of the horseshoe crabs of the Delaware Bay.

The American eel supported an intense commercial fishery in the Delaware River until the early 1900s. The eel were caught by specially crafted weirs, designed to trap the adults on their migration toward the sea to spawn. In such contraptions eel were caught in vast numbers. A catch of 50,000 eels weighing more than 44,000 pounds reported in 1912 was deemed to be a low catch year. Today eel are caught mainly by anglers, largely for food or sport.

In 1980 it was reported that 125,000 to 150,000 pounds of American eel were caught every year in the lower Hudson and Delaware rivers. Commercial eelers in Delaware alone reported landing 135,780 pounds of American eel in 2007, a 10% increase from the 123,494 pounds landed in 2006. 2007 landings were the highest since 2004 but 13% less than the 155,516 pounds landed in 2003, the year with the highest eel landings since logbook reporting. American eel are harvested for regional markets, including being targeted for several ethnic groups, and European food markets. American eel do not successfully reproduce in captivity. As a result, the intensive aquaculture industry that exists in eastern Asia is dependent upon an annual supply of wild-caught glass eels and elvers. The glass eels and elvers are shipped live to Asian facilities where they are grown to maturity through aquaculture. In the past, Asia relied upon Asian stocks of eel, but due to overharvesting those stocks became inadequate to support the demand. The next target became the European eel which also declined dramatically. The American eel is now the remaining target.

The life history of the species, such as late age of maturity and a tendency for certain life stages to aggregate, can make this species particularly vulnerable to overharvest. In 2006, the Atlantic States Marine Fisheries Commission (ASMFC) completed a stock assessment for American

“Slippery as an eel” -- more than a figure of speech:

Eels can cover their entire bodies with a mucous layer, making them nearly impossible to capture by hand.

eels, and it was determined that the abundance was at or near record low levels. While American Eel populations are such that the species was considered for federal endangered species status, in 2007 that level of protection was denied the American Eel.

From a biological perspective, much is still unknown about the species. Information about abundance and status at all life stages, as well as habitat requirements, is very limited.

Special Niches of the American Eel Species

The American eel supports one of the largest freshwater mussel populations in the Upper Delaware, the *Elliptio companata*, a mussel which relies on the eel for its successful reproduction. The *Elliptio* can be found in the Upper Delaware because of the presence of the American eel. These mussels have an enormous filtration capacity and are able to filter six times the Delaware's average daily summer flow. With almost 2 million mussels per mile, the clean water benefits we receive from this species, which is dependent upon the American Eel for their survival, are invaluable.

**MUSSELS IN THE UPPER
DELAWARE FILTER 6 TIMES
THE AVERAGE FLOW PER
DAY.**

River Values Report,
Delaware Riverkeeper Network

In all of its life stages, eel serve as an important prey species for many fish, aquatic mammals, and fish-eating birds. Although fisheries are a fraction of what they were historically, eel support valuable commercial, recreational, and subsistence fisheries and are an important part of the ecosystem. Eels, in all stages of their life-cycle, perform a valuable role as an energetic intermediary in the web of life by converting small fish and invertebrates produced lower on the food chain into useful forage for larger fish, birds, and mammals on both sides of the estuary's saltline. Accordingly, the effects of the loss of American eel from aquatic food webs, though not quantified, may be substantial.

Biggest Threats Facing the Species

It is not known how or why American eel go to certain streams for their long maturing period. We do know that over 20 percent of female spawning eels have come from Canadian waters, and those waters are now experiencing a serious crash in numbers of yellow eels. A decline in one area such as this affects the entire population. American eel populations are already in decline and the eels could become scarce and could even disappear if current trends continue.

Barriers to migration, loss and alteration of habitat, predation, overfishing, parasitism and pollution are among the biggest threats for American Eel.

Barriers to Migration and Loss of Habitat:

Habitat can be damaged and/or lost to the American eel as the result of barriers that stand in the way of their successful upstream migration. Barriers can prevent the American eel from reaching the habitat needed for their growth and maturation.

Nearshore habitat destruction can also be an issue for American eel and needs to be considered as river projects move forward.

While the mainstem Delaware River has no dams, a number of important tributaries do,

including the Schuylkill and Lehigh Rivers. Some of the impediments on tributaries are passable, by design or accident, but others are not. Eelers do use the fishways on the Lehigh at the Easton, Chain and Hamilton Street dams. The Cementon Dam on the Lehigh, above Hamilton Street, does not have a fishway and yet some eelers still successfully pass.

There are also dams on the Schuylkill -- some of which have fish passage facilities or are proposed to receive them in the future. But some of the dams in existence on the Schuylkill do seem to pose impediments to eel migration. While some eels pass the dams that are downstream of New Kernsville, it is unclear how many are able to successfully overcome that barrier.

In addition, some adults that have made the trip upstream and have lived long enough to mature are caught and killed in hydropower turbines on dams on their downstream swim to the ocean. A study conducted on the St. Lawrence River found that 40% of the migrating adult eels on their way downstream to their spawning grounds were killed by a series of hydroelectric turbines.

Overall, while eels are able to pass some of our watershed's dams, they are impediments that can prevent or compromise travel and so they are a concern for the American Eel.

Commercial Fishing:

Glass eels fetch a high price on the Asian market, and so this young life phase of American eel has been heavily harvested in the United States during the past 30 years or more. Glass eels are particularly vulnerable to harvest because they aggregate seasonally (February, March, April) in order to migrate. Illegal poaching has been noted to occur in both Delaware and New Jersey.

Pennsylvania and New York have no commercial eel harvest while New Jersey and Delaware both have commercial eel harvests that have a minimum 6 inch limit but an open season that is all year long. Having no seasonal harvest limits can have a large impact on eels. In New Jersey, the majority of eels harvested (90%) were for food while 9.7% were harvested for bait and 0.17% for personal use. In Delaware yellow eels for food-use comprised 79% of total fished, and bait eels comprised the remaining 21% of landings.

The eel harvest industry also affects the horseshoe crabs of the Delaware Bay as horseshoe crabs are used as bait for eel, as well as conch. Horseshoe crabs have suffered overharvesting in the Delaware Bay, partly for use as bait for the eel -- so we have this incredibly unhealthy dynamic where one species at harm from overfishing is used to catch another species at harm from overfishing.

The ASMFC Eel Management Board is responsible for and reviews state plans for the Atlantic Coast States. As with many ASMFC efforts to attempt to preserve sustainable fisheries, there is strong resistance from the commercial fishing industry to put any additional restrictions, such as maximum size limits for eels as well as seasonal closures that last 30, 60 or 90 days (currently the season is open all year for New Jersey and Delaware).

The Delaware Valley Fish Company, established in 1972, is the main eel dealer in our

Watershed and is located in Norristown PA. On its website, the Delaware Valley Fish Company says its “the nation's leading fresh water eel exporter. Maintaining its own fleet of tank trucks, the company is able to purchase directly from producers and warehouse its product in a specially designed tank facility”. This company has an annual revenue of \$5 to \$10 million and employs a staff of approximately 5 to 9 people (<http://www.manta.com/c/mm21751/delaware-valley-fish-co>).

Water Quality Harms:

While further study is needed, chemical contamination of American eel is known to occur and could be associated with an increased incidence of disease and reproductive impairment. American eel have a high fat content and a bioaccumulation of toxins occurs in the fat of the fish. Because eel are long lived, their exposure to endocrine disrupting contaminants could affect their sexual development, maturation, fertility and fecundity (ability to reproduce). In some regions, American eel have bioaccumulated (to build up within the tissue of the organism) polychlorinated biphenols (PCBs) in levels above the food health standard (2.0 ppm). Studies have also shown bioaccumulation of mercury and other heavy metals, dioxin and chlordane at levels warranting attention in some jurisdictions. Because of contamination, some states have issued health advisories regarding consumption of American eel. 2012 Pennsylvania advisories indicate that American eel in the Delaware estuary and tidal tributaries (including the Schuylkill River) to the Delaware should not be eaten at all due to PCB contamination. From Trenton north to the Delaware's source, 2 meals a month of eel are advised due to mercury contamination.

Dissolved oxygen (DO) has been found to affect American eel and so has been found to be a strong predictor of the distribution of American eel. In North Carolina high catches of American eel regularly occurred in waters with DO levels above 4 mg/L. In the Chesapeake Bay, VA, 82% of American eel caught were in waters with DO levels between 5 and 9 mg/L. The Delaware Estuary continues to suffer an oxygen sag during certain times of the year, and the DO criteria for estuary waters in place by the DRBC in the area of the Ben Franklin Bridge is only 3.5 mg/l – as such DO levels in the Delaware are an issue to be tackled and approved upon.

Global climate change science is indicating a northward deviation of the Gulf Stream (Castonguay *et al.* 1994b; Knights 2003) and a reduction of oceanic productivity (Dekker 1998). Weakening currents can interfere with American eel movement and survival either by starvation or by unfavorable transport patterns that extend the duration of oceanic migration (Knights 2003), both leading to reduced survival.

An Asian parasite that affects the eels' swim bladder has been a concern in recent years. Impairment of the swim bladder can prevent the successful return of the American eel to the Sargasso Sea to reproduce.

Jurisdictional Issues:

American eel are a particularly challenging species to conserve and manage on a coastwide basis for a number of reasons. During its life-span the American eel will have navigated through and resided in a wide range of habitats, including the oceanic waters of the Sargasso Sea, the brackish waters of coastal estuaries, and

the inland freshwater river systems. Additionally, throughout this journey, the American eel will have been under a myriad of management authorities, from the high seas to multiple federal, state and local governments. While these factors can create difficulties in implementing a comprehensive and all-inclusive management strategy, it also provides an opportunity for increased coordination between the various managing agencies and the ability to connect essential fish habitat, which may benefit other species as well.

That the species is affected by many different decision-makers should never be used as an excuse not to take appropriate action within an entity's jurisdiction. If each agency and entity took the best actions they could within their jurisdiction the species would be better protected and dependent communities better served.

What do we need to do?

It is important to improve oxygen levels in the Delaware Estuary and River to ensure optimal conditions for the American Eel. Dissolved oxygen levels in the Delaware Estuary and River could be important for the protection of American eel. In North Carolina American eel seemed to prefer waters with DO levels above 4 mg/L, in VA large numbers were found in waters with DO of 5 mg/L and above.

Dam removals are on the rise in the Delaware River Watershed since many old dams are no longer functioning and/or are in a state of disrepair. For example, several dams on the Darby Creek will be removed as part of settlement for the Athos I oil spill. DRN has been involved with dam removals on various rivers helping to lead dam removal projects for Sprogel's Run and the Manatawny Creek. We need to continue advocating for dam removals in our communities and working with partners to ensure more habitat is opened up, working from the downstream up. And passage for immovable dams that serve both fish and eels, need to be installed.

We need to target decision-makers at the American Eel Management Board of the Atlantic States Marine Fisheries Commission (ASMFC) because better fish harvest limitations need to be instituted to ensure the species is protected. At a minimum, maximum eel length take as well as specific closures of the fishery certain times of year are needed.

Growing eels are primarily benthic, utilizing substrate (rock, sand, mud) and bottom debris such as snags and submerged vegetation for protection and cover. Therefore, as with other fish species, healthy riparian buffers and large woody debris and other natural matter within streams helps provide this vital habitat and should be protected.

Small eels feed predominantly on aquatic insect life while larger eels feed on fish and crayfish. As the aquatic food chain and macroinvertebrates decrease in streams and rivers due to decreased water quality, there is less of a food supply for the American eel. The protection of the base of the foodchain is essential to ensuring and sustaining healthy eel populations.

For more information on American eel:

- Atlantic States Marine Fisheries Commission: American Eel
- Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs (January 2009)
- NatureServe Explorer: American Eel, www.natureserve.org
- Pennsylvania Fishes, Pennsylvania Fish and Boat Commission, Chapter 9, American Eel.
- FishBase: American Eel
- Marine Biology Laboratory: American Eel
- PFBC: American Eel
- Sowles et al, 1997.
- COSEWIC Assessment and Status Report on the American Eel (*Anguilla rostrata*) in Canada (<http://publications.gc.ca/collections/Collection/CW69-14-458-2006E.pdf>)
- Tesch, F.W. 1977. The eel: biology and management of anguillid eels. Chapman and Hall, London. 437 p.
- Tesch, F.W. 1998. Age and growth rates of North Atlantic eel larvae (*Anguilla* spp.) based on published length data. Helgoländer Meeresunters 52: 75-83.

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