USFWS Discussion Paper for Drought Contingency Planning for Freshwater Mussels in Southeast U.S.

Note to Reader: This document is a draft of a single task - assembling the literature and current expert views as a starting point for discussions regarding reasonable options that may be taken, if necessary, to reduce drought impacts on freshwater mussels. Reviewers are asked to provide additional literature or other information regarding any aspect of this document. It will be used as a regional guidance document and updated periodically. We envision the next step will be to begin specific and focused watershed-based discussions of actions that might be necessary.

Problem:

The 2008 drought situation has the potential to be severe. Based on projections for rain and streamflow, there is an equal chance for the drought to persist and produce historic low flows this summer. Unlike a spill, this event could affect most aquatic species in many watersheds throughout the Southeast.

Potential mortality differs under different flow scenarios. For specific watersheds and specific species, the potential for mortality may be framed as a percent of potential loss expected based on available population information and level of understanding of potential impacts. The percentage of expected loss can be thresholds for implementing, or not implementing, certain actions to reduce the level of impacts suffered by individuals and populations. For identified thresholds, the goals may be to avoid and minimize harm and injury to the listed mussels. The goal for a worse case scenario; e.g., multiple catastrophic low flows, may be to prevent extinction.

Specific objectives for different flow scenarios would include:

- Maximize survival and fitness
- Preserve genetic diversity
- Minimize risk to species by (a) avoiding localized extirpation, (b) avoiding fragmentation, and/or (c) avoiding extinction
- Minimize effort
- Minimize cost
- Gather data to inform future decision-making

Introduction

This is a drought contingency plan for freshwater mussels that can be applied in most situations during times of severe drought. Although decisions will be made on a case-by-case basis, this plan outlines information that should be considered to make the best decision possible regarding actions taken to preserve vulnerable freshwater mussel species during times of severe drought. Prior to the onset of drought, contingency planning should occur to establish who will do which actions, when they will be done, where they will be done and how they will be accomplished. An evaluation of drought effects and effects to freshwater mussels as a result of actions taken should also be planned.

1.0 Determine if Intervention Action is Needed

1.1 Prior to onset of drought (While important considerations for planning actions, the comments below are also applicable to pending or forming drought, within a drought, and could be implemented as possible intervention actions).

1.1.1 Identify resource managers, watershed groups, and individuals for each major basin/ecosystem with imperiled mussels.

1.1.2 Are there NPDES discharges to the stream? Is yes, identify locations and consider impacts of water quality degradation (e.g., DO, NH3, chlorine) when flows are below 7Q10. (It is possible to engage state water quality agencies and have existing NPDES permits re-written to establish effluent limits based on alternative low flow regimes (i.e., 1Q10), encourage the use of ultraviolet radiation or ozonolyis for disinfection instead of chlorination, and plan for alternative wastewater disposal practices (e.g., land application)).

1.1.3 (Planning phase) Prioritize streams and establish network of people to monitor these sites at least once a week to determine when action should be taken.

1.1.3.1 Information to collect during weekly or bi-weekly observations at a minimum should include DO, water temperature, air temperature, canopy coverage, stage/elevation, wetted perimeter, flow (cfs), conductivity, and pH. The information will be used to assess current conditions in at-risk stream reaches and establish critical thresholds to determine when possible intervention is needed.

1.1.4 If applicable, establish stream specific triggers as to when action should be taken for prioritized streams.

1.1.4.1 Some sources that can be utilized to assist in establishing triggers include: http://drought.unl.edu/dm/monitor.html, http://waterdata.usgs.gov and http://www.cpc.ncep.noaa.gov/products/predictions/long_range/lead01/off01__prcp.gif.

1.1.4.2 For streams with no stream gauges or streams with losing and gaining reaches, weekly observations of water depth and wetted perimeter will be vital to determine when action should be taken.

1.2 Pending or forming drought (forecast)—drought-specific information

1.2.1 Obtain drought forecast information including GIS data and USGS stream flow data (http://drought.unl.edu/dm.dmshps_archive.htm).

1.2.2 Determine potential for severity of drought, as determined by the U.S. Drought Monitor (http://www.drought.unl.edu/DM/monitor.html) in areas of listed and candidate species.

1.2.3 Are any species vulnerable to drought? If yes, identify species and locations.

1.2.4 Are there streams susceptible to going dry that contain listed and candidate species? If yes, identify streams and location within the basin

1.2.5 Alert network of potential individuals to implement drought monitoring and affirm availability to participate.

1.2.6 Work with entities in regulated systems to develop a Low Inflow Protocol (LIP) before drought conditions occur. LIP could establish procedures for reductions in water use during periods of low inflow, considering the shared responsibilities of all parties with interests in water quantity to establish priorities and to conserve limited water supply. LIP could provide trigger points and procedures for sharing the reduced availability as hydrologic conditions worsen, based on streamflow, reservoir levels, and groundwater.

1.3 Within a drought

1.3.1 (real-time) Implement network of people to monitor priority sites at least once a week to determine when action should be taken

1.3.2 Evaluate triggers weekly to determine appropriate action

1.3.3 Implement actions as needed

2.0. Possible intervention actions for mussel protection during severe drought

2.1 Move down slope or to deeper water nearby

2.1.1 No published literature found.

2.1.2 Personal Communication

Paul Hartfield (FWS 2007): Relocating mussels may reduce some mortality, but not all. Moving mussels out of areas they currently occupy into deeper portions of the channel may expose them to detrimental geomorphic effects when the water rises that results in later mortality. Preferably if you relocate mussels, they should be moved into deeper areas where the species naturally occurs.

Paul Johnson (AABC 2008): For species that are more widespread (most of them), you are more likely to do more harm than good moving them under stress than leaving them where they are (or moving them back to water where they are).

Gary Wege (FWS 2007): Rescue of mussels from shallow exposed flats by simply putting them in deeper water is really labor intensive, but it can be done especially in "hot spots" where stranded mussels are congregated.

Teresa Newton (USGS 2007): In some reaches of the Upper Mississippi River, conservation groups moved stranded mussels to deep water. It is unclear how effective that was, but it is certainly an option. It depends on the size of the system and the number of mussels.

Jason Wisniewski (GA DNR 2008): Moving mussels may be a realistic approach for areas where unionids are found in low densities, sites are few, and are relatively close in proximity to one another, but will not be effective when considering large areas with large populations because of the amount of time and effort needed to collect and move the unionids. Considering the timing of year when translocations will likely occur (warmer months), unionids will have to be moved within a few hours of emersion or they will likely become stressed and severely compromise the survival of these individuals. Waller et al. (1995) indicated that two Amblemine species showed signs of stress when emersed for more than 2 hours in higher air temperatures and suggested that stress could be minimized by conducting relocations or sampling in moderate temperatures with high relative humidity. A contrasting study on the Mississippi River found that unionid mussel survival was not compromised when emersed for 24 hours during mid summer drawdowns to control zebra mussels (Tucker et al. 1997). However, they also suggested that survival may be quite variable between thin shelled species in the Anodontine or Lampsiline subfamilies than in the Amblemine subfamilies. It should also be noted that this study was conducted in Illinois and not the Deep South.

2.1.3 Considerations

- The species should already occur in deeper areas to avoid placing in inhospitable flow conditions.
- The effort is labor/cost intensive.
- Involved personnel need to be experienced in handling mussels, identified and prepared to go on short notice.
- Any moving should be prior to exposure, especially in warm weather, to minimize stress and mortality.
- Relocation sites need to be identified in advance.

2.2 Translocate within current range

2.2.1 Literature

A study conducted in the St. Croix River showed high survival in three species of mussels after relocation to a site 48 km upstream (monitored 2 years), and a site 14 km downstream (monitored 3 years). The mean annual survival of recaptured mussels ranged from 85% to 100% at the upstream site, and from 88% to 100% at the downstream site. The relatively high survival of mussel during this study demonstrates the importance of proper handling and transport protocols when relocating mussels, and the selection of suitable relocation habitat with stable substratum. When established correctly, *in situ* refugia may be a viable tool for preserving unionid mussels (Cope *et al.* 2003).

A translocation study of *Margaritifera hembeli* in two headwater streams in Louisiana showed “translocated mussels survived well . . .” 12 months after translocation, 81% of the mussels were recovered alive (because some translocated mussels were never located either live or dead, the survival rate is likely an underestimate). The study concluded that translocation is a viable management tool for protecting populations of endangered mussels like *M. hembeli* from short-term disturbances, if sites with stable substrata and existing mussel populations are available as translocation sites, and proper translocation procedures are followed (Bolden and Brown 2003).

A discussion paper on the conservation of pearl mussels populations (a highly endangered species in Scotland) in regards to threats from different types of river engineering work states “The translocation of small numbers of adult mussels may possibly be considered as a potential management tool, but . . . mussel translocation should be considered as experimental, and as a last resort and not the first option for river managers” (Cosgrove and Hastie 2000).

Cope and Waller’s (1995) review of literature evaluated the relative success of mussel relocation as a conservation and management strategy, and found that reported mortality varied widely among projects and species and was difficult to assess. Mean mortality of relocated mussels was 49% based on an average recovery rate of 43%. The methods of relocation, when reported, varied widely among project, the survival of the relocated mussel was generally poor (~50%) and the factors influencing mussel survival were poorly understood. The authors reviewed 37 relocation projects; the majority of which were conducted because of construction projects that were forced to comply with the ESA.

Relocating the population to a similar but stable and protected habitat is an option to be considered. Such an approach has been tried in various regions of the United States, but with limited success in most instances (Parmalee and Bogan 1998).

Many things must be accounted for in order to successfully complete any relocation. Hamilton et al. (1997) concluded that habitat type at the transplant site is critical to the success of the project. Conditional survival varied greatly among 4 species relocated in the Apalachicola River and survival of *Elliptoideus sloatianus* was statistically greater (100% survival) when transplanted into cobble substrates than those transplanted into sand substrates (Hamilton et al. 1997). However, this study only monitored survival for 10 months. Brim Box et al. (2002) found that approximately 80% of the mussels found in their study of the ACF occurred near the banks or sloped edges of creeks and rivers. As a result, suitable habitat for many mussels in the ACF may also be those habitats at highest risk of dewatering during severe drought.

Aside from considering macrohabitat, microhabitat within these sites may be critical to the success of the relocation (Dunn 1993). Layzer and Madison (1995) have suggested that suitable habitat for unionids may be a result of low shear stress in the vicinity of their occurrence while Sparks and Strayer (1998) suggest the interstitial dissolved oxygen should be considered when choosing reintroduction sites. Additionally, Sparks and Strayer (1998) found that mortality of juvenile *Elliptio complanata* was eminent when exposed to dissolved oxygen concentrations of 1.3 mg/l for a week or more.

Dunn (1993) also hypothesized that unionids may be more tolerant of natural disturbances than disturbances related to relocation activities where the relocation alone may result in mass mortality of individuals (Dunn et al. 2000). Dunn and Seitman (1993) provided several guidelines for conducting successful relocations, which focused on the use of experienced personnel and selection of sites with stable substrate and established unionid populations. However, one must also question the impact that the transplanted individuals may have on the already established population when translocating these unionids to sites that already have established communities.

2.2.2 Personal Communication

Bob Butler (FWS 2008): Mussel community carrying capacity may be the reason that a particular species does not occur at specific sites that already harbors an assemblage of mussels or where the species only occurs in limited numbers. We have very little (if any) available data on carrying capacity of mussels/communities in beds/stream reaches. This may actually be an issue for any movement of mussels, intra- and inter-stream, but especially for inter-stream transfers.

2.2.3 Considerations

- Identify suitable relocation sites (stable substrate, species present, similarity of habitat of the transplant site and source site (Dunn and Sietman 1993)) in advance.
- Carrying capacity of receiving population.
- Land ownership considerations (State, Federal, private lands).
- Any additional Section 7 issues to consider (e.g. Safe Harbor, HCP, essential or non-essential experimental populations).
- Genetics issues (outbreeding depression).
- Long-term monitoring (once a year for 3-5 years).
- Follow protocols for proper site selection, transport, and handling (see Dunn *et al*. 2000 and Cope and Waller 1995).

2.3 Translocate outside of current range but within historic range (Reintroduce)

2.3.1 Literature

A discussion paper on concerns of freshwater mussel translocation programs states "the primary concerns of conservation efforts, such as salvage programs and translocations, should be conservation of the gene pool and prevention of disease transmission." The authors state it is imperative to determine genetic structure and effective population sizes before translocation (Villella *et al.* 1997).

Researchers evaluated many recent mussel translocations and found that success of relocation/reintroduction or transplantation may be dependent on selecting suitable habitat, reducing stress during handling and transport, and time of year (Dunn *et al.* 2000).

After DO and flow mitigation below Douglas Dam on the French Broad River, researchers reintroduced almost 20,000 mussels of 18 species and monitored them for up to four years. There assessment was that survival of translocated mussels was high, and successful reproduction of at least one translocated species occurred (Layzer and Scott 2006).

In a paper to discuss evolutionary concerns in mussel relocation programs researchers stated that conservation efforts should intervene as little as possible when managing the genomes of threatened species. However, when relocations are deemed necessary, every precaution should be taken to minimize the effects of gene drift and inbreeding depression by providing sufficiently large effective population sizes. Those involved in relocations should also exercise vigilance to avoid the pitfalls of outbreeding depression resulting from mixing divergent evolutionary lineages and the potentially catastrophic consequences of introduced pathogens. Management efforts that focus on the protection of existing populations, and the discovery and protection of new populations of threatened taxa, may represent a more realistic conservation strategy than the creation of populations of unknown ecological and evolutionary potential (Villella *et al.* 1998).

Prior to committing to translocation outside of current range, but within historic range, there is a need to address the causes of decline within the historic range. Habitat degradation and the introduction of exotic species can drastically increase mussel population declines by affecting reproduction, recruitment, survival, and dispersal. Only after the causes for decline have been identified and corrected can the effective implementation of a relocation program be used to safe guard small population problems and re-establish populations within historical ranges (Jones et al. 2006)

2.3.2 Personal Communication

Jason Wisniewski (GA DNR 2008): The first question to consider is why are these unionids currently not at sites or in low densities at sites outside of their current range. If individuals are relocated to historically occupied areas and the threats to the species have not eliminated that resulted in the initial extirpation of the species from a site, it is probable that putting more individuals in the site will have the same ill-fated results.

The second concern relates to the genetic integrity of the species. If we move individuals to sites outside of their current range, how many do we have to move to make the relocation genetically successful? How many can we move without hurting the donor population (especially since we are already going to have mortality of individuals due to drought)? Are we only moving individuals who will be unable to survive the drought? It is difficult to say without the appropriate genetics study as to whether the species in sub-basins could be ecologically significant units, and the impact genetic contamination could have on the persistence of the species rangewide.

2.3.3 Considerations (also, include issues from 2.2.3 above):

- Effects on resident community (carrying capacity, and disease transmission).
- Genetic issues (effective populations size, and inbreeding depression).
- Size of donor population (may not be a consideration if moving only exposed mussels).
- Quarantine may be necessary.
- New population may need to be supplemented until recruitment occurs, so long-term process.
- Has original threat been removed or mitigated?
- Is new location vulnerable degradation in future?
- Is fish host(s) present?
- Follow protocols for proper site selection, transport, and handling (see Dunn *et al*. 2000, and Cope and Waller 1995)
- Will mussels be moved back? If so, when and how many.
- Has threat that caused mussels to be moved been eliminated? If not and mussels are returned, same action will likely have to be performed during the next drought.

2.4 Move to Holding Facilities

2.4.1 Literature

An experiment was conducted to evaluate the relocation of mussels into refuges (e.g., hatchery ponds) as a management tool. The researchers placed five species into a pond or back into the river using 4 treatments for 36 months. Mortality was four times greater in the pond than in the river (survival rates were 35% pond vs. 75% river). The study concluded that the high mortality rates, reduced growth rates, and poor physiological condition of relocated mussels suggest that relocation of mussels into artificial ponds is a high risk conservation tool. There are few alternatives in certain locations and with some species; in these cases, relocation may be justified. These results strongly suggest that alternatives be explored (Newton *et al.* 2001).

An annual report of long-term holding (~ 1 to 2 years) of mussels in captivity showed survival rates were highly variable (survival rates ranged from 14% to 97% and averaged 53%). The rates varied greatly between holding facilities, treatments, and mussel species (Layzer *et al.* 1996).

Boyles 2004, conducted a study on mussels at White Sulphur Springs NFH from 2001-2003. Survival rates, glycogen levels, and gametogenic activity were compared for captive and wild mussels. There were no significant differences in rates or levels of mussels held in recirculating ponds versus wild mussels.

2.4.2 Personal Communication

Paul Johnson (AABC 2008): Do not move mussels into holding facilities unless you absolutely have to, bad things can happen with large number T & E's in holding. Also, there are very few places equipped to hold thousands of animals.

Jason Wisniewski (GA DNR 2008): We can spend lots of time and money to salvage mussels from the river and take them to the hatchery until the drought is over. We may have to take unionids back to the river only to have to do the same thing in 2012, 2018, 2027, etc. If the threats cannot be fixed, it is not realistic to think that recovery can ever be achieved using this technique. Furthermore, we do not currently have personnel experienced in the captive care of many endangered species at any of the State or Federal hatcheries in GA, FL, and AL (with the exception of the ADCNR facility in Marion). Also, we do not know how many mussels need to be held in the hatchery to provide a good “ark” and preserve the genetic integrity of the population.

Sandy Abbott (USFWS 2008): Warm Springs NFH established a mussel refugia program in 2000 to help with drought-induced impacts to federally-listed and native mussels in Spring Creek, Miller County, Georgia. Mussels were salvaged and transported to the hatchery in June of 2000. The hatchery had an approximately 70% survival rate after one year (Bouthillier, pers. com., 2008) and released the mussels back into the areas they were salvaged from in late summer of 2001. Mussels were tagged before returning to Spring Creek although no monitoring plan was established. To date, two mussel surveys have been conducted in areas these mussels were released (2004 and 2007) and only six tagged mussels have been found. This puts the overall detectability rate of salvaged mussels returned to Spring Creek at less than 1%.

Jeff Garner (Alabama Wildlife and Freshwater Fisheries) regarding the Alabama mollusk meeting on Jan 16-17, 2008: There was a consensus among attendees to the Alabama meeting that we should be diligent, but cautious, in monitoring vulnerable species. To take the drastic measure of bringing them into captivity is not warranted at this time and has the potential for major damage to the populations.

2.4.3 Considerations

- Availability of suitable holding facilities (See Attachment #1).
- Drought-induced stress levels in mussels may negate our best efforts at salvage.
- Follow protocols on proper transport and handling (see Dunn *et al*. 2000, and Cope and Waller 1995)
- Criteria to determine when drought conditions have subsided and mussels can be returned to streams
- Are mussels returned to original location?
- Long-term monitoring (3-5 years) once returned to stream.

2.4.4 Considerations for selecting a qualified holding facility (see Attachment #2)

- Experienced personnel (at least one full-time and one part-time position) that are up-to-date on mussel husbandry techniques.
- A good water source, and water quality/chemistry that is suitable for mussels.
- Holding structures such as raceways or tanks.
- Effluent capture system to contain mussels, and prevent an accidental introduction.
- Protocols in place to quarantine and house mussels to prevent spread of disease, parasites, and exotic mussels within the facility.
- Demonstrated success in long-term holding of surrogate mussel species.
- Demonstrated success in holding large numbers of mussels.
- Facility is preferably located within basin.

2.5 Summary of Possible Actions

2.5.1 Move down slope or to deeper water nearby. *Best option, when available.*
2.5.2 Translocate within current range. *With proper site selection and handling.*
2.5.3 Translocate outside of current range but within historic range (reintroduce). *With caution and data; requires written plan and input from experts to address the considerations listed above.*
2.5.4 Move to holding facilities. *With extreme caution and as a last resort. The general consensus among mussel biologist is that placing mussels into captive holding should not be considered unless extinction is imminent and only when no other options are available.*

2.6 EVALUATION TABLE FOR PROBLEMS

Alternatives	Possible Consequences	Uncertainties	Other Considerations
Do nothing except document loss, study movement and genetics	1. Percent mortality may be severe 2. Could lose more of the population than expected	1. Accuracy of population estimates (if wrong could lose more or less than expected)	
Move downslope or to	1. Prevent/reduce mortality	1. Stress from moving	1. Return to original

deeper water nearby	2. Preserve genetic diversity 3. Mortality or decreased fitness if placed in unsuitable habitat 4. Mortality if location is unsuitable once flows return	2. Is new location suitable when flows increase 3. What is suitable habitat 4. Survival at new location 5. Carrying capacity at new location	location after event? 2. Need personnel experienced in handling mussels willing to participate 3. Identify suitable relocation sites in advance
Translocate within current range	1. Prevent/reduce mortality 2. Preserve genetic diversity 3. Mortality or reduced fitness at new location if unsuitable 4. Mortality or reduced fitness from handling and transport 5. Outbreeding depression	1. Stress from moving 2. Is new location suitable when flows increase 3. What is suitable habitat 4. Survival during transport 5. Survival at new location 6. Carrying capacity at new location 7. Unknown population genetics	1. Identify suitable relocation sites in advance 2. Land ownership considerations 3. Need personnel experienced in handling mussels willing to participate
Translocate outside current range (reintroduce)	1. Prevent/reduce mortality 2. Preserve genetic diversity 3. Reintroduce into historic range 4. Mortality or reduced fitness at relocation site if unsuitable 5. Mortality or reduced fitness from handling and transport 6. Loss of individuals and genetic diversity in Apalachicola River 7. Inbreeding depression 8. Disease introduction to residents	1. Stress from moving 2. Is new location suitable when flows increase 3. What is suitable habitat 4. Survival during transport 5. Survival at new location 6. Carrying capacity at new location 7. Unknown population genetics 8. Are there suitable reintroduction sites 9. Effective population size 10. Unknown disease issues	1. Identify suitable relocation sites in advance 2. Are fish hosts present? 3. Has original threat been mitigated? 4. Land ownership considerations
Move to hatchery	1. Prevent/reduce mortality 2. Prevent extinction 3. Mortality from handling and transport 4. Mortality at hatchery 5. Mortality reduced fitness after returned into river 6. Loss of genetic diversity	1. Stress from moving 2. Survival during transport 3. Survival at hatchery 4. Survival after returned to river 5. Unknown population genetics 6. Effective population size	1. Availability of suitable holding facilities 2. Holding capacity is limited 3. Public could interpret this alternative as "the" answer

* Two additional columns that should be considered in this table include "Risk to Species" and "Level of Effort". These will be watershed specific and therefore were not included in this table.

3.0 Activities/Issues associated with Intervention

3.1 Protocol for Handling Mussels in situ

To minimize stress, all mussels should remain in a mesh collecting bag kept in the water until being measured and photographed one-at-a-time. Mussels should not be exposed to air any longer than it takes to actually measure and photograph the animal. Federally protected and candidate species must be handled gently and returned to the area of collection. They should be carefully re-bedded into the sediment in the correct position (Hail *et al.* 2007, Strayer and Smith 2003, Young *et al.* 2003). Care should be taken to orient the mussel in the posterior up position. If uncertain of the correct position, the mussel should be placed on the substrate surface and left to appropriately burrow into the correct direction, position, and depth (Carlson *et al*. 2007).

3.2 Permit needs

A section 10(a)(1)(A) Endangered Species Act recovery permit from the Service (http://permits.fws.gov) is required for Federal employees and private citizens to handle or move federally-listed mussels.

50 CFR 17.21(c)(3) …any employee or agent of the Service, any other Federal land management agency, the National Marine Fisheries Service, or a State conservation agency, who is designated by his agency for such purposes, may, when acting in the course of his official duties, take endangered wildlife without a permit if such action is necessary to: (i) Aid a sick, injured or orphaned specimen; or (ii) Dispose of a dead specimen; or (iii) Salvage a dead specimen which may be useful for scientific study; or (iv) Remove specimens which constitute a demonstrable but non-immediate threat to human safety, provided that the taking is done in a humane manner,…

50 CFR 17.21(c)(4) Any taking pursuant to the above must be reported in writing to the U.S. Fish and Wildlife Service, Division of Law Enforcement, P.O. Box 19183, Washington, DC 20036, within 5 days. The specimen may only be retained, disposed of, or salvaged in accordance with directions from the Service.

50 CFR 17.21(c)(5) ….any qualified employee or agent of a State Conservation Agency which is a party to a Cooperative Agreement with the Service in accordance with section 6(c) of the Act, who is designated by his agency for such purposes, may, when acting in the course of his official duties take those endangered species which are covered by an approved cooperative agreement for conservation programs in accordance with the Cooperative Agreement, provided that such taking is not reasonable anticipated to result in: (i) The death or permanent disabling of the specimen (ii) The removal of the specimen from the State where the taking occurred; (iii) The introduction of the specimen so taken, or of any progeny derived from such a specimen, into an area beyond the historical range of the species; or (iv) The holding of the specimen in captivity for a period of more than 45 consecutive days.

States have full authority for threatened species, and limited authority for endangered species (50 CFR 17.21(c)(5)0. For endangered species, they can authorize persons to act as agents of the state to rescue mussels (move to deeper water, but not place in captivity greater than 45 days or kill them), salvage dead specimens, translocate within historic range, or any other activity that does not exceed the limits of 50 CFR 17.21(c)(5). Limits are greater than 45 days or kill. For threatened species, states can authorize all activities.

If expediting authorizations is imperative, Service employees could be issued a sub-permit under the Assistant Regional Director's permit for rescue and salvage activities. This sub-permit would allow Service employee's to designate qualified individuals outside the Service as our agents for drought related activities. Service personnel would be required to submit an application for the sub-permit along with an activity description and complete the intra-Service section 7 consultation process. No public notice would be required.

State Permits

Requirements for state permits, relating to the collection, holding, or transporting of mussels, vary from state to state. Individuals planning on working with mussels in any type of capacity (collection, salvage, translocation, transporting across state lines, etc.) should check with each state's permitting office where mussel work is anticipated to see if and what type of permits are needed.

Table of Contact Information for Obtaining State Permits

Alabama	**Georgia**	**Florida**
AL Division of Wildlife and Freshwater Fisheries Emailjoeanne.stjohn@dcnr.alabama.gov 334-242-3465	GA DNR Todd Nims Todd.nims@dnr.state.ga.us 770-761-3044	FL Fish & Wildlife Conservation Commission Angela Williams Permit Coordinator 850-921-5990 ext. 17310
North Carolina	**South Carolina**	**Tennessee**
NC Wildlife Division of Wildlife Management Daron Barnes Daron.barnes@ncwildlife.org NC Wildlife Division of Inland Fisheries Diane Renzi diane.renzi@ncwildlife.org	SCDNR Barbara Hasty hastyb@dnr.sc.gov 803-734-3891	TN Wildlife Resources Agency Frank Fiss Frank.Fiss@state.tn.us 615-781-6575

3.3 Collection of genetic material

Contingency planning should include provision for collection of genetic material where appropriate. Any action plan should include a determination of how much material is needed, how it will be collected and by whom, and the fate of the material.

3.4 Protocol for handling mussels in hatcheries

3.4.1 Facilities authorized to hold mussels should have an approved protocol in place. This may also be found in propagation, reintroduction, and augmentation plans.
3.4.2 A section 10(a)(1)(A) Endangered Species Act recovery permit from the Service (http://permits.fws.gov) is required for Federal employees and private citizens to handle, move or hold federally-listed mussels.
3.4.3 MOU's may be an option in some cases instead of going through a lengthy permitting process. An MOU has been created between state agencies in Tennessee and West Virginia to allow transport of freshwater mussels across state lines.

3.5 Monitoring

3.4.1 Monitoring plans should be established, especially if mussels are federally-listed, and should be conducted before, during, and after drought conditions subside to the greatest extent practicable.
3.4.2 A monitoring plan for each intervention should be developed prior to taking the action, including how success and failure are defined.

4.0 Research Needs

4.1 Age and growth determination via thin sectioning. Determine the age of unionids to back-calculate whether or not the mussels were alive before and during drought. Try to generate models for strong/weak year classes based on discharges throughout the year.
4.2 Studies of the condition of species being severely affected by the drought. Collect glycogen samples and/or other indicators to determine the severity of stress of allowing the mussels to stay where they are or moving them to other sites or hatcheries.
4.3 Studies of the overall mortality of individuals due to drought. These studies could be done as a long-term tagging study to look at population size and growth trends.
4.4 Movement studies. Estimate to what extent unionids move in response to drought and how long it takes them to move a certain distance.
4.5 Population genetics studies. A critical step before any actions should be taken to relocate mussels outside of their native sites.

5.0 Literature Cited

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7.0 Personal Communication

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Attachment #1. Facilities Potentially Capable of Assisting with Mussel Refugia

Hatchery	Location	Mussel Experience	Refugia Experience	Propagation Experience	Phone
Greer Ferry NFH	Heber Springs, AR	No	Yes (fish)	Yes (fish)	501-362-3615
Mammoth Springs NFH	Mammoth Springs, AR	Yes	Yes	Yes	870-625-3912
Welaka NFH	Welaka, FL	No	Yes (fish)	Yes (fish)	386-467-2374
Chattahoochee Forest NFH	Suches, GA	No	Yes (fish)	Yes (fish)	706-838-4723
Warm Springs NFH	Warm Springs, GA	Yes	Yes	Yes	706-655-3382
Wolf Creek NFH	Jamestown, KY	No	Yes (fish)	Yes (fish)	270-343-3797
Natchitoches NFH	Natchitoches, LA	Limited	Yes (fish/turtles)	Yes (fish)	318-352-5324
Private John Allen NFH	Tupelo, MS	No	Yes (fish)	Yes (fish)	662-842-1341
Edenton NFH	Edenton, NC	No	Yes	No	252-482-4118
Bears Bluff NFH	Wadmalaw Island, SC	No	Yes (fish)	Yes (fish)	843-559-2315
Orangeburg NFH	Orangeburg, SC	No	No	Yes (fish)	803-534-4828
Dale Hallow NFH	Celina, TN	Yes	Yes	Yes	931-243-2443
Erwin NFH	Erwin, TN	No	No	Yes	423-743-4712
White Sulphur Springs NFH	White Sulphur Springs, WV	Yes	Yes	Yes	304-536-1361
Non-Federal Hatcheries					
Arkansas State University					501-972-3082
Alabama Aquatic Biodiversity Ctr	Marion, AL	Yes	Yes	Yes	334-683-5000
Tennessee Aquarium Research Institute	Cohutta, GA	No	Yes (fish)	Yes (fish)	706-694-4419
Center for Mollusk Conservation	Frankfort, KY	Yes	Yes	Yes	502-573-0330
North Carolina State University Mussel Barn	Raleigh, NC	Yes	Yes	Yes	919-513-6655
Tennessee Technology University	Cookville, TN	Yes	Yes	Yes	931-372-3032
Aquatic Wildlife Conservation Ctr	Buller, VA	Yes	Yes	Yes	276-783-2138
VT Freshwater Mollusk Conservation Ctr	Blacksburg, VA	Yes	Yes	Yes	540-231-5927
Other Options					
Bo Ginn	Millen, GA				

(formerly NFH)					
McKinney Lake (formerly NFH)	Hoffman, NC				

Attachment #2. Assessment of Possible Mussel Holding Facilities for ACF Basin (Values in columns 3 and 4 are for the ACF basin only. Each watershed would assign a new value for these columns.)

Type	Hatchery	Location	In ACF Basin 1=yes 0=no	Proximity to River (mi.)* 3=<180 2=181-360 1=361-540 0=>541	Is Water Suitable As Is?** 1=yes 0=no	Active Mussel Facilities? 2=full time 1=part-time or not op. past 2yrs 0=no	Staff Mussel Husbandry Expertise? 2=expert 1=some 0=none	Mussel Refugia Experience? 1=yes 0=no	Space 2 = >200 ft raceways or troughs 1 = <200 ft 0 = ponds or circular tanks only	Effluent Capture System 1=yes 0=no	Current Availability 1 = yes 0 = no / don't know	Total 13 pts available
Federal	Warm Springs NFH	Warm Springs, GA	1	2	0	2	1	1	2	1	1	**11**
State	Alabama Aquatic Biodiversity Center	Marion, AL	0	2	1	2	2	1	2	1	0	**11**
Federal	Mammoth Springs NFH	Mammoth Springs, AR	0	0	1	2	1	1	2	1	1	**9**
Federal	Dale Hollow NFH	Celina, TN	0	1	0	1	2	1	1	0	1	**7**
Federal	Private John Allen NFH	Tupelo, MS	0	1	1	1	1	0	1	1	1	**7**
Federal	Welaka NFH	Welaka, FL	0	2	1	0	0	0	2	0	1	**6**
Private	Tennessee Aquarium Research Institute	Cohutta, GA	0	1	1	1	0	0	2	1	0	**6**
Federal	Natchitoches NFH	Natchitoches, LA	0	0	1	1	1	0	1	0	1	**5**
State	Cordele SFH	Cordele, GA	1	3	1	0	0	0	0	0	0	**5**
State	Dawson SFH	Dawson, GA	1	3	1	0	0	0	0	0	0	**5**
Federal	Orangeburg NFH	Orangeburg, SC	0	1	1	0	0	0	1	0	1	**4**
State	Blackwater SFH	Holt, FL	0	3	1	0	0	0	0	0	0	**4**
Federal	Bears Bluff NFH	Wadmalaw Island, SC	0	1	0	0	0	0	0	1	1	**3**
State	McKinney Lake	Hoffman, NC	0	0	0	0	0	0	0	0	0	**0**
Federal	Edenton NFH	Edenton, NC	0	0	0	0	0	0	0	0	0	**0**

* Distances greater than 360 miles will likely require holding mussels overnight; this should only be considered if other options are not available.
**Does source water need to be amended to make it suitable for mussels (pH, hardness, temperature, etc.).