THE PATH OF THE AMERICAN EEL

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THE PATH OF THE AMERICAN EEL

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ABSTRACT

Our project focused on creating a set of recommendations for WWF Hong Kong with the goal of improving the sustainability of the American eel population and its trade with East Asia. We conducted archival research and semi-structured interviews with eel stakeholders to understand the regulations controlling eel's harvest and trade, threats to their habitat, how they are farmed using aquaculture, and the culture of eel consumption. We concluded that the major threats to the American eel are habitat fragmentation and adult eel mortality caused by dams and hydropower facilities. Additionally, while the current eel fishing regulations and enforcement in the United States are effective, regulations in other countries need to be improved.

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The team worked together to edit the entire document and write the Abstract, Executive Summary, Prologue, and Recommendations.

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TABLE OF CONTENTS

TITLE PAGE	i
ABSTRACT	ii
ACKNOWLEDGMENTS	iii
AUTHORSHIP	iv
TABLE OF CONTENTS	v
TABLE OF FIGURES	vi
EXECUTIVE SUMMARY	viii
PROLOGUE	01
ECOLOGY	02
THREATS	04
FISHERY	08
TRADE	13
AQUACULTURE	15
RECOMMENDATIONS	20
REFERENCES	24
APPENDIX A: Methods	34
APPENDIX B: Interviewees	37
APPENDIX C: IRB From Example	43
APPENDIX D: Interview Questions	45
APPENDIX E: Taiwan Certificate	47
APPENDIX F: USFW Certificate	49

TABLE OF FIGURES

Figure 1: Migration patterns 02

Figure 2: Life cycle 03

Figure 3: Typical eel ramp pass 04

Figure 4: Eel mortality caused by turbine 05

Figure 5: Helical eel ramp 05

Figure 6: USGS eel ramp 06

Figure 7: Index of abundance of yellow American eels along the Atlantic coast 09

Figure 8: Number of licensed elver rivers by county in the Maritimes region 11

Figure 9: OPG's RH Saunders generating station on the Saint Lawrence River 12

TABLE OF FIGURES

Figure 10: Eels being weighed for sale 14

Figure 11: Guangdong locator map 16

Figure 12: Eel aquaculture farm 17

Figure 13: Global Japan, mainland China, and Korea eel consumption based on FAO production data, converted to live eel weight, 1197-2013, tonnes 18

Figure 14: Grilled eel 19

Figure 15: Unagi Kabayaki 19

EXECUTIVE SUMMARY

Eels play a major role in the human diet in Europe and Asia; however, freshwater eels have been disappearing around the world (U.S. Fish and Wildlife Service, 2019). There has been an average decline of 92% between 1970 and 2016 of eel species globally (Musing et al., 2018). Over 60% of the eel populations are considered threatened. The life of an eel is much more complex than it may appear at first glance, and it faces numerous threats throughout its life that have contributed to the decline of its population. Eels migrate thousands of miles, overcome habitat fragmentation caused by dams, and can thrive in a wide range of environments. Additionally, after being caught by fishermen, they are shipped to other countries and farmed by aquaculturists before they make it to our plates. Because of the eel's complex and far-reaching life cycle and path, scientists, conservationists and the fishing and aquaculture industries are looking for ways to sustain the eel's population so that it can continue to be an important source of income and food around the world.

The American eel is born deep in the Sargasso Sea (Maxwell & Iles, 2016; Boivin et al., 2015). An adult female eel releases eggs, which then rise to the surface and hatch into larvae, drifting west along the currents of the Atlantic Ocean. By the time the larvae arrive at the coast, they have transformed into glass eels (Hudson River Sloop Clearwater, Inc., 2017). Once the eels have begun to grow, they become elvers that continue to migrate upstream through estuaries and rivers. When the elvers reach their full size, they become yellow eels, and when they reach sexual maturity, they become silver eels and migrate back to the Sargasso Sea to spawn (Clarke, 2020).

The American eel population is exceptionally resilient and is distributed throughout a great range between Greenland and Venezuela. Due to the large range of the American eel, information about its abundance, population status at all life stages, and habitat requirements are limited (White & Simpson Defilippi, 2017). According to the ASMFC’s 2017 stock assessment, which assesses the status of the American eel, the population remains depleted compared to its historic levels, but it has been stable over the past 20 years.

Scientists have identified several threats that may be contributing to the overall lower numbers of the American eel population, and that are preventing the American eel from being sustainable. The lack of upstream and downstream passage is the eel's greatest population threat. As the glass eels begin moving upstream to freshwater, they encounter dams on rivers, which block their migration further into their freshwater habitat. This contributes to the ecological problem of habitat fragmentation, which greatly impacts the population. As the silver eels move downstream toward the Sargasso Sea to spawn, they can be killed by the turbines of hydropower facilities. This has an exponential negative impact on the American eel population as many of the eels killed are mature female eels carrying millions of eggs (Haro, n.d.).

Overall, the lack of eel passage and adult mortality are a greater threat than the commercial elver fishery.

In each country that an American eel fishery is located, there are different regulations that control the fishery. When these regulations are followed, a fishery can be sustainable; however, when regulations are broken or ignored, or when a fishery is unregulated, the fishery can become unsustainable and negatively impact the American eel population. There are glass eel fisheries in Maine, the Maritime provinces of Canada, and in several Caribbean countries, most notably Haiti and the Dominican Republic. The fisheries in the Caribbean are either unregulated or have regulations that remain unenforced, and the Canadian fishery lacks traceability once the eels have been sold to a buyer.

According to an experienced trader, once the glass eels are fished, the harvester will sell them to a buyer, and the buyer sells them to an exporter who exports the eels to Hong Kong. Once the eels arrive in Hong Kong, the transparency of the eel trade falters (anonymous trader, personal communication, February 4, 2021). Eel is typically imported to Hong Kong because it has the lightest restrictions and minimal required paperwork compared to neighboring destinations such as China or Taiwan; it is easier to smuggle eels into China from Hong Kong rather than ship them directly to China. From Hong Kong, the eels are sent to aquaculture facilities to be grown to adulthood. These facilities are located in China, Taiwan, Japan, South Korea, the Philippines, and Vietnam. China has had large scandals where aquaculture facilities have been found to be using large amounts of carcinogens (Wong, 2005). Taiwan, Japan, and the Philippines are known for ethical practices and high-quality aquaculture. Once the eels are raised to harvestable size, they are shipped to restaurants and grocery stores around the world. Eels that were first caught in North America as elvers are shipped to Asia to be raised, then sold back to restaurants in North America, which is an inefficiency that needs to be addressed.

With this comprehensive understanding of the path of the American eel, we created a set of recommendations for WWF - Hong Kong to promote a sustainable American eel trade between North America and East Asia. The following is an overview of our recommendations aimed to improve the sustainability of the American eel.

RECOMMENDATION ONE: IMPROVE COMMUNICATION AND EDUCATION

The first step to improve the sustainability of the American eel is to have all the stakeholders communicate with each other on at least an annual basis and share new findings, research progress, concerns, and possible solutions. Additionally, more research needs to be done about the American eel's ecology and biology in order to make better informed decisions about its management. Eel consumers and providers, such as restaurant owners, chefs, supermarkets, and distributors, need to be more educated about eels.

RECOMMENDATION TWO: PROTECTION OF EEL HABITAT

We recommend the introduction of fish passageways such as eel ramps, stairs, or other modifications, as well as modifications to hydropower facilities to allow both upstream and downstream passage for all species.

RECOMMENDATION THREE: BETTER REGULATION OF AQUACULTURE

Regulating aquaculture and increasing transparency will improve the sustainability of the American eel. We recommend expanding aquaculture in the United States, while working to increase regulations in other countries such as China, Haiti, Vietnam, and Taiwan.

RECOMMENDATION FOUR: EXPAND & IMPROVE LEGISLATION

We recommend more legislation protecting and regulating American eel fishing, trade, and aquaculture at national and international levels be passed and enforced.

THE PATH OF THE AMERICAN EEL

PROLOGUE

We are in the midst of planet earth's sixth extinction crisis (Thunberg, 2018, 4:12). Today's extinction rate is thousands of times higher than the natural baseline rate. Average global temperatures are rising because we burn fossil fuels, causing glaciers to melt, sea levels to rise, and forests to burn, leading to the destruction of countless species' habitats, and we have killed off countless species for food, medicine, and furs. One species that is particularly exploited for food is the eel: "With a long, snake-like appearance, eels may seem an unlikely delicacy--but several varieties of Japanese eel have been popular for hundreds of years. This includes unagi (freshwater eel), anago (saltwater eel) and hamo (conger eel). Unagi in particular is prized for its soft, fatty meat and bold, rich taste" (Savor Japan, 2016, p.1). Along with its appealing taste, eel's high protein content, health benefits, and cultural significance are just some of the reasons it is so popular.

The *Anguilla* genus is the most consumed genus of freshwater eels (Monticini, 2014). There are 19 species of eel within the Anguilla genus, and four are considered to be of commercial interest by The United Nations Food and Agriculture Organization (FAO): European eel (*Anguilla anguilla*), American eel (*Anguilla rostrata*), Japanese eel (*Anguilla japonica)*, and short-finned eel (*Anguilla australis*). The European eel, American eel, and Japanese eel are the most popular species to eat and have the highest demand by consumers (Ringuet et al., 2002).

The Japanese eel was first commonly used for food, but overfishing caused the population to become severely depleted, so people turned to the European eel as a replacement (BBC, 2014). The European eel has also recently become endangered, so in 2011 it was offered legal protection by the European Union. Thus, in the early 2010's the market for the American eel expanded in order to replace European and Japanese eel. The American eel is facing several environmental and legislative threats affecting its population and the sustainability of its trade. Eels may not seem like the most charismatic creatures and are probably too slippery and snake-like to be the symbol of an environmental movement, but the American eel needs to be protected in order to prevent it from following the path of the European and Japanese eels.

The life of an eel is much more complex than it may appear at first glance. Eels migrate thousands of miles, overcome habitat fragmentation caused by dams, and can thrive in a wide range of environments (J. Zydlewski, personal communication, January 13, 2021). Additionally, they are shipped and farmed around the world in order to make it to our plates. Because of the eel's complex and far-reaching life cycle and path, scientists, conservationists and the fishing and aquaculture industries are looking for ways to sustain the eel's population so that it can continue to be an important source of income and food around the world. The purpose of our project was to thoroughly identify the complete path of the American eel in order to present a set of recommendations to WWF Hong Kong with the goal of improving the sustainability of the American eel's population and trade.

ECOLOGY

Although never recorded or seen by human eyes, the American eel likely spawns in the deep waters 1000 miles east from Bermuda in the Sargasso Sea. It has semelparous and panmictic reproduction. Semelparous means that it undergoes only one reproductive cycle in a lifetime before death and panmictic reproduction means that it only breeds within its subspecies. Females are known to release 20-30 million eggs during their spawn (Maxwell & Iles, 2016; Boivin et al., 2015). The eggs then rise to the surface and hatch into larvae, which drift west along the currents of the Atlantic Ocean. Their oceanic migration varies in distance and duration. Some glass eels can settle along the east coast of the United States while others continue to the Gulf of St Lawrence, Canada, and Greenland. Pictured below in Figure 1 is a depiction of the American Eels migration patterns.

After spending about 2-3 years drifting along the ocean's currents, the larvae approach coasts such as the Chesapeake Bay. “The species has phenotypic plasticity that allows eels to adapt to a wide range of habitat types, from estuaries to freshwater headwater habitats. As a result of this plasticity, the species is widely distributed in accessible lakes, rivers, streams, and estuaries from eastern Canada to Venezuela” (Shepard, 2015, p.v).

Figure 1: Migration patterns (Fish and Aquatic Conservation, n.d.)

By the time they reach the coast, the larvae have transformed into glass eels (Hudson River Sloop Clearwater, Inc., 2017). At this stage, they are still transparent but are now two to three inches long and have developed fins. They seek fresh water and may move short distances over land for access to ponds and lakes. After spending two days in freshwater and beginning to feed, the glass eels develop pigmentation in their skin and start their journey on becoming yellow eels.

The eel's protein-rich diet highly influences their productivity (Dave et al., 1976). Eels require dietary protein as it supplies essential amino acids (Knight, 2016). Adult American eels typically feed at night on worms, small fish, crustaceans, clams, insects, dead organisms, and mollusks (Fish and Aquatic Conservation, n.d.; Florida Fish and Wildlife Conservation Commission, n.d.).

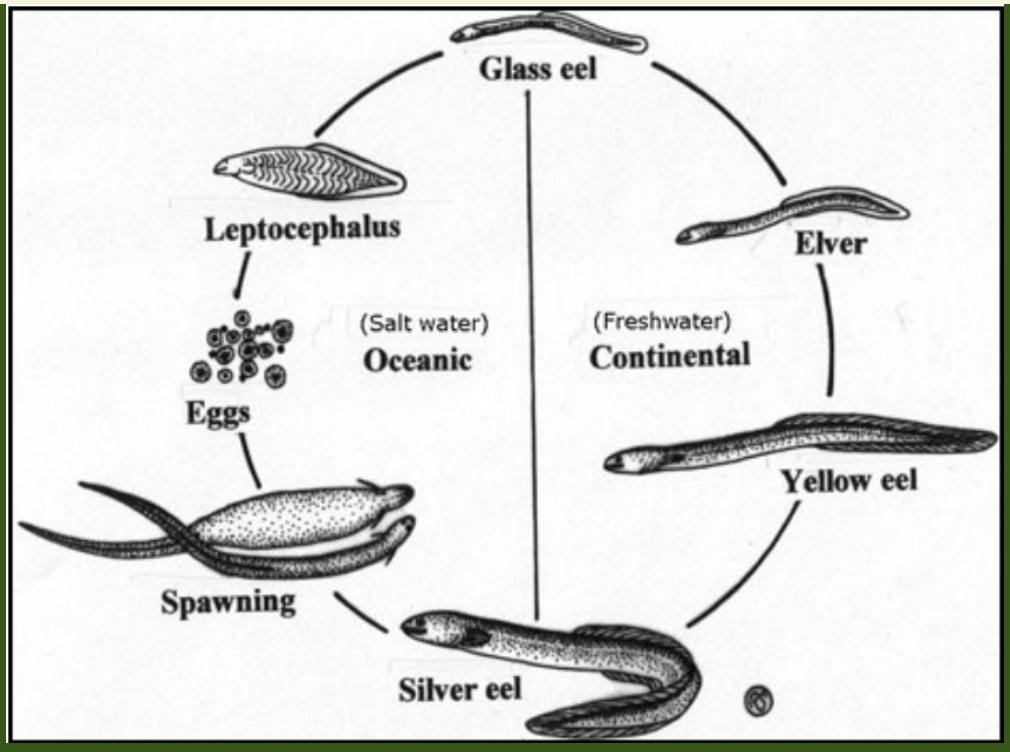

Figure 2: Life Cycle (Ontario Ministry of Natural Resources, n.d. Copy of an official work published by the Government of Canada. Not reproduced with affiliation or endorsement of the Government of Canada)

Once the eels have grown to be about four inches long, they become darker elvers (young eels) that continue to migrate upstream through estuaries and rivers. Figure 2 above summarizes the undisturbed lifecycle along with various migration patterns of the American eel. Eventually, dark elvers become yellow eels; at this stage, they have grown to their maximum length and prefer fresh water, but they are still not ready to reproduce (Clarke, 2020). Eels can remain as yellow eels for up to 20 years before they reach sexual maturity and become silver eels. After living in the rivers for as many as 20 years, the mature eels decide to head back to saltwater. Now, the eel has begun the silver eel life stage and will migrate to the Sargasso Sea in the Atlantic Ocean to breed.

Currently, it is believed that the development of sexual reproductive organs starts in the eels late juvenile stage when they are 260 mm long (Clarke, 2020). It is thought that eels that spend more time in brackish water tend to become males, while eels that head up stream towards freshwater rivers and lakes tend to become female. The eels that stay in fresh water for most of their life grow to be larger and older than eels that stay in brackish water. Their sex is also affected by the size of the population in their immediate area - less dense populations tend to have more females. There are many factors involved in understanding when eels become male or female that researchers are still working to understand.

THREATS

The American eel population has been very resilient. The American eel is distributed throughout a wide geographical range, from Venezuela to Greenland. As of 2020, the range has shrunk from its historical size, but still covers a vast area of land and ocean. Due to the large range of the American eel, information about its abundance, status at all life stages, and habitat requirements is limited (White & Simpson Defilippi 2017). According to the 2017 stock assessment, which estimates the size of the American eel population, the population remains depleted in the U.S waters. Based on our research we have identified several factors contributing to the overall lower levels of the American eel population.

These factors include a combination of the following:

- Historical Overfishing
- Habitat Loss and Fragmentation
- Predation
- Turbine Mortality
- Climate Change
- Toxins and Contaminants
- Viruses and Diseases

After speaking with many eel experts from several departments, as explained in our methodology section, we concluded that the lack of upstream and downstream passageways is currently the eel's greatest population threat (Khan, 2019). As the glass eels begin moving upstream to freshwater they come across dams on rivers, which block their entrance into estuaries and other freshwater resources. Some eels that are considered more adventurous are able to climb over the dams; however, these eels, if not caught by fishermen in their glass eel stage, come across another obstacle in their downstream migration on their way back to the Sargasso Sea.

Figure 3: Typical Eel Ramp Pass (Anonymous conservationist, personal communication, February 4, 2021. Reprinted with permission.)

Obstacles with upstream passage create habitat fragmentation and limit the juvenile eel's access to its preferred growth habitat. Obstacles encountered during downstream passage can severely injure or kill adult migrant eels that try to pass through turbines or over spillways, ultimately killing millions of eels as the majority of eels that passtravel downstream passage are on their way to reproduce (Haro, n.d.). Figure 4 below is a picture showing adult eel mortality due to turbines.

Figure 4: Eel mortality caused by turbines (Sustainable Eel Group, n.d. Reprinted with permission.)

Overall, the lack of fish passageways, and eel passageways in particular, is a greater population threat than regulated fishing as the majority of glass eels do not naturally make it to adulthood due to obstacles in their way: "even if we were taking 10% of them [as a result of fishing], we would not be affecting the number of eels that mature and breed" (N.Ross, personal communication, January 22, 2021).

Fortunately, the recent research and development has led to several solutions regarding upstream and downstream passage. Researchers have found that traditional fish lifts are ineffective for eel passage and that specialized passageways should be developed for eels (Haro, n.d.).

Figure 5: Helical eel ramp (Anonymous conservationist, personal communication, February 4, 2021. Reprinted with permission.)

Besides providing the eels with a safe passage, the ramps can include traps to count migrants that can improve stock surveys. Overall upstream passage benefits can be achieved at a relatively low cost (Shepard, 2015).

Unlike upstream passage, solutions regarding downstream passage are more costly and tend to be more complex (Shepard, 2015). Eels tend to migrate at night and move towards the bottom of the river. The turbines of the dam tend to reach the bottom of a river and have the potential to slice the eels as they pass. Furthermore, the turbines along with natural water current suck the eels in, preventing them from avoiding the turbine. To address these issues, deep bypass structures with entrances near the bottom are a promising solution to increase effectiveness of downstream eel passageways (Haro et al., 2016). Another possible solution is nighttime shutdowns of the turbines affecting eel downstream passage. A new design utilizing airlift technology (the Conte Airlift Bypass) to induce flow in a bypass pipe was tested and concluded to be a viable method for American eel downstream passage as well.

Although there is research and development designated for downstream eel passage, it is not understood as well as upstream passage. Overall the decision and action to make changes to the dams has to come from the companies in charge of them, and there has been a significant push back from these companies to make changes or take the dams down (G.Wippelhausser, personal communication, January 26, 2021). The ASMFC has recommended that every single state include fish passage in their dams, but they do not have the power to require it. One way to require companies to create downstream eel passageways is to include it in the states' water quality certification requirements. These certifications include a list of requirements, enforced by the state, for any development that affects the state's water. So if each state included fish and eel passageways on their certifications it would require companies to modify their dams for eels and fish to pass through safely.

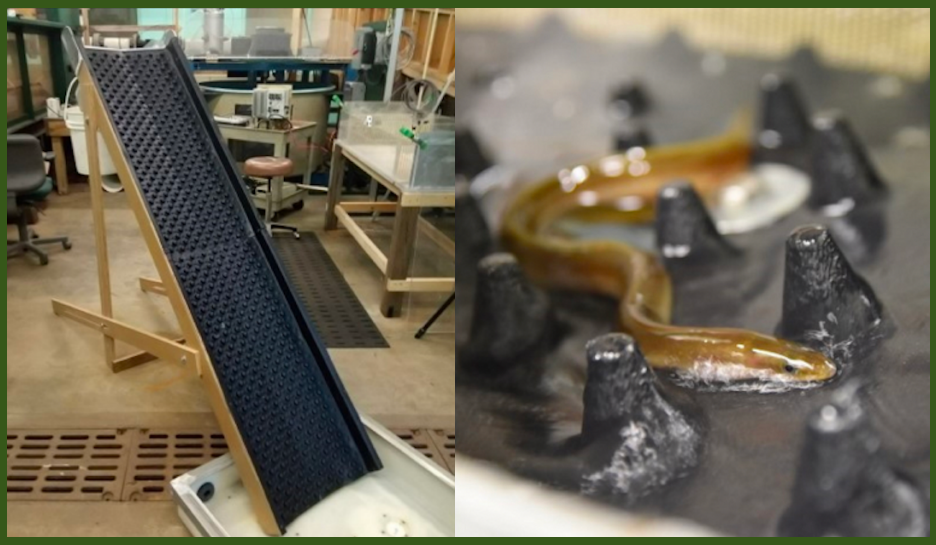

Figure 6: USGS Eel Ramp (Haro, 2019)

In addition to obstacles with upstream and downstream passage, an exotic parasitic nematode called *Anguillicoloides crassus* has also impacted the American eel population (Shepard, 2015). *A. crassus* infests the eel's swimbladder and can cause significant eel mortality especially in crowded aquaculture conditions. Although *A. crassus* does not tend to cause mortality in the wild, it impacts the eels migration and spawning as it decreases its swimming efficiency. It is uncertain whether it prevents the eel's from completing their spawning migration to the Sargasso Sea. More research needs to be done to get a thorough understanding of *A. crassus*'s effect on the eel in the wild and especially on their migration.

There are several other factors influencing the American eel population's status; however, there are limited direct actions at this time that can be taken to address them. Updated information suggests that ocean habitats and currents are changing in response to weather, wind, and increasing temperatures due to climate change (Shepard, 2015). These changes may affect the American eels spawning success, larval growth and survival; however, it may also simply influence the American eel to make changes to its habitat throughout its life cycle.

FISHERY

The American eel is fished in many locations throughout its range, and at various stages of its life. In each country that an American eel fishery is located, there are different regulations that control the fishery. When these regulations are followed, a fishery can be sustainable; however, when regulations are broken, or when a fishery is unregulated, the fishery can become unsustainable and negatively impact the American eel population.

In the United States, the American eel is fished in its glass eel or elver stage, and in its yellow or silver stage (ASMFC, 2019). There are different regulations for each stage of eel. Most lucrative and most often discussed is the elver fishery. Some glass eel fishing occurred in the United States as early as the 1950s but did not become a large and well-paying industry until the mid-1990s (Walker et al, 2019). During this time, most states imposed regulations on the size of eel that could be caught, effectively banning elver fishing in every state except Maine, Connecticut, South Carolina, and Florida by the late 1990s. Then, in 1998, the market prices dropped considerably, eventually leading to the closure of fisheries in Connecticut and Florida, and the great reduction of fishing in South Carolina. Connecticut also eventually imposed regulations on the size of eel that could be caught and banned elver fishing. Today, South Carolina allows a total of ten people to obtain elver fishing licenses, although usually, only two individuals participate in this type of fishing each year. Florida occasionally reports some elver fishing, but none has occurred since 2014. The vast majority of elver fishing in the United States occurs in Maine.

In the early 2010s, the demand for American eel increased dramatically after the European Union banned exports of the European eel (Jonach, 2019), raising the market price to about $900/lb in 2011, and in 2012 the price reached over $2000/lb (Walker et al, 2019). The high prices and the ability of fishermen and suppliers to use cash transactions led to a huge increase in poaching and other illegal fishing activity, causing Maine to implement new regulations in 2014. A quota was set at 35% of the previous year's stock, and a new card-swipe system was implemented that tracked every transaction. This resulted in a huge decrease in infractions, from around 200 in 2013 to under 20 between 2014 to 2016. However, the prices for elvers continued to climb, reaching a peak price of $3000/lb on the opening night of the 2018 season. By the end of the season, some people had been circumventing the card swipe system, causing the Maine Department of Marine Resources to end the season two weeks early. In the 2019 season, the price continued to increase (anonymous trader, personal communication, January 20, 2021). The 2020 season was largely impacted by the COVID-19 pandemic, and prices dipped to about $500/lb by the end of the season.

The Maine glass eel season begins in March of each year, when the glass eels reach the freshwater streams of Maine (Matt Wyman, personal communication, February 4, 2021). The fishery is regulated by a number of bodies, including the Atlantic States Marine Fisheries Commission (ASMFC) (ASMFC, 2017). The purpose of the ASMFC is to manage the conservation of 27 fished species that exist throughout the Atlantic United States. The

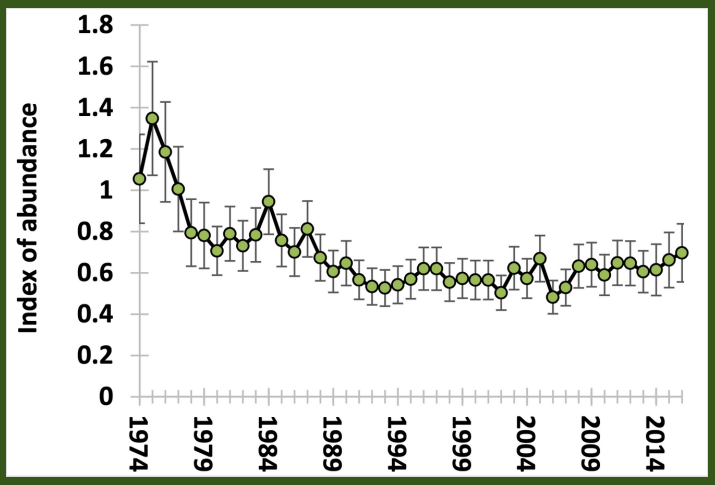

Figure 7: Index of abundance of yellow American eels along the Atlantic Coast, 1974-2016 (ASMFC, 2017)

ASMFC implemented the American Eel Fisheries Management Plan (FMP) in November of 1999. The FMP sets the glass eel quota for Maine and South Carolina and sets restrictions for adult fishing. The FMP also includes stock assessments of the American eel that are done every five years. These stock assessments take into account both fishery-dependent and fishery-independent data to determine the status of the American eel population. Fishery-dependent data includes landings in both the glass eel and yellow eel harvests, and fishery-independent data includes young-of-year surveys and yellow eel surveys that are primarily done by catching, counting, and releasing eels. Young-of-year surveys are surveys of glass eels entering the freshwater every spring. Figure 7 shows the overall trend of the American eel population over the last 40 years from the most recent stock assessment in 2017.

The ASMFC also requires that every state with an active elver fishery completes a life cycle study of the American eel (Gail Wippelhauser, personal communication, January 26, 2021). This study involves catching and tagging yellow eels in order to assess their population size every year (Jason Bartlett, personal communication, January 27, 2021). In addition, glass eels are trapped and counted every spring, and silver eels are trapped and counted every fall. The study also gathers other biological and ecological information about the American eel and its population. The current glass eel quota is 9,688 pounds per season (ASMFC, 2019). There are about 2,000 elvers per pound, so the quota includes about 20 million elvers per season (Trotter, 2019). Fourteen percent of the quota goes to Native American tribes (Walker et al, 2019), and 200 pounds of the quota is set aside for aquaculture (Gail Wippelhauser, personal communication, January 26, 2021). The company American Unagi receives all of the aquaculture quota. They work with 10 elver fishermen to receive their quota every year, and provide local eel to restaurants in Maine (Sara Rademaker, personal communication, January 29, 2021). The remaining quota is split up among the licensed fishermen in Maine (ASMFC, 2019).

The regulations placed on Maine's elver fishery are highly effective, and based on expert opinion it is unlikely that there is any illegal activity currently occurring in Maine (David Sykes, personal communication, January 13, 2021). In order to receive a license, the fishermen enter a lottery and are chosen at random. There are currently about 900 licensed harvesters, although the number varies every year (ASMFC, 2019). The licenses are different depending on what fishing method can be used (Cassidy Bigos, personal communication, January 29, 2021). Some licenses allow for fyke nets, which are conical fish traps with netting to exclude larger fish (FAO Fisheries Division, n.d.), and some allow for dip nets, which are hand-held nets dipped into the water. Each fisherman is required to carry a swipe card and a photo ID to verify that they have a license, and to ensure that

only the owner of the license is fishing (Matt Wyman, personal communication, February 4, 2021). When the harvester sells their eels to a buyer, their swipe card is used to record the weight of the eels sold. The swipe card system not only allows the quota to be tracked, but also allows that season's landings to be recorded. Eel buyers are also required to obtain a buyer's license, and the transaction is also recorded on the buyer's card. The process of weighing the eels is observed by a Maine Marine Patrol officer. In addition, a list of the harvesters who sold eel and the weight of eel they sold is provided to the Marine Patrol officers daily, so that they can compare the data to their observations of the harvesters while they fished. Other fishing regulations state that harvesters cannot steal from eel passage, and that they must leave the middle third of the river unobstructed.

Before the implementation of these regulations, however, there was rampant poaching and other illegal activity (Matt Wyman, personal communication, February 4, 2021). Punishment for illegally fishing began in the early 2010s with the Maine Marine Patrol implementing fines. However, the amount of illegal activity soon became too great for the state to deal with on its own, so the Fish and Wildlife Service (2019) stepped in and began Operation Broken Glass. From 2011 to 2014, undercover agents led investigations of illegal elver fishing, including infractions such as over-harvesting in Maine and fishing in states other than Maine and South Carolina, eventually culminating in the execution of 20 search warrants in seven different states. Nineteen people were convicted of violating the Lacey Act between 2017 and 2018. Since this operation was completed, the Fish and Wildlife Service believes that there is little illegal activity occurring in the United States (David Sykes, personal communication, January 13, 2021). However, it is possible that there is illegal fishing occurring in states other than Maine, and poached eel could be shipped to Hong Kong in other seafood shipments, which is a method commonly used to smuggle the European eel (Florian Stein, personal communication, January 27, 2021). However, due to the strong regulations in Maine and the success of Operation Broken Glass, the lack of regulations and enforcement in Canada and the Caribbean are having a larger negative impact on the American eel population, and especially the sustainability of its population, than the glass eel fishery in the United States.

There is also an adult eel fishery in the United States (ASMFC, 2019). Yellow and silver eels are fished to be stock for local aquaculture farms, either to be bait for striped bass fishing (Cassidy Bigos, personal communication, January 29, 2021) or to be sold to restaurants or seafood markets. One of the regulations set by the ASMFC's FMP is to set a recreational size limit of nine inches, and a recreational possession limit of 50 eels per person per day (ASMFC, 2019). Each state in the American eel's range has its own adult eel fishery regulations that can be more restrictive than those set by the ASMFC. In addition, the ASMFC has a plan to impose regulations on the adult eel fisheries if the landings grow too high. In Addendum V to the Interstate Fishery Management Plan for the American Eel, completed in August 2018 and updated in October 2019, the ASMFC set a coastwide landings cap at 916,473 pounds, which is the average annual yellow eel landings from 1998 to 2016. Annually, the coastwide landings are compared to this cap, and if the coastwide cap is exceeded by 10% for two consecutive years, then restrictions will be put in place where the states responsible for exceeding the cap are required to impose egulations. The ASMFC suggests that these regulations could include seasonal restrictions, gear restrictions, or size restrictions.

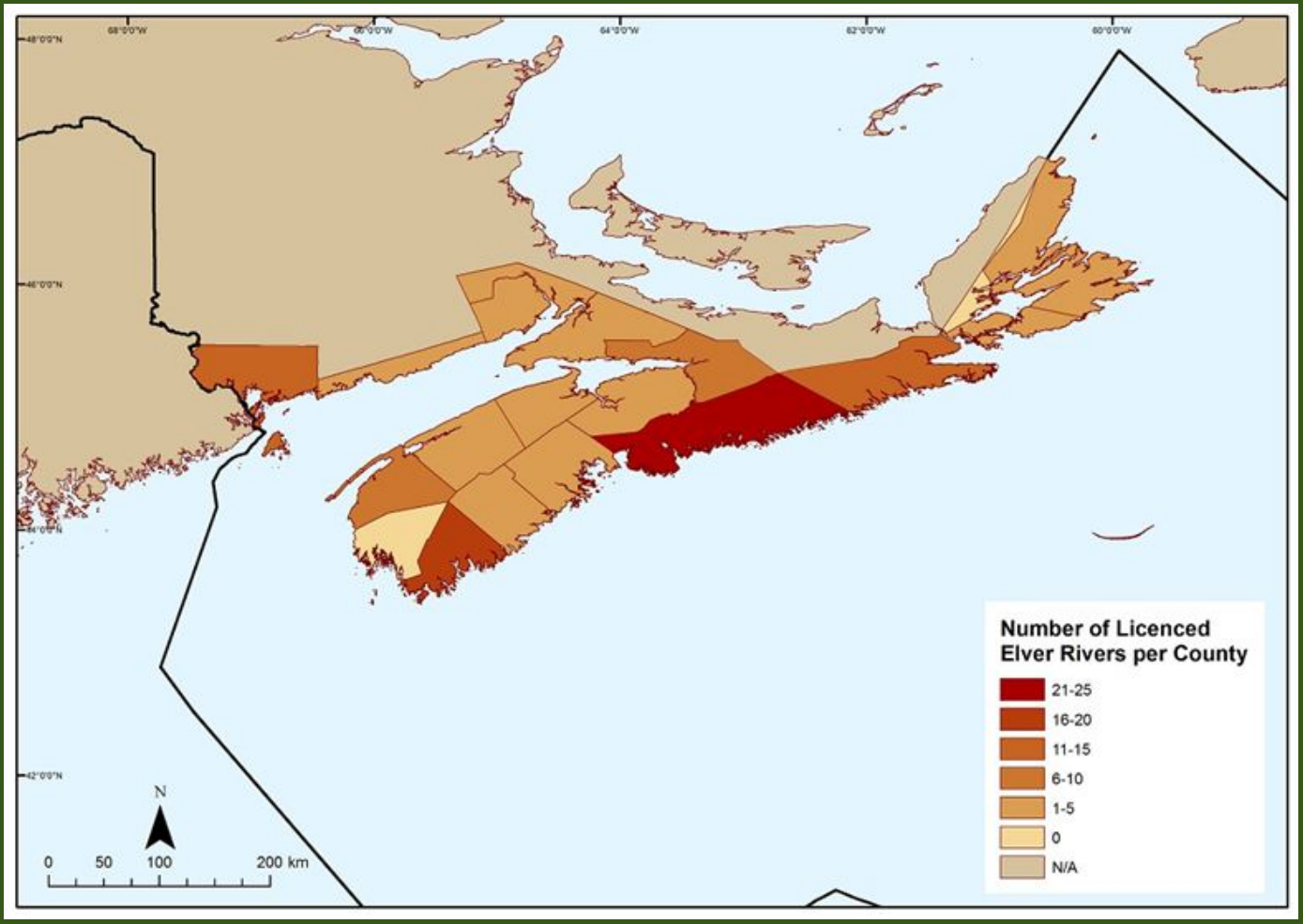

Figure 8: Number of licensed elver rivers by county in the Maritimes region (Department of Fisheries and Oceans, 2014. Copy of an official work published by the Government of Canada. Not reproduced with affiliation or endorsement of the Government of Canada)

The American eel is also found in eastern Canada (Fisheries and Oceans Canada, 2018). There are active elver fisheries in the Maritimes, pictured above, and there was an active fishery in Ontario until 2008 when the American Eel was placed on the Ontario Endangered Species Act (MacGregor et al, 2018). This protected the eel from being taken from the wild, protected the eel's habitat beginning in 2013, and implemented a recovery strategy for the American eel population in Ontario. The recovery strategy includes the removal of dams and implementation of fish passage, especially on the St. Lawrence River, in order to restore the eels' habitat in Ontario, as well as the implementation of downstream passage to reduce mortality due to turbines. The American eel has suffered a 98% decline in abundance in the upper St. Lawrence River and Lake Ontario since the 1970s. Habitat fragmentation occurring on the St. Lawrence River is likely what caused the American eel population to decline to such low levels in Ontario's watershed, as the St. Lawrence river feeds much of the American eel's habitat in Ontario.

In Canada, the first recorded commercial fishery activity began in the early 1980s, when the government issued a few experimental licenses to those who expressed an interest in elver fishing (Government of Canada, 2018). The fishery slowly developed and grew in

Figure 9: OPG's RH Saunders generating station on the St. Lawrence River (ceedub13, 1998)

landings and number of licenses until 1998 when the Elver Advisory Committee was created and new regulations were put into place in the form of the Elver Integrated Fisheries Management Plan. The legal fisheries, located in the Maritimes provinces of New Brunswick, Nova Scotia, and Prince Edward Island, are heavily regulated and observed. There are currently nine licenses for elver fishing, eight of which are commercial fishery licenses and one of which is a communal commercial fishery license. The communal license is owned by seventeen people. The licenses allow multiple authorized people to operate under each license, and in 2017 there were a total of 175 individuals licensed to fish for elvers. Each license also only allows for fishing in a specific river or body of water. In addition, each license has a quota that must not be exceeded, and the fishermen must follow specific reporting and observation rules (anonymous trader, personal communication, February 4, 2021). Each harvester is required to fill out a logbook each day they work harvesting eel. They record the number of hours spent working, what gear they used, and the amount they caught. The Department of Fisheries and Oceans Canada enforces these regulations. Officers will randomly check the harvest and compare it to the logbook to ensure that the numbers match. They will also randomly check the harvester's facility to ensure that the records are accurate.

There is also a yellow and silver eel fishery throughout the eel's range in Canada (anonymous trader, personal communication, February 22, 2021). This fishery has no regulations, which poses a significant threat to the American eel, as taking an adult or mature eel from the wild has a larger ecological impact than taking a glass eel. Canada needs to impose management on the yellow and silver eel fishery.

In the range of the American eel that lies south of the United States, there is little information about the animal's range, stock, and commercial fisheries (Kwak et al, 2019). The vast majority of research that has been done about the American eel has been done in North America, and the southern countries often have not passed regulations about the eel trade or cannot enforce regulations (Voice of America, 2015). For example, elver fishing was banned in Puerto Rico in 2004, but there is still illegal fishing due to the high prices fishermen can get for selling eel and the inability of the government to pay for enforcement of the ban. From trade data, and confirmed by the Fish and Wildlife Service, it can be seen that live eel is exported out of Caribbean countries, namely Cuba, Haiti, and the Dominican Republic (Tridge, 2020). Most of these eels are exported to Canada through Toronto, then to Hong Kong, although some are probably leaving North America through Miami International Airport, Atlanta International Airport, or possibly Dulles International Airport (anonymous trader, personal communication, February 4, 2021).

TRADE

There are three parties in the trade process of the eel that the governments of the United States and Canada have jurisdiction over, before being imported into Hong Kong (anonymous personal communication, February 4, 2021). The first party is the eel harvester and the second party is the eel buyer, who purchases the eel directly from the harvester. The regulations controlling the eel harvest and the transaction between the harvester and buyer were outlined in the previous section. The third party is the exporter, who will purchase the eels from the harvester and sell them to buyers in Hong Kong. In some cases, the buyer is also acting as the exporter, although the majority of people involved in the trade are only acting in one role. In addition, most exporters will use freight forwarders to export their eels.

In the United States, when the eels are leaving the buyer's facilities and being packaged to be exported out of the country, Maine Marine Patrol officers observe and facilitate this process (Department of Marine Resources, 2020). They will watch the eels be weighed, then mark the weight of both the eel product alone and the entire package on the box, then seal the box with a tamper-proof Maine Marine Patrol seal. This is done in order to ensure that no eel can be added to the box between the time it leaves the buyer's or exporter's facilities and the time it reaches Hong Kong. After this point, the eels are under federal jurisdiction of the U.S. Fish and Wildlife Service.

Before the eels leave the exporter's facility, the exporter must notify the U.S. Fish and Wildlife Service 48 hours in advance so that an officer can come to inspect the packages (Department of Marine Resources, 2020). In addition, the exporter is required to fill out a Export Declaration before the eels leave the exporter's facility (anonymous trader, personal communication, February 4, 2021). In the United States, most eels are exported out of John F. Kennedy International Airport or Boston Logan International Airport. Customs officials at these airports are trained to look for the Maine Marine Patrol seal on any package declared as eel, and to ensure that every eel package has an Export Declaration and has been inspected by the U.S. Fish and Wildlife Service. The traceability system in the United States is effectively enforced up until the point of export.

In Canada, the traceability system breaks down once the eels reach the exporter's facility (anonymous personal communication, February 4, 2021). This may be because the eels are under federal jurisdiction of the Department of Fisheries and Oceans (DFO) until they leave the buyer, but once they reach the exporter they are under provincial jurisdiction until they leave the country; there is no implemented traceability system once the jurisdiction changes hands. Eels usually leave the country through the Toronto Pearson Airport, where wildlife officials are either not present or not trained to deal with eel shipments.

Glass eels caught in the Caribbean are usually exported to Hong Kong through the Toronto Pearson Airport in Canada (anonymous personal communication, February 4, 2021). This is most likely occurring because of the relatively loose regulations surrounding eel exports compared to the United States. In addition, there is a well-

established fish market in Toronto's Chinatown that is already set up to hold live fish, and there are many passenger flights going between Canada and the Caribbean during the Caribbean glass eel season in the winter, as many Canadian people travel south to get out of the cold. However, it is also possible that eels are being exported to Hong Kong through other airports in the United States, like Atlanta, Miami, and Dulles. Customs officials at these airports are probably not trained to look for eel shipments, so gray market eels caught in the Caribbean could be exported through these airports; however, this is pure speculation based on information from some knowledgeable members of the eel trade and there is trade data to support the movement of eels through Canada.

Packing techniques for export are similar in both Canada and the United States (anonymous trader, personal communication, January 20, 2021). The eels are placed in a bag with oxygenated water. The temperature and oxygen saturation of the water are both crucial to the eel's survival. This bag is packed inside a styrofoam box with gel packs to ensure that the water stays cool. This styrofoam box is then packed inside a cardboard box. The industry standard for eel survival is 97%, although most importers in Hong Kong expect a survival rate of 99%. If mortality does occur, usually a leak in the bag causes a loss of oxygen for the eels.

Figure 10: Eels being weighed for sale (Calabrese, 2018. Reprinted with permission)

The eels are either shipped out on cargo flights or on passenger flights (anonymous trader, personal communication, January 20, 2021). Passenger airlines are generally preferred due to the reliability of their schedule, as keeping the eels packed in a box for too long can be fatal and it is important for the eels to arrive in their holding facilities in Hong Kong as quickly as possible. The COVID-19 pandemic has also affected this aspect of the eel industry. With passenger flights occurring less often, exporters have had to use the less reliable cargo flights more often in the 2020 season.

The trade of the American eel could also be regulated internationally by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). There are three appendices under which a species could be listed. Appendix I includes those species who are threatened with extinction, and Appendix II includes those species that are not necessarily threatened with extinction, but whose trade needs to be regulated to prevent exploitation that is incompatible with the survival of the species. Appendix III includes species who are protected in at least one country, and that country requests help protecting that species. The different appendices offer different protections and regulations. The European eel is currently listed under Appendix II, which requires a certificate to be obtained when the species is exported. The American eel is not listed under CITES, but if it were to be listed under Appendix II alongside the European eel, the regulations in Canada and a number of Caribbean countries would be better regulated by requiring an export certificate. CITES additionally has a trade database which would then include the American eel, thereby making the study and regulation of the American eel trade much easier.

AQUACULTURE

The next step of the eel's journey is its arrival in Hong Kong. Hong Kong is the hub for eel imports, yet there is little transparency for what happens to the eels in Hong Kong. The following is what we have pieced together from anonymous interviews and archival research, but more transparency and enforcement of regulations is needed to have an accurate understanding of the path of the eel in Hong Kong and beyond.

Traders often import their eels to Hong Kong as it is the easiest to get through regulations (anonymous trader, personal communication, January 20, 2021). The process of importing eels to Hong Kong includes a certificate that can be obtained and submitted to the government, but few Hong Kong importers actually require the certificate from U.S. sellers. Once the plane has landed in Hong Kong the eels are transported to a commercial aquarium facility. Here the eels are removed from their packaging and placed in large tanks to recover from the stress of traveling. There is a government facility for this purpose, but many importers have opened their own aquariums since they were tired of having to work through the government owned one. These commercial aquariums then become legally responsible for the eels and complete the money transaction for the purchase.

At around this point in the trade process is when it has been speculated that blending occurs (anonymous trader, personal communication, January 20, 2021). Blending is the process of illegally mixing together glass eels of different species, such as European and American eel, in order to market the glass eels or elvers as a more expensive eel. The European eel in an example of the more expensive variety. The labeling of the eel is now inaccurate, hindering the traceability of the eel. The different species are difficult to distinguish by eye, especially at the glass stage, making it difficult to track which species are being sold and where. If eels were sold directly to China, some experts believe it would cut down on blending by removing the middleman.

Importing directly to China is much more difficult than importing to Hong Kong (anonymous trader, personal communication, February 4, 2021). China has many more regulations and much more paperwork that needs to be completed and approved before an import can occur. They have a detailed import certificate for the health and food quality of the eel that is one of the most detailed certificates compared to other countries. Even if the time is taken for a North American exporter to go through this process, in the past they have been rejected saying they were still missing paperwork. Along with this pushback, many customers do not want to receive imports directly through China, as they prefer working through Hong Kong. There is also speculation that China pushes for eels to come through Hong Kong to turn a blind eye to illegal activity, while benefiting from it.

Once the eels have rested in the aquariums in Hong Kong, they are picked up by their buyers, typically middlemen, who transport the eels into mainland China (anonymous trader, personal communication, January 20, 2021). This can be done legally or illegally.

The illegal importation of eel to China is much more feasible by going through Hong Kong instead of directly to China. One benefit of transporting them illegally is to avoid paying taxes. Once the eels are in China, they are transported to an eel aquaculture farm. These farms are most commonly located in the coastal southern province of Guangdong, highlighted in red on the map.

Figure 11: Guangdong locator map (Wikipedia Commons, 2011)

The eel farms in China are where transparency is most lacking (anonymous trader, personal communication, January 20, 2021). Given the short time frame between when the eels enter the farm as glass eels and leave as adult eels, it implies that there is heavy use of growth hormones at the farms. There are also physical implications of the growth hormone such as larger spine bones and thicker skins (J. Huang, personal communication, January 20, 2021). These characteristics are seen as lowering the quality of eel for restaurants and such eels are often sold at lower prices. Along with growth hormones, testing has shown signs of other concerning chemicals being used such as malachite green for the cleaning of the eel tanks. China has had large scandals where they found large amounts of carcinogens being used in their aquaculture facilities (Wong, 2005). Yet there is still little regulation of which chemicals can be used and at what dosages. More regulations and enforcement are needed to create sustainable and ethical aquaculture in China. This has been difficult in the past, as aquaculture facilities are not large corporations, but rather small family-owned farms that have partnerships with eel importers (anonymous trader, personal communication, January 20, 2021).

China is not the only destination for eels to be raised in aquaculture. Once the eels land in Hong Kong, they can be shipped to a number of destinations such as Taiwan, Vietnam, Philippines and Japan. Japan, Taiwan, and the Philippines in particular are known for their ethical practices and high quality aquaculture (Chang, 2009).

Figure 12: Eel aquaculture farm (Taiwan Trade, 2021)

Taiwan has strict regulations for eel farmers, and all eel is required to go through two rounds of testing to be certified to be sold (Chang, 2009). Farmers also have to keep daily records of the health of the eels. They ensure quality eel through these regulation processes as well as focusing on smaller details such as the quality and temperature of the water. Japan is also known for its higher quality eel due to strict farming regulations and quality testing.

One practice highlighted by an owner of several US based restaurants was how they clean the eel. Eels are bottom feeders, which results in the dirt being consumed into their bodies. To get the most out of an eel a farmer could kill the eel once it is grown, but the dirt will still be inside the eel (anonymous personal communication, January 20, 2021). To get rid of the dirt, the eel can be placed in cold water for about 2-3 days, which produces higher quality eel by cleaning it out before killing it. This also helps prevent the transmission of diseases through the eel. However, this results in the eel losing about 20% of its body weight, which loses some product for the farmer.

Restaurants have a choice of what quality eel they choose to buy. Due to the large demand for eel, aquaculture farms in China grew in popularity as they supplied large quantities of cheaper eels. Restaurants have the choice of buying cheaper eel that has been raised in unregulated conditions or more expensive eel that has been raised in as natural of a way as possible. An owner of several restaurants in the US chooses to source his eel from a Japanese distributor because of their higher quality. Another restaurant owner noted the historical appreciation for eel in Japan: “Japan has a deep appreciation and focus on high quality eel and eel consumption” (M. Miyake, personal communication, January 27, 2021).

Once the eel is raised, it is prepared to be shipped out for consumption. Some eel is shipped live to be held in tanks at restaurants where it is killed and prepared fresh (J. Huang, personal communication, January 20, 2021). Some eel is killed and frozen, either whole or butchered and frozen as fillets. Another preparation is where the eel is butchered and cooked in basic seasonings such as soy sauce before it is frozen and packaged. This eel is then distributed around the world to Hong Kong, China, Japan, Europe, and the United States.

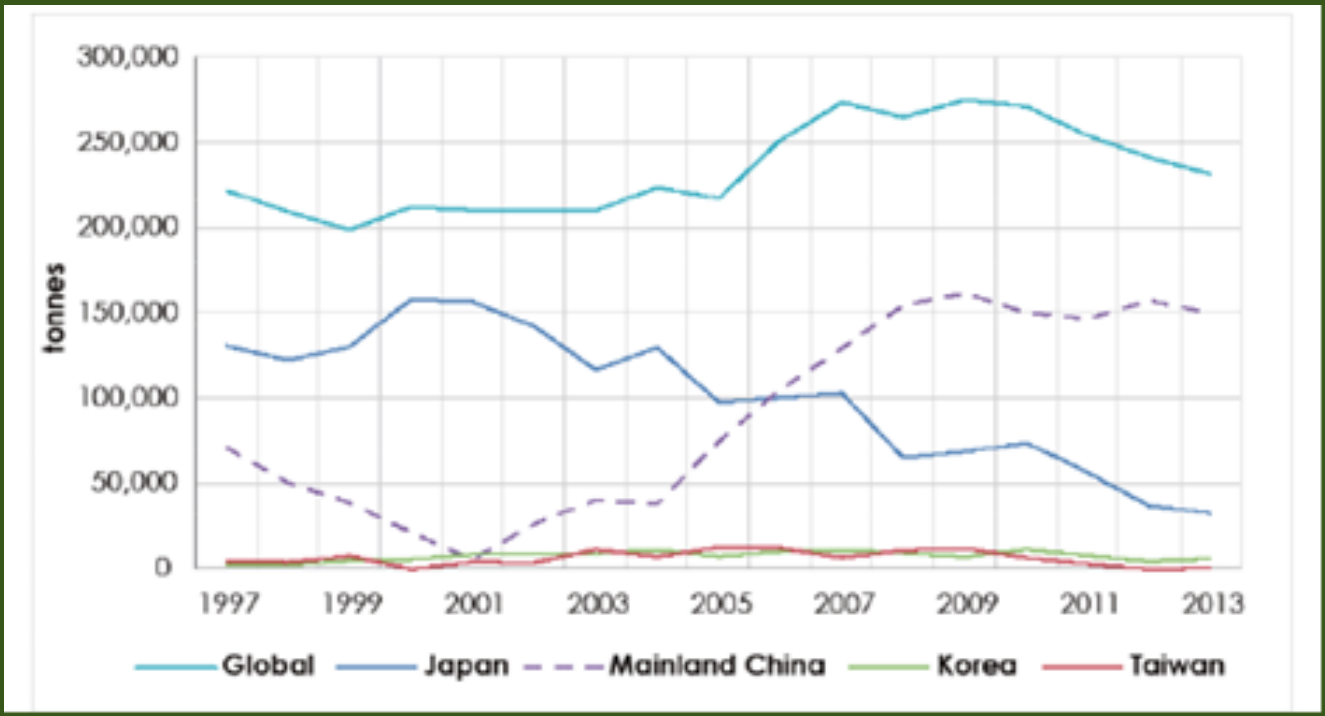

Figure 13: Global Japan, mainland China, and Korea eel consumption based on FAO production data, converted to live eel weight, 1197-2013, tonnes (Shiraishi, H. & Crook, V., 2015)

The eel that was fished in America is shipped across the world to be raised and then sold back to restaurants in America (anonymous trader, personal communication, January 20, 2021). This is an inefficiency that is beginning to be addressed. There is not yet a large eel aquaculture industry established in North America. There are two major companies addressing this: American Unagi and NovaEel.

The first company, American Unagi, is based in Maine. Its goal is to supply responsibly sourced and raised local eel (Rademaker, n.d.). Having eel raised right in Maine where it is fished combats the traceability problem highlighted above. It also grows the local and national economy. They use no hormones or antibiotics, and their fishery is overseen by the Maine Department of Marine Resources and Atlantic States Marine Fisheries Commission. American Unagi is a safer and more sustainable option for restaurants to source their eel from. If restaurants and consumers were more educated on the sustainability of eel, they could make more educated consumption decisions, promoting companies like American Unagi instead of overseas farms.

Another company working towards raising local eel in North America is NovaEel. They are based in Nova Scotia and are working on a feminization treatment of eel where they use estrogen to change male eels to females (N. Ross, personal communication, January 22, 2021). This is a desirable change as female eels can grow several pounds more than male eels. This results in more sellable eel product per eel. The use of the hormone must be approved by the Canadian Government and will be heavily regulated. There are various opinions on this treatment for eels. Some say it is harmless, while others question its ethics. While there may be concerns, there is assurance that the hormone use will be regulated and transparent. The hormone will also not still be present in the eel at the time of consumption. However, the effects of growth hormones outlined about will still appear in these eels.

Alongside all these efforts to meet the culinary demand for eel, there is a bigger goal being researched by many around the world: closing the loop (J. Zydlewski, personal communication, January 13, 2021). Closing the loop means breeding and raising eels in captivity without the need for any fishing. This has been a difficult and expensive endeavor as the eel travels millions of miles in its migration and has a unique diet as larvae. Little is also known about how eels reproduce. Eels have been bred in captivity, however, this process is a long way from reaching consumer demands at reasonable prices. Closing the loop would allow for part of the American eel population to remain undisturbed, although conservation efforts should be focused on protecting the eel's habitats and regulating fishing rather than on researching closing the loop.

Through all these efforts to raise elvers to adulthood, they finally reach their end destination: on a plate ready to be eaten. Eel can be purchased in many types of restaurants ranging from Japanese to Chinese to Italian. Some of the common preparations are pictured below. Eel can also be purchased at supermarkets to be prepared at home. While they are a tasty meal, we often don't think much about the many challenges eels face and the extensive travel around the world eels have made just to reach our plates.

Figure 14: Grilled Eel (Wikimedia Commons, 2009)

Figure 15: Unagi Kabayaki (Wikimedia Commons, 2005)

RECOMMENDATIONS

The problem we have tried to address with our research is the sustainability of the American Eel and its trade between North American and East Asia. We researched the path of the American eel from birth to death, and we have identified various factors that affect its sustainability. The following recommendations aim to improve the sustainability of the American eel by targeting those factors that impact the American eel's survival most directly.

RECOMMENDATION ONE: IMPROVE COMMUNICATION AND EDUCATION

There are many stakeholders involved in the consumption, trade and management, and conservation and sustainability of the American eel on an international scale. We believe that the first step to improve the sustainability of the American eel is to have all the stakeholders communicate with each other on at least an annual basis and share new findings, progress, concerns. This practice could enable a clear understanding of all perspectives regarding the American eel and the actions necessary to improve its sustainability. In addition to the need for more knowledge about eel's ecology, eel consumers and providers, such as restaurant owners, chefs, supermarkets, and distributors, need to be more educated about eels, their life cycle, habitats, characteristics, and challenges.

Thus, our specific phased sub-recommendations include:

Recommendation One-A: That WWF-Hong Kong annually attends American eel symposia where several eel stakeholders and governing bodies come together to present solutions for the American eel. This will allow vital information about the eel to be shared with stakeholders around the world. There are several existing meetings of this nature that WWF could become more involved in through their attendance and participation as well as establishing regular connections with all attending members. Additionally, we recommend that WWF - Hong Kong develops a relationship with the ASMFC and collaborates on implementing the recommendations described throughout.

Existing Eel Meetings:

- North American Eel Science Symposium
- American Fisheries Society Annual Symposium
- Sustainable Eel Group Annual Meeting
- Sargasso Sea Commission American Eel Range States Workshops
- Anguillid Eel Symposium at the World Fisheries Congress

Recommendation One-B: We recommend WWF dedicate more resources to the research on the eel's biology and ecology, allowing for a stronger understanding of the eel's habitat, lifecycle and true population status, especially in the marine and estuary portions of their habitats. We recommend that this dedicated research at least include increased recruitment surveys of the American eel in more locations in its range, surveys of silver eels traveling downstream, and research about how to more accurately perform a stock assessment of the species. This could specifically be improved in the Gulf of Mexico and the Mississippi River Basin by organizations such as the Gulf States Marine Fisheries Commission and Florida Fish and Wildlife Conservation Commission. We want to emphasize the importance of this research, as well as research on the fishing and trade of the American eel, in less known and less regulated regions of the eel's range, such as in the Caribbean.

Recommendation One-C: We recommend that WWF – Hong Kong continue to educate businesses serving and/or selling eel and people consuming eel in Hong Kong about the sustainability issues of the eel. We also recommend that WWF extends this education to eel consumers, restaurants, and supermarkets internationally.

RECOMMENDATION TWO: PROTECTION OF EEL HABITAT

To address the issue of habitat fragmentation, we recommend the introduction of fish passageways such as eel ramps, stairs, or other modifications, as well as modifications to hydropower facilities, to allow both upstream and downstream passage for all species.

Thus, our specific phased sub-recommendations for Recommendation Two include:

Recommendation Two-A: We recommend states modify their water quality certifications to require eel passage around all waterway obstructions. In order to get eel passageways introduced in the United States, different states will need to get a water quality certification that includes the approval of various fish passageways. Additionally, we recommend that Section 18 - Fish Passage Prescription of the Federal Power Act be updated to require fish and eel passage ways at all hydroelectric facilities.

Recommendation Two-B: Once the revised water quality assessment is required, appropriate eel passageways would need to be implemented. We recommend that companies such as River Power LLC, USGS Conte Lab, Lakeside Engineering. Inc., U.S. Fish and Wildlife Service and the Maine Department of Marine Resources, who have already begun working together to design state of the art engineering solutions, install American eel upstream and downstream passageways where required. Some designs and details about eel passage are included in the Threats section of this report. It is important to note that upstream passage implementation must be paired with downstream passage to ensure the eels that are migrating upstream are also able to migrate downstream. These designs should be regularly tested for effectiveness after implementation at facilities.

RECOMMENDATION THREE: BETTER REGULATION OF AQUACULTURE

While aquaculture in the United States is well regulated, most of the eels are still raised in East Asia in less regulated environments. We recommend expanding aquaculture in the United States, while working to increase regulations in other countries such as China, Haiti, Vietnam.

Thus, our specific recommendation for aquaculture in North America includes:

Recommendation Three: We recommend that restaurants source their eels from North American eel farms such as the ones mentioned in our report. In order for these companies to grow, they would need to acquire an increased supply of glass eels. We recommend that the state of Maine redistributes their glass eel quota to increase the amount of glass eels directed to local aquaculture.

RECOMMENDATION FOUR: EXPAND & IMPROVE LEGISLATION

We recommend more legislation protecting and regulating American eel fishing, trade, and aquaculture at national and international levels be passed and enforced.

Thus, our specific phased sub-recommendations for Recommendation Four include:

Recommendation Four-A: International: We recommend WWF works toward listing the American eel on CITES Appendix II, either under the normal definition of Appendix II or as a look-alike species to the European eel. We also recommend an international standard to be placed regarding American eel shipments. The standards can include the following:

- Improve the declaration requirements for live eel shipments. Currently, live eel shipments do not specify the life stage or species of the eel product. Furthermore, a limited number of airports are trained to identify legal and illegal eel shipments. We recommend that the Miami International Airport, Atlanta International Airport, and Toronto International Airport personnel, especially, are trained in the identification of eel shipments.
- WWF works with the UN to update the Harmonized System code for live eel (030192) to differentiate between their species and life stages (glass eel, yellow eel, and silver eel) to improve the traceability of the American eel trade.
- Eels should be tested to ensure that they do not have any diseases or viruses.
- All eels to be sent to aquaculture facilities should be screened to ensure that they have not been blended with other eel species.

Furthermore, we recommend that an international standard be placed on American eel aquaculture. The standard can include the following:

- All eels used in aquaculture facilities should be screened to ensure that they have not been blended with other eel species.
- Regulations for the maximum amounts of permitted chemicals and medicines that can be allowed in eel aquaculture.

Recommendation Four-B: Hong Kong: We recommend that WWF-HK works with the Hong Kong government to require an Import Certificate for the American eel as this serves as documented proof that the eel being traded was legally, sustainably sourced, and labelled accurately. We recommend that this certificate include the eel's species, origin, weight of shipment in kilograms, name of exporter from North America and importer from Hong Kong. An example of the certificate used for Taiwan can be found in Appendix E.

Recommendation Four-C: United States: We recommend the ASMFC increase regulations regarding yellow American eel fishing by decreasing the permitted amount of yellow American eel fished due to the nature and vulnerability of their life cycle and reproduction.

Recommendation Four-D: Canada: We recommend the Department of Fisheries and Oceans impose regulations regarding silver and yellow American eel fishing due to the nature and vulnerability of their life cycle and reproduction. Due to the success of the regulations put in place by the ASMFC in Maine, we recommend Canada introduce a similar system. We also recommend that Canada impose a traceability system between the buyer and export, similar to the Maine Marine Patrol's system in Maine. The systems imposed by the ASMFC and Maine Marine Patrol are outlined respectively in the Fishery and Trade sections of our report.

We hope the detailed path of the American eel paired with our recommendations will positively impact the sustainability of the American eel. Our findings and recommendations can be used to educate governing bodies, consumers, and other stakeholders. The viability of the American eel is dependent on those addressed in our report taking the described actions and coming together to recognize their common goal of sustaining the American Eel. We also hope that this report gave you more insight on the complex life of the American Eel and inspires you to care about conserving the American eel and other species threatened with extinction.

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APPENDICES

APPENDIX A: METHODS

The purpose of our project was to present a set of recommendations to WWF Hong Kong to help make the trade of American eel between North America and East Asia more sustainable. The first objective of this project to help us achieve our goal was to identify the international, national, and state laws pertaining to the American eel trade. The second objective was to determine the quantity of legal and illegal trade, sale, and transport of the American Eel from North American to East Asia. The third objective was to determine the role of the American eel in traditional Chinese and East Asian cultures and cuisine. The fourth objective was to determine some potential and feasible means for sustaining the American eel population. By achieving these four objectives, we created some potentially feasible and useful recommendations for WWF – Hong Kong to promote a more sustainable American eel trade between the North America, Hong Kong, and East Asia, then assessed these preliminary recommendations using a SWOT analysis. In this chapter we describe the methods that we used to help us achieve each of these objectives.

Objective 1: Identify the international, national, and state laws pertaining to the American eel trade.

We utilized **Archival Research** in order to achieve Objective One. The purpose of the archival research was to identify the international, national, and state laws pertaining to the American eel trade. The archival research was undertaken using the United States Fish and Wildlife Service archives, the Canadian Department of Fish and Game archives, and the University of Maine archives.

We utilized the same set of **Semi-Structured** Interview questions in order to achieve Objective One and Objective Two. We conducted semi-structured interviews with 2 national and state government representatives in sectors addressing marine life and eel transport. We chose to interview 2 people who hold different roles in the government and who work on regulating the eel trade. One of the interviews gave us insight on the national regulations and monitoring of the eel trade and an understanding of the laws regarding the American eel trade. The other interview focused on state procedures and regulations in relation to American eel trade. Specifically, we interviewed Maine Marine Patrol Officer and a Resident Agent in charge from the US Fish and Wildlife Service. We began contacting government officials in January 2021. We conducted interviews over Zoom and by telephone. We followed the official IRB protocols (See Appendix C). The questions that were asked in the interviews can be found in Appendix C.

Objective 2: Determine the amount of legal and illegal trade of the American Eel from North America to East Asia

We utilized **Archival Research** in order to achieve Objective Two. The purpose of utilizing archival research was to determine the amount of legal and illegal trade, sale, and transport of the American Eel from North America to East Asia. We focused our research on trade statistics and previous illegal eel operations.

As mentioned for Objective One, the same set of **Semi-Structured Interview** questions were utilized to achieve Objective One and Objective Two. The questions asked during the interviews can be found in Appendix C. We interviewed 1 person who is an eel trader in North America. This interview provided us with an understanding of legal and, illegal American eel trade and well as the procedures involved when buying, selling, and exporting eels to Hong Kong.

Objective 3: Determine the role of the eel in traditional Chinese and East Asian culture and cuisine.

The first method we utilized in order to achieve Objective 3 was **Archival Research**. The purpose of the archival research was to determine the role of eel in traditional Chinese culture and cuisine. We began our search at universities where Chinese cuisine is taught and historical ethnographies of Chinese culture and cuisine.

The second method we utilized in order to achieve Objective 3 was **Semi-Structured Interviewing**. We interviewed a restaurant owner who owns 6 restaurants in Massachusetts. We also interviewed 3 chefs in the United States who serve and prepare eel. We reached out to restaurants in the United States that serve eel in East Asian preparations. We utilized snowball sampling in order to reach more contacts. We began interviewing chefs in January 2021. We conducted interviews over Zoom, by telephone and received written responses to our questions. During our interviews we followed the required IRB protocol. Our semi-structed interview questions can be found in Appendix D.

Objective 4: Determine some potential and feasible means for making the American eel population sustainable.

The first method we utilized in order to achieve Objective 4 was **Archival Research**. Our archival research was conducted online and in the WPI Resource Library. We also studied past editions of the South China Morning Post.

The second method we utilized to achieve Objective 4 was **Semi-Structured Interviewing.** We conducted semi-structured interviews with marine conservationists and representatives from marine conservation groups.

We interviewed 11 representatives from national and international conservation groups. Eel conservationists from the Sustainable Eel Group, American Unagi, IUCN, Nova Eel, and Eel Town located in the US were also contacted in January and February 2021. We conducted interviews over Zoom or by telephone. We followed the official IRB protocol and asked the questions found in Appendix F. We used the information gathered from these interviews to provide an initial understanding of how the sustainability of the eel trade could be improved. To initially find whom we were going to interview, we researched major eel conservation groups online such as the Sustainable Eel Group, and then utilized snowball sampling to reach more contacts.

Objective 5: Determine the feasibility and appropriateness of preliminary recommendations

The method that we used in order to achieve Objective 5 consisted of a SWOT analysis. Based on the interviews and archival research we had conducted throughout our project, we created a set of recommendations for WWF Hong Kong. We selected six individuals whom we had interviewed to achieve our objectives, to conduct a SWOT analysis of our recommendations. The SWOT analysis consisted of three separate meetings composed of 1-2 members along with written feedback from two individuals. Separate meetings were conducted due to differences in time zones and confidentiality concerns. The selected individuals were from the World Wildlife Fund, Maine Department of Marine Resources, and other global eel stakeholders including conservationists. The six selected individuals represent a comprehensive view of the American eel industry. The specific members of the focus group were determined throughout the interview process of our project after consultation with our sponsor. We followed the official IRB protocol and asked the questions found in Appendix G. The SWOT analysis was conducted in February 2021 via Zoom or by telephone.

APPENDIX B: INTERVIEWEES

JOSEPH ZYDLEWSKI

"The goal of effective fish passage is to make the dam invisible to the fish. We are a long way from that."

Joseph is a Professor in the Department of Wildlife, Fisheries and Conservation Biology and Ecology and the School of Marine Sciences at the University of Maine, Orno and an employee of USGS. His research focuses on the physiology and behavior of migratory fish. More recently, he has been looking into management of anthropogenic threats like dams. In regards to eels, he has been looking into their survival as they migrate downstream and the mortality risk in regard to dams as they travel. He has also been looking into environmental factors associated with eel migration patterns. From our interview with him, we learned about the major threats to the American eel population, and that the biggest impacts come from habitat fragmentation and adult eel mortality.

FLORIAN STEIN

Florian Stein is a PhD student and the Director of Scientific Operations for the Sustainable Eel Group (SEG) in Europe. He serves as an advisor for law enforcement and international organizations such as the United Nations and FAO. He also works with agencies such as the U.S Fish and Wildlife Service and Environment Canada. He has recently contributed to the chapter on eels published in the 2020 World Wildlife Crime Report by the United Nations Office on Drug and Crime (UNODC). From Florian, we learned details about the illegal trade of the European eel, and about how important traceability is when solving issues in wildlife trade.

ANDREW KERR

"Eels with their long shape and turbines just don't mix.... And when you think of a big adult eel you think of it as one eel, but actually if you put your glasses on, you see it's a big female and it has 1 million eggs for every kilo, so when you kill an eel age 20 to age 30 at the end of its life cycle, you're not killing one eel, you're actually killing a percentage of the eggs it's carrying, it has a totally disproportionate effect."

Andrew Kerr is Chairman of the Sustainable Eel Group in Europe, an organization working towards improving the sustainability of the European eel. His passion for eel developed by living near the River Severn where he heard in his youth stories of the eels' super abundance, and then later in life of their decline. He has worked 25 years in management consulting specializing in organizational development, leadership and change. From our interview with him, we learned about the sustainability efforts being led by SEG and what issues are the most important to tackle with the American eel. He also emphasized the importance of communication, as the eel trade is an international and political issue.

JASON BARTLETT

Jason Bartlett works for the department of Marine Resources in Maine. Currently he is working on the life cycle study for the American eel to improve our understanding of the eel's ecology. Ultimately, the results from this study will help maintain the sustainability of eel fisheries. From Jason, we learned about the life cycle study, about the current status of the American eel population, and about where future research needs to be focused.

GAIL WIPPELHAUSER

Gail is a biologist at the Department of Maine Resources. She works on the American eel life cycle study, as well as yearly stock assessments completed by ASMFC. She also works to require eel passage in dams and hydropower facilities. She worked on the first successful project to remove a dam from Maine's rivers. Outside of eels, Gail has published many research papers on Sturgeon, Alewife, and other fish. From Gail, we learned about the process required to get fish passage implemented in dams and the importance of protecting the eels' habitats.

DAVID BUNT

David Bunt is the Director of Conservation Operations for the Sustainable Eel Group in Europe. He has more than 35 years of knowledge and experience regarding fishery management. He first became interested in fish management as an undergraduate student. His degree was in environmental biology, and the courses taken for this degree inspired him to pursue fishery management. He then pursued a masters in Aquatic Resourcing specializing in fish. Following his education he worked with the Water authority in the UK and an Environment agency, then began working as a consultant for SEG. He developed the SEG standard which has been implemented in eel fisheries throughout Europe and improved the sustainability of European eel fishing. From David, we learned about the SEG sustainability standard and its role in the protection of the European eel, as well as what actions need to be taken to improve the sustainability of the American eel.

SARA RADEMAKER

Sara Rademaker started an aquaculture company known as American Unagi in 2014 with the intention of using Maine harvested glass eels as their sole source for a land based aquaculture farm. Sara wanted to provide consumers with a fully traceable and fully accountable eel. American Unagi's eels are grown without the use of hormones or antibiotics. American Unagi's fishery is managed by the Maine Department of Marine Resources and Atlantic States Marine Fisheries Commission, thus allowing consumers to feel confident that American Unagi eels are sourced from responsibly managed wild stock. From Sara, we learned about American Unagi's methods and more about the benefits of doing glass eel aquaculture in the United States to provide sustainable and locally sourced seafood.

NICK WALKER

> “There's always an economic argument for species conservation, but in this case if it doesn't go right to preserving [eels'] habitats and their access to migration, nothing else is going to matter.”

Nick Walker is a conservation biologist studying all aspects of American eel and eel conservation around the world. He is also the Founder & Executive Director of Eel Town and owner of Journal Editors of America LLC where he helps researchers publish in high-impact academic journals and textbooks. Overall, he works on connecting eel researchers from around the globe and helping the eel population. From Nick, we learned a wealth of information about all aspects of the American eel and its trade.

NEIL ROSS

Neil Ross is the research director of NovaEel. He is working to develop eel aquaculture in North America. He has headed research at Symbiotic Envirotek and the National Research Council of Canada. His expertise covers a wide variety of aquaculture, marine biology, and chemical technologies. His technological expertise is fueled by a passion for sustainable fish solutions. From Neil, we learned about NovaEel’s work and more about the American eel’s ecology and threats in the Canadian portion of its range.

CASSIDY BIGOS

Cassidy Bigos is a contractor at the Department of Maine Resources Maine. Her work focuses on habitat assessments, habitat structure implementation, and monitoring of many fish species, as well as Atlantic salmon handling and transportations. While her main focus is not on eel, she still is involved in field work with eels. Her field work has ranged from implementation of eel passage, pot trapping, and pigmentation studies. From Cassidy, we learned a wealth of information about many aspects of the American eel trade, especially pertaining to the implementation of fish passage and more details about the elver fishery regulations.

DAVID SYKES

David Sykes is the Resident Agent in Charge of the New England Office of the U.S. Fish and Wildlife Service. He supervises 6 state agents across New England. He works with offices in the field and takes their cases to a federal prosecutor to tackle illegal activity. He was the lead supervisor for Operation Broken Glass, the largest investigation of illegal glass eel trade and fishing. From David, we learned about the glass eel harvest regulations in Maine and Operation Broken Glass, as well as other issues with regulations in the Caribbean.

AITOR IBÁÑEZ ALONSO

Aitor Ibáñez Alonso is a student at Utrecht University. He has just completed his masters in Global Criminology. His thesis focused on the trafficking of glass eels in Europe. While his thesis focused on the European eel, he also collected data and researched the American and Japanese eel. From Aitor, we learned more about the illegal trade of the European eel, the role of CITES, and the importance of considering the global impact of our recommendations.

MATT WYMAN

Matt Wyman is a Sergeant in the Maine Marine Patrol. He has been a part of the Maine Marine Patrol for the past fourteen years. At the patrol, he has worked with both the lucrative Maine lobster and elver industry. He has worked both in the field and overseas officers in the field. From Matt, we learned crucial details about the enforcement of elver fishing regulations in Maine.

JACK HUANG

Jack Huang is the owner and operator of six Japanese restaurants located in and around Boston. He also supplies sushi to Boston University, Fenway Park, and several 5 star hotels. Jack is passionate about sushi and using high quality ingredients at all his restaurants. From Jack, we learned about why eel is so popular, and gained insight into the opinions of the restaurant industry.

"In Japan in the summer we eat [eel] because the texture is so refreshing. You know, summer is hot and humid in Asia, so it is one of the foods used to celebrate summer... it's very high in protein and the texture is not that greasy, which is good for summer."

“[Restaurants should] tell people the quality of their eel and how their eel is different. You might not make a lot of money like other products, but you are saving the planet, you're saving this world, and you’re helping your children by giving less toxic eel, we already have enough toxic in the world.”

MASA MIYAKE

Masa Miyake has been a part of the restaurant industry for 40 years, beginning in his native Japan, then NYC, and finally Portland, Maine, where he has resided for the past 15 years. He currently owns and runs two Japanese restaurants in Portland- Miyake, focused on sushi, sashimi, and chefs tasting menus, and Pai Men Miyake- a fast paced ramen noodle bar.

“Masa slaughters and cleans them, then filets them, and then they are steamed. The steaming is a very important step as this helps to render the texture soft and delicate.”

“Japan in particular has had a deep appreciation and focus on high quality eel and eel consumption, featuring restaurants that specialize in and only serve eel”

APPENDIX C: IRB FORM EXAMPLE

Informed Consent Agreement for Participation in a Research Study Non-Videotaping-Semi-Structured Interviews

Semi-Structured Interview with Eel Conservationists

Investigators: Sydney Atkinson (slatkinson@wpi.edu), Grace Malabanti (gmalabanti@wpi.edu), & Karina Mirochnik (kmirochnik@wpi.edu)

Primary Contact Information: gr-HKEels-C21@wpi.edu

Project Title: *The Potential of Sustainable American Eel Commerce*

Sponsor: Jovy Chan (jovychan@wwf.org.hk)

SCRIPT

Introductions: Hello. We would like to thank you for taking the time to meet with us today. How would you like to be addressed? At this time we would like to introduce our team members.

Introduction to format of this meeting: You are being asked to participate in a research project. Before you agree, however, we wish to inform you about the purpose of the project and the procedures and protocols we follow. Our goal here is to ensure that you are making a fully informed decision regarding your participation and feel comfortable in participating.

Purpose of our project: The purpose of our project is to present a set of recommendations helping to make the trade of American eel between the United States and East Asia sustainable.

Procedures and Protocols: It is important that we take a moment to explain our responsibilities and your rights regarding this one hour in duration semi-structured interview. Eventually our final IQP document, which includes the results of our interaction with you (your answers), will be stored on the WPI library website or may appear in a published paper.

Record keeping and confidentiality: We would like to receive your verbal permission to publish your responses as well as the names, titles, and any affiliations that you may have with individuals or groups that we may discuss during this interview. Anonymity is guaranteed unless your permission is received. You have the option to remain anonymous and continue to participate in the interview/study. If we wish to use a quote that identifies you, we will ask for your permission and you have the right to review any quotes or information before publication.

The answers to your questions, today, will be maintained in our pass-coded computer to only be reviewed by this team. No one else will have access to the answers. Raw data not published will be deleted upon completion of the project. These records will be accessible to only the three members of our team. They will be permanently deleted from our pass-coded computers. Records of your participation in this study will be held confidential so far as permitted by law. However, the study investigators, the sponsor or it's designee and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data will not identify you.

Risks to participants: There are no anticipated, perceived or known risks to you that we are aware of as a result of your participation in this semi-structured interview.

Benefits to research participants and others: There are no monetary or other benefits to you or others who participate in this semi-structured interview.

For more information about this research or about the rights of research participants, or in case of research-related injury, contact: See investigator contacts above. In addition, include the contact information for the IRB Manager (Ruth McKeogh, Tel. 508 831- 6699, Email: irb@wpi.edu) and the Human Protection Administrator (Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu).

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. The project investigators retain the right to cancel or postpone the experimental procedures at any time they see fit.

Final Comments before undertaking Interview

1. Do you have any questions about our project or any of our responsibilities or your rights?

2. If not, then may I have your permission to record this session or conversation? (If they agree, ask their permission once recording, so that their consent is recorded.)

APPENDIX D: INTERVIEW QUESTIONS

Interviews with Eel Conservationists

1. Please take a moment to tell us about your career and work with eels.
2. We know that the conservation status of the American eel is controversial and highly debated. How much trouble do you think the American eel population is in?
3. As you know, the European eel and Japanese eel are now endangered. What do you think is impacting the American eel population?
4. What are some actions that your organization has taken or is taking to create sustainability of endangered eels?
5. What additional actions do you think need to be implemented to aid the sustainability of the American Eel?
6. In your opinion, how big of an impact are the elver fisheries having on the American eel population?
7. What impact are your organization's actions making on the sustainability of American Eels?
8. We were thinking about initiating an Eel Stewardship Fund in North America to help restore the American Eel Habitat. What are your thoughts on implementing this?
9. Is there something we should have asked about that we did not ask? Is there something you want to tell us about that you did not already say?
10. Are there any other contacts you can connect us to, with whom we can conduct a similar interview?

Interviews with Eel Traders

1. Please take a moment to tell us about your career.
2. What are the laws regarding the amount of eels that you can buy/sell per year, per catching season?
3. What is the life stage (glass, elver, yellow, or silver) of the eels that you buy/sell?
4. How many tons do you sell of each stage of eel per catching season?
5. How do you ship the eels? Can you describe the packaging and weighing procedures and/or standards?
6. Whom do you sell your eels to and where are they located, and where do they end up once they've been sold?
7. We know that the conservation status of the American eel is controversial and highly debated. How much trouble do you think the American eel population is in?
8. What measures are being taken or should be taken to ensure that the American elver trade is sustainable?
9. Is there anything else you would like to talk about, or are there any questions that we didn't ask you today that we should have asked you?
10. Are there any other contacts you can connect us to, with whom we can conduct a similar interview?

Interviews with Chefs and Restaurant Owners

1. Please tell us about your experience in the culinary industry.
2. Please elaborate on the storage and cooking of eels. In what stages do you buy eels (glass, yellow or silver)?
3. Please elaborate on the sourcing of the eels that you use in your cooking?
4. Would you be able to put us in contact with your distributor?
5. Do you know what species of eel you serve?
6. Please elaborate on the culture and history of eel consumption?
7. What proportion of your cuisine uses each stage of eel?
8. There is a program being run in Europe to help maintain the eels population (The Eel Stewardship Fund). For every eel dish sold, restaurants have agreed to donate a small percentage to support scientific research and conservation measures ultimately leading to eel recovery. We are trying to gauge interest for a program like this in the US. Would your restaurant be interested in participating in a similar fund for the American Eel?
9. Is there anything else you would like to share that we didn't cover?
10. Is there anyone who you could put us in contact with that could help us with our project?

Interviews with Law Enforcement

1. Please take a few minutes to tell us about your job.
2. We are aware that there are international, national, and state laws regarding the American eel that's traded between the United States and East Asia. We also assume that eel fishermen are licensed and have been educated as to the laws and regulations regarding the fishing and trade of the American eel to Asia. Who polices and enforces these state laws and regulations? What challenges do they have?
3. Who enforces the international and national trade laws? What challenges do they have?
4. Out of all the elvers caught in the United States, approximately what percent are shipped within the United States and what percent are exported to East Asia? What about eels raised on farms in East Asia? Are there any sources that track where they are exported to?
5. How do you know that the eels being exported are from Maine or South Carolina?
6. Please explain the supply/demand aspect of American eel trade and consumption based on your knowledge of the eel industry.
7. Regarding the illegal eel trade, please tell us what you can about events taking place now and/or where we can find out more about the illegal eel trade.
8. Is there anything else that you would like to discuss that we did not talk about today?
9. Is there anyone else you can connect us to who would be able to help us with our project.

APPENDIX E: TAIWAN CERTIFICATE

Veterinary Certificate for the Export of the Glass Eel and Eel Fry to Taiwan

Part 1: Details of dispatched consignment

I.1 Exporter: Name: Address:	I.2 Certificate reference number: I.3 Competent Authority:
I.4 Importer: Name: Address:	
I.5 Country of export:	
I.6 Country of destination:	
I.7 The water area or aquaculture facility of origin: Name: Address:	
1.8 Quantity and total weight:	1.9 Date of departure from the water area or aquaculture facility of origin:

Species (Scientific name)	Common name	Age or stage
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Part		Certificate reference number:

F-3

II. The undersigned Certifying Official certifies that the animal(s)/gametes described above satisfy(ies) the following requirements:

Three days prior to the shipment from the water area or aquaculture facility of origin, the live fish, and their gametes and fertilized eggs have been inspected and found healthy and free from infestation of ectoparasites or clinical signs of any communicable disease.

Signature of Certifying Official:

_____

Name of Certifying Official in block letters:

_____

Authority of Issuance:

_____

Place of Issuance:

_____

Date of Issuance: Official Stamp:

_____

APPENDIX F: USFW CERTIFICATE

OMB APPROVED NUMBER 0579-0278

United States Department of Agriculture Animal and Plant Health Inspection Services Veterinary Services (USDA/APHIS/VS)	Department of Interior US Fish and Wildlife Service (DOI/USFWS)	Department of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service (DOC/NOAA-Fisheries)

HEALTH CERTIFICATE FOR THE EXPORT OF LIVE FINFISH, MOLLUSKS, AND CRUSTACEANS (AND THEIR GAMETES) PART 1 OF 2

NOTE: Mark all the relevant items with (X) in the appropriate space.

CERTIFICATE NUMBER

I. Identification

☐ Farmed/Aquaculture Stocks ☐ Public resource/Wild/Feral Stocks

☐ Adult ☐ Juvenile ☐ Larvae ☐ Male Gametes ☐ Unfertilized eggs ☐ Fertilized eggs

1. Genus/species (Latin Name): (Common Name):
2. Age (years): ☐ Unknown ☐ 0-1 ☐ >1 ☐ Brood
3. Total Net Weight (kg): (if known) Number (X1000): Lot Identification: Number of Containers in Consignment:

II. Place of Origin

1. Country/State: 2. Zone/Compartment:
3. Aquaculture Establishment (Name and Address and Map Coordinates or GPS if known):

III. Destination

1. Country/State: 2. Zone/Compartment:
3. Aquaculture Establishment (Name and Address and Map Coordinates or GPS if known):

IV. Declarations

The undersigning representatives of the US Competent Authority attest that:
All samples from the present consignment used in determining the health status of the ☐ ***Country*** ☐ ***Zone/Compartment*** ☐ ***Aquaculture establishment*** were collected and tested in accordance with the procedures described in the ☐ ***OIE Diagnostic Manual for Aquatic Animal Diseases (current ed.),*** or ☐ ***USFWS/American Fisheries Society-Fish Health Section Standard Procedures for Aquatic Animal Health Inspections (AFS "Blue Book", current ed.)***, with negative results

The Competent Authority certifies that live aquatic animals or their gametes in the present consignment have as their place of production a ☐ ***Country*** ☐ ***Zone/Compartment*** ☐ ***Aquaculture establishment*** that has been subjected to an official health surveillance scheme according to the procedures described in the ☐ ***OIE Diagnostic Manual for Aquatic Animal Diseases (current ed.),*** or ☐ ***USFWS/American Fisheries Society-Fish Health Section Standard Procedures for Aquatic Animal Health Inspections (AFS "Blue Book", current ed.)***, and which is officially recognized as being free from the pathogens or diseases listed in the applicable table on the reverse side.

ONLY ONE ENDORSEMENT IS NEEDED. STAMP APPLICABLE BOX BELOW AND CROSS OUT/INITIAL NON-APPLICABLE BOXES.

USDA/APHIS/VS * **(Farm raised aquatic livestock)**	**DOI/USFWS** **(Freshwater public resource/feral aquatic animals)**	**DOC/NOAA-Fisheries** **(Marine wildlife/feral aquatic animals, and aquatic animals in the Exclusive Economic Zone)**
Accredited or Federal Veterinarian:	**Approved Aquatic Animal Inspector:**	**Approved Aquatic Animal Inspector:**
Name (print):	Name (print)	Name (print):
Signature Date	Signature: Date:	Signature: Date::
Endorsing Area Veterinarian in Charge:	Address:	Address:
Name (print):		
Address:		
	Federal veterinarian (if applicable)	Federal Veterinarian (if applicable)
	Name (print)	Name (print)
Signature: Date:	Signature: Date:	Signature: Date:
Stamp of Competent Authority:	**Stamp of Competent Authority:**	**Stamp of Competent Authority:**

VS FORM 17-141
(MAR 2006)

* USDA/APHIS/VS may, on request by DOI or DOC, endorse health certificates for non-farm raised aquatic animals
ANY ADDITIONAL INFORMATION OR SPECIFIC REQUIREMENTS OF IMPORTING COUNTRIES MAY BE ATTACHED TO THIS FORM IN AN ADDENDUM

According to the Paperwork Reduction Act of 1985, no persons are required to respond to a collection of information unless it displays a valid OMB number. The time to complete this collection of information is estimated to average .5 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the form.

CERTIFICATE NUMBER:

HEALTH CERTIFICATE FOR THE EXPORT OF LIVE FINFISH, MOLLUSKS, AND CRUSTACEANS (AND THEIR GAMETES) PART 2 OF 2

EXPORT OF LIVE FINFISH AND GAMETES

Freedom from the diseases/pathogens listed below has been established for the areas denoted on the right	Country		Zone		Aquaculture Establishment	
	Yes	No	Yes	No	Yes	No
Epizootic hematopoietic necrosis/EHNV						
Infectious hematopoietic necrosis/IHNV						
Infectious pancreatic necrosis/IPNV						
Infectious salmon anemia/ISAV						
Oncorhynchus masou virus disease/OMV						
Viral hemorrhagic septicemia/VHSV						
And any of the following if required by the importing zone						
Spring viremia of carp/SVCV						

EXPORT OF LIVE MOLLUSKS AND GAMETES

Freedom from the diseases/pathogens listed below has been established for the areas denoted on the right	Country		Zone		Aquaculture Establishment	
	Yes	No	Yes	No	Yes	No
Bonamiosis *(Bonamia ostreae, B. exitiosa)*						
Haplosporidiosis *(Haplosporidium costale, H. nelsoni)*						
Marteiliosis *(Marteilia refringens, M. sydney)*						
Mikrocytosis *(Mikrocytos mackini, M. roughleyi)*						
Perkinsosis *(Perkinsus marinus, P. olseni)*						
And any of the following if required by the importing zone						

EXPORT OF LIVE CRUSTACEANS AND GAMETES

Freedom from the diseases/pathogens listed below has been established for the areas denoted on the right	Country		Zone		Aquaculture Establishment	
	Yes	No	Yes	No	Yes	No
Taura syndrome/TSV						
White spot disease/WSSV						
Yellowhead disease/YHV						
And any of the following if required by the importing zone						

The animals in this shipment are intended for aquaculture or ornamental purpose only.

VS 17-141
(MAR 2006)

INSTRUCTIONS FOR FORM VS 17-141 Part 1: HEALTH CERTIFICATE FOR THE EXPORT OF LIVE FINFISH, MOLLUSKS AND CRUSTACEANS (AND THEIR GAMETES)

VS 17-141 is a model export form for the export of live aquatic animals or gametes that may be electively used by US producers. Under an arrangement among the 3 co-Competent Authorities for aquatic animals, APHIS may, when requested by USFWS or NOAA-Fisheries, endorse form VS 17-141 for animals under those Agencies' jurisdictions. However, only APHIS may endorse health certificates for exported farmed aquatic animals, excluding any originating from the Executive Economic Zone (EEZ). Requests from USFWS or NOAA-Fisheries for APHIS endorsement of VS 17-141 should be directed to the applicable VS Area Office. USFWS or NOAA-Fisheries seeking APHIS endorsement must submit certificates signed by a Federal veterinarian in order for such certificates to be endorsed by APHIS.

STEP-BY-STEP INSTRUCTIONS ARE INCLUDED FOR FILLING OUT VS 17-141 BELOW, CORRESPONDING TO THE SECTIONS IN THE FORM.

1. CERTIFICATE NUMBER: This should go in the box provided. If USFWS or NOAA-Fisheries is requesting APHIS endorsement and has already assigned a number, VS should still assign its own certificate number.

2. IDENTIFICATION: On the first line, the producer or submitter should mark whether the consignment is of farmed or non-farmed (public resource/wild/feral stocks) origin. A single consignment would not typically be expected to contain both types of aquatic animals; but if it did, additional VS 17-141 (part 1 and part 2) certificates or addenda may be used as needed.

a. On the second line, the producer or submitter should mark the appropriate boxes designating lifestage. If more than one lifestage is being shipped in the same consignment, mark all relevant boxes.

b. On the third line, if more than one species is being consigned, their names may be attached as an addendum or listed on additional VS 17-141 forms.

c. On the fourth line, the producer or submitter should mark the box corresponding to the age of aquatic animals in the shipment, if known. If broodstock of any age are being shipped, they can be so designated in this section.

d. On the fifth line, the net weight (exclusive of container weight) should be listed by the producer or submitter, as well as the total number of aquatic animals/gametes in the consignment, regardless of the number of species being shipped. The Lot Identification block refers specifically to the consignment being exported and should contain the unique identifying code for this consignment. Identifiers may consist of a production code or any other designation that can facilitate tracking should the need arise later. The number of individual containers making up the total shipment should also be noted by the producer or submitter.

3. PLACE OR ORIGIN: This section refers to the country, state and production facility from which the aquatic animals in the consignment are being shipped. (Currently the US has no designated aquatic animal zones or compartment, but once those have been established, they may be referenced.) Global Positioning Satellite coordinates may be supplied if known.

4. DESTINATION: This sections refers to the receiving areas for the consignment. Many other countries have existing zones or compartments, which should be identified when known by the producer or submitter. Global Positioning Satelite coordinates may be supplied if known.

5. DECLARATIONS: a. *Attestations:* The first part of this section deals with attestations (statements) from the submitting person, who must be designated by his or her respective agency as an authorized representative. For APHIS, this can be an accredited veterinarian (accredited in the state from which the animals originate), or a federal or state veterinarian. For certificates submitted to USFWS or NOAA-Fisheries for endorsement, the submitter should be an Approved Aquatic Animal Inspector as officially designated by those agencies.

The health status of the US, or of any future-designated zones or compartments, has not yet been established for most applications of aquatic animal export certification. However, individual production facilities (aquaculture establishments) may demonstrate evidence of disease freedom as stipulated under the World Organization for Animal Health (OIE) or US Fish and Wildlife Service's AFS-FHS (Blue Book) certification schemes. OIE information may be found at http:/www.oie.inat/eng/normes/fcode/A_summry.htm.

The relevant submission and testing protocol utilized for the consignment should be checked in this section. Only one protocol per certificate may be selected by the submitter. For OIE purposes, original testing results from an APHIS-USFWS-and or NOAA approved aquatic pathogen detection laboratory (not exceeding 60 days prior to the endorsement date in age) should be provided by the submitter for endorsement purposes. The laboratory report should indicate the personnel who collected and submitted the samples; the date of collection and submission to the laboratory; the number of animal samples tested; the types of tissues used in testing; the specific pathogens or diseases assayed and specific tests used. Results should meet the importing country's requirements.

b. *Certifications:* There are 3 endorsement boxes for the 3 agencies on VS 17-141, but only one endorsement per consignment is needed. The certification statements in this section may only be filled out by the VS Area Office or by designated representatives of USFWS and NOAA-Fisheries. The health status of individual US production facilities ('aquaculture establishments') may be certified so long as a continuous and minimum 2-year health history, corresponding to the stipulations of the OIE Diagnostic Manual for Aquatic Animal Diseases or the American Fisheries Society/Fish Health Section's Blue Book, has been provided to VS by the producer. Freedoms may be certified for individual diseases or pathogens as indicated by the boxes checked on the reverse side of the certificate.

6. ENDORSEMENT: Only one of the three boxes on the certificate need be endorsed per consignment. Endorsing personnel, after determining that the certificate is complete and accurate, including all necessary testing results, should endorse the certificate with a signature in relevant box, and strike out/initial the other two boxes as Not Applicable. The embossing stamp should be applied over the shaded area of the endorsed box.

VS 17-141 part 2: The submitter should indicate the section (Finfish, Mollusk s, Crustaceans) of this page for which laboratory testing results are being supplied. Under the relevant section, individual pathogens and diseases for which freedom may be declared based on those results should be X-ed in under the (Yes) column for the level of testing being provided. Currently there are no Country or Zone-level programs for the US, so those blocks should be lined out, as a declaration of freedom may currently be provided on the Aquaculture Establishment level only. Depending on the species of aquatic animal being exported, submitter should put an N/A in the (Yes) column for those diseases for which exported species are not known to be susceptible.