Atlantic States Marine Fisheries Commission

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MEMORANDUM

October 16, 2015

To: **American Eel Management Board**

From: **American Eel Technical Committee**

RE: **Update on Maine's American Eel Life Cycle Survey Proposal**

Addendum IV to the Interstate Fishery Management Plan for American Eel requires that any state or jurisdiction with a commercial glass eel fishery must implement a fishery-independent life cycle survey covering glass, yellow, and silver eel life stages within at least one river system.

In June 2015, Maine had proposed a three-year survey on glass, yellow, and silver eel life stages in the Cobboseecontee Stream drainage. However, the Technical Committee (TC) expressed concern about the use and applicability of that survey design for science and management. The TC recommended further development of Maine's life cycle survey design prior to implementation, and re-established a subcommittee to help address concerns with the survey design that were expressed by the TC.

Since the August Board meeting, the subcommittee worked with Maine to refine the proposed survey design that would meet the study objectives for this particular river system. The updated Life Cycle Survey proposal for Maine is enclosed. The recommended duration of the Life Cycle Survey is at least 17 years, representing one life cycle. The TC commended the subcommittee for the work on the survey design, and endorsed its implementation noting a few comments below to consider:

1.) Explore mechanisms to eliminate poaching of glass eels at the fyke net sampling site.

2.) Cannibalism of elvers on glass eels in the fyke net may be an issue and should be monitored if possible.

3.) The release site for the glass eels should be in a location that minimizes the potential for recapture.

4.) Glass eels may not be uniformly distributed across the channel so finding a mechanism to measure distribution would be a good way to test that assumption.

5.) For the yellow eel mark recapture methods: a commercial box pot design should be used over a Gee minnow trap; and overnight hauls should occur instead of few 2-day soaks.

6.) Subsamples of yellow eels needs to be representative for development of an age-length key.

The TC would like to receive an update from the state of Maine in spring 2017 that reports on the first year implementation of the survey design and any issues/concerns encountered. The TC would also add that this sampling framework was approved specifically for the Cobboseecontee Stream drainage in Maine. Future life cycle survey designs for other river systems will need to be reviewed and approved by the TC as sampling methodology is specific to individual river systems and survey methods may not be transferrable between river systems.

Enc: Maine Proposed American Eel Life Cycle Study

M15-87

Maine Proposed American Eel Life Cycle Study

October 8, 2015

Introduction

Addendum IV to the Interstate Fishery Management Plan for American Eel requires that any states or jurisdiction with a commercial glass eel fishery must implement a fishery independent life cycle survey covering glass, yellow, and silver eels within at least one river system. If possible and appropriate, the survey should be implemented in the river system where the glass eel survey (as required under Addendum III) is being conducted to take advantage of the long term glass eel survey data collection. At a minimum the survey must collect the following information: fisheries independent index of abundance, age of entry into the fishery/survey, biomass and mortality of glass and yellow eels, sex composition, age structure, prevalence of *Anguillicoloides crassus,* and average length and weight of eels in the fishery/survey. Survey proposals will be subject to the American Eel Technical Committee (TC) review and Board approval.

Study area

The Maine Department of Marine Resources (MDMR) will conduct a fishery independent life cycle study of American eel in Cobboseecontee Stream drainage (Figure 1). West Harbor Pond, location of the glass eel survey (Figure 1) was excluded as a potential study site, because the pond has become increasingly anoxic due to salt water intrusion, and Boothbay Harbor is drawing increased amounts of water from the upper drainage. Cobboseecontee Stream drainage was selected for its configuration, its proximity to MDMR's office, and the presence of three dams (Figure 2) that provide places to monitor and sample eels. In addition, MDMR previously conducted a study of glass eels and tested upstream eel passage designs in the lower portion of this drainage. Glass eels have been harvested at the mouth of Cobbosseecontee Stream annually since 1996; therefore MDMR will close the stream to the harvest of glass eels and elvers for the duration of this study. A silver eel fishery existed at the outlet of Cobbosseecontee Lake (Figure 2) until the mid-1990s, but there is no harvest information for that fishery.

Methods –general

The life cycle study will be conducted over a period of at least 17 years, the average age at which females eels emigrate in Maine (Oliveira and McCleave 2000). Sampling typically will be conducted from April through October and life stages will be sampled with different gears at different frequencies and at different locations throughout the drainage to accomplish life stage-specific objectives. Between November and March, biological samples will be processed and data will be digitized and analyzed.

Methods – glass eels

The specific objectives for the glass eel study are to 1) develop an annual index of abundance and determine 2) biomass, 3) mortality, and 4) average length and weight of eels in the survey. Age, sex composition, and prevalence of *A. crassus* will not be determined for glass eels.

To accomplish objectives 1, 2, and 4, glass eels will be captured daily just upstream of the mouth of Cobbosseecontee Stream with fyke nets that will be set on either side of the stream. By Maine law, the net must be 30 feet or less in length from cod end to either wing tip, is fitted with netting that measures 1/8-inch bar mesh or less, contains a 1/2-inch or less bar mesh excluder panel that covers the entrance of the net, and consists of not more than one funnel end, one cod end and 2 wings. Nets will be deployed in spring when glass eels begin migrating upstream in this area (approximately mid-May through mid-June) as soon as spring flows have subsided. Sampling will occur 24 hours per day during the first year, with nets being tended during each ebbing tide. If daytime sampling indicates little to no glass eel upstream migration during that time period, daytime sampling may be eliminated in future years. Similar to the mandatory young-of-year surveys, the daily catch will be weighed to obtain total biomass, and the weight and number of glass eels in a subsample will be used to estimate the number of eels in the catch. Environmental variables including water temperature, water level, and discharge will also be recorded, as well as gear fishability (1=good to 4=void). Once a week, 60 glass eels will be individually weighed and measured and pigment stage assessed.

A secondary glass eel collection device, termed an artificial habitat collector device (Silberschneider et al. 2001), will be fished just upstream of Dam 1 to determine if any glass eels are exiting the survey area by climbing over or through the dam (Figure 3). If sampling determined that glass eels are not escaping upstream of Dam 1, this sampling effort can be eliminated after the first study year.

Assumptions of Sampling Methods:

1) Fyke nets capture a consistent proportion of the population each day and from year-to-year.
2) Migration is uniform across the width of the river. During the first year, field observations will be made to confirm this assumption.
3) There is no net-induced mortality (i.e., no predation on glass eels in the net)
4) Glass eels are captured once and there is no fall-back behavior.
5) Others?

Impacts to Survey results if Assumptions are not met:

1) Will add significant noise to the glass eel abundance index making comparisons with older ages of the same cohort difficult.
2) If more eels migrate along the sides of the river, then we may overestimate abundance by assuming the same number is passing through the middle of the river where nets are not being deployed, and underestimate natural mortality of glass eels. If the opposite is true, then we will be underestimating glass eel abundance.
3) Predation on glass eels in the net would reduce our estimate of abundance and may impact our assessment of the strength of the glass eel run if compared with other

systems. May not necessarily impact this life-cycle survey, since we are following the cohort.

4) Cause an overestimate of recruitment and overestimate of natural mortality.

Methods - yellow eels

The objectives for the yellow eel studies are to 1) develop an index of abundance; 2) determine age of entry into the survey, 3) biomass, 4) mortality, 4) age structure, 5) prevalence (percent of eels infected) of *A. crassus,* and 5) average length and weight of yellow eels in the survey. In order to accomplish these objectives, yellow eels will be sampled using one of the two methods listed below in conjunction with upstream monitoring.

Method 1:
Sample multiple sites between the mouth of Cobbosseecontee Stream and Dam 1 (actual number and size of sites to be determined). These sites will be selected in a stratified random sampling design with strata representing distinct habitat types. Sites will have block nets on the upstream and downstream ends to meet the assumptions of a closed population for a removal estimator. At each site, four electrofishing passes will be conducted. By using four electrofishing passes, capture efficiency can be allowed to vary between electrofishing passes in a generalized removal estimator (White et al. 1982), thus allowing for less biased population estimates. Catches of eels on each pass will be enumerated within length classes (appropriate length classes to be determined) and population estimates will be made for each length class. A subsample of eels from each length class will be sacrificed for otolith extraction, aging, and development of an age length key. During the first year, we will attempt to sample 10-15 eels in each 50-mm size class from 100-849 mm TL). Subsamples in subsequent years may be adjusted based on the results from year 1.

Method 2:
Mark-recapture methods may be employed to estimate yellow eel abundance if electrofishing is not feasible throughout the study reach of Cobbosseecontee Stream. Baited eel pots will be deployed for at least 48 hours for a marking period, captured eels will be enumerated within length classes and marked with a fin clip or fin punch, and then released alive. After a period of 1 week, pots will be set again for a recapture period. Eel pots will be rectangular with a single funnel entrance terminating in a cloth tube to reduce escapement. Again catches of eels in each length class will be enumerated and the number of marked eels from the previous sampling will be noted. During the recapture period, a subsample of eels from each length class will be sacrificed for otolith extraction, aging, and development of an age length key.

Upstream Monitoring:
The number of eels passing upstream of Dam 1 during the course of the year (prior to when annual electrofishing or mark recapture surveys are conducted) can also be partitioned by age classes based on the age length key. The numbers passing upstream can then be added to the number of each age class estimated via electrofishing to yield a grand total number of eels in each age class that inhabited the reach between the mouth of Cobboseecontee Stream and Dam 1.

Sampling from the first year may indicate that eels do not pass the dam until they are older than age 1 or 2. If this is the case, then population estimates of eels larger than the size classes corresponding to age 1 or 2 would not be necessary. Population estimates of the youngest age classes are of greatest interest so that mortality from the age 0 glass eels stage can be estimated. There is no yellow eel fishery in this system, so we will have to capture older, larger eels to determine age distributions, and develop catch curves for estimating natural mortality of this life stage.

Also, population estimates of eels in the reach upstream of the mouth of Cobboseecontee Stream assume no immigration or emigration of eels from/to the mainstem of the Kennebec River. The ability to restrict population estimates to the youngest age classes would be expected to most closely meet this assumption.

At the lowermost dam (Figure 2, Dam 1), upstream migrating eels will be captured at the top of one or more eel passages from approximately May through September. This is an effective method of sampling small yellow eels; 99% of the yellow eels using upstream passage at this barrier from 1997–1999 were ≤ 150-mm TL (Wippelhauser unpublished data). For yellow eels captured at the lowermost barrier, the daily catch will be weighed to obtain total biomass, and the weight and number of eels in a subsample will be used to estimate the number of eels in the catch. Once a week, 60 eels will be individually weighed and measured and euthanized for later determination of age and examination for the presence of *A. crassus*.

Mark-recapture methods will be used to assess the abundance of yellow eels in upstream lakes and ponds. Because there are numerous large lakes in the drainage that cannot be sampled simultaneously within the three-year study period, MDMR will focus on sampling Pleasant Pond (746 acres). A total of 36 baited eel pots made of 0.5-inch mesh will be deployed in a grid pattern throughout the pond and allowed to fish for 48 hours before being tended. This mesh size is expected to provide an unbiased sample of eels ≥30-cm TL (Morrison and Secor 2003).

For yellow eels captured by electrofishing or in pots, each captured yellow eel will be weighed, measured, and PIT tagged (12 mm tag) if > 150 mm TL, with the exception of a subsample that will be euthanized for later determination of age, sex, and presence of *A. crassus*.

Assumptions of Sampling Methods:

1) All, or a significant majority of the yellow eels are captured by the passage structure.
2) Immigration and emigration from the Kennebec River are equal.
3) Catch curve assumptions apply (no trend in recruitment over time, Z is constant among age groups above a certain age (M in this case since there is no yellow eel fishery), other assumptions apply if a longitudinal catch curve is used (catchability is constant among age groups, and there is known CPUE).

Impacts to Survey results if Assumptions are not met:

1) Biased estimates of mortality if catch curve assumptions are not met.

Methods – silver eels

The objectives for the silver eel studies are to 1) develop an index of abundance; 2) determine age of entry into the survey, 3) biomass, 4) mortality, 5) age structure, 6) prevalence (percent of eels infected) of *A. crassus*, and 7) average length and weight of silver eels in the survey. In order to accomplish the first objective, silver eels from the entire drainage will be enumerated with a DIDSON (Dual Identification SONar) at the American Tissue Project downstream eel passage (Figure 2, Dam 2). The DIDSON will be aimed at the deep gate through which eels pass downstream (the turbine intake is screened with one-inch punch plate), and will record during the nighttime. This method of visualizing migrating eels was tested successfully at the site in 2007 (Gail Wippelhauser unpublished data). A fyke net will be set downstream to capture eels for biological sampling (length, weight, otolith for ageing, and swim bladder parasite).

Assumptions of Sampling Methods:

1) Only silver eels are passing through the American Tissue Project eel passage.
2) The passage is the only way downstream.

Impacts to Survey results if Assumptions are not met:

1) Overestimating silver eel abundance if yellow eel also use the eel passage structure; we will need to know proportions if yellow eels do use the passage to reduce silver eel abundance estimates.
2) Underestimate silver eel abundance if there is another way downstream.

1. **Analysis – glass eels** The total number of glass eels recruited during each day, *p*, will be estimated by multiplying the total number of glass eels caught in each fyke net by the proportion of the width of the stream sampled. The total estimate of glass eel recruitment, *R*, will be estimated using the area-under-the-curve (AUC) method:

$$R = AUC = 0.5\sum_{i=2}^{n}(t_i - t_{i-1})(p_i + p_{i-1})$$

   Where t_i is the number of days measured from the first day glass eels enter the stream to the *i*th sampling day. If all days are sampled, then we can simply sum the catch for each day and do not need the AUC, in fact they would be the same.

2. For each year, the average length and weight of glass eels will be calculated from the weekly measurements made on individual glass eels.

Analysis – yellow eels at upstream passage (≤150-mm)

1. If electrofishing is used to assess yellow eels, the total population estimate for each size class can be calculated as in Hankin (1984) and Sweka et al. (2006).

$$\hat{Y}_s = \frac{N}{n}\sum \hat{Y}_i$$

$$\hat{V}(\hat{Y}_s) = \frac{N_s(N_s - n_s)\sum\left(\hat{Y}_i - \hat{\hat{Y}}_s\right)^2}{n_s(n_s - 1)} + \frac{N_s \sum \hat{\sigma}_i^2}{n_s}$$

Where $\hat{Y}_s$ = the total population in stratum *s*, $\hat{Y}_i$ = the population estimate at site *i*, N_s = the number of potential sites in stratum *s*, n_s = the number of sites sampled in stratum *s*, $\hat{V}(\hat{Y}_s)$ = the variance of the stratum *s* population estimate, $\hat{\hat{Y}}_s = \sum \hat{Y}_i / n_s$ = the mean population estimate n stratum *s*, and $\hat{\sigma}_i^2$ = the variance of the population estimate in site *i*.

2. Once the total population estimates for each size class are calculated, these can be multiplied by the proportion at age in each size class to derive an estimate of the abundance of each age class within a size class. Abundance of each age class from different size classes can be summed for the total abundance of an age class.
3. If mark-recapture is used to assess yellow eel, Chapman and Bailey's modified Petersen estimator will be used to estimate the abundance of each size class (Seber 1982)

$$\hat{Y} = \frac{(M+1)(C+1)}{(R+1)} - 1$$

$$\hat{V}(\hat{Y}) = \frac{(M+1)(M-R)(C-R)}{(R+1)^2(R+2)}$$

Where *M* = the number marked in the first sample, *C* = the number of individuals captured in the second sample, and *R* = the number of individuals in the second sample that were marked.

4. For each year, the total number and biomass of eels using upstream passage at the lowermost barrier will provide an annual index of abundance of eel recruitment into inland waters of eels.
5. For each year, the average length and weight of glass eels will be calculated from the weekly measurements made on individual eels.
6. Sagittal otoliths will be aged. Annular rings in each otolith or otolith section will be counted at least twice by two readers.
7. The presence of *A. crassus* nematodes found inside the swim bladder of each subsampled eels will be recorded.
8. Because there is no commercial or recreational fishery for yellow eels in the watershed, natural losses will be estimated from catch curves.

Analysis – yellow eels ≥150-mm and silver eels

1. For each year, the abundance of yellow eels in Cobbosseecontee Stream will be estimated from multiple pass depletion (electrofishing) and of yellow eels in Pleasant Lake (baited pots) from marked and recaptured eels (equations in Lockwood and Schneider 2000).

2. For each year, the number of silver eels emigrating from the watershed at the second dam will be estimated by visual inspection of the high-resolution, DIDSON image files.
3. For each year, the average length and weight of yellow eels and silver eels will be calculated from the weekly measurements made on individual eels.
4. Sagittal otoliths from yellow eels >100-cm TL and silver eels will be aged using the sectioning and dying techniques described by Oliveira (1996). Annular rings will be counted in each otolith section at least twice by two readers.
5. The presence of *A. crassus* nematodes found inside the swim bladder of each subsampled eels will be recorded.
6. Because there is no commercial or recreational fishery for yellow eels in the watershed, natural losses will be estimated from catch curves.
7. Gonads will be examined macroscopically and by the squash method of Guerrero and Sheldon (1974) and classified as male, female, or undifferentiated. Oliveira and McCleave (2000) reported that sex in 95% of the American eels sampled in four river systems in Maine could be differentiated by 250–270 mm TL, depending on the river system.

References

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Table 1. Schedule of field activities to be conducted annually during the study period.

Activity	Apr	May	Jun	Jul	Aug	Sep	Oct
Glass eel fyke netting							
at stream mouth	daily	daily	daily				
at head-of-tide	daily	daily	daily				
Yellow eel e-fishing or potting							
mouth to Dam 1				1-2 weeks			
Yellow eel recruitment							
at Dam 1		daily	daily	daily	daily	daily	
Yellow eel potting							
in lakes			biweekly	biweekly			
Silver eel DIDSON							
at Dam 2					daily	daily	daily

Figure 1. Location of proposed study area for life cycle study in Cobboseecontee Stream drainage (large oval) and location of glass eel survey in West Harbor Pond drainage (small oval).

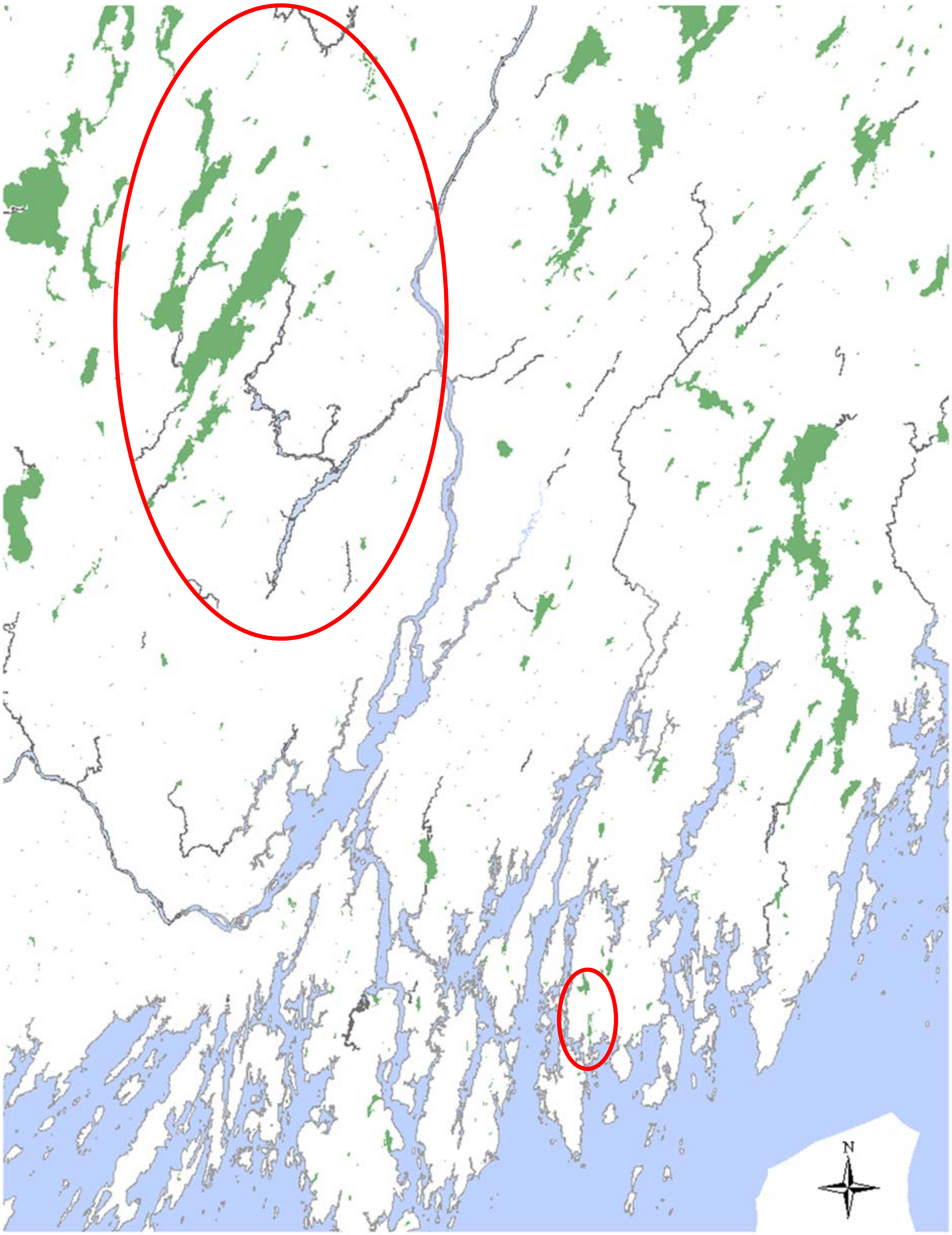
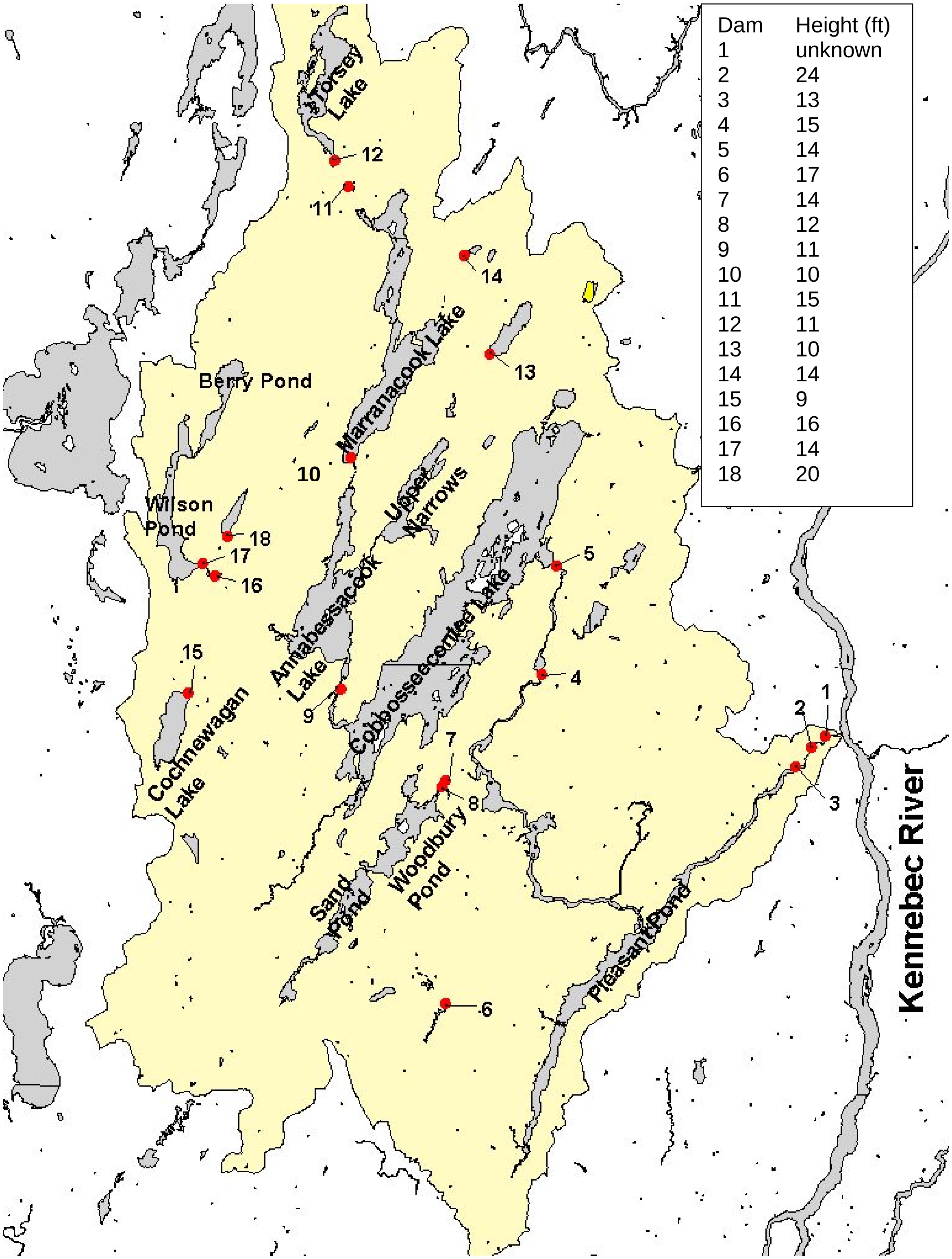


Figure 2. Detailed map of Cobbosseecontee Stream drainage showing location of major water bodies and dams (red circles). None of the dams have upstream eel passage. The American Tissue Hydropower Project (Dam 2) has a downstream eel passage facility.



Dam	Height (ft)
1	unknown
2	24
3	13
4	15
5	14
6	17
7	14
8	12
9	11
10	10
11	15
12	11
13	10
14	14
15	9
16	16
17	14
18	20

Figure 3. Artificial habitat collectors as described in Silberschneider et al. 2001. Photo credit: Sheila Eyler (USFWS).