River Herring Counting Protocol

OVERVIEW

In the past, the Massachusetts Division of Marine Fisheries (*MarineFisheries*) has employed a variety of strategies for enumerating diadromous fish runs. These methods have included electronic counters, volunteer visual-monitoring, trapping, and video recording. While stocks of diadromous fish have declined on the east coast in recent years, interest in population monitoring and restoration has increased, particularly for river herring (alewife *Alosa pseudoharengus* and blueback herring *Alosa aestivalis*). As concern and counting efforts have grown there have been concurrent advances in monitoring technologies and strategies that can greatly improve accuracy of counts. In addition to monitoring specific runs, the *MarineFisheries* Diadromous Fish Biology and Management Project also provides advice and technical assistance to communities and civic groups. Any individuals wishing to count fish should contact the MDMF at the onset of planning to discuss their interests and receive technical assistance.

A variety of technologies are currently employed by the state and volunteer groups to count fish runs. Implementation has not been haphazard but the quality of data is highly variable. There has been consistency in this process in that most groups using in-person visual counting techniques commonly follow the method proscribed by either Nelson (2006) or Rideout (1979). These methods are statistically sound, but are based on theoretical models that have not been compared to census counts to truly estimate accuracy. Also, these methods are based on accepted premises such as river herring not migrating at night, which is now being called into question with the use of video and acoustic capture technologies (Wildman CTDEEP, Magowan et al 2012). Night-time migrations were also observed in the past by Richkus (1974), but at lower rates than during the day. Single-channel electronic counters (Smith-Root 1001 or 1101) are also in use by both MDMF and volunteer groups. The growing application of multi-channel counters indicate an advantage over single-channel counters when enumerating species like river herring that often migrate in large numbers. Finally, *MarineFisheries* has also recently deployed video monitoring systems similar to that described in Burak (2012). Each approach has distinct advantages and limitations that should be understood and will be discussed below.

This document is intended to act as a guide as MDMF improves diadromous fish monitoring over the next decade. Future efforts by MDMF will be based upon experiences here and in other states that have successfully integrated run monitoring into river herring management. As counting efforts expand, decisions about monitoring should be made using a two-tiered system. First, MDMF staff should consider where counting technology can best be utilized. Once a decision has been made as to where monitoring is most needed and applicable, site conditions and data needs will dictate the specific

technology used. The following guide summarizes (1) the rationale for introducing counting technology to a run and (2) the advantages and disadvantages of available counting methods.

SITING

Sites with high quality census estimates are extremely important to current and future management of river herring. The scarcity and need of such sites is highlighted in the 2012 river herring stock assessment by the Atlantic States Marine Fisheries Commission (ASMFC 2012). Improving counting sites to provide long term census data and creating new sites with consistent high quality data is a high priority for *MarineFisheries* Diadromous Fish Biology and Management Project. In this initial phase of implementation, *MarineFisheries* staff will be highly selective when choosing where new technologies will be installed, especially given startup costs of roughly $10,000, the allocation of staff time, and regional needs. Priorities for selecting sites include runs with existing complementary data, existing coverage in coastal drainage areas, sites with new fish passage to monitor effects of restoration, and sites with unique funding opportunities. Site selection should also factor the amount of spawning habitat below the site since this can alter the interpretation of counts.

Sites with Existing Data

Many runs in Massachusetts have pre-existing data sets that census data would complement both for internal and external (ASMFC) use. Perhaps the most important dataset to pair with census data would be population demography. Currently, *MarineFisheries* collects biological data to represent population demography from the following water bodies: Parker River, Mystic River, Charles River, Monument River, Nemasket River, Town Brook, and Herring River (Harwich). If feasible, installing either video or electronic counting arrays at these sites should be a top priority since the pairing of these data will provide a detailed picture on population status for each river.

MarineFisheries also collects other types of data that would help steer siting. One example of this is sites where long term run estimates have occurred. These estimates may be derived from previously employed technologies (SR-1000 or 1001 counters), well-performed visual counts, or academic research projects in the recent or more distant past. Historical data can be especially useful in comparing current runs to earlier 'baselines.' Finally, the presence of a stream flow gage monitored by the US Geological Survey is a positive attribute when considering potential counting sites.

Geographic Location

MDMF seeks to establish long-term river herring monitoring stations in each of the major coastal drainage areas in Massachusetts: Merrimack River, North Shore, Boston Harbor, South Shore, Cape Cod and Buzzards Bay. Siting decisions should consider existing coverage in each drainage area and the representativeness of potential watersheds. With limited resources for equipment, sampling

and processing data, drainage areas with few or no stations could receive priority over areas with higher coverage.

Index of Abundance Stations

The highest priority under river herring monitoring for MDMF will be to establish at least one long-term index of abundance station in each of the major coastal drainage areas. Monitoring at these index or "sentinel" stations should include biological sampling of the river herring run and the sampling goals should align with management needs for improved indices of abundance for the ASMFC stock assessment and development of ASMFC Sustainable Fisheries Plans.

Monitoring Restoration Efforts

Sites where active restoration projects such as dam modification/removal or fishway installation are scheduled to occur can be candidates for monitoring. These can be attractive sites not only for the importance of quantifying the effects of restoration efforts within the system but also because the most efficient and effective monitoring sites are often those that were designed with the possibility of run counting included. Availability of power supply, engineering of hydraulics within passage structures, and viewing windows are all site features that are easier to plan ahead of time rather than retrofit at a later date. Not all restoration sites will be suitable for monitoring. Future funding proposals for fish passage projects should consider the role of monitoring during the feasibility, design, and installation process. Careful planning is needed during the design phase to be sure that long-term monitoring objectives are compatible with shorter term goals related to the response to restoration. Additionally, the amount of available spawning habitat and habitat condition are important considerations for restoration monitoring.

Sites with External Funding

Some sites considered as a lower priority to MDMF based upon our internal criteria and management mission may still have the potential for applying counting technology through external groups with funding and strong local interests. There could be cases where it is beneficial for MDMF to provide technical assistance or potentially lead a project. In cases where opportunistic funding identifies a potential site for counting, MDMF should evaluate the site based on this guideline's criteria and provide a recommendation. The suitability of a site to provide high quality counting data and the relevance of the site to regional goals will be important considerations. Sites that move forward towards implementation will receive MDMF technical assistance for deployment and data processing.

METHODS

A wide variety of passive and active gears can be used to monitor fish populations. Some are better suited for relative measures (e.g. stationary nets in rivers, seine samples) while others are designed to supply accurate measurement of a population or portion of a population. In the case of river herring, MDMF monitors populations at fish passage structures. Often all or the vast majority of the breeding habitat is upstream of the monitored structure, meaning that for practical purposes the count performed is a census of the breeding population at that location for a given spawning year. Our protocol is focused on selecting appropriate sites and equipment to provide census counts. It is important to note that in some situations the potential for monitoring occurs above a substantial part of the spawning habitat (e.g. the Charles River, the Mystic River). In these situations the techniques employed would be identical but the data would only reflect part of the population.

- **Traps**
    - Fish traps are easy to construct out of many materials dependent upon budget, portability, and durability. Common materials can include metal, wood, and PVC. In the case of river herring, consideration should be given to design aspects that prevent trap-based mortality. These considerations include mesh size, shape, and overall size of the trap. Traps should also have a securable cover to dissuade poaching or bird-related mortality. Traps are best employed at the upstream exit of fish passage structures since these features funnel all fish movement to one location already.
    - Advantages: The principal advantage of a trap is that it allows, given adequate time and conscientious workers, a complete and accurate count of fish at a passageway.
    - Disadvantages: Traps can be cumbersome and difficult to install. Depending on location there may be issues with trap security, bycatch of non-intended species, and bird-related mortality. Large fish runs have the potential for fish mortality to result from over-crowding when a large pulse of fish arrives and overwhelms the capacity of the trap. Traps require a significant labor and time commitment for all these reasons, and will require professional oversight in most cases.
- **Visual Count**
    - Visual counts are typically conducted by trained volunteers who inspect or watch a site for durations of time and then make an estimate of how many fish were present. They can be based upon units of time, number of visits, or other temporal strata. These

measures are sometimes simply used as relative measure or can be expanded to estimate actual run size. While visual counting is exposed to greater biases than technology-based counting that can reduce data quality, it provides relative measures of abundance that can be useful to local management agencies and is performed by volunteers, reducing work load on agency employees.

- Advantages: MDMF has developed a methodology that allows us to estimate statistically based run counts from properly conducted visual count surveys (Nelson 2006).
- Disadvantages: Estimates are based upon statistical theories that have not been validated by comparing visual count derived estimates to actual census data. Furthermore, the quality of data is highly variable due to factors such as non-random sampling, site conditions, counter experience and ability, run timing, and visual conditions (eg turbidity, time of day).

- **Video**
  - Video counting of diadromous fish has been in practice for quite some time, most often at larger dams and specifically for salmonids. These more traditional setups involved a room included in the fishway design that shared a wall made of plexiglass or similar material with the fishway exit or a resting pool near the exit. Video cameras could be set up to provide a complete record or counts for when technicians were not present. As technology has advanced, video has become far more adaptable and is now being used in small fishways and retrofit to existing fishways. Video counts will be hindered by water turbidity and flow but can be highly accurate and contain a wealth of information. Some considerations include:
    - Orientation: Video can be setup in either the vertical or horizontal plane. The vertical plane can be easier to manage as far as water or weatherproofing as well as maintenance and access. The drawbacks to video in the vertical plane are that species identification is much more difficult and lighting can also be highly problematic. Horizontal plane setups can be more difficult and expensive to implement as they require either dedicated rooms or plexiglass casings with waterproof cameras, however when properly calibrated horizontal plane video can provide species identification and high quality images.
    - Salmonsoft: This is a software package that can be installed on a PC that controls the recording of digital video. Properly calibrated, Salmonsoft will

record a 'rolling segment' where the tail will be deleted if no fish is detected by the program's motion algorithm. When fish are detected the program creates a digital video file on the PC according to the user's preference. This program greatly reduces the amount of video to review but does introduce added costs and concerns including PC housing, power, and environmental conditions.

- Advantages: Video systems allow genus or even species level identification as well as additional information about the timing of movements. They can also be used to monitor for invasive species.
- Disadvantages: Significant initial startup cost and time invested to review video, cleaning, high power demands.

- **Electronic counting**
  - Electronic counting, like video, has been in practice for several decades. While developed for hatchery applications these systems have proven sturdy and flexible enough to be adapted to a wide range of field uses. In New England the Smith-Root (SR) brand counter has been the primary brand employed. In Massachusetts both MDMF and community organizations have used SR counters, but have not adopted the more appropriate multiple tube counters, instead relying on single channel counters. In the future, the MDMF will invest in multiple channel counters at new sites and investigate methods for switching to multiple tube channel counters at sites with existing, long-term single channel counts. Below is a more detailed description about the design and applicability of single and multiple tube counters for enumerating river herring.
  - Ideally, a river herring specific counter would provide high count accuracy without hindering upstream movement of spawning adults. As described by SR, their electronic counters operate "on the "Balanced Resistance Bridge Principle" using water in the count head as two elements of a four element Balanced Bridge. Passage of a fish through one of the tubes of the count head causes corresponding changes in that tube's conductance. These conductance changes are used by the *(counters)* to sense the presence of fish in the tubes of the counting head." Additionally, SR recommends that tube dimensions should be tailored to the targeted fish with a tube diameter set to the minimum length expected and a 3:1 minimum tube length:diameter ratio. In the case of river herring this suggests tubes of a 4" diameter in 12" length. The primary difference between the two SR systems (1101 and 1601) is the number of channels the counting box supports. The 1101 allows the use of one channel while the 1601 can support up to

16 channels. With the 1601 you can run multiple tubes of this dimension which allows many (~50,000) fish to pass in 24 hour span while achieving counts of >95% accuracy (D. Ellis, CTDEEP).

- Configurations: As mentioned above, these systems can be highly adaptable both in tube array design and siting. Arrays can be constructed in almost any pattern that still allows wiring access. Arrays can then be sited in structures like bypass channels or fishways, or even mid-stream with vexar fencing or other material directing fish to the counter.
- Maintenance: it is critical that the counting channels and support structures are routinely maintained to remove debris, ensure passage is suitable and retrieve data. In many cases maintenance must be performed daily to prevent the system from clogging and potentially obstructing migrating fish.
- Advantages: Electronic counters provide a highly accurate count, require no time investment to finalize data, offer great siting flexibility, have low power needs comparative to video, and are simple enough to be operated by competent volunteers.
- Disadvantages: Significant initial startup cost, time stamping is possible but extra $5000-$6000 for 8 channels, $1100 for 4 channels, cannot simultaneously discern between up and downrunning fish, does not provide species identification, and can block movements of larger fish species.

***MarineFisheries* Authorizations**

The construction of fishways and supporting structures in Massachusetts require approval from *MarineFisheries* to ensure that suitable passageways are constructed and maintained. This review process and authorization applies to counting equipment placed inside of or in the immediate vicinity of fishways. Starting in 2011, *MarineFisheries* began requiring annual letters of authorization for groups placing technology-based counters in fishways.

***MarineFisheries* Technical Assistance**

External groups seeking to initiate visual counts or to deploy technology-based counts should contact *MarineFisheries* for technical advice on site selection, data collection and data processing. Our staff is

available to provide recommendations at all stages of this process and to assist with or complete the processing of count data.

Temperature Loggers

MarineFisheries deploys water temperature loggers at all monitoring sites for diadromous fish. We recommend that all counting groups monitor water temperature at counting sites using our published Standard Operating Procedures (Chase 2010).

Contact Information

Any questions about counting river herring in Massachusetts can be directed to the Diadromous Fish Biology and Management Project staff listed below:

Boston and Northshore, general questions: Ben Gahagan, (978) 282-0308 x114
ben.gahagan@state.ma.us

South Shore, Cape Cod, and Buzzards Bay: John Sheppard, (508) 990-2860 x109
john.sheppard@state.ma.us

Literature Cited

Brad Chase (2010): Quality assurance program plan (QAPP) for water quality measurements for diadromous fish monitoring 2008-2012, version 1.0, Massachusetts Division of Marine Fisheries Technical Report 42.

David Ellis and Timothy Wildman (2012): personal communications.

Kevin Magowan, Joshua Reitsma & Diane Murphy (2012): Use of Dual-Frequency Identification Sonar to Monitor Adult River Herring in a Small Coastal Stream, Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 4:1, 651-659.

Gary Nelson (2006): A Guide to Statistical Sampling for the Estimation of River Herring Run Size Using Visual Counts, Massachusetts Division of Marine Fisheries Technical Report 25.

William Richkus (1974): Factors influencing the seasonal and daily patterns of alewife (*Alosa pseudoharengus*) migration in a Rhode Island river, Journal of Fisheries Resource Board of Canada 31: 1485-1797.

S.G. Rideout, J. E. Johnson, and C. F. Cole (1979): Periodic counts for estimating the size of spawning population of alewives, *Alosa pseudoharengus* (Wilson), Estuaries 2(2): 119-123.