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Research Plan

**1.0 Rationale:**

The American eel (*Anguilla rostrata*) is a catadromous migratory fish species, whose drastic decline has resulted in their listing as endangered on the IUCN Red List. This study examined influences of environmental factors- water flow and tributary temperature, factors that may be influenced by climate change- on the abundance and fitness of juvenile eels through novel methods during spring arrival. A fyke net was placed annually (2008-2019) in a Hudson River tributary to track seasonal glass eel migration. Daily, eels were counted and weighed, as a proxy for fitness. A HOBO Logger, installed above the head of tide, measured water depth (a proxy for flow), with air and water temperature noted separately. Our ten-year analysis reveals an annual peak arrival of glass eels, typically occurring mid-season, likely in response to optimal water temperatures (55̊F) and conditions, around Julian dates 95-116. It was found that the fittest eels arrive with lower water temperatures and higher water flows, earlier in the season. Glass eels arriving later were weaker, likely the result of longer, more strenuous migrations. These findings suggest that the fittest eels have the highest chance at survival; however, shifting environmental conditions, particularly water temperature and flow may pose challenges for migrating eels in terms of overall energy reserves and food availability, further influencing the outlook for this species. Collectively, our findings provide novel insight on patterns of American eel abundance and fitness in a tributary of the Hudson River, a critical habitat for this culturally, economically, and ecologically important species.

**2.0 Purpose/ Hypotheses:**

This research aims to:

1. Monitor juvenile eels entering the Hudson River tributary, Furnace Brook, during their spring migration season across a 12-year period (2008-2019).
2. Investigate the influence of water temperature and tributary water flow on juvenile eel abundance and fitness.
3. Evaluate the relationship between juvenile eel arrival time with water temperature and flow, abundance, and fitness.

It is hypothesised that:

1. Tributary temperature is negatively correlated with eel fitness and abundance, due to seasonality.
2. Juvenile eel catches, and weights peak during the middle of the migration season (April) due to optimal environmental conditions.
3. Water flow will be the highest at the start of the season and the magnitude of water flow plays a role in arrival time of glass eels.
   1. **Procedures:**

3.1 Furnace Brook Study Site

Furnace Brook is one of 14 established American eel monitoring study sites located in freshwater tributaries of the Hudson River. Sites will be monitored by the New York State Department of Environmental Conservation (NYSDEC); this is a citizen science project ongoing for over a decade (2008-2019). A sampling permit will be obtained by the NYSDEC. Furnace Brook is located in Cortlandt, New York, in the lower part of the Hudson River within the brackish water zone. It is a unique study site as it is one of three locations where seasonal eel ingress has been monitored annually over a twelve-year period. The site is located within a setting with woody vegetation, a salt marsh, and few private residencies. Furnace Brook is positioned between a local unpaved road and a recreational hiking trail with steep slopes and marshy banks to either side.

3.2 Fyke Net Placement

Similar to the sampling procedure at all other DEC eel monitoring sites, a Sheldon type fyke net (provided by the NYSDEC) will be installed annually in early spring (March-May) near the mouth of Furnace Brook, measuring 13 feet wide at the mouth of the net and held in place with garden stakes pounded into the streambed. It will be strategically placed on the northern bank of the tributary to capture juvenile eels who follow the stronger current along the north edge of the stream. The fyke net will be placed with the mouth opening downstream to capture eels on their upstream migration; glass eels and elvers enter into the fyke net through the mouth and into the funnels and are then unable to leave the net.

3.3 Juvenile Eel Data Collection

Glass eel counts will be obtained daily by visiting the fyke net for the duration of the glass eel migration season (approximately March-May). A standard protocol will be followed each year and historical data from 2008-2016 (NYSDEC), will be used to supplement the work of the student researcher (2017-2019). Sampling will be performed within two hours of low tide as a safety precaution. Every day during the glass eel migration season, a minimum of two volunteers wearing chest waders will visit the fyke net and carefully remove juvenile eels from the fyke net. Eels will immediately be placed into a small three-gallon bucket containing fresh stream water and counted.

20 glass eels will be randomly selected and weighed on an OHAUS electrical scale, however, if less than 20 glass eels are counted, they are not weighed. Average weight per glass eel will be calculated as an indicator of individual fitness. Lastly, all juvenile eels will be released upstream unharmed, preventing the recapture of these eels in the fyke net and helping them continue their upstream migration in search of suitable habitat. Glass eels are not harmed and there is no mortality of glass eels.

3.4 Environmental Factors

Handheld water and air thermometers will be placed each day by the sampler to monitor air and water temperatures (℉). Additionally, an Onset U20L HOBO Logger will be deployed above the head of tide at the location of eel release during years 2017-2019 only. The HOBO Logger will continuously records water temperature, absolute barometric pressure, and sensor depth. Herein, sensor depth (water depth at the logger’s sensor) will be used as a proxy for water flow.

3.5 Data Analysis

Handwritten field observations will be recorded in a data binder and are then transferred to Microsoft Excel 2016 and analysed with GraphPad Prism 8 to create graphical representations and run statistical tests; statistical significance was held at p ≤ 0.05. An overall correlation will be run including data from all years as well as individual correlations for each year for water temperature relationships. Julian dates will be used to track arrival at the site over the years. For the analysis of peak arrival, the number of days in the particular season will be divided by three to distnguish between early, mid, and late spring arrival. Data will be analysed for the years 2008-2018. However, only data from the years 2017 and 2018 will be analysed for water flow because the HOBO logger was introduced in 2017.

**4.0 Risk and Safety:**

Several safety precautions are in place for this study. One is that sampling may only take place in a two-hour window on either side of low tide because water may rise to unsafe levels at high tide. Additionally, if there is a storm or other weather event causing the water level to rise, sampling will not take place on that day. To avoid injury or accidental drowning, there must always be at least two people present at the sampling site.

**5.0 Vertebrate Animal Research**

In this specific study, there are no acceptable alternatives to the American eel since they are the focus of the present research. This research is very important because eels are extremely vital to an ecosystem. Without eels present, ecosystems would be disrupted. In order to collect the glass eels, eels are collected in a fyke net and will be taken out by hand and placed in a bucket filled with some water. Once all glass eels are taken out of the fyke net, they will be counted by placing them in a small fish net and allowing them to wiggle out and fall into another bucket of water below. This is done in order to minimise contact. 20 eels will be taken out, dried lightly with a small cloth, and weighed on an electrical scale. Once sampling is complete, glass eels are released above the small dam to prevent recapture. It is not predictable how many eels will be in the fyke net each day. Extreme care will be taken to ensure that the glass eels are not harmed at any point in this research. No glass eels will be taken from their habitat. In addition, there will be no mortality of the glass eels. A NYSDEC sampling permit will be issued to authorize this research.

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