# PETITION TO LIST THE AMERICAN EEL *(Anguilla rostrata)* AS A THREATENED SPECIES UNDER THE ENDANGERED SPECIES ACT

Eel Mortality from Turbines -AD Latornell Symposium 2008

**Submitted To**: U. S. Fish and Wildlife Service, Washington D.C. and Sacramento Field Office, California

**Submitted By**: Council for Endangered Species Act Reliability

**Date**: April 30, 2010

# Council for Endangered Species Act Reliability

April 30, 2010

**CESAR**

**VIA FACSIMILE & CERTIFIED MAIL**

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**Re: American Eel Petition**

Dear Sirs and Madame:

The Council for Endangered Species Act Reliability ("CESAR") hereby petitions the Departments of Interior and Commerce to list the American eel (*Anguilla rostrata*) as threatened pursuant to the federal Endangered Species Act ("ESA"), 16 U.S.C. §§ 1531, et seq. This petition is filed under 5 U.S.C. § 553(3) and 50 C.F.R. § 424.14 and includes new information that became available subsequent to the 'not warranted' 12-month finding published by the Fish and Wildlife Service ("FWS") on February 2, 2007[1] (herein "2007 Final Determination").

The petition includes this cover letter and the attached petition consisting of Parts I through IV, as well as all documents cited herein which are hereby specifically incorporated by reference.

[1] Fed. Reg. 22, 4967, 22, 4997 (Feb. 2, 2007).

Please do not hesitate to contact me at (916) 341-7407 if you need more information. My address appears above.

Sincerely,

Craig Manson
Executive Director
Council for Endangered Species Act Reliability

cc: Gary Frazer
Marvin E. Moriarty
Enclosures

**Petition to List the American Eel as an Endangered Species**
**Pursuant to the United States Endangered Species Act**
**16 U.S.C. §§ 1531, et seq.**

**PETITIONERS:**

Petitioner the Council for Endangered Species Act Reliability ("CESAR") requests the United States Fish and Wildlife Service ("FWS") and the National Marine Fisheries Service ("NMFS") list the American eel (*Anguilla rostrata*) as threatened under the United States Endangered Species Act, 16 U.S.C. §§ 1531, et seq. This petition is filed under 5 U.S.C. § 553(e) and 50 C.F.R. § 424.14.

## I. STATUS OF THE AMERICAN EEL

The American eel (herein "American eel" and "eel" interchangeably) is in steep decline across its range. This decline commenced in the mid-1980s and has continued to present populations which demonstrate a decrease of several orders of magnitude from the near past. The decline is based on the following factors:

- **Loss of habitat** – American eels have lost an estimated 84 percent[2] of their habitat; much of it due to the operation of dams which impede or completely block migration, reducing or removing habitats available for spawning, feeding, and growth. Further, dams have fragmented river habitats and changed upstream habitat by slowing water flow and changing temperatures. In addition, river habitat has been altered by changes in streambeds and banks and streamside vegetation, all of which are affected by the operation of dams.
- **Overutilization** – commercial and recreational fisheries that harvest virtually every life stage of the American eel throughout its habitat do so with little to no regard for population status.
- **Disease** – The spread of the invasive swim bladder parasite, *Anguillicola crassus*, has disrupted the eel's swim bladder function. This parasite, introduced to the immunologically naïve American eel, has quickly colonized populations and created what appears to be a potentially catastrophic epizootic.
- **Inadequacy of existing regulatory mechanisms** – The only regulatory authority currently exercised is that of Atlantic States Marine Fisheries Commission ("ASMFC"). That organization has done little over the past decade to effectively reverse the declines in eel recruitment, halt commercial and recreational take of American eels, or

[2] Busch et. al 1998; Using spatial data from the EPA, dam locations from the U.S. Army Corps of Engineers, and eel presence/absence data from the State of Maine and the U.S. Fish and Wildlife Service, the authors found a reduction of 84% of the stream habitat available. This estimate is conservative as it only tallies losses on the American portion of the eel habitat, and not addressing habitat loss on the Canadian side.

implement consistent methods to accurately assess their population size. Other available authorities, such as that of the states and the Federal Energy Regulatory Commission ("FERC"), have been exercised only sporadically and are clearly insufficient to halt the decline of the species.

- **Other factors** – Other documented factors adversely affecting American eel populations include climate change, mortality and morbidity from acidification of stream flows, mortality and injury in hydroelectric turbines when mature eels are migrating downstream, and contaminants ranging from Mercury to PCBs.

This petition summarizes the natural history of the American eel, population information, and a description of existing threats to the species and its habitat. Petitioners are seeking listing of the species as threatened under the ESA. This petition is based on information developed by the FWS in its 2007 Final Determination that listing was "not warranted", new information published since that final agency action, as well as information not considered in that review.

### A. Background

On May 27, 2004, the ASMFC requested that the FWS and the NMFS conduct a status review of the American eel based on extreme declines in the Saint Lawrence River/Lake Ontario portion of the species' range. The ASMFC also requested an evaluation of the appropriateness of a Distinct Population Segment ("DPS") listing under the ESA as well as an evaluation of the entire Atlantic coast American eel population. The FWS responded that the American eel was not likely to meet the discreteness element of the policy requirements due to lack of population subdivision. However, the FWS did undertake a range wide status review of the American eel in coordination with NMFS and ASMFC.[3]

On November 18, 2004, the FWS and the NMFS received a petition requesting the listing of the American Eel as a threatened species under the ESA. The petitioners cited destruction and modification of habitat, overutilization, inadequacy of existing regulatory mechanisms, and other natural and man-made factors (such as contaminants and hydroelectric turbines) as the threats to the species. After initially finding that the petition presented substantial information indicating that listing the American eel may be warranted, the FWS made a final determination that listing of the eel under the ESA was "not warranted". The final rule contains the following findings:

- The species has been extirpated from some portions of its historical freshwater habitat over the last 100 years or so, mostly as a result of dam construction which blocked access;

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[3] U.S. Fish and Wildlife Service, 12-Month Finding on a Petition To List the American Eel as Threatened or Endangered, 72 Fed. Reg. 4967-4997 (Feb. 2, 2007).

**Petition to List the American Eel as an Endangered Species**
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- There is also evidence that the species' abundance within freshwater habitats, and to some degree estuarine habitats, has declined in some areas likely a result of harvest or turbine mortality, or a combination of factors;
- The species remains widely distributed over the majority of its historical range;
- An indication of decline exists in yellow eel abundance, but recent glass eel recruitment trends, although variable from year to year, appear stable over the past 15 years;
- The American eel is a highly resilient species, with the ability to occupy the broadest range of habitats within freshwater, as well as estuarine and marine waters, and it remains a widely distributed fish species.
- Although roughly 25 percent of the American eel's historical freshwater habitat is now inaccessible due to dams, the loss of this habitat does not threaten the species' long-term persistence;
- A large amount of freshwater habitat still remains (roughly 75 percent of historic freshwater habitat in the United States remains available and occupied by the American eel);
- Although the significance of the estuarine and marine eel contribution to reproduction is considered speculative by some there is no doubt that substantial amounts of estuarine and marine waters remain available to, and are occupied by, the American eel throughout its range;
- Recreational and commercial eel harvests are no longer factors of concern at a population level due to economics, the species' resilience, and existing regulatory mechanisms;
- Although mortality during outmigration due to parasites and contaminants, and the potential effects of contaminants on early life stages, remain a concern, there is no information indicating that these threats are currently causing or are likely to cause population level effects to the American eel;
- There is no information indicating that predation or competition with non-native species or mortality from turbines is causing population-level effects;
- Recruitment success of the American eel is dependent on ocean conditions, and variation in ocean conditions cause fluctuations in recruitment. However, because the available information indicates that the species remains widely distributed and glass eel recruitment trends appear stable over the past 15 years: observed ocean conditions do not threaten the current population status of the American eel;
- There is no information to indicate that ocean conditions are likely to threaten the American eel at a population level in the future.

### 1. FWS 2005 Status Review Information

The FWS reports that its 2007 12-month finding is based on the contents of the petition, existing literature, and information gathered during the status review that preceded the finding. The FWS identifies the documents most relevant to the status review as the stock assessments for the Atlantic coast, the American eel data assembled for the Canadian stock assessment and specific published research on life history and potential threats to the American eel.

The 12-month finding stated that the status review focused on available data within the North American Continent. The FWS was unable to identify data on eel distribution, habitat use, habitat degradation or loss, or other threats (other than international harvest data) from Central or South America, although some Caribbean Islands provided distribution information.

The 12-month finding referenced two scientific workshops in which over 25 scientific experts participated. The expert panelists represented a broad and diverse range of scientific perspectives relevant to the status review of the American eel. Participating individuals had expertise on threats, or life history characteristics associated with threats, to the American eel. Each of the participating experts was asked a series of questions. These questions asked the experts to assess the information used by the FWS in their status review as to its completeness, relevance, and quality. The FWS recorded each expert's individual assessment of the likelihood of eel extinction based on the information presented.[4]

### B. Evolution And Population Structure

The American eel evolved approximately 52 million years ago and is among the longest-living animals in North America and one of longest-lived fishes of North America. A record exists of an American eel living 88 years in captivity and Swedish television carried the story of Håkan Wickström, who pulled a 130+ year old eel out of a well! American eels are both catadromous[5] and diadromous[6]. Eels spawn in ocean waters, migrate to coastal and inland continental waters to grow, and then return to ocean spawning areas to reproduce and die. Female American eels in northern latitudes reach ages of 20-50 years old before their one-way spawning migration to the Sargasso Sea.

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[4] *Draft Minutes*, American Eel Great Lakes/Canada Threats and Population Dynamics Workshop U.S. Fish and Wildlife Service in cooperation with National Marine Fisheries Service January 31 — February 2, 2006 Buffalo, New York and FWS. 2006. *Draft* Minutes from the American eel status review Workshop 2: Great Lakes/Canada threats and population dynamics. Buffalo, NY, January 31-February 2, 2006.

[5] Meaning that they live in fresh water, and breed in the ocean.

[6] Meaning that they travel between salt and fresh water.

There are two closely related recognized species of eel found in the North Atlantic -- the American eel and the European eel. Genetic research indicates that the American eels are one, well-mixed, single breeding population. This is in contrast to many anadromous species (which, even though they have an oceanic phase, return to their rivers of origin to spawn), where mating is within separate populations that are geographically or temporally isolated. Similarities between the American and European Eel are remarkable.[7]

### C. Life History

American eel eggs hatch in the Sargasso Sea. Ocean currents are hypothesized to transport the eels to the Atlantic coasts of North America and northern portions of South America and the Gulf of Mexico. The Gulf was a significant route when they populated the Mississippi. European reporters of the Illinois Nation document heavy use of eels in the upper Mississippi River. They enter coastal waters, where they may stay, may move into estuarine waters, or migrate up freshwater rivers. Upon nearing sexual maturity, these eels begin migration toward the Sargasso Sea, completing sexual maturation en-route. Spawning occurs in the Sargasso Sea. After spawning, they are believed to die.

Eels usually live on the muddy bottoms of freshwater streams or in freshwater stream-fed ponds. They generally seek deep streams and often work their way up brooks along the coast, but can penetrate hundreds to thousands of kilometers inland via major waterways. For example, historically, the American eel was found as far inland as Iowa (via the Mississippi River). Eels are able to leave the water and hide under muddy stones in swampy ground a few feet from the shores and can forage on the sand along streamsides. Eels are omnivorous.

Much of the information surrounding the ecology of eels is the result of speculation, hypothesis, or inference as there is inadequate knowledge to more specifically identify their life cycle requirements.

#### 1. Egg and Larval Life History Stage

American eel eggs are believed to hatch into a leaf-like, laterally compressed larval stage known as "leptocephalus" in the Sargasso Sea. American eel spawning and eggs have never been observed. However, as leptocephali are found primarily in the Sargasso Sea, biologists infer the location of spawning and egg distribution. While there have been leptocephali found drifting outside the Sargasso sea, to date, that behavior has been treated as an anomaly. Leptocephali distribute in the upper 300 meters (m) of the ocean and are subject to transport from surface currents. The Sargasso Sea is bounded by a powerful western boundary current, the Florida Current and Gulf Stream, which flows to the north and northeast along the Atlantic coast of

[7] See page 40 of 42 from the February 2007, 2006 FWS Workshop on the American Eel Great Lakes/Canada Threats and Population Dynamics Workshop: In response to a question of how much the European Eel should be used as a surrogate "*John Casselman noted that the similarities are rather remarkable. He noted that, because of currents, the European species may take longer to get there, but there is remarkable synchrony.*"

North America. The Florida Current transports water from the Caribbean, Gulf of Mexico, and more distant regions through the Straits of Florida.

The transport mechanism for the leptocephali is largely unknown, although it is believed that a majority of the leptocephali enter the Florida Current and Gulf Stream from the Sargasso Sea. Although there are several theories, the path taken by the remainder is unknown. Other than likely current transport, very little is known about the leptocephali. It can be inferred, based on recent studies on other species, that they may feed on marine snow or detrital particles such as zooplankton fecal pellets.

The American eel undergoes significant morphological and physiological changes twice during its life cycle. The first occurs when the leptocephali enter the Continental Shelf waters; the second is during sexual maturation. The leptocephali's leaf-like, laterally compressed shape transforms during metamorphosis into a reduced, characteristically eel-like shape, as they become transparent "glass eels." Leptocephali are unusual fish larvae that are filled with a transparent gelatinous energy storage material, and they can swim either forwards or backwards equally well. This may be an important aspect in leaving the Gulf Stream. This directional swimming is the only way that leptocephali can cross and detrain from the Gulf Stream system and cross the Continental Shelf waters, due to the lack of any persistent oceanic transport mechanism that can account for the large-scale transport of millions of larvae across the current.

### 2. Juvenile Life History Stage

There is considerable annual variation in the number of juvenile eels in coastal waters as either unpigmented "glass eels" and pigmented "elvers." The variation in recruitment between years can be quite significant. Some of the young eels remain in brackish or salt waters, others migrate up rivers to a variety of fresh water habitats, and others develop movement patterns between these habitats.

Information on mortality rates for all of the eel's life stages is limited. However, the available data from mark-capture studies indicate juvenile mortality rates of 99 percent and elver mortality in fresh waters may be density-dependent.[8] There is uncertainty regarding early juvenile mortality. Surviving elvers mature into fully pigmented "yellow eels."

#### a) Mortality rates may decrease with size.

One study in Prince Edward Island, Canada, calculated loss from the population due to mortality and emigration. Estimates of loss in American yellow eels from the Prince Edward Island study are reported at 22 percent, with mortality rates decreasing to 12 to 15 percent as the juvenile yellow eels age (Anonymous 2001 in Morrison and Secor 2003, p. 1498), the reasons for this are unknown, but may be due to lower mortality from predation and starvation as size increases.

[8] Jessop (2000), p. 514, Vøllestad, L.A. and B. Jonsson (1988).

**b) Juvenile diet.**

Because they are omnivorous, eels can adapt to changes in prey species and abundance. Yellow eels are opportunistic, consuming nearly any live prey that can be captured. Smaller eels eat benthic invertebrates; larger eels include mussels, fish, and even other eels in their diet. Yellow eels also adapt to seasonal changes, decreasing intake or ceasing to eat during the winter. Eels can also respond to local abundances of appropriately sized prey through the seasons (Tesch 2003, pp. 152-163). This adaptability with respect to diet allows for resource partitioning as well as the ability to withstand sudden changes in local environmental conditions and the ability to occupy a geographically wide variety of habitats.

**c) Density-dependent dispersal.**

As young eels begin to grow, density-dependent competition promotes eels to disperse into less crowded areas (Feunteun et al. 2003, pp. 201-204; Ibbotson et al. 2002 in Knights et al. 2006, p. 10). Aggressive interactions at high density can inhibit feeding and growth, but stimulate dispersive swimming activity in smaller eels (Knights 1987 in Knights et al. 2006, p. 10), the latter likely as a defense against predation. As size differences in these juveniles increase, cannibalism can also be an important cause of mortality (Knights 1987 in Knights et al. 2006, p. 10). Density dependent dispersion ensures wider distributions, further minimizing intra-specific competition. Benefits of density dependent dispersion include selection of optimal habitat productivity and temperature, lower predation risks, rapid colonization or re-colonization of habitats, and avoidance of inter-specific competition. Upstream, larger females predominate, densities of eels decline, and individuals tend to become more sedentary and occupy territories (Feunteun et al. 2003, p. 201).

Generally, density dependence is a function of population, the higher the population of eels, the more likely mortality results from cannibalism. Logically, one would not expect this to occur when a species is experiencing the kind of catastrophic declines exhibited over the past two decades by eels. However, it is possible that anthropogenic barriers could create artificial density conditions where the few eels are found congregated at some barrier such as a dam. At that point, density dependent cannibalism would occur situationally with potentially catastrophic effects for the already small eel population.

**d) Distribution clines.**

There is a theory that there are latitudinal clines in eel distribution related to river typologies. For example, the American eel tends to extend farther inland in southerly lowland drainages compared to distributions in the shorter and steeper post-glacial stream systems in the Northeast (Jessop et al. 2004 in Knights et al. 2006, p. 11). Smogor et al. (1995, p. 799) and Knights (2001 in Knights et al. 2006, p. 8) have documented decreases in densities with increasing distance from the Continental Shelf in a predictable pattern. Although mean watershed densities decrease by an order of magnitude with distance inland from the

Continental Shelf, mean biomass only declines by about 50 percent because mean body weight and eel length increase (and hence increased fecundity). This, according to Knights et al. (2006, p. 10), helps maintain biomass relative to carrying capacity. Machut (2006, p. 13) indicates that as barrier intensity increases, so does eel growth above the barrier. It is well documented that as eel density decreases, the proportion of females increases, which, assuming females are the limiting sex, would be, according to Knights et al. (2006, p. 13), a compensatory mechanism during times or in areas of low density. However, as discussed later in this petition this mechanism can have unintended consequences if all the of the highly fecund females living above turbines will be destroyed or mortally injured before spawning.

### 3. Sexually Maturing Life History Stage

#### a) Sex determination.

There are no morphologically differentiated sex chromosomes in the American eel and, prior to sexual differentiation, eels are intersexual, meaning they can develop into either sex. When yellow eels reach a length of about 20-35 cm it is possible visually to distinguish males from females (by post-mortem inspection of their gonads). There is significant variation in age and size at differentiation. Biologists speculate that sex determination is influenced by environmental factors, including eel densities. Studies indicate that increasing eel density increases the incidence of male eels and decreasing density produces more females. It has been hypothesized that his life history strategy results in population responses that are beneficial to eel conservation. For example, with this strategy, when recruitment declines, so will density and tendencies to migrate far upstream in rivers, which leads to relative increases in the number of larger females and compensatory increases in fecundity. The results of this strategy may take a number of generations (and hence decades) to manifest itself, but it can produce benefits in the face of threats, past, present and future, such as changes in ocean currents and climate. However, the strategy is ineffective when large, fecund females are destroyed by anthropogenic factors (such as turbines) before they can spawn.

#### b) Silvering.

Beginning at 3 years old in the southern portion of the range, and up to 24 years in the northern portion, the yellow eels begin metamorphosis. The actual age of silvering increases with increasing latitude. The metamorphosis from bottom-oriented yellow eels to silver eels is important physiologically as it prepares the eels for oceanic migration and eventual spawning. It is unknown what actually triggers silvering. It is speculated that environmental factors may contribute. Habitat conditions, such as food availability and temperature, will influence the size and age of silvering eels. Thus, variation in length and age at maturity can occur in different habitats.

Growing season length and temperature vary by latitude and thus, age at maturity also varies with latitude. Characteristics of silver eels vary across the species' range. Eels from northern areas, where migration distances are great, show slower growth and greater length, weight, and age at migration, resulting in their better preparation for a longer migration. This also leads to a higher contribution to recruitment from larger, more fecund females.[9]

It appears that favorable growth conditions cause eels to silver more rapidly, such as is the case in aquaculture, under experimental conditions, or in brackish water and at low latitudes. For example, Morrison et al. (2003, p. 95-96) found annual growth rates in brackish water were two times higher than growth rates of eels that resided entirely in fresh water. Also American eels in the warmer, more stable water conditions of the U.S. southern Atlantic coast waters develop into silver eels about 5 years sooner than northern populations.

Variation in maturation age benefits the population by allowing different individuals of a given year class to reproduce over a period of many years, which increases the chances of encountering environmental conditions favorable to spawning success and offspring survival. For example, variability in the maturation age of eels born in 2006 may result in spawners throughout 2010-2030, during which time favorable environmental conditions are likely to be encountered at least during some periods. However, disproportionate loss of older, more fecund eels to anthropogenic causes can remove that mechanism from contributing to the continued existence of the eel.

Males and females differ in the size at which they begin to silver. Eels appear to need to reach a certain size to begin the silvering process, with this size increasing with age (thus, rapidly growing eels will silver at smaller sizes than slow-growing eels). In males, silvering happens at a very early stage, at a size typically greater than 35 centimeters (cm). In females, silvering happens at a size greater than 40 to 50 cm.

Metamorphosis occurs gradually beginning in summer, and in the fall eels metamorphosing in preparation for migration back to the spawning grounds have a silvery body color, enlarged eyes and nostrils, and a more visible lateral line. During metamorphosis, the structure and metabolism of the liver changes and the swim-bladder also changes.

It is believed that, generally, a drop in temperature signals final metamorphosis characterized by gut regression and cessation of feeding. Once metamorphosis is complete and the appropriate environmental conditions exist, emigration occurs. Biologists theorize that responding to a drop in temperature synchronizes emigrating eels, and increases their chances of reaching the Sargasso Sea simultaneously. The specifics of the important environmental variables are unknown and the subject of much speculation; among the variables considered to have the potential to affect migration are increasing temperatures, delays in migration, or possibly low fat content. It has, however, been observed that even after eggs and sperm have developed, eels are capable of gut regeneration and feeding. This leads to the conclusion that silvering may occur more than once in the lifetime of an eel under specific (and as yet unknown) circumstances. If so, this phenomenon could explain the extreme variability in age and size of silver eels. Biologists are uncertain as to the cause of final sexual maturation of eels,

[9] McCleave 2001a, p. 803, MacGregor 2008, Knights et al. 2006.

but hypothesize that high pressure they experience during migration in the open ocean may be the trigger.

### 4. Life History Stage at Emigration

#### a) Energy requirements.

To successfully complete their emigration from the continent to the Sargasso Sea, great endurance and an extensive fat reserve are required. Larger, fatter eels have an advantage over smaller eels in reaching the Sargasso Sea and having sufficient energy stores to reproduce. Eels are very efficient swimmers and larger eels appear more efficient than smaller eels. Also, larger eels usually have larger fat stores per body weight. Silver eels have ceased feeding, and use their stored fat for energy during their migration and for completing gonadal growth. In a study conducted on European eels, the most recent estimate of necessary energy (fat) needed to successfully complete the migration to the Sargasso Sea from Europe and spawn is 20 percent fat reserves, of which 13 percent is for transport, and an additional 7 percent for completing gonadal growth. In European silver eel, about 50 percent of the eels studied had a fat percentage of 20.

It is unknown if American eels require the same fat reserves as European eels because American eels travel a shorter distance to reach the Sargasso Sea than do European eels. Actual distances, routes, and depths of migration for adult eels are unknown. Distances traveled by migrating silver American eels likely vary from under 1,500 km to over 4,500 km, shorter than the 5,000 km to 7,000 km likely traveled by European eels. It is not known whether American eels follow the Deep Western Boundary Current or the upper portions of the ocean to return to the Sargasso Sea.

#### b) Fecundity.

Fecundity varies with size and increases exponentially with length, ranging from about 0.6 million to almost 30 million eggs depending on the size of the female. Fecundity is also linked to the habitat which the eel occupies. In an eel farm growth experiment, favorable nutrition was one of two factors identified as producing eels with a high reproductive capacity. This high fecundity is thought to compensate for larval mortality which is believed to be well in excess of 99 percent. Loss of fecundity related to the Saint Lawrence River stock is staggering (Casselman and Marcogliese 2007). That stock was all female, and as far as the upper Saint Lawrence River Lake Ontario was concerned, large, and highly fecund (Casselman 2006).

#### c) Spawning.

Spawning is believed to take place in the Sargasso Sea. Some biologists have hypothesized that there is some (as yet unidentified) feature of the surface water that serves as a cue for migrating adults to cease migration and begin spawning. While spawning has never been documented, the 2007 Final Determination assumes that adult eels die after spawning.

**5. Range**

The range of the American eel includes all accessible river systems and coastal areas to which western North Atlantic Ocean oceanic currents provide transport. These drainages and coastal areas range from Northern Brazil/Venezuela to southern Greenland and include most Caribbean Islands and Bermuda.

Currently, the majority of the American eel population is located along the Atlantic seaboard of the United States and Canada. The historic distribution of the American eel within its extensive continental range is well documented along the United States and Canadian Atlantic coast and inland. The FWS reports that the distribution is less well documented in the Gulf of Mexico, Mississippi watershed, and Caribbean Islands, and least understood in Central and South America if indeed they exist there in any abundance at all. We were unable to document any populations of any size or any harvest data that would support a statement that there are American eels in any meaningful numbers. Further, the documentation in the Mississippi watershed confirms that eel populations have nearly disappeared. Some commercial catch data for Mexico, Cuba, and the Dominican Republic may exist[10].

**D. Population Status**

Eel populations throughout the world are declining catastrophically. The European eel fishery has collapsed and the European eel is likely to become extinct in the foreseeable future. As a result, there is additional harvest pressure on the American eel. However, American eel populations are and have been declining nearly as precipitously for two decades across its range in Canada and the United States. Recruitment of both the European eel and American eel have fallen to levels possibly as low as 1 percent of their highest levels.[11]

Juvenile recruitment to the Saint Lawrence River system and Lake Ontario virtually ceased during the 1990s, recruitment in the mid-to-late 2000s was 4 orders of magnitude smaller than that of the 1970s, and there is no information that demonstrates any reversal to this downward trend. In 1985, nearly a million juvenile eels migrated into the Saint Lawrence River; that number had fallen to levels approaching zero by 2000, and there is no data which demonstrates any reversal to this downward trend. Recruitment of the European eel and American eel have fallen to levels possibly as low as 1 percent of their highest levels.[12]

Ontario's Ministry of Natural Resources indicated that Ontario's commercial eel harvest peaked at more than 500,000 pounds in 1978 and had declined to 30,000 pounds in the first decade of the 21st century. Ontario officials blame the eel's plight on overharvesting, migration barriers, climate conditions and hydro-electric turbines. Studies on the St. Lawrence River hydro-electric

[10] MacGregor 2008.
[11] Aoyama 2009.
[12] Aoyama 2009.

dams reveal cumulative mortality of 40 percent of emigrating silvering eels.[13] Ontario closed its fishery in 2004.

In 1974, the number of juvenile eels counted annually at the Conowingo Dam on the Susquehanna River was 126,543 and was nearly zero in by the turn of the 21st century. At the November 18, 2002 meeting of the ASMFC Eel Management Board, Mr. Richard Snyder, ASMFC representative for Pennsylvania, stated: "No American eels really pass the Conowingo Fish Lift, based on the annual samplings there lately."

U.S. harvests of American eels on the Atlantic Coast have declined 64 percent of the long-term average since 1950; almost 44 percent below the 20-year average; and about 30 percent below the five year average, based on 2002 harvest reports collected by the ASMFC, Geer (2004).[14]. Limburg and Waldman (2009) report an even steeper decline of 72.2 percent in recent decades.

On August 14, 2003, eel biologists from 18 countries meeting in Quebec, Canada, drafted and unanimously approved a declaration titled: *The Quebec Declaration of Concern: Worldwide Decline of Eels Necessitates Immediate Action.*

The Declaration states:

> *"The steep decline in populations of eels endangers the future of these legendary fish. With less than 1 percent of major juvenile resources remaining, precautionary efforts must be taken immediately to sustain these stocks. In recent decades, juvenile abundance has declined dramatically; by 99 percent for the European eel (Anguilla anguilla) and by 80 percent for the Japanese eel (Anguilla japonica). Recruitment of American eel (Anguilla rostrata) to Lake Ontario, near the species' northern limit, has virtually ceased.*
>
> *"Eels, which depend on freshwater and estuarine habitats for their juvenile growth phase, anthropogenic impacts (e.g. pollution, habitat loss and migration barriers, fisheries) are considerable and may well have been instrumental in prompting these declines. Loss of eel resources will represent a loss of biodiversity but will also have considerable impact on socioeconomics of rural areas, where eel fishing still constitutes a cultural tradition. Research is underway to develop a comprehensive and effective restoration plan. This, however, will require time. The urgent concern is that the rate of decline necessitates swifter protective measures. As scientists in eel biology from 18 countries assembled at the International Eel Symposium 2003 organized in conjunction with the 2003 American Fisheries Society Annual Meeting in Quebec, Canada, we unanimously agree that we must raise an urgent alarm now. With less than 1 percent of juvenile resources remaining for major populations, time is running out. Precautionary*

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[13] Verreault et. al 2004.
[14] Geer, Patrick. Minutes of March 29, 2004 Atlantic State Marine Fisheries Commission meeting. Alexandria, Virginia.

> *action (e.g., curtailing exploitation, safeguarding migration routes and wetlands, improving access to lost habitats) can and must be taken immediately by all parties involved and, if necessary, independently of each other. Otherwise opportunities to protect these species and study their biology and the cause of their decline will fade along with the stocks."*

According to official minutes of the March 29, 2004 meeting of the American Eel Management Board of the ASMFC in Alexandria, Virginia, Mr. Patrick Geer, Technical Committee chairman of the American Eel Management Board, stated:

> *"You can see, basically, they've had very little or no recruitment for the last nearly ten years at this point [in the St. Lawrence River system]. Typically, when the eels get to this area on the St. Lawrence River, they're five to seven years old. They're noticing in the last few years they're getting much older than that, so they're speculating they're having a failure of recruitment to the St. Lawrence system."*
>
> *U.S. landings on the Atlantic Coast are down about 64 percent of the long-term average back to 1950, almost 44 percent below the 20-year average and about 30 percent below the five year average. This is from 2002 landings reports."*

On November 10, 2004 a public information document for potential changes to the interstate fishery management plan was provided by the ASMFC and contains the following information:

Dr. John Casselman presented findings of a continued decline in the abundance of eel in the Saint Lawrence River. This decline in the northern portion of the population is of concern because this segment of the population consists mainly of large, fecund females which are believed to have a direct effect on recruitment of eels along the coast. Dr. Casselman has since noted that this phenomenon is occurring everywhere.[15]

In 2006, Canada nominated the American eel as a species of special concern based on declines in populations. A 2006 report on the American eel prepared by the Committee on the Status of Endangered Wildlife in Canada 2006 includes the following information:

- Indices of abundance in the upper St. Lawrence River and Lake Ontario have declined by 99 percent since the 1970s.[16]
- The only other data series of comparable length is from the lower Saint Lawrence River and Gulf of St. Lawrence, where four of five time series showed declines.

[15] Dr. Casselman pers comm.

[16] Page vii. Changes in the data series for the eel were evaluated between years prior to 1980 and 2000-2005. The interval between these periods represents about 3 times the approximate generation time of female American eels. Percent change between early and recent ranged from -99.5-+74.8 percent. All four landing series and five of the six survey indices were negatives. The sole U.S. series was -67.5.

- These eels were a substantial portion of the breeding population of the species (estimates range from 59.2 percent to 48.8 percent of the spawn output[17]).
- The collapse of the Lake Ontario-Upper St. Lawrence components may have significantly affected total reproductive output.
- Positive trends in some indicators are too short to provide strong evidence that this component is increasing.
- Possible causes of the decline include: habitat alteration, dams, turbine mortality, harvest, ocean conditions, acid rain and contaminants.
- The report did not indicate that the species was data deficient.[18]
- The ASMFC noted that since the fishery's peak in the mid 1970s at 3.5 million pounds, commercial landings have declined significantly to a near record low of 868,215 pounds in 2001[19] , and the most recent data record a catch of even less, 714,723 in 2008. Recreational data concerning eel harvest appears to indicate a decline in abundance. According to the NMFS Marine Recreational Fisheries Statistics Survey, recreational harvest in 2001 was 10,805 eel, a significant decrease from the peak of 106,968 eel in 1982."[20]
- Environment Canada notes that annual landings of eels have declined from 1,000 tonnes per year in the 1930s and did not reach 100 tonnes in 2007, despite the fact that the value was $7.65/kg, making it one of the most valuable species in Canada's commercial freshwater fishery.[21]
- ASMFC notes that harvest and habitat loss are the primary causes of any decline in abundance of American eel. Harvest risk is based on the fact that eels are slow maturing, early life stages gather seasonally for migration and are thus more easily caught, yellow eel harvest accrues cumulative stress over multiple years, and all eel mortality is pre-spawning mortality.

A final report, issued January 2005, Estimation of Reproductive Capacity of the American Eel found:

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[17] Page vii.
[18] Page x.
[19] Addendum I To The Interstate Fishery Management Plan For American Eel Approved for Public Comment October 31, 2005; page 4.
[20] Addendum I To The Interstate Fishery Management Plan For American Eel Approved for Public Comment October 31, 2005; page 5.
21 The American Eel of the St. Lawrence: A Species In Decline for the Past 40 Years: http://www.ec.gc.ca/default.asp?lang=En&n=EEB1B2FF-1&printerversion=true.

- Study results strongly suggest that the larger eels arrive at the spawning site with much higher remaining fat reserves for their gonad production during final maturation, resulting in higher quality and quantity of offspring.
- Successful fertilization was obtained in the bigger eels and no difference between locations was observed.
- Larger and fatter eels have a much higher chance of success to reach the spawning site and when they reach it, they also have a higher percentage of energy stores left for reproduction. Obviously, those eels are the best future genitors for the eel population.

A draft addendum to The Interstate Fishery Management Plan for American Eel, ASMFC, dated October 31, 2005 contains the following information:

- Available data points to decreasing recruitment.
- Available data points to localized declines in abundance.

In 2007, the FWS determined that listing of the American Eel was not warranted. As part of their determination the FWS held two workshops regarding American Eel Great Lakes/Canada threats and Population Dynamics Workshop (FWS in cooperation with NMFS), (expert opinions paraphrased) draft minutes, Jan/Feb 2006:[22]

- Karin Limburg: felt it **could go extinct** on the North American continent;
- Guy Verreault felt it **could go extinct** regionally;
- Catherine Couillard felt there was a **good likelihood of local extinction**, and a spiraling effect could be created to plunge the species into further decline;
- John Casselman felt **local extinctions were already occurring;**
- Bob Graham did not feel extinction was likely but that **local or regional extinction could occur;**
- Ken Oliviera did not believe it could go extinct, but thought that there might be some threshold he does not know about that would change that opinion;
- Pete Hodson thought **local extinctions were a fact** and predicted the Lake Ontario and Saint Lawrence River declines;
- Len Machut felt there was a **good possibility of extinction;**

[22] FWS. 2006. *Draft* Minutes from the American eel status review Workshop 2: Great Lakes/Canada threats and population dynamics. Buffalo, NY, January 31-February 2, 2006.

- Rob Macgregor felt **regional extinctions at the range extremities likely**, they were a grave warning, and we were on track for bigger problems;
- Paul Angermeier did not believe rangewide extinction was imminent but it was approaching some unknown level at which it would be threatened;
- Alastair Mathers felt **local extinctions were likely**, we needed to take action across the range, and the only way to address the decline was to take broader scale action;
- John Dettmers thought the likelihood of extinction throughout the range was low, but that range contraction and **local extinction was high**. He felt we could not rule out the possibility of extinction;
- Joe Hightower felt the possibility of extinction was low; however, he noted particular data indications over time that would change his opinion.

Nevertheless, the FWS determined that listing of the eel for protection under the ESA was "not warranted."

### E. Petition to List

As a result of the data indicating continued population decline, CESAR hereby presents a second petition to the FWS to list the American eel under the ESA. The American eel is currently threatened with extinction due to the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial and recreational purposes, disease and possibly predation, the inadequacy of existing regulatory mechanisms, as well as global warming, and anthropogenic factors related to generation of hydroelectric power and the spread of swim bladder parasites from ship ballast water.

Following is a detailed and specific recitation of the threats to the species.

## II. CRITERIA FOR ENDANGERED SPECIES ACT LISTING

FWS and NMFS are required to determine, based solely on the basis of the best scientific and commercial data available, whether a species is endangered or threatened because of any of the following factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific or educational purposes; (3) disease or predation; (4) the inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence. 16 U.S.C. §§1533(a)(1) and 1533(b).

Petitioners provide evidence below showing that all of these factors are acting in concert to cause the precipitous decline of American eel in the United States of America, thus warranting the species' protection under the ESA.

### A. The Present Or Threatened Destruction, Modification Or Curtailment Of The Species' Habitat And Range

#### 1. Loss Of Habitat Or Range

In their 2007 Final Determination the FWS estimated that the available coastline (including barrier islands) from Maine to Texas (Atlantic and Gulf coasts) is 29,612 km and noted that this extensive range should provide the American eel with a buffer against adverse conditions. However, significant anthropogenic changes within the range have reduced the accessible habitat by percentages perilously close to 100 percent in some places. Access to the Atlantic coastal tributaries has been lost or restricted by 84 percent. Habitat loss is greatest from Maine to Connecticut at 91 percent. States from New York to Virginia have seen stream habitat reduced by 88 percent, and from North Carolina to Florida stream habitat has been reduced by 77 percent.[23] Drainages in the Gulf of Mexico excluding the Mississippi River Basin have seen significant habitat and population reductions.[24] Eels are still found in limited areas in Alabama and Mississippi, however, eels native to much of Texas have been eliminated from most central and western areas of the state. Statewide eel populations have declined drastically on virtually all of Arkansas's major rivers. Also, Eels have been eliminated from large areas of the Missouri Ozarks. Eels have been eliminated from Southern Kansas and only occur sometimes in streams in northeastern and central Kansas.

These reductions in habitat and their causes can have cascading adverse effects on eel populations.

Female American eels spend most of their lives in freshwater habitat along the Atlantic seaboard prior to returning to the Sargasso Sea to spawn. Safe and efficient access to and from their freshwater habitat is essential to the survival of the American eel. Coastal river systems along the Atlantic seaboard are the sole migratory pathways for female American eels to gain access to their required freshwater habitat. While it is possible that some eels spend their entire life cycle in salt water, oceanic research indicates such behavior is rare and virtually nonexistent; catch data from commercial trawling confirms empirically that this is rare. Certainly the marine component is small and at best an unknown and unquantified life strategy which provides little foundation for reliance on it as a basis for sustaining the American eel production.

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[23] Atlantic States Marine Fisheries Commission Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs; Habitat Management Series #9 January 2009; Chapter 10.

[24] NatureServe. 2004. Downloadable animal datasets. NatureServe Central Databases. Available from: www.natureserve.org/getData/dataSets/watershedHucs/index.jsp ([access date:3/19/10] The U.S. Geological Survery and National Park Service are partners with Natureserve.

The ASFMC states:

> *"By region, the potential habitat loss [for American eels] is greatest (91 percent) in the North Atlantic region (Maine to Connecticut) where stream access is estimated to have been reduced from 111,482 kilometers to 10,349 kilometers of stream length. Stream habitat in the Mid Atlantic region (New York through Virginia) is estimated to have been reduced from 199,312 km to 24,534 km of unobstructed stream length (88 percent loss). The stream habitat in the South Atlantic region (North Carolina to Florida) is estimated to have decreased from 246,007 km to 55,872 km of unobstructed stream access, a 77 percent loss".*
>
> *Of 15,570 dams blocking American eel habitat*[25] *in the United States, Busch et al. (1998) reported that 1,100 of these dams are used for hydro-electric power. Virtually none of these 1,100 hydro-electric dams provide, or are required to provide, safe and efficient upstream and downstream passage for American eels to utilize their historic freshwater habitat. Virtually none of the 14,470 non-hydroelectric dams reported by Busch et al. (1998) provide, or are required to provide, safe and efficient upstream and downstream passage for American eels to utilize their historic freshwater habitat.*

The Maryland Department of Natural Resources, MBSS Newsletter March 1999, Volume 6, Number 1 states:

> *"The most dramatic example of the decline of American eel abundance is dam construction on the Susquehanna River. Prior to the completion of Conowingo and three other mainstem dams in the 1920's, eels were common throughout the Susquehanna basin and were popular with anglers. To estimate the number of eels lost as a result of construction of Conowingo Dam, we used MBSS data on American eels from the Lower Susquehanna basin and extrapolated it to the rest of the basin above the dam. Our best conservative guess is that there are on the order of 11 million fewer eels in the Susquehanna basin today than in the 1920s.*
>
> *"The magnitude of this loss is corroborated by the decline in the eel weir fishery in the Pennsylvania portion of the Susquehanna River. Before the mainstem dams were constructed, the annual harvest of eels in the river was nearly 1 million pounds. Since then, the annual harvest has been zero. Given the longevity of eels in streams (up to 20 years or more) and their large size, the loss of this species from streams above Conowingo Dam represents a significant ecosystem-level impact. Because adult eels migrate to the Sargasso Sea to spawn and die -- transporting their accumulated biomass*

[25] Some argue that this is a conservative estimate. K. Limburg pers comm.

> *and nutrient load out of Chesapeake Bay -- the loss of eels has increased nutrient loads in the basin and reduced them in the open ocean where they are more appreciated."*

The number of juvenile eels counted annually at the Conowingo Dam on the Susquehanna River has declined from a peak of 126,543 in 1974 to nearly zero in recent years (ASMFC 2000). At the November 18, 2002 meeting of the ASMFC Eel Management Board, Mr. Richard Snyder, ASMFC representative for Pennsylvania, stated: "No American eels really pass the Conowingo Fish Lift, based on the annual samplings there lately."

Dohne (2004) states:

> *"As for elvers, the local evidence is equally thin but just as bleak. At York Haven's dam -- whose fish ladder is the only one on the lower Susquehanna to specifically monitor eel traffic -- no elvers appeared during this spring's shad run (April through mid-June)."*

A recently published work by the American Fisheries Society 'Eels at the Edge' (2009) is a compilation of papers addressing the plight of the American eel. [26] Papers included in the volume address overfishing in the Chesapeake Bay. The papers document that this area, once considered one of the biggest eel producers along the Atlantic Seaboard, may now depend on recruitment from areas where fishing mortality is low.

Dams limit the amount of habitat available to eels and disproportionately eliminate larger more fecund females prior to spawning. This particular type of habitat reduction and limitation logically leads to reduced eel productivity and abundance.

NatureServe catalogues the incidence and effects of dams in specific geographic regions of the United States: [27]

| **Geographic Area** | |
|---|---|
| Atlantic coastal streams from Maine to Florida | 15,115 dams that can hinder or prevent upstream and downstream fish movement.<br><br>Loss of access to 84 percent of the stream habitat.<br><br>A reduction from 556,801 kilometers to 90,755 kilometers of stream habitat available.<br><br>Only 7 percent of these dams are covered by regulatory programs that could provide fish passage. |

[26] Eels at the edge : science, status, and conservation concerns edited by John M. Casselman and David K. Cairns. Published Bethesda, Md. : American Fisheries Society, 2009.
[27] NatureServe. 2004. Downloadable animal datasets. NatureServe Central Databases. Available from: www.natureserve.org/getData/dataSets/watershedHucs/index.jsp {[access date:3/19/10]; The U.S. Geological Survery and National Park Service are partners with Natureserve.

| | |
|---|---|
| Eastern Canada | Obstruction by hydroelectric dams may contribute to reduced eel abundance (Jessop 2000). Silver eel declines in the St. Lawrence River basin may be due to escapement reductions from upper St. Lawrence dams and water flow control, rather than fisheries (Richkus and Whalen 1999). In Canadian lakes, Smith and Saunders (1955) found smaller standing stocks of eels in lakes that were farther from the ocean and that had obstructions such as dams, falls, and lakes. |
| New Brunswick | Impoundment of the upper estuary of the Petitcodiac River resulted in reduced abundance of American eels (Locke et al. 2003). |
| New York | The U.S. Geological Survey examined historic records and literature and compared the information with recent fisheries surveys contained in the Statewide Fisheries Database and other sources. Results indicate dramatically reduced numbers of eels statewide. Eel are thought to be extirpated from the New York portions of the Susquehanna watershed.[28] |
| Maine | Within a year after the removal of Edwards Dam on the Kennebec River, large numbers of American eels were observed in upstream habitats that had been inaccessible for more than 150 years (O'Donnell et al. 2001). |
| Rhode Island | In Rhode Island, eels were commonly collected throughout the state but were not well represented in the upper reaches of the Blackstone and Pawtuxet River watersheds, undoubtedly due to the many dams that impede upstream migration (Libby 2004). |
| Connecticut | Eel densities are much lower in headwater regions of streams that have many, or high, dams or falls. Movement upstream appears to be affected by both the number and height of obstructions (Levesque and Whitworth 1987, Whitworth 1996, Hagstrom et al. 1996). |
| Pennsylvania | American eel passage has been blocked for many years on the Susquehanna River by four large hydroelectric projects on the lower river (Conowingo, Holtwood, Safe Harbor, and York Haven). Fish passage facilities designed for American shad were installed in each of these facilities within the past 15 years, but eel passage may be limited. No eels were passed at |

[28] State of New York, Department of Environmental Conservation, Bureau of Fisheries 2008-2009 Annual Report.

| | |
|---|---|
| | these fishways in 2005.<br><br>In the Delaware River basin, elvers use fishways at the Easton, Chain, and Hamilton Street dams, but quantification of eel passage is not possible.<br><br>Cementon Dam, upstream of the Hamilton Street Dam, lacks a fishway, but at least some elvers successfully pass this dam.<br><br>The Schuylkill River, a major tributary of the Delaware River in Pennsylvania, has nine dams, some of which have fish passage facilities, are breached or partially breached, or are scheduled for fishway installation within the next few years.<br><br>A dam upstream of the Felix Dam was exposed when the Felix Dam was breached and is currently an impediment to fish passage.<br><br>There are no plans to remove the two uppermost dams (New Kernsville and Auburn) on the Schuylkill River. Some eels pass the dams downstream of New Kernsville, but the efficiency of passage is unknown. |
| Maryland | More than 1,000 human-made barriers to migratory fish (Leasner, DNR, pers. comm.) reduce access of American eels and other fishes to their historical habitats.<br><br>Stream survey data suggest that mainstem dams have been a major factor in this decline by blocking the upstream migration of juvenile eels. |
| South Carolina | Populations of diadromous fishes (eels are diadromous) in the Santee-Cooper Basin are significantly depressed relative to historical levels, primarily as a result of the more than 50 dams in the basin. |
| Mississippi | Upstream movement of eels could be impeded by dams. |
| Alabama | Dams on major rivers impede eel progress to far upstream reaches. |
| Kansas | Much formerly occupied habitat is now inaccessible as a result of dams and flow diversions. |
| Iowa | Construction of impassable flood control dams on the Des Moines, Iowa, and Chariton Rivers undoubtedly has restricted the migration of eels in these drainages. |

## 2. Overutilization For Commercial, Recreational, Scientific Or Educational Purposes

### a) Commercial

American eels are commercially harvested at all of their life stages except the larval state. They are harvested in all of their habitats as well; freshwater lakes and rivers, estuaries, the Atlantic Ocean, the Gulf of Mexico and the Caribbean Sea. Commercial American eel fisheries are found from Maine to the Gulf of Mexico as well as inland in every state of their range excepting Alabama and Mississippi. Eels have been largely extirpated from the Mississippi Basin although they were once found in substantial numbers throughout the drainage.[29] Commercial fisheries for glass eels, elvers, silver and yellow exist in Asia and Europe, Mexico, Cuba and the Dominican Republic. Eels are variously harvested for aquaculture, bait and food.

It is undisputed that overutilization of American eel is now occurring across the species' range in the United States of America. ASMFC (2000) states: "Harvest pressure and habitat loss are listed as the primary causes of decline in abundance of American eel (Castonguay et al. 1994a and 1994b). Several factors contribute to the risk that heavy harvest may adversely affect eel populations: (1) American eels mature slowly, requiring 7 to 30+ years to attain sexual maturity; (2) glass eel aggregate seasonally to migrate; (3) yellow eel harvest is cumulative stress, over multiple years, on the same year class; and (4) all eel mortality is pre-spawning mortality.

ASMFC (2000) further states: "Since the fishery's peak in the mid 1970s at 3.5 million pounds, commercial landings have declined significantly to a near record low of 868,215 pounds in 2001. Recreational data concerning eel harvest appears to indicate a decline in abundance. According to the NMFS Marine Recreational Fisheries Statistics Survey, recreational harvest in 2001 was 10,805 eel, a significant decrease from the peak of 106,968 eel in 1982."

Geer (2004) states: "U.S. landings on the Atlantic Coast are down about 64 percent of the long-term average back to 1950, almost 44 percent below the 20-year average and about 30 percent below the five year average. This is based on 2002 landings reports."

In its 2008 Addendum II the ASMFC chronicles the continued decline of the American Eel.[30] The Commission notes that American eels continue to support both recreational and important commercial fisheries throughout their range and fisheries are executed in rivers, estuaries, and the ocean.

The addendum states that commercial glass eel harvest is legal in Maine and South Carolina, although reported landings are minimal in South Carolina. Yellow and silver eel fisheries exist in all states and jurisdictions with the exception of Pennsylvania and the District of Columbia. South Carolina and Georgia recorded no commercial yellow or silver eel landings in 2007.

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[29] MacGregor et.al. 2008.
[30] Atlantic States Marine Fisheries Commission ADDENDUM II TO THE FISHERY MANAGEMENT PLAN FOR AMERICAN EEL Approved October 23, 2008.

The addendum also records a decline in commercial landings from a high of 1.8 million pounds in 1985 to a low of 641,000 pounds in 2002. Landings of yellow and silver eel in 2007 totaled 834,500 pounds.[31] New Jersey and Delaware and Maryland account for 73 percent of the coast-wide commercial landings. Each state reported landings of over 100,000 pounds of eel and Maryland reported landings of over 300,000 pounds in 2007.

Massachusetts, Pennsylvania, Georgia, Florida, and the District of Columbia were granted *de minimis* status for the 2007 commercial fishing year. *De minimis* is approved if a member states' commercial landings of yellow and silver eel for the previous year are less than 1 percent of the coast-wide landings for the same year.

Records of the ASMFC show the Commission has failed to undertake protective measures for the remaining American eels living along the Atlantic seaboard of the United States; nor has the ASMFC taken any action to restrict or prohibit the ongoing harvest of American eels along the Atlantic Seaboard during the past five years as they wait to confirm these already obvious declines in abundance.

#### b) Recreational

The addendum notes that few recreational anglers directly target eels and most landings are incidental when anglers are fishing for other species. There is a commercial fishery for human consumption of eels, but there is also a commercial fishery for eels that are used and sold as bait for larger sport fish such as striped bass. Finally, some recreational fishermen may catch their own eels to utilize as bait.

This petition presents new information, not available at the time of the 2007 Final Determination which documents continued widespread population decline, and little information that shows any reverse in this decline. We believe this new information is substantial and coupled with the information already before the FWS, warrants a 12-month status review.

### 3. Disease Or Predation

#### a) Threats To The American Eel From The Swim Bladder Parasite: *Anguillicola Crassus*

The spread of the swim bladder parasite Anguillicola crassus to American and European eels can be attributed to an expanding eel trade between East Asian countries, Europe, and the U.S. in the 1980s, as well as eel aquaculture (Kirk 2003). Similar to other epizootics that have had severe consequences for new host species, American and European eels were immunologically naïve, allowing this parasite to quickly colonize populations of new hosts.

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[31] Harvest data for 2007 comes from the 2008 State Compliance Reports. The landings are preliminary and some are incomplete.

It is recognized that several factors contributed to the decline of the American eel, including: dams, hydro-electric turbines, habitat modification, commercial and recreational fishing, and oceanic changes (Castonguay et al. 1994, Haro et al. 2000, Casselman 2003, Friedland et al. 2007). However, the recent introduction of *A. crassus* into North American eel populations is a threat that was not fully appreciated until the last several years. In its 2007 final listing determination the FWS noted that:

> *"We remain cautious in extrapolation of these preliminary laboratory studies with regard to rangewide implications given the absence of evidence for population-level effects, such as reduced recruitment of glass eels (which would be an indicator of decreased outmigration survival). This being said, we acknowledge the statement by the International Council for the Exploration of the Sea (ICES 2001, p. 6) that due to the fairly recent invasion of the U.S. by A. crassus and the long-lived nature of at least a portion of the American eel population, the impact of A. crassus on American eel may not yet have been fully realized."*

The following paragraphs provide additional information that was not considered by the FWS in its 2007 Final Determination.

**b) The threat of *A. crassus* is spreading**

A study by Aieta and Oliveira (2009) sampled yellow phase American eels from 38 locations, ranging from Rhode Island's Pawcatuck River in the south, to the St. Lawrence River and Newfoundland in the north, in the years 2005-2007. The swim bladder parasite A. crassus was found in all locations within New England, with infection rates of 7 to 76 percent per location. Locations in New Brunswick and northern Nova Scotia which had infected eels had rates of infection ranging from 3 to 30 percent. No infected eels were found in Southern Nova Scotia or the St. Lawrence River. The authors therefore reported that there was no significant correlation of the parasite with latitude. This suggests that there may be more than one transport mechanism for the parasites. The authors also concluded that it was only a matter of time before the parasite reached the St. Lawrence River system. A similar study (Rockwell et al. 2009) found additional infestations on Cape Breton Island, Nova Scotia; more than half of the eels sampled in the Mira River were infested with the parasite.

**c) The extent of damage to American eels caused by *A. crassus* parasitism was previously unrealized**

It was not until 2006 that the results of the first pathogenesis study of A. crassus infections in wild American eels was reported (Sokolowski and Dove 2006). That study documented the seriousness of Anguillicola crassus infestations in American eels:

> *"All of the examined American eels showed gross signs of previous or ongoing infections with A. crassus; the normally translucent swim bladder appeared opaque and blood vessels were dilated. When present, A. crassus worms were visible in the lumen of the*

> *swim bladder; in one case, A. crassus eggs and L2 larvae were associated with a blood-filled swim bladder. Histologically, the swim bladders of infected eels showed focal, multifocal, and diffuse changes, including abnormal papillose appearance of the mucosa; hyperplasia of the lamina propria, muscularis mucosa, and submucosa; edema of the mucosa and muscularis mucosa; dilation of the blood vessels in the lamina propria; L2 larvae in the lumen of the swim bladder (Figure 4); and damage in the submucosa attributable to migrating L3 and L4 larvae (Figures 2, 3). Pathologies included fibrosis or lymphocytic infiltration (or both) around L3 and L4 larvae in the submucosa (Figure 3); destruction of the mucosa, which in some cases completely exposed the mucosal blood vessels (Figure 4); L2 larval penetration of the tissues of the swim bladder and bacterial infections in the submucosa (Figure 5) and muscularis mucosa (Figure 6); and migration of an L4 larva through the rete mirabile (Figure 7). In one case, the submucosa was infiltrated with an adult worm and L2 larvae. In two American eels, a total of three A. crassus L3 larvae were found free in the intestine."*

In a 2004 letter to the journal *Science*, Sures and Knopf (2004) raised the worldwide alarm that *A. crassus* is an unappreciated threat to eels on both sides of the Atlantic ocean. This is due to the fact that they inhibit the ability of eels to reach spawning grounds in the Sargasso Sea:

> *"The parasites migrate into the swim bladder and suck the eel's blood. Pathological effects include thickening, inflammation, fibrosis, and changes in the epithelial cells of the swim bladder wall (6), as well as alterations of the gas secretion into the swim bladder (7). In severe cases, pathologic alterations even lead to a complete loss of the swim bladder lumen, or the lumen becomes totally filled with worms (see figure). From these massive alterations of the swim bladder, one may expect a loss of its function. Although eels are benthic when living in freshwater habitats, a functional hydrostatic organ is essential for their spawning migration through the Atlantic, where eels perform diurnal vertical migrations ranging between 40 to 600 m (8). Thus, eels with a damaged swim bladder are unlikely to reach their spawning grounds in the Sargasso Sea. "It is clear that A. crassus was not the initial reason for this negative trend, because the decline of European eel fry began before the parasites' appearance in Europe. However, A. crassus may now be contributing to the rapidly decreasing numbers of the Atlantic freshwater eels and may be a crucial factor among an array of threats."*

Clearly, the cumulative effects of *A. crassus* parasitism in combination with injury from hydroelectric turbines, accumulation of contaminants, and low fat stores, further lowers the ability of American eels to successfully reach their spawning grounds and reproduce. When coupled with the take of reproductive aged silver eels by commercial fisheries and recreational fisheries (who frequently waste this resource by using them for fishing bait), and mortality when passing hydroelectric dams (>50 percent mortality per dam[32]), it is reasonable to conclude that fewer American eels are reaching their spawning grounds in the Sargasso Sea than ever before.

**d) Experimental evidence shows that parasitism by *A. crassus* makes eels more vulnerable to mortality from hypoxia**

Experiments conducted by Gollock et al. (2005) tested the hypotheses that eels infected with *A. crassus* would be vulnerable to mortality when exposed to hypoxic conditions, and that an increased oxygen demand due to parasitism would alter their physiological response to hypoxic stress. Their results were consistent with the hypotheses: parasitism by *A. crassus* exacerbated the corticosteroid stress response associated with exposure to severe hypoxia. Their hypothesis was also consistent with field observations of eels parasitized by *A. crassus* in lakes in eastern Europe. The eels suffered high mortalities while living in alternating conditions of nighttime hypoxia and higher than normal daytime water temperatures (28°C). These experimental results and field observations led the authors to conclude that parasitism by *A. crassus* increases an eel's *"exposure to the compounding effects of sequential periods of high temperatures during the day and hypoxia during darkness [when photosynthesis from phytoplankton ceases] and will be more stressful and could ultimately result in mortalities." Thus, eels infected with A. crassus fare poorly in hypoxic conditions and appear to suffer high mortalities* when additional stressors are added. Such experiments have not been conducted on American eels; however, because American and European eels are closely related and have similar life histories, the same cause and effect mechanisms can be expected to affect their physiology.

**e) Experimental evidence shows that parasitism by *A. crassus* can lead to failure of migrating eels to reach their spawning area, and compromise the reproduction of those eels that do reach their spawning area**

The hypothesis that eels burdened with *A. crassus* infections could be experiencing migratory failure was experimentally tested by Palstra et al. (2007a). These authors used experimental data to test the hypotheses that: 1) parasitic sanguivorous *activities* – related to parasite weight – reduce swimming endurance; and 2) mechanical damage of the swim bladder impairs buoyancy control. The experiment consisted of placing eighty silver eels suffering various degrees of infection into swim-tunnels designed to simulate long-distance migration and measuring their swimming capacity, performance, and physiological parameters. The authors reported:

> *"Infected eels had lower cruising speeds and a higher cost of transport. Eels without parasites, but with a damaged swim-bladder, showed similar effects. Almost half of the eels that contained damaged swim-bladders (43 percent)*

[32] On the downstream journey, eels may have to pass through turbines at hydroelectric dams. Mortality may be 50% or more for some types of turbines, with 80-100% being injured (Haro et al. 2003).

> *stopped swimming at low aerobic swimming speeds (<0.7 m/s). Simulated migration trials in a recent related study* [(Palstra et al. 2007b)] *have confirmed that eels with a high parasite level or damaged swim-bladder show early migration failure (<1000-km)."*

In other words, the eels with high parasite levels or damaged swim bladders simply do not have the endurance or ability to complete their migration. In the wild, eels with heavy parasite loads or damaged swim bladders will spend more energy on migration, leaving less fat for egg or sperm production.

It was previously recognized that eels migrated at varying depths (Tesch 1999). The importance of swim bladder function to migrating and spawning eels, however, was underscored by the first live captures of pre-spawning eels at spawning grounds by Chow et al. (2009) These authors captured giant mottled eels (*A. marmorata*) and two Japanese eels (*A. japonica*) approximately 130 km south of the Suruga Seamount using trawl nets at depths >230m. Without a functioning swim bladder, such as those damaged by *A. crassus*, eels cannot make vertical migrations into or out of such depths.

An additional discovery from these eels - that is relevant to understanding the energetic requirements for reproduction of American eels - is the tremendous energetic investment that eels make in reproductive tissues. The gonad-somatic index (relative weight of gonad to body weight) in one of the *A. japonica* eels captured by Chow et al (2009) was 18.8 percent, and an *A. marmorata* eel specimen had a gonad-somatic index of 13.4 percent. These are much higher percentages than those typically found in wild male silver-stage eels from coastal areas (~1.0 percent). These observations show that there is a tremendous investment in reproductive tissues prior to spawning and that fat reserves are essential for high fecundity.

In their paper titled *"Decreasing eel stocks: survival of the fattest?"* Belpaire et al. (2009) used data on fat reserves in eels (from wild-caught eels) to model (based on previous data from swim tank endurance tests) the conditions under which migration and spawning could be completed by European eels. They reported that eels from Belgium and the Netherlands sampled from 1975 to 2005 had reduced fat content (approximately one third less), and thus had a reduced chance of completing their migration *and* having adequate reserves available for spawning. Although American eels have approximately half the distance to migrate to the Sargasso Sea than their European counterparts, similar energetic constraints could prevent them from reaching their spawning grounds or from being in strong enough condition upon arrival to spawn.

**f) The cumulative effects of *A. crassus* parasitism and other factors will lead to such lost density in spawning areas that eels will be unable to reproduce**

The probability of American eels finding a mate under conditions of low recruitment, increased migratory failure, and a skewing of the sex ratio towards males (discussed elsewhere) leads inevitably to the conclusion that eels swimming in the vast Sargasso Sea will have increasing difficulty finding mates. This "Allee effect" will further drive down productivity and edge the species closer to extinction (Allee 1931). This same mechanism has been recently invoked in the extinction risk of the polar bear (Molnár et al. 2008).

### 4. Inadequacy Of Existing Regulatory Mechanisms

In the document, Status of Fishery Resources off the Northeastern U.S. NEFSC - Resource Evaluation and Assessment Division Dec 2006, the authors state: *"A preliminary analysis of the suite of indices indicates a strong downward trend in abundance (ASMFC 2006a and 2006b); however an analytical assessment of Atlantic coast eel stocks has not been completed."*[33] Three years later, such a stock assessment still has not been completed.

Similarly, the U.S. Fish and Wildlife Service Strategic Plan Fiscal Year 2007 to 2011 Region 5 - only suggests limited actions such as a *"focus on restoration of diadromous fish passage through dam removal, or installation of fish passage structures."* Little is offered in the way of a detailed plan, proposed budget, or biological means of measuring the effectiveness of results relative to increasing eel numbers.

NMFS gives scant mention to the American eel in its recent and influential policy document: Our Living Oceans: Habitat. Status of the Habitat of U.S. Living Marine Resources. Policymakers' Summary (NMFS 2009). Below is all the mention of eels in this document, with no specific mention of the American eel, the only catadromous fish in the United States:

> ***Habitat Impacts***
>
> *"Dams fragment river habitats and present impediments to catadromous fishes such as eels (which spawn in the ocean and grow to maturity in fresh water) and anadromous fishes such as salmon, sturgeon, striped bass, shad, and river herring (Roni, 2005; NMFS, 2008). Dams also change upstream habitat by creating reservoirs that slow water velocities and alter temperatures. Reduced freshwater flows resulting from water removals for domestic and commercial use can affect river and downstream estuarine habitats as well. Altering natural flows and the processes associated with flow rates (such as nutrient and sediment transport) impact in-stream habitats, shoreline riparian habitats, and prey bases. Water quality may also be reduced from water withdrawals: temperature, salinity, and concentrations of toxic chemicals all increase as water volumes shrink; dissolved oxygen decreases; and pathogens may be introduced.*
>
> *Changes to stream beds and banks and streamside vegetation can have major impacts on adjacent aquatic habitats. Hydrologic characteristics such as temperature and*

[33] http://www.nefsc.noaa.gov/sos/spsyn/op/eel/index.html.

*dissolved oxygen can be altered, and habitat complexity can be reduced by lowering the availability of large woody debris. Changing flow and channel structure, increasing stream bank instability and erosion, and altering nutrient and prey sources also degrade riverine habitat.*

***Impacts To Living Marine Resources***

*By blocking upstream access for migrating species, dams greatly reduce the amount of habitat available for spawning, feeding, growth, and migration. Adequate freshwater flow is critical to all life stages, from eggs to spawning adults, so reduced flow can have a negative effect on anadromous and catadromous fish populations. As an example, a drought extending from 2001 through 2005 in the Klamath River basin of California and Oregon, combined with above-average withdrawals for agricultural use during the drought, allowed for the proliferation of endemic diseases, causing large fish kills. As a result, the Klamath River Chinook salmon stock fell below conservation objectives. This triggered the declaration of a commercial fishery failure by the Secretary of Commerce in 2006, which authorized a total of $60.4 million for distribution to eligible participants in the West Coast salmon fishery (DOC, 2006)."*

There has been little in the way of systematic effort to alleviate the threat of dams to eels despite the documented benefits of dam removal to eels and other native fish (Conyngham et al. 2006). An additional problem is that the actual number of structures is greatly under-reported.

**a) Regulation Promulgated Through The Atlantic States Marine Fisheries Commission Has Failed To Protect The American Eel From Decline**

The "mission" of the 16 state ASMFC is: *"To promote the better utilization of the fisheries, marine, shell and anadromous, of the Atlantic seaboard by the development of a joint program for the promotion and protection of such fisheries, and by the prevention of physical waste of the fisheries from any cause."* And while the stated "vision" of the ASMFC is to promote: *"Healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration well in progress by the year 2015,"* this agency has a consumptive mission and has been in constant denial of the indicators of decline. For example, it is well known that freshwater habitat for the American eel has been adversely modified in many ways by human actions, yet the ASMFC (2009) persists in its optimism. In their summary on Present Conditions of Habitat and Habitat Areas of Particular Concern for American Eel they state: *"Much of American eel habitat has not been quantified."* And, *"Fortunately, American eel are habitat generalists, and therefore may be somewhat resilient to impacts on habitat availability."*

ASMFC's regulation and reporting on eel landings are also clearly inadequate to regulate eel harvest. The Monterey Bay Aquarium's program, "Seafood Watch" reported in 2007 (Halpin 2007) that *"Export data from the U.S. underscore the unreliability of capture data for eels. As* *mentioned above it has been estimated that reported landings of European eels within the EU are 50 percent of true landings. It appears that a similar problem occurs within the US, as exports of eels greatly exceed domestic landings. Looking only at fresh and frozen eels, exports have exceeded reported landings by as much as 2,760 mt (949 percent) (Figure 16).The lumping of multiple eel and eel-like species is not enough to explain discrepancy."* Seafood Watch urges consumers to avoid eel consumption.

The stock status of American eels is currently classified as *"Unknown"* and a contributing factor to this apparent lack of information is the fact that the 2005 ASMFC Stock Assessment *failed peer review*. However, the Peer Review Panel on that report concurred that yellow eel abundance was at an historic low. The fact that the ASMFC can state that the status of the stock is unknown in the face of declines of up to 4 orders of magnitude in a panmictic population is incredible. The next benchmark assessment has been scheduled for late 2010, although there are numerous indicators that eel abundance is declining and that threats to the American eel are not abating.

The ASMFC has done little over the past decade effectively to reverse the declines in eel recruitment, halt commercial and commercial take of American eels for recreational use as bait, or implement consistent methods to accurately assess their population size (ASMFC 2008; Taylor et al. 2008). The data reporting in the U.S. contrasts sharply with that in Canada (Cairns et al. 2008). In June of 2008, Table C of the NMFS - Status of U.S. Fisheries, listed the American eel as within the Jurisdiction of the ASMFC and summarized stock status as "unknown" for the following categories: 1) "Overfishing? (Is Fishing Mortality above Threshold?), 2); "Overfished? (Is Biomass below Threshold?)"; and 3) "Approaching Overfished Condition?" The Revised September 2009 ASMFC Stock Status Overview also lists the species status and trends as "unknown" and their stock status and rebuilding schedule as *"No rebuilding schedule."* It is unconscionable that a resource agency charged with regulatory responsibility for a resource could exist in near total ignorance of the status of that resource for *decades*. And yet, when faced with quantitative evidence that the species is in decline, this agency continues to claim that its status is "unknown" and continues to oversee the harvest of silver eels that are necessary to replenish the stocks (ASMFC 2008). This is why it is imperative that the inadequate regulatory authority of the ASMFC yield to the primacy of federal law under the ESA to prevent this species from becoming endangered in the reasonably foreseeable future.

### b) International Experts On The American Eel Concur On The Inadequacy Of Current Regulatory Mechanisms To Protect This Species

The conclusions of a bi-national team of experts on the American eel have further detailed the inadequacy of current regulatory mechanisms in the United States and Canada to halt the decline (MacGregor et al. 2008):

> *"Management actions aimed at protecting American eel and European eel have largely been unsuccessful in halting declines and rebuilding stocks as, until*

> *recently, actions have not been well coordinated at the appropriate scale in recognition of the unique life cycle of these species."*

The primary reasons for failure of the FWS to list the eel as threatened or endangered under the ESA were also noted by MacGregor et al. (2008):

> *"In the meantime, the FWS has determined that listing American eel as threatened or endangered is not warranted (Federal Register 2007). The finding was constrained by the need to demonstrate that American eel is in danger of extirpation within a significant component of its range, or likely to become an endangered species within the foreseeable future. Because of a lack of scientific information relating to population-level status of American eel and the best genetic information that the species is panmictic, the FWS concluded that range-wide persistence of American eel was not in doubt. The finding appeared to rely heavily on information suggesting that some American eel complete their life cycle in marine environments and on two short-term data series relating to glass eel abundance. The finding placed less emphasis on longer-term data series that illustrated declining trends in abundance of yellow and silver American eel. Unlike the Species at Risk Act in Canada, the Endangered Species Act does not provide for designation and protection measure for species of special concern.*
>
> *It is not within the scope of this paper to comment substantially on the official designation of American eel under species at risk legislation; however, we are compelled to comment that (1) numerous data series suggest American eel is in decline in significant components of its range, (2) substantial habitat has been lost, (3) numerous and significant sources of anthropogenic mortalities exist for American eel, and (4) American eel is semelparous with late onset of maturity, particularly for the northern, more fecund segment of the population. Numerous threats have been identified, and their cumulative effects were not addressed in detail within the 12-month finding, but they apparently have been substantial. The precipitous (99%) loss of recruitment to Lake Ontario and the Susquehanna River, the major declines in silver American eel landings in Québec fisheries, the fact that yellow American eel are at or near historic lows within the ASMFC jurisdictions, and the 50% decline in the Chesapeake Bay VIMS index all point to significant cause for concern, regardless of designation as a species at risk. The lack of designation under the Endangered Species Act should not be perceived as a reason for inaction. Waiting to take appropriate action until a species is threatened with extinction is not in the best interests of agencies, ecosystems, or stakeholders. Strong, coordinated management actions are required to reverse the decline in American eel, actions that include habitat as well as fisheries management. Managers must also be mindful of the parallels between the experiences managing European eel and those of American eel. We certainly do not wish to be faced with the even more dire circumstances of European eel (ICES 2006; Dekker 2008, this volume)."*

Despite this call to action, regulatory mechanisms remain wholly inadequate to reverse the decline of the American eel.

Contrary to the positive forecasts promoted by the FWS 2007 Final Determination in their single-author, qualitative "analysis," the risk of endangerment and extinction facing the American eel and other eel species is real and has been clearly recognized by the top scientists in the eel research community for years. In 2003, the *Québec Declaration of Concern* was signed at the International Eel Symposium of the American Fisheries Society. It stated:

> *"The steep decline in populations of eels (Anguilla spp.) endangers the immediate future of these legendary fish. With less than 1% of major juvenile resources remaining, precautionary action must be taken immediately to sustain the stocks."*

This declaration underscores the inadequacy of regulatory mechanisms that have clearly failed to reverse this decline over the past two decades:

> *"As scientists in eel biology from 18 countries assembled at the International Eel Symposium ... we unanimously agree that we must raise an urgent alarm now. With less than 1% of juvenile resources remaining for major populations, time is running out. Precautionary action (e.g., curtailing exploitation, safeguarding migration routes and wetlands, improving access to lost habitats) can and must be taken immediately by all parties involved and, if necessary, independently of each other. Otherwise, opportunities to protect these species and study their biology and the cause of their decline will fade along with the stocks."*

This declaration (AFS 2009) was signed by eel scientists representing Aboriginal Nations, Belgium, Canada, Denmark, France, Germany, Great Lakes Fishery Commission, Ireland, Italy, Japan, Korea, Morocco, Netherlands, New Zealand, Sweden, Taiwan, United Kingdom, and the United States. It appears as the final chapter of the 2009 publication "Eels at the Edge" (American Fisheries Society 2009).

There are currently no regulatory mechanisms in the United States of America which adequately protect the American eel from extinction.

In its Addendum II, the ASMFC stated: "While the status of the American eel stock is uncertain, the latest stock assessment information indicates that the abundance of yellow eel (a juvenile life stage) has declined in the last two decades and the stock is at or near low levels. Further, relative abundance is likely to continue to decline unless mortality decreases and recruitment increases."

The Addendum then went on to state in the wake of the FWS 2007 Final Determination that listing of the American Eel was 'not warranted':

*"The primary objective of this document is to recommend stronger regulatory language to improve upstream and downstream passage of American eel to state and federal regulatory agencies."*

**c) The United States Fish and Wildlife Service (FWS)**

Pursuant to Section 18 of the Federal Power Act[34] ("FPA"), the FWS has the legal authority to require the licensees of private hydro-electric dams to provide safe and efficient upstream and downstream passage for American eels at hydro-electric dams in the historic range of American eel in the United States.

To date, the FWS has declined to exercise this legal authority in order to conserve the remaining American eels of the Atlantic seaboard of the United States of America. Instead, using weak inferences in their 2007 Final Determination to find that the eel's listing was 'not warranted'.

**d) The National Marine Fisheries Service (NMFS)**

Pursuant to the FPA the NMFS has the legal authority to require the licensees of private hydro-electric dams to provide safe and efficient upstream and downstream passage for American eel at hydro-electric dams in its historic range.

To date, NMFS has declined to exercise this legal authority in order to conserve the remaining American eels of the Atlantic seaboard.

**e) The Federal Energy Regulatory Commission (FERC)**

Pursuant to The FPA, FERC has the legal authority to require licensees of private hydro-electric dams to provide safe and efficient upstream and downstream passage for American eels in the historic range of American eel in the United States.

To date, FERC has declined to exercise this legal authority in order to conserve the remaining American eel stocks of the Atlantic seaboard of the United States.

**f) The United States Environmental Protection Agency (EPA)**

Pursuant to the federal Clean Water Act ("CWA"), [35] the EPA has the legal authority to require the licensees of private hydro-electric dams to provide safe and efficient upstream and downstream passage for American eels at hydro-electric dams to allow these waters to meet their designated uses for fishing and habitat for aquatic species as required under the CWA. Further, the CWA provides the authority to regulate the disposition of ballast water. To date,

[34] 16 U.S.C. § 797(e).
[35] 33 U.S.C.§§1251 *et seq.*

the EPA has declined to exercise this legal authority in order to conserve the remaining American eels of the Atlantic seaboard.

**g) The Spread Of *A. Crassus* Is Due To Inadequate Regulation Of Ship Ballast Water Discharge.**

Numerous authors, as well as panelists in the 2004 FWS sponsored workshop, pointed out that ballast water of ships is the most likely mechanism for the rapid spread of the parasite from one location to another, through the dispersal of its intermediate hosts. This hypothesis is consistent with observations that busy deep water ports receiving empty ships (therefore laden with ballast waster), such as Boston Harbor and Hudson River, had some of the highest prevalence rates (76 percent and 60 percent respectively), while the parasite either did not occur or was at low prevalence in some coastal locations that had little or no shipping traffic (Morrison and Secor 2003; Rockwell et al. 2009). In infested areas, the frequency of infected eels, and the average number of *A. crassus* within their swim bladders, has been increasing (FWS Workshop 2004; Machut and Limburg 2008).

Ballast water is used to ensure the stability of ships when transiting the ocean with less than a full load, and is discharged in ports of call during the process of loading and unloading cargo (Bright,1998). The ability of thousands of invasive species of zooplankton, copepods, clams, and other invertebrates to invade new locations is made possible through the discharge of ship ballast water (Mooney and Hobbs 2000). Ballast water containing invasive species from riverine or coastal waters is regularly transported around the globe through international shipping. The further transport of invasive species along coastlines and inland waterways can occur through discharge from smaller commercial and recreational vessels, or aquaculture. The spread of zebra mussels is an excellent example of this ongoing problem.

A 2005 report by the Congressional Research Service (Buck 2005) documented extensively the inadequacy of regulations controlling invasive species transported in ballast water. The ongoing threat of parasites carried in the ballast water of ships was not mentioned anywhere in the 2007 Final Determination to not list the American eel.

**h) Atlantic States Marine Fisheries Commission (ASMFC).**

Pursuant to the federal Magnuson-Stevens Fisheries Conservation Act, the ASMFC has the legal authority to limit or prohibit the harvest of American eel along the Atlantic seaboard of the United States. To date, the ASMFC has declined to exercise this legal authority.

On March 10, 2004 the American Eel Management Board of ASMFC issued a press release recommending the protection of American eels under the ESA. The statement reads in part:

> *"Canadian and U.S. data show 2003 commercial landings are the lowest on record since 1945 and there are indications of localized recruitment failure in the Lake Ontario/St.*

*Lawrence River system. The International Eel Symposium at the 2003 American Fisheries Society Annual Meeting reported a worldwide decline of eel populations, including the Atlantic coast stock of American eel ... The Commission also recommended that the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) consider American eel in the Lake Ontario/St. Lawrence River/Lake Champlain/Richelieu River system as a candidate for listing as a Distinct Population Segment under the Endangered Species Act. The Board also recommended that the FWS and NMFS consider designating the entire coastwide stock as a candidate for listing under the ESA."*

Despite this statement in March 2004, ASMFC has not reduced or prohibited the ongoing harvest of all life stages of American eel from the waters of the Atlantic seaboard.

**5. Other Natural Or Manmade Factors Affecting Its Continued Existence**

**a) Anthropogenic Impacts on American Eel**

**(1) Upstream Passage at Dams.** Female American eels spend most of their lives in freshwater habitat along the Atlantic seaboard prior to returning to the Sargasso Sea to spawn. Safe and efficient access for juvenile eels to their freshwater habitat is essential to the survival of the American eel. Coastal river systems along the Atlantic seaboard are the sole migratory pathways for female American eels to gain access to their required freshwater habitat.

ASMFC (2000) states:

*"By region, the potential habitat loss [for American eel] is greatest (91 percent) in the North Atlantic region (Maine to Connecticut) where stream access is estimated to have been reduced from 111,482 kilometers to 10,349 kilometers of stream length. Stream habitat in the Mid Atlantic region (New York through Virginia) is estimated to have been reduced from 199,312 km to 24,534 km of unobstructed stream length (88 percent loss). The stream habitat in the South Atlantic region (North Carolina to Florida) is estimated to have decreased from 246,007 km to 55,872 km of unobstructed stream access, a 77 percent loss."*

The Maryland Department of Natural Resources, MBSS Newsletter March 1999, Volume 6, Number 1 states:

*"The most dramatic example of the decline of American eel abundance is dam construction on the Susquehanna River. Prior to the completion of Conowingo and three other mainstem dams in the 1920's, eels were common throughout the Susquehanna basin and were popular with anglers. To estimate the number of eels lost as a result of construction of Conowingo Dam, we used MBSS data on American eels from the Lower Susquehanna basin and extrapolated it to the rest of the basin above the dam. Our best*

*conservative guess is that there are on the order of 11 million fewer eels in the Susquehanna basin today than in the 1920s.*

*"The magnitude of this loss is corroborated by the decline in the eel weir fishery in the Pennsylvania portion of the Susquehanna River. Before the mainstem dams were constructed, the annual harvest of eels in the river was nearly 1 million pounds. Since then, the annual harvest has been zero. Given the longevity of eels in streams (up to 20 years or more) and their large size, the loss of this species from streams above Conowingo Dam represents a significant ecosystem-level impact. Because adult eels migrate to the Sargasso Sea to spawn and die -- transporting their accumulated biomass and nutrient load out of Chesapeake Bay -- the loss of eels has increased nutrient loads in the basin and reduced them in the open ocean where they are more appreciated."*

(2) **Downstream Passage at Dams.** Depending on their geographic location, female American eels spend 20 to 50 years in freshwater habitat along the Atlantic seaboard before returning to the Sargasso Sea to spawn. Safe and efficient access for maturing female American eels from their freshwater habitat to the Atlantic Ocean is essential for female American eel to spawn in the Sargasso Sea. Coastal river systems along the Atlantic seaboard are the sole migratory pathways for female American eels to gain access to their oceanic spawning grounds.

Records of severe kills of female American eels by the turbines of hydro-mechanical and hydroelectric dams have existed since as early as the 1880s. A corporate history of the S.D. Warren Paper Company describes severe kills of female American eels at the company's dam at Ammoncongin Falls on the Presumpscot River, Maine during the 1880s. The Presumpscot River is the outlet of Sebago Lake, the second largest lake in Maine. The dam at the outlet of Sebago Lake has long been called the Eel Weir Dam. The S.D. Warren corporate history states at page 46:

*"Water power had its peculiar troubles: every cold winter morning anchor ice would clog in the intakes, and the mill would be down. Then when warm weather came, the water would be full of eels and eels are fish with tough hides. The blades of the water wheels would not chew them up and there are frequent entries in the record stating the water supply had failed and the mill was down, because the eels had stopped the wheels."*

One hundred years later, a similar report was made in 1996 by the operator of the Damariscotta Mills hydro-electric dam on the Damariscotta River in Newcastle, Maine to Lewis Flagg of the Maine Department of Marine Resources ("MDMR"). [36]

[36] November 12, 2004 Petition from Timothy A. Watts and Douglas H. Watts, requesting that the FWS and NMFS list the American eel as an endangered species under the Endangered Species Act.

Hydro-electric dams located on the coastal watersheds of the Atlantic seaboard are a major source of mortality for female American eels as they attempt to migrate from freshwater to the Sargasso Sea to spawn. Of 15,570 dams blocking American eel habitat in the United States, Busch et al. (1998) reported that 1,100 of these dams are used for hydroelectric power. Few of these 1,100 dams provide safe passage for migrating female American eels. As a result, downstream passage by female American eels at these dams is via the project turbines, which results in the death of virtually all female eels attempting to migrate (see Appendix for graphic photographs of the effects of turbines on migrating eels[37]).

Radio tagging studies of migrating female American eels by the MDMR at two hydro-electric dams in Maine indicate nearly 100 percent of adult female eels entering project turbines are killed or severely injured and, therefore, are unable to complete their spawning migration (MDMR 2002).

Despite clear evidence of the deadly effects of turbines on large eels, ASMFC (2000) states:

> *"Downstream passage to the American eel's historic habitat is just as important as successful upstream access. Therefore, turbine induced mortality during downstream passage needs to be resolved since it impacts prespawning adult silver eel."*

A December, 1994 memorandum written by State of Maine fisheries biologist Frederick W. Kircheis states: *"Apparently eels are attracted to the current drawn by the turbines while migrating at night. "*

Radio-tracking of adult American eels by the MDMR just above the Lockwood hydro-electric project on the Kennebec River during fall 2002 indicates that 40 percent or more of the adult American eel attempting to migrate past the Lockwood Project each fall are entrained and killed in the Lockwood Dam turbines, despite the availability of the project spillway for passage (MDMR 2003).

Radio-tracking of adult female American eels by the Maine Department of Marine Resources (MDMR) at the Benton Falls Project in 2000 and 2001 indicate more than 50 percent of the migrating eels attempting to pass the Benton Falls Project are entrained and killed in the project turbines. The studies also found that 100 percent of the eels entrained in the Benton Falls Project turbines were killed by them. In fall 2001, MDMR staff used an underwater video camera at this project turbine outfall to attempt to locate two radio-tagged eels which had passed through. The video camera revealed large numbers of dead eels and eel carcasses resting on the river bottom at the turbine outfall. MDMR's 2001 study reported stated: *"Based on two years data, the surface bypass at Benton Falls is not efficient at passing eels."*

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[37] Powerpoint presented at A.D Latornell Conservation Symposium 2008, Barriers Management Session, Alliston, Ontario, November 20, 2008

The State of Maine states it has no legal authority to stop the ongoing killing of female American eel at the Benton Falls Project.

The FWS has documented large kills of migrating female American eels at the Holyoke Dam, the lowermost hydro-electric dam on the Connecticut River. [38]The Connecticut River is the largest watershed in New England. To date, no provision for safe passage of migrating female eels is provided at the Holyoke Dam or any other hydro-electric dam in the Connecticut River watershed.

There is no question that hydro-electric dam turbines inflict carnage on migrating eels. On the downstream journey, eels may have to pass through those turbines. Mortality may be 50 percent or more for some types of turbines, with 80-100 percent being injured (Haro *et al.* 2003). This is particularly important because the largest eels migrating downstream will be caught by the turbines. Upstream passage past dams is difficult. As a result, few eels live upstream of dams. However, those that do successfully migrate upstream of dams, grow larger than eels that remain downstream of the dam. This is because there is more competition for food and space downstream of the dam. These larger eels found upstream of dams are disproportionately female. The larger the eel, the more fecund. So while the eels that are able to migrate upstream from a dam grow larger and more fecund, sadly, because of their large size, they are more likely to be killed by turbines. The existing configuration results in turbines killing a higher percentage of large, fecund females on their way to spawn. This has a disproportionately detrimental effect on recruitment.

**b) New Scientific Information Supports The Conclusion That The Effects Of Global Warming On Oceanic Conditions Have Contributed To The Decline Of The American Eel.**

According to several recent authors (including several available but not cited in the FWS literature used in support of their decision), changes in oceanic conditions are currently contributing to the dramatic decline of anguillid eels worldwide (ICES 2006; IPCC 2007; Bonhommeau et al. 2008; Friedland et al. 2009; Tsukamoto 2009). The mechanisms by which this is occurring are primarily: sea surface temperature changes affecting depth of the mixed layer which disrupts the primary productivity in eel's spawning areas, as well as changes in latitude of the 22.5°C isotherm (affecting northern extent of spawning area), the transport and survival of their larvae (leptocephali).

Friedland et al. (2009) reported changes in the sea surface temperature in the Sargasso Sea and its effect on European eels. These changes included shifts in the winds in the northern Sargasso Sea, reducing southward Ekman transports and larval retention in the Sargasso Sea gyre. Such changes could also affect recruitment of the American eel because of the proximity of its

[38] November 12, 2004 Petition from Timothy A. Watts and Douglas H. Watts, requesting that the FWS and NMFS list the American eel as an endangered species under the Endangered Species Act.

spawning area to that of the European eel in the southern Sargasso Sea, and similarities in the early migration pathways of both species out of the Sargasso Sea (Friedland et al. 2009; Tsukamoto 2009). Similarly, increased temperature negatively affects cross-shelf transport of eels and the condition and size of eels upon arrival at the coast (Wuenschel and Able 2008).

Little attention has been paid to the influence of changing ocean conditions contributing to the decline of eels until recent years. Bonhommeau et al. (2008) analyzed the relationships between oceanic conditions in eel spawning areas and glass eel recruitment success of three species of Anguilla: *A. anguilla*, *A. rostrata*, and *A. japonica*. They report that global warming since the 1970s appears to have hastened the decline of these species due to regime changes that decreased primary productivity and therefore eel recruitment.

Climate models based on historical temperature data and simulations for the 1870–2000 period were developed by Donner et al. (2005) and revealed that *"observed warming in the region* [including the sea surface temperature anomaly in the tropical North Atlantic] *is unlikely to be due to unforced climate variability alone."* The authors further show that under different scenarios of future greenhouse gas emissions, temperature rise that would both affect coral and primary productivity of the mass coral bleaching in the Eastern Caribbean (and hence the Antilles and North Equatorial currents). These effects can be expected even after stabilization of atmospheric $CO^2$ levels, adding to the long term threat to the American eel.

The worldwide recruitment decline in freshwater anguillid populations began almost simultaneously in the 1980s. While there are many factors that have contributed to this decline, recent analyses point to oceanic changes as being the most likely factor driving this trend (Bonhommeau et al. 2008; Friedland et al. 2007). Although the American eel has an evolutionary history (measured in tens of millions of years) and has survived climate changes before, this species has not previously faced the rapid, cumulative effects of anthropogeneticlly-exacerbated environmental climate change (IPCC 2007), coupled with other deleterious anthropogenetic environmental changes. These include: loss of habitat due to dams blocking migration, morbidity and mortality resulting from low stream pH (Jessop 2000; Vélez-Espino and Koops 2009), mortality and injury in hydroelectric turbines when mature eels are migrate downstream, commercial and recreational fishing harvest, contaminants ranging from mercury to PCBs (Ashley et al. 2007), and an invasive swim bladder nematode infestation (*A. crauss*) that disrupts swim bladder function and is especially debilitating during the long migration of eels to spawning areas in the Sargasso Sea. The life history traits and resilience exhibited by American eels, while allowing them to colonize diverse habitats in North America, is inadequate in the face the cumulative effects of these simultaneous threats.

**c) Toxic Contaminants.**

**ASMFC (2000) states:**

> *"American eel are benthic, long-lived and lipid rich. Therefore, American eel can accumulate high concentrations of contaminants, potentially causing an increased*

*incidence of disease and reproductive impairment as is found in other fish species (Couillard et al. 1997). An analysis of the contaminants in migrating silver eel in the St. Lawrence River showed that the highest concentrations of chemicals were in the gonads. Concentrations of PCB and DDT were found to be 17 percent and 28 percent higher in the gonads than in the carcasses. The chemical levels in the eggs could exceed the thresholds of toxicity for larvae. Also, since the migrating females are not feeding, the chemical levels in the eggs could be even higher at hatching, increasing the likelihood of toxicity to the larvae (Hodson et al. 1994)."*

Because of mercury contamination, in 2008 the Vermont Department Of Health issued a Fish Consumption Advisory suggesting that no more than three meals per month of American eels be consumed (Vermont Fish & Wildlife Department 2008). Women of childbearing age, pregnant women, and breastfeeding mothers were advised to restrict their consumption to no more than one meal per month. Elevated levels of mercury in streams of the eastern United States are primarily the result of the burning of coal for electrical power generation. That has also resulted in acid rain that has altered stream chemistry and ecology, and has killed fish in acidified streams for many decades.

### 6. Emerging threats to the American eel

Emerging threats to American eels include: electro-magnetic fields from submarine cables, acoustic disturbance from offshore wind development (Oham et al. 2007), and the potential for biofuel production from floating biomass (including sargassum) harvested from gyres in the open ocean (Markels 2009).

## III. CONCLUSION

American eels are virtually unique from other animals in that they spawn only once in their lives, in the Sargasso Sea. Eels are harvested at virtually every stage of their lives. They have lost access to 90 percent of their habitat due to anthropogenic activities. The remaining habitat is severely degraded due to a number of anthropogenic threats, including contaminants, urbanization and acid rain. Those eels which successfully evade harvest and find suitable habitat to mature are at risk of death or mortal injury as a result of contact with hydro-electric dam turbines during their downstream spawning migration. Even then, if they survive the turbines, the invasive parasite *a. crassus* can still kill them before they can complete their spawning migration.

The government has the legal authority to eliminate all mortality to American eels caused by human harvest and hydro-electric turbine mortality using the authorities of FERC and the NMFS. Those authorities have not been exercised.

The FWS has the ultimate authority to protect the American eel under the ESA. In 2007, ignoring the advice of experts and the data demonstrating catastrophic declines, the FWS chose not to list this species. Instead, the FWS 2007 Final Determination not to list the American eel was based on weak inferences. Ignoring the information presented the FWS painted an overly optimistic picture of the American eel's status and was dismissive of threats to the species, even in the face of contrary data and analysis. The decision not to list the American eel as threatened or endangered was based upon weak epistemological grounds.

The new information presented herein, including data and research not used or not available to the FWS at the time of their 2007 Final Determination demonstrates continued declines in American eel populations and more specific evidence of significant threats. The American eel is threatened and declining throughout all or a significant portion of its range and, therefore, qualifies for listing as threatened based on the provisions of the ESA.

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**Petition to List the American Eel as an Endangered Species**
**Pursuant to the United States Endangered Species Act**
**16 U.S.C. §§ 1531, et seq.**