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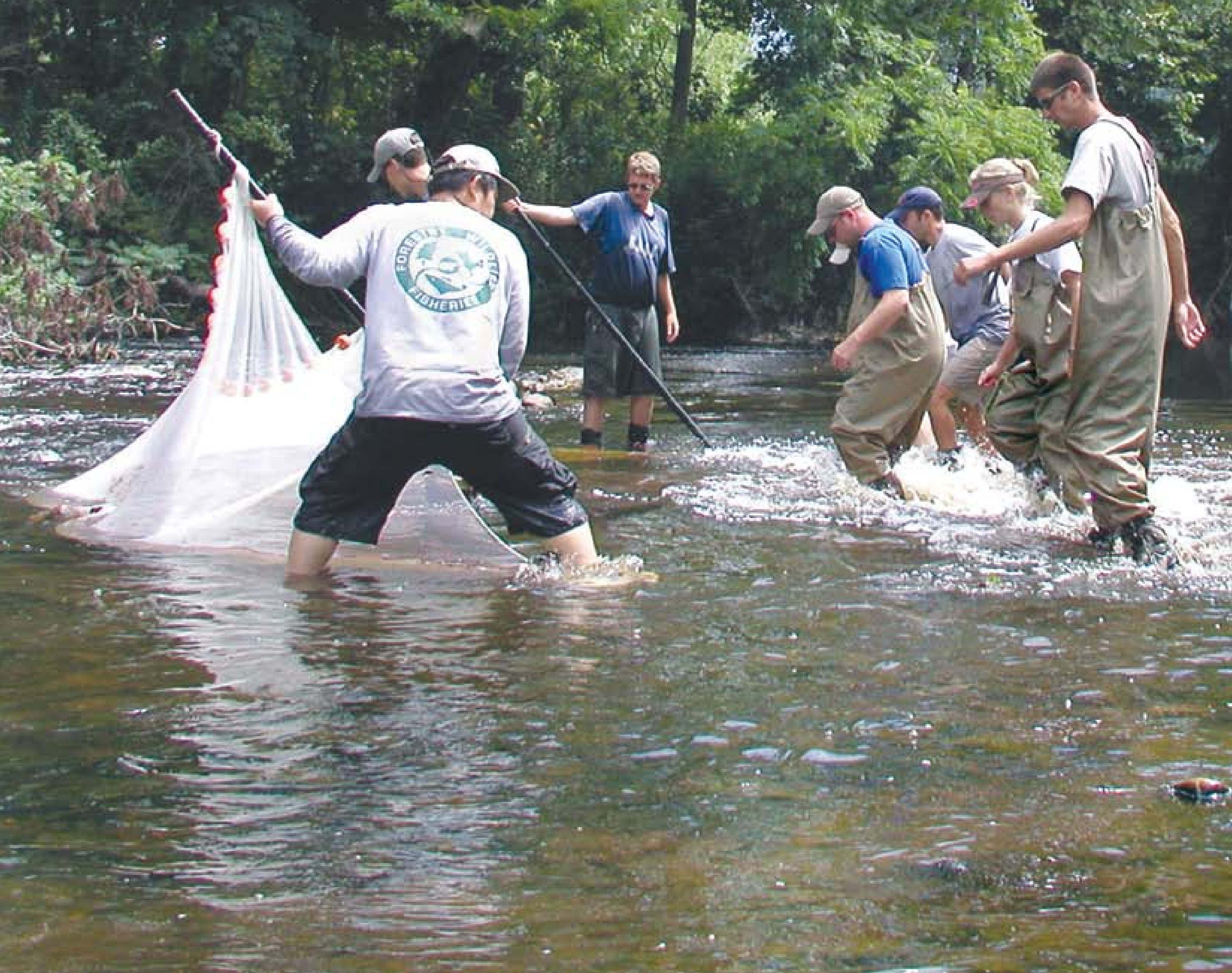
Guidelines for Propagation and Translocation for Freshwater Fish Conservation

Factors Influencing Tropical Island Freshwater Fishes: Species, Status, and Management Implications in Puerto Rico



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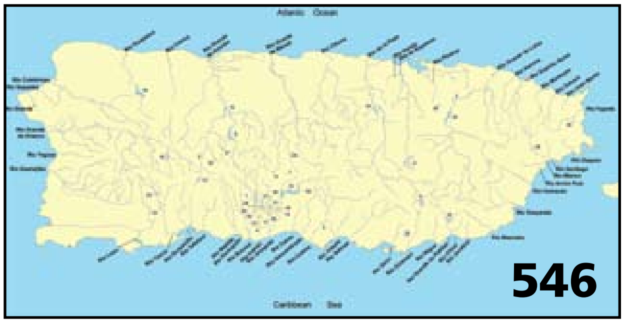

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CREDIT: Joyce Coombs

FEATURE:
ENDANGERED SPECIES

Guidelines for Propagation and Translocation for Freshwater Fish Conservation

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ABSTRACT: Reestablishment of locally extinct populations and augmentation of declining populations are management activities used with increasing frequency in the conservation of imperiled fishes in the United States. Unfortunately, these options were not always carefully or appropriately used in past cases, partly owing to a lack of guidelines that address scientifically-based protocols for propagation, translocation, reintroduction, and augmentation (PTRA). PTRA programs are an important management tool for the recovery of imperiled fishes when undertaken with careful planning, including everything from determining that PTRA is necessary to incorporating knowledge of life history and genetics into the PTRA plan. In addition, PTRA programs must also assemble advisory groups, obtain funding and permitting, construct and maintain propagation facilities, and raise community awareness of the program. Because such diverse skills are needed, successful PTRA programs should prepare for long-term partnerships to achieve the goal of recovery.

Guía de propagación y trasladación para la conservación de peces de agua dulce

RESUMEN: En los Estados Unidos de Norteamérica, el restablecimiento de poblaciones localmente extintas y la recuperación de poblaciones en descenso son actividades de manejo utilizadas cada vez con más frecuencia en la conservación de peces en peligro o amenazados. Infortunadamente, en el pasado dichas opciones no siempre fueron usadas de forma apropiada ni cuidadosa, debido en parte a la falta de guías científicas sobre los protocolos de propagación, trasladación, reintroducción y recuperación (PTRR). Los programas de PTRR son importantes herramientas de manejo para recuperar las especies de peces que se encuentran en peligro o amenazadas cuando son planeadas con el debido cuidado, incluyendo desde determinar si el PTRR es necesario, hasta la incorporación de conocimientos acerca de ciclos de vida y aspectos genéticos al cuerpo del programa. Adicionalmente, los programas PTRR deben reunir distintos grupos de asesores, recabar fondos y permisos; construir y mantener la infraestructura necesaria para actividades de propagación así como también despertar la conciencia de la comunidad con respecto al programa. En virtud de que todas estas tareas son indispensables, aquellos programas PTRR que resulten exitosos debieran estar dispuestos a establecer sociedades de largo plazo si el objetivo es alcanzar la recuperación de los peces en peligro.

THE NEED FOR PTRA GUIDELINES

Over the past 20 years, the number of imperiled freshwater fishes in the United States has almost doubled (Jelks et al. 2008). Habitat destruction has been a major contributing factor to the steady decline of fish populations (Etnier 1997; Jelks et al. 2008). Though conservation actions have restored some freshwater habitats, fragmentation or isolation may limit recolonization by fishes and prevent full recovery of the community (Detenbeck et al. 1992; Lonzarich et al. 1998; Morita and Yamamoto 2002). In these scenarios, recovery of the target species and complete restoration of the system may depend on PTRA: propagation or translocation for reintroduction or augmentation. Propagation is the production of individuals within a captive environment for the purpose of reintroduction to the wild. We define translocation as the movement of wild-caught fishes from one place to another within their known range. We consider relocations of fishes outside of their native range as introductions. An augmentation is the addition of individuals to an existing wild population. A reintroduction is a release of fishes within their historic range where a population no longer exists. Augmentations and reintroductions can be accomplished through the release of propagated or translocated fishes. When implemented with a scientific foundation, PTRA can be a powerful tool in the recovery of imperiled fishes.

Short-term goals of PTRA projects are often to prevent the extinction or population loss of imperiled fishes (Johnson and Jensen 1991; USFWS 2000; Shute et al. 2005). In some drastic situations, propagation and maintenance of an ark population is necessary to prevent extinction of an entire species when all suitable wild habitat has been lost (Miller and Pister 1971; Flagg et al. 2004). PTRA projects are often an integral part of Endangered Species Act (ESA) recovery plans because establishment of additional populations are typically a criterion for down-listing or even delisting (USFWS 2000; Paragamian and Beamesderfer 2004). With foresight, PTRA projects can also be used as a tool to prevent listings by halting a downward spiral of decline and ultimately stabilizing populations (Goldsworthy and Bettoli 2006). Our objectives are to provide guidelines and precautionary rules for planning, executing, and monitoring PTRA programs for freshwater fishes in order to improve their likelihood of success and aid the recovery of aquatic ecosystems.

GUIDING PRINCIPLE: DO NO HARM

The first priority for the recovery of a species is to improve the status of wild populations in their natural habitat (USFWS 2000). PTRA should not be a substitute for addressing the factors that resulted in the decline of the species in the wild (Snyder et al. 1996). PTRA activities should only be undertaken if other recovery options addressing the current limiting factors are not likely to be effective in the foreseeable future (Philippart 1995; USFWS 2000). The threat of losing a species or population if no PTRA action is taken must be assessed and contrasted with the difficulties involved with PTRA. Sometimes, it may be better to do nothing than to risk activities that might cause even more harm to an imperiled species or ecosystem (Snyder et al. 1996; Ford 2002; Metcalf et al. 2007; Walker et al. 2008). However, if wild populations do not appear to be sustainable without action, then a PTRA program can be an effective, and sometimes essential, recovery tool, so long as this guiding principle is followed (Box 1).

Box 1.
Best Case Scenario: Abrams Creek Restoration

Abrams Creek in the Great Smoky Mountains National Park was poisoned with rotenone in 1957 to improve fishing for the nonindigenous rainbow trout (*Oncorhynchus mykiss*), causing the loss of many native fishes, though the habitat remained pristine. A multi-agency captive propagation project was initiated in 1986 to restore several federally-protected fishes to this stream (Shute et al. 2005). Conservation Fisheries, Inc. (CFI) of Knoxville, Tennessee, has managed the captive propagation and is the lead in monitoring both source and target populations. Because a project using captive propagated non-game fishes had never been undertaken, this program has been a learning process that will serve as a template for future restoration projects.

Captive propagation initially focused on the federally-endangered smoky madtom (*Noturus baileyi*) and the federally-threatened yellowfin madtom (*N. flavipinnis*). In 1993, the federally-endangered Citico darter (*Etheostoma sitikuense*) was included in the species being restored to Abrams Creek. Over the 20-year span, more than 3,000 smoky madtoms, 1,600 yellowfin madtoms, and 3,500 Citico darters have been released. These three species have been reproducing, recruiting, and dispersing into suitable habitats in Abrams Creek, where numbers of fishes now often rival those seen in the source population in nearby Citico Creek.

Attempts were also made to establish the federally-threatened spotfin chub (*Erimonax monachus*) in Abrams Creek. After several failed translocation efforts, captive propagation was undertaken. A total of 12,000 spotfin chubs were released into Abrams Creek, but efforts to restore this species have now ceased because no significant recruitment was ever documented.

Although progress on this project was often impacted by inadequate funding, it has been a great success overall with three of the four imperiled species now thriving in at least some sections of Abrams Creek. The most important lesson from this project has been patience—evidence of success took many years to materialize. Nearly 5 years passed before any released fish were recaptured in Abrams Creek, and 10 years before in-stream recruitment was documented. Those undertaking PTRA projects must be persistent to increase the chances of eventual success.

—PLR & JRS

Abrams Creek, site of a multi-agency captive propagation project to restore several federally-protected fishes that were lost from a rotenone application during the 1950s (Shute et al. 2005).

Photo: Conservation Fisheries, Inc.

RULE 1: DETERMINE THAT PTRA IS NECESSARY

The decision to incorporate captive propagation or translocation involves several important considerations and must be evaluated on a case-by-case basis. First, an evaluation of the viability of a wild population must be conducted to determine its current status in terms of occurrence and abundance. This may be particularly difficult with rare fishes, when failure to detect the presence of the species does not necessarily imply its absence (Box 2; Gu and Swihart 2004). In these cases, greater sampling effort, multiple survey techniques and equipment, and estimating detection probabilities are necessary to increase confidence in the assessment of abundance (Yoccoz et al. 2001; Royle et al. 2005; Albanese et al. 2007). Repeated surveys using different sampling methods need to be conducted as fishes may differ in their habitat use seasonally or throughout their life cycle (Bayley and Peterson 2001; Royle and Nichols 2003; MacKenzie and Royle 2005). Even if individuals are detected, augmentation may be determined to be necessary if the long-term prognosis for recovery does not appear feasible or recruitment is failing (Philippart 1995).

Box 2.
Beyond Detectability: The Alabama Sturgeon

The Alabama sturgeon (*Scaphirhynchus suttkusi*) is a federally-endangered species restricted to large-river habitat in the Mobile Basin in Alabama and, historically, northeast Mississippi. It was proposed for listing as endangered in 1993. A coalition of businesses in Alabama opposed its listing, suggesting it was extinct since none had been collected in eight years. Collecting efforts in the Alabama River by the USFWS produced a single specimen later that year, but the USFWS withdrew the proposal to list the Alabama sturgeon in 1994 because there was "insufficient information to justify listing a species that may no longer exist" (USFWS 1994). Over the next five years, six specimens were collected by commercial fishers, the USFWS, and the Alabama Division of Wildlife and Freshwater Fisheries (ADWFF), demonstrating that this species was not extinct. These data plus the threat of a lawsuit prompted the USFWS to list the Alabama sturgeon in 2000, but additional efforts, including 30,400 survey hours from 2000 to 2005, failed to produce any specimens with the last verified sighting by a fisher in 2000 (Rider and Hartfield 2007). While sampling for paddlefish, ADWFF personnel captured an Alabama sturgeon in the Alabama River in April 2007, seven years after the last confirmed catch. Clearly, large-river fishes can go undetected for many years, even with efforts directed at their capture. Any hypotheses of population loss or extinction based on negative sampling data are valid only if directed efforts using correct fishing gear in appropriate habitat are employed over years or even decades.

—*BRK*

The Alabama sturgeon, an endangered species that persists even though it goes undetected for years despite targeted collecting efforts. Illustration: Joe Tomelleri.

Second, the decision to begin PTRA activities must be based upon the need for action within the historical range of the species (IUCN 1987). Knowledge of the historical range should be based on locality data from scientific literature and museum records. Introductions should never be made outside of the historical range of a species, regardless of its imperilment, because it may have unintended negative impacts on the native species assemblage present at the introduction site (Box 3).

Box 3.
Do No Harm

The watercress darter (*Etheostoma nuchale*) is a federally-endangered fish native to only four springs in the Black Warrior River drainage of the Mobile Basin in Jefferson County, Alabama. These sites are in the greater Birmingham metropolitan area, where development threatens these springs with groundwater pollution and reduced flows due to extensive impervious surfaces. In response to these threats, the USFWS and local biologists established an additional population of watercress darters in 1988 by translocating 200 individuals from Roebuck Spring (Village Creek watershed) to Tapawingo Spring (Turkey Creek watershed), outside of the native range of the species. The translocation was successful; watercress darters are now found by the thousands throughout Tapawingo Spring and the surrounding wetland area.

However, this tale does not have a happy ending, at least not for another imperiled fish, the rush darter (*Etheostoma phytophilum*), which was not described as a distinct species until 1999 (Bart and Taylor 1999.) This darter also lives in springs and spring-fed streams and is a candidate species for federal listing with a distribution in the Black Warrior River drainage in three isolated populations, including the Turkey Creek watershed and Tapawingo Spring. As the nonnative watercress darters grew in numbers, rush darters became rarer at this site, with the last rush darter collected in 2001. It appears that rush darters can not co-exist with watercress darters in Tapawingo Spring, presumably due to competition for resources. Rush darters are still found at two other locations in the Turkey Creek watershed, but these sites have faced major habitat degradation. One site is a series of small spring seeps that almost dried up in the recent drought, and a building was constructed on the site of the other spring, leaving only a spring run that is precariously located along a state highway. The moral of this story is to never move a species, even one that is endangered, outside of its current or historical range because you never know what negative impacts it can have on the native fauna.

—BRK

Tapawingo Spring, site of the local extinction of rush darters (right).

Photos:
Bernard Kuhajda

Third, the suitability of the habitat in the historical range should be considered. A variety of factors must be considered, including water quantity and quality, substrate, spawning sites, nursery areas, and food supply (Shute et al. 2005). If habitat is not present in the quantity or quality necessary for all life stages, then any PTRA project is doomed to fail in the longterm. Consideration should also be given to the longterm sustainability of the habitat in the face of any future threats such as development that could cause degradation (Carroll et al. 2003). If habitat restoration is needed, that should be completed prior to any PTRA activities (Kauffman et al. 1997; Jones et al. 2006). Through habitat improvement alone, fishes may be able to reestablish self-sustaining populations by immigration or by increasing from a formerly undetectable level, making PTRA unnecessary (Lonzarich et al. 1998; Irwin and Freeman 2002; Bednarek and Hart 2005). However, if a species or population is under immediate threat of extinction or loss, consideration should be given to the establishment of an ark population.

At the conclusion of these evaluations, PTRA may be determined to be unwarranted for the survival of the species. Preliminary propagation without releases may still be advisable, as it will allow hatchery staff to gain the technical skills necessary for propagation in case it becomes necessary for recovery at a later date. If preliminary propagation is undertaken, the PTRA program should follow all of the same guidelines as those with releases.

RULE 2: GET APPROVAL AND ADVICE

After determination that PTRA is necessary, an advisory committee needs to be assembled if a recovery team or group does not already exist. The advisory committee should include biologists with research experience with the species, state agency scientists from wildlife and environmental agencies, federal agency scientists, as well as local stakeholders that may include private landowners, local and/or tribal governmental officials, members of the zoning board, and representatives from nongovernmental organizations (Runstrom et al. 2002). The role of the advisory committee is to provide guidance to the program at every step, as well as to help coordinate the program with other recovery activities for the species.

Environmental laws, regulations, and policies governing augmentation and reintroduction of imperiled fishes are complex and based on issues such as resource use, suitability, and security of transplant sites (Box 4). PTRA efforts must be conducted with approval from the agency(s) with authority and responsibility for the species and the habitat. Well-meaning but unauthorized PTRA activities could compromise wild populations of imperiled fishes.

If the fish is federally listed as endangered or threatened, or is a candidate for listing, a recovery plan may have already been drafted and approved. Many recovery plans have already prioritized PTRA activities as part of the strategy for conserving and recovering the species. If there is no recovery plan or if PTRA is not identified as a recovery strategy, PTRA activities can only

Box 4.
Fish Restoration by Translocation in the Pigeon River, North Carolina

The Pigeon River, a tributary of the French Broad River in the Tennessee River drainage, was severely polluted by paper mill effluent for nearly a century. Several fish populations were lost from the affected reach or from the entire Pigeon drainage and had no route to recolonize naturally from the nearby extant populations due to dams blocking dispersal. Ongoing efforts since the early 1990s have made great improvements to water quality and fish habitat, creating an opportunity for a PTRA project.

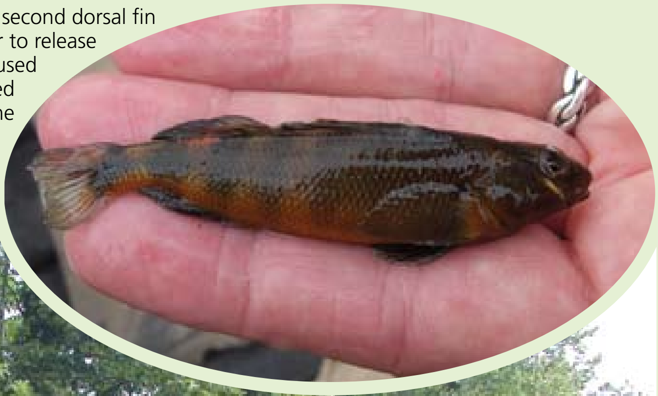
Though recovery of habitat has been substantial, the Pigeon River is still degraded from both point and non-point pollution. Therefore relatively common fishes believed to be tolerant of existing habitat conditions were utilized for translocation. Source populations were chosen from upstream of the impacted reach, tributaries, or other streams in the upper French Broad River system within the same Blue Ridge physiographic province.

Translocations have included mirror shiners (*Notropis spectrunculus*), saffron shiners (*N. rubricroceous*), silver shiners (*N. photogenis)*, telescope shiners (*N. telescopus*), Tennessee shiners (*N. leuciodus*), and gilt darters (*Percina evides*). Translocations began in spring 2003 for all species except gilt darters (spring 2005) and Tennessee shiners (spring 2007). As of 2007, 5,317 mirror, 2,533 telescope, 1,674 silver, and 670 Tennessee shiners, and 323 gilt darters have been released.

Successful translocation appears to depend heavily on the details of the technique. Native cyprinids are notoriously fragile, therefore minimal and careful handling of shiners during capture, preparation for transport, and release is essential. Fishes are translocated in April just prior to spawning and in October when young of the year are easily captured and air and water temperatures are favorable. Translocations in August when air and water temperatures were high resulted in unacceptable levels of mortality.

Annual assessment of survival in the Pigeon River indicates that silver and telescope shiners have done well, are recruiting, and have dispersed up to eight river miles from release sites with silver shiners re-established over at least 10 miles of the targeted reach. Mirror shiners are also surviving and appear to be recruiting, but are at lower densities and with less expansion. After only one translocation effort, Tennessee shiners appear to be doing well. Saffron shiners proved to be too uncommon for capture in effective numbers and habitat in the targeted restoration reach was marginal at best, so efforts were terminated after the first year. Gilt darters have been more difficult to recapture and assess their status because only one tagged adult and one untagged sub-adult have been recaptured, but these limited data may still indicate successful reproduction and recruitment in the Pigeon River in North Carolina.

—Steve Fraley, North Carolina Wildlife Resources Commission, and Joyce Coombs, University of Tennessee, Knoxville



Gilt darters are tagged under their second dorsal fin with visible implant elastomer prior to release into the Pigeon River. Tags can be used to determine the survival of released fish or to detect reproduction by the capture of untagged fish.

Collecting fish for the Pigeon River reintroduction program. Different collecting methods or different collecting times, daily or seasonally, can be used to minimize stress on fishes.

Photos: Joyce Coombs

be undertaken if approved by the U.S. Fish and Wildlife Service (USFWS) regional director and/or state nongame or fisheries director (USFWS 2000). If the fish is state-listed or a species of conservation concern, the state agency tasked with its management may have adopted a recovery plan. If a fish is not federally listed or a candidate species, state or regional peer groups (state nongame wildlife panels or various ichthyological societies) should be consulted for advice on PTRA activities and/or as a source for members of an advisory committee.

Biologists involved in PTRA activities for fishes must be knowledgeable of regulations and obtain necessary federal, state, and local permits for proposed actions. Most PTRA activities with fishes involve capture of wild individuals for translocation or captive propagation and require protected species permits from the state and USFWS.

Federal permits. The ESA requires individuals to acquire Section 10 recovery permits in order to collect, propagate, or conduct research on federally-listed species. The activities authorized by permits differ depending on endangered or threatened status. Applications for native endangered and threatened species permits can be found on the USFWS website (www.fws.gov/endangered/permits/index.html) or by contacting the regional office. A fee may be required for a permit or to amend an existing permit. For information on ESA permits issued by NOAA Fisheries (e.g., marine and anadromous species), visit their permit web page (www.nmfs.noaa.gov/pr/permits/). Applicants should allow at least 180 days for processing of the application.

State permits. States require permits prior to collecting native species or conducting PTRA activities. Regulations vary between states, so special consideration should be given to work involving a single species found in multiple states. Contacts for state permits are available from state fish and wildlife agencies via their websites.

Special use permits. Land management agencies often require special use permits prior to collecting on their lands or conducting PTRA activities, especially whenever PTRA activities involve collection or release of fishes from national forests, parks, or wildlife refuges. State parks, forests, or wildlife management areas also have rules or coordination steps dealing with the collection or release of fishes within their boundaries. Native American tribes may require separate permits for collection and/or release of fishes on their reservations.

Institutional Animal Care and Use Committee. U.S. federal law dictates that institutions which use laboratory animals for federally-funded research or instructional purposes must establish an Institutional Animal Care and Use Committee (IACUC) to oversee and evaluate such programs. Animal welfare at all stages of a PTRA program should have protocols approved by IACUC committees, including the capture of broodstock, transportation, husbandry techniques, and euthanasia. At this stage, a veterinarian with fish experience should also be identified to consult on minimizing stress, disease prevention and treatment, and euthanasia. Numerous guidelines on the use of fish in research or aquaculture are available to help draft these protocols (e.g., OLAW 2002; AFS 2004; CCAC 2005)

Plan Ahead. If fishes will be transferred across jurisdictional boundaries during any PTRA activities, permits will likely be required from each entity. In all instances, permits (federal, state, tribal or land manager) should be requested well in advance (several months) of proposed PTRA activities. In some cases, permits may require more than a year for processing and approval.

RULE 3: CHOOSE THE SOURCE WISELY

Two options are available to managers wishing to implement PTRA activities. If individuals are highly abundant in the source population(s), translocation will typically be the best recovery tool. Translocation allows for natural recruitment of the newly established population and eliminates or minimizes most problems associated with propagation facilities, such as transmission of disease, contact with exotic species, domestication, or artificial selection. If the source population is not robust enough to support translocation, a captive propagation program may be the better alternative. Captive propagation programs can vary from rearing eggs or young collected from wild populations to holding broodstock at propagation facilities for repeated spawning. However the PTRA program is carried out, the intent should be to replicate natural patterns of diversity and to allow the natural environment to drive the adaptation and fitness of the target population.

Determining which population will be used as the source for propagation or translocation is one of the most important decisions. With augmentation programs, a prior genetic and/or morphological study in an evolutionary framework must be conducted to identify a source population or populations that are most closely related to the target population. Unfortunately, since the target population for reintroduction programs is presumed to be locally extinct, a comprehensive genetic study of the target species is not possible, and morphological studies may not resolve evolutionary relationships to the population level. In these situations, a genetic study of other species with a similar distribution may help to determine if there are replicated patterns of biogeography where populations in one geographic area are always closely related to populations at the target site. These repeated patterns would indicate which population is the best source from an evolutionary standpoint, providing the greatest likelihood of restoring the ecosystem to its pre-disturbance state (Box 5).

In some cases, multiple populations may be identified as good candidates for a source population based on the genetic data. The next consideration is how to maximize the natural levels of genetic diversity captured from the source. Higher genetic diversity is not only necessary for the species to adapt to environmental change but is also positively correlated with population fitness (Reed and Frankham 2003). Though high abundance or larger range size could be used as proxies for genetic studies, as each are positively correlated with genetic diversity (Blackburn et al. 1997; Franklin and Frankham 1998; Pyron 1999; Boessenkool et al. 2007), a genetic study examining the variation in each source is the best option. Genetic studies may also reveal alleles that are naturally absent in a target population, and therefore prevent accidental introduction through a PTRA program. For example, a study of blotchside logperch (*Percina burtoni*) in the upper Tennessee River suggested that populations in the Clinch and Holston rivers had genes unique to each. However, both sets of genes are present in a population in the Hiwassee River, downstream from both the Clinch and Holston rivers (George et al. 2006). In this scenario, using individuals from the Hiwassee River as a source population would be unwise because genetic variation not naturally present could be introduced in the other populations. Although the

Box 5.
Replicated Patterns of Biogeography

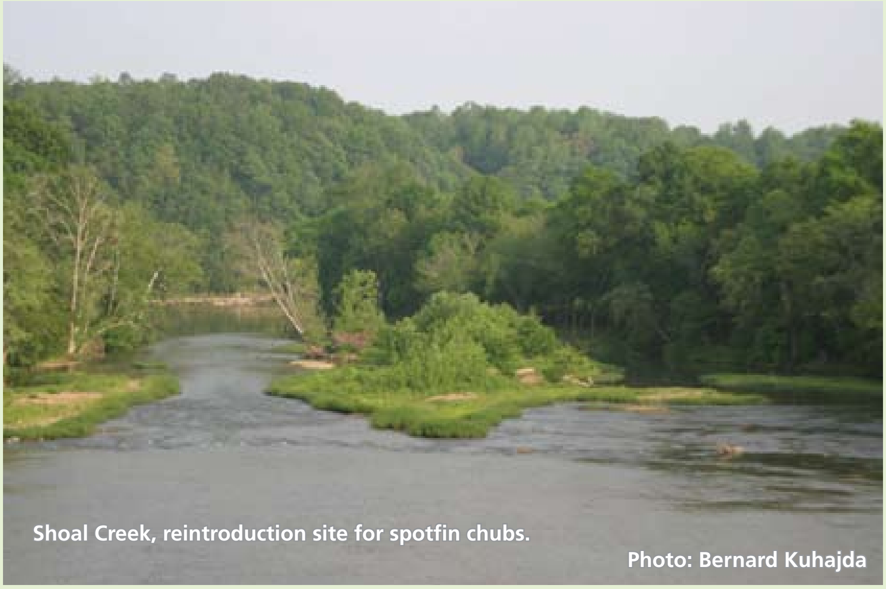
The spotfin chub (*Erimonax monachus*) is a widespread federally-threatened species currently extant in four river systems in Tennessee, Virginia, and North Carolina, but locally extinct from several areas across its range. In 2004, various agencies considered reintroducing spotfin chubs into Shoal Creek in the middle Tennessee River drainage in Alabama and Tennessee, and the initial consideration for a source population was the nearby Buffalo River in Tennessee, a tributary to the Duck River of the lower Tennessee River drainage. This population was considered because of its close proximity in air miles to Shoal Creek and because they are both in the Highland Rim upland physiographic province. But these two systems are separated by over 400 river kilometers and the Coastal Plain, a lowland physiographic province that potentially acts as a barrier for upland fishes. Another potential connection between the Buffalo River and Shoal Creek is headwater stream capture, but this is an unlikely route for spotfin chubs because they are large-stream fishes.

But biogeographic patterns of other fish relationships in the Tennessee River drainage based on molecular phylogenies suggest an alternative choice for a source population. The boulder darter (*Etheostoma wapiti*) was historically found in Shoal Creek and is still found in the adjacent Elk River. It is more closely related to the wounded darter (*Etheostoma vulneratum*) from the upper Tennessee River drainage than to the coppercheek darter (*Etheostoma aquali*), which is endemic to the Duck and Buffalo rivers (Wood 1996). The Tennessee darter (*Etheostoma tennesseense*) is found throughout the middle and upper Tennessee River drainage, including Shoal Creek, and is more closely related to the snubnose darter (*Etheostoma simoterum*) from the extreme upper Tennessee River drainage, than it is to the Duck darter (*Etheostoma planasaxatile*), which is endemic to the Duck and Buffalo rivers (Powers and Mayden 2007). Lastly, blotchside logperch (*Percina burtoni*) in Shoal Creek are closely related to other middle and upper Tennessee River drainage populations, whereas populations in the Duck and Buffalo rivers (and one lower Tennessee River stream) represent a new undescribed species (George et al. 2006). Based on these replicated biogeographic patterns, spotfin chubs from the Emory River located further upstream in the Tennessee River drainage were considered the appropriate stock for reintroduction of this species into Shoal Creek. Even though Shoal Creek and the Emory River are not in close proximity and are in different physiographic provinces (Highland Rim versus Cumberland Plateau), other fish species with similar distributions show more recent gene flow between these two upland habitats than across the Coastal Plain between Shoal Creek and the Duck River system.

—BRK

Spotfin chub. Replicated patterns of biogeography of other fishes were useful in determining the source population for spotfin chubs that were reintroduced into Shoal Creek in the middle Tennessee River.

Illustration: Joe Tomelleri



Shoal Creek, reintroduction site for spotfin chubs.
Photo: Bernard Kuhajda

Emory River, source site for spotfin chubs based on replicated patterns of biogeography.
Photo: Anna George

Box 6.
The Consequences of the Founder Effect

The striped bass (*Morone saxatilis*) had been reduced to small remnant populations in a few Gulf of Mexico tributaries due in part to numerous impoundments that altered riverine habitat. The largest population was in the Apalachicola-Chattahoochee-Flint (ACF) river drainage in Alabama, Georgia, and Florida. To recover this population, the Striped Bass Technical Task Force (SBTTF), a group of state, federal and university personnel, established a series of captive populations that serve as striped bass broodstock repositories. In an effort to assess founder effects, a sub-sample of the striped bass broodstock repository in Lewis Smith Lake, Alabama, was screened using 11 microsatellite markers to determine if it had maintained similar levels of genetic variation when compared to striped bass from throughout the ACF.

The Lewis Smith Lake broodstock appears to have significantly less genetic diversity than that of the wild populations. This is probably due to a founder effect where too few individuals were used to establish and maintain this repository, though the exact cause of this difference is difficult to discern. Correcting the discrepancy requires supplementing Lewis Smith Lake broodstock with individuals from a broader sampling of striped bass in the ACF basin. Nonetheless, it is important to highlight that only after baseline genetic data were collected could this perceived threat be quantitatively evaluated.

—Greg Moyer, USFWS

goal is to maximize diversity in the target population, this should not come at the expense of maintaining natural patterns of diversity.

PTRA projects must also be carefully planned to prevent loss of genetic variation in captive populations, which may decrease the overall fitness of the wild population upon reintroduction (Hindar et al. 1991; Busack and Currens 1995). Numerous studies demonstrate that genetic diversity can be reduced in propagation facilities (Vuorinen 1984; Sekino et al. 2002; Osborne et al. 2006) and in translocation projects (Stockwell et al. 1996). Founder effect, the loss of variability due to a restricted number of individuals colonizing a new location, can occur if a limited number of broodstock are used for translocation or to establish a captive population (Box 6). Another risk is artificial selection, which can lead to unpredictable and rapid changes in critical life-history traits that differ from those in the wild population (Ford 2002; Frankham 2008). Artificial selection can negatively impact the reproduction of wild populations. Studies of various salmonids indicate that hatchery-reared fish are up to 40% less successful per generation in reproduction when reintroduced (Araki et al. 2007). This reduction may be due to altered morphological and behavioral characters that are used in breeding competitions (Fleming and Gross 1993; Berejikian et al. 2001) or by producing smaller eggs than those from wild individuals (Heath et al. 2003). Therefore, the PTRA plan must carefully set

Box 7.
Fish on the Edge: Extreme Life Histories

Fishes can have extremely different life-history strategies with varying body sizes, time to maturation, number of eggs produced, parental care, dispersal abilities, and life span. Where a species occurs on this spectrum of life-history strategies plays an important part in the development of a plan for PTRA.

Two imperiled species that reflect extremes in life-history traits are the spring pygmy sunfish (*Elassoma alabamae*) and the pallid sturgeon (*Scaphirhynchus albus*). Historically, spring pygmy sunfish were known from three different spring systems in the Tennessee River drainage in northern Alabama, but only one native population exists. Movement for an individual is restricted due in part to a maximum size of 25 mm. They spawn at one year of age and most die shortly thereafter with the female producing 60–65 eggs in a clutch (Warren 2004). In contrast, pallid sturgeon are capable of moving several hundred kilometers in the main stem of the Missouri, Mississippi, and Atchafalaya rivers where they are distributed from Montana to Louisiana. They attain lengths of over 1.5 m and live for over 30 years. Males do not spawn until the age of 3–9 years, females not until 5–15 years with 2–7 years between spawning. Females can produce 170,000 mature eggs in a spawning season (USFWS 1993; Mayden and Kuhajda 1997).

These extreme differences in life histories greatly impact the basic plan for any PTRA project. A spring pygmy sunfish propagation program could be successful at only one facility with a few aquaria due to its small size, few offspring per female, and the need for fewer stockings of progeny. Pallid sturgeon require multiple fish hatcheries due to their large size, long lives, and the large number of eggs produced by each female. Because of their large geographic range and long life span, tens of thousands of progeny must be stocked annually over multiple years. However, because one female pallid sturgeon can produce so many offspring, care must be given to prevent swamping of the gene pool with large numbers of progeny from predominately one or a few females. The length of time broodstock and progeny are held in captivity is also different depending on life history. Pallid sturgeon broodstock, barring any disease, are always returned to the river after captive spawning because (1) it will be years before they are ready to spawn again and (2) they are long-lived and will likely spawn in the future. Spring pygmy sunfish broodstock would not be released because they would likely not contribute any more progeny in the wild. Spring pygmy sunfish progeny could be held in captivity for only a short time (months), compared to perhaps 1–2 years for pallid sturgeon, which need a longer time to reach a size that can likely survive in the wild. A basic knowledge of the life history is important for planning a successful PTRA project.

—BRK & ALG

The life-history strategies of the spring pygmy sunfish and pallid sturgeon greatly impact the needs of each species' PTRA program. Spring pygmy sunfish are short-lived, native to a single creek system, and a program could be undertaken with a few aquaria in a single facility. Pallid sturgeon, a very long-lived and wide-ranging species, require a long-term PTRA program coordinated with multiple agencies, hatcheries, and conservation groups.

Illustrations: Joe Tomelleri

guidelines for minimizing artificial selection or loss of natural diversity in the offspring or translocated fishes. Throughout all of these decisions, detailed knowledge of the life history of the specific species is critical (Box 7).

The mating design for the program should be structured to minimize the risk of artificial selection. Variables that can be manipulated, such as the total number of males and females, number of partners for each, and the number of times broodstock are spawned, must be considered in the context of life-history traits, such as courtship and sexual selection, length of spawning season, the number of eggs produced, and viability of gametes. Free mate choice is preferred to minimize domestication, but if not feasible, protocols must be in place to minimize the impact of artificial selection through multiple randomly-selected pairings (Wedekind 2002; Fraser 2008). New broodstock should also be introduced frequently, preferably every breeding season (Harada et al. 1998; Iguchi and Mogi 2007). PTRA plans must set guidelines for an appropriate number of age classes of broodstock and whether to mix pairings between generations. Stocking equal numbers of offspring from each family group is expected to remove some effects of artificial selection, especially in highly fecund species (Allendorf 1993; Frankham et al. 2000). Stockings may continue for up to 20 years, particularly for longer-lived fish, which require multiple age classes of broodstock or multiple collections from the source population to increase genetic diversity or reduce the rate of genetic adaptation to captivity (Lynch and O'Hely 2001; Ford 2002; Drauch and Rhodes 2007). Whenever possible, genetic screenings of the broodstock and offspring should be conducted to ensure genetic diversity is being captured and inbreeding is minimized (Kozfkay et al. 2008).

Random genetic screenings are also essential to ensure that species identifications are correct. Although this concern may seem to only apply to smaller-bodied cryptic fishes that may be confused without the help of a taxonomist, even popular game species have proven difficult to identify (Box 8). The best results in the world will not save a PTRA project from a miserable failure if the wrong species is propagated or translocated.

Finally, do no harm to the source population. Although it is important to use enough individuals to ensure healthy and natural levels of diversity in the target population, the removal of the broodstock or individuals for translocation should not significantly impact the source population. It may be wise to establish some protective measures for the source population over the planned course of the PTRA project to ensure healthy stability of that population. Such measures could range from monitoring the source population to temporary regulatory protection. Failure to protect source populations could result in failure of some PTRA projects. Thus, an often overlooked, but essential part of PTRA projects is monitoring the source population, prior to and following the collection of the broodstock, to make certain that it remains healthy (Jones et al. 2006).

Box 8.
Oops: The Story of the Greenback Cutthroat Trout

As popular game fishes, trout and char have been moved between drainages for hundreds of years. In the western United States, trouts were widely propagated and stocked outside of their native range, starting in the late 1800s. These introductions were often in streams that contain other species of native trout, leading to competition and hybridization with close relatives. For example, Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) were moved from west of the Continental Divide into streams east of the divide, where it was mixed with a distinct subspecies, the greenback cutthroat trout (*O. c. stomias*).

The greenback cutthroat trout did not fare well when faced with the combined effects of competition with nonindigenous Colorado River cutthroat, mining, pollution, and fishing pressure, and the subspecies was considered extinct in 1937. A few "pure" populations were discovered in the 1950s, though by the end of the twentieth century, greenback cutthroat trout were found in only 0.5% of their historical range (Young and Harig 2001). Conservation programs strived to increase the number of self-sustaining populations from 9 to 20 through captive propagation and reintroduction, and the recovery of the species appeared on track as a success story for the ESA.

However, with the advent of new genetic techniques, researchers found that greenback cutthroat trout were not being recovered; the nonnative Colorado River cutthroat trout were instead being propagated and established (Metcalf et al. 2007). Analysis of variable DNA markers indicated that only four recovered populations were pure greenback cutthroat trout, and the species inhabited less than 13 kilometers of streams. Because populations of the two closely related subspecies had been repeatedly moved across the Continental Divide from the 1890s to the 1930s, broodstock for the greenback cutthroat trout were misidentified non-native Colorado River cutthroat trout on the east side of the divide.

Despite this severe setback to recovery, it is not all bad news for the greenback cutthroat trout. The discovery of a genetically pure population on the west side of the Continental Divide suggests that other populations may persist outside of its native range, preserving genetic diversity that did not survive elsewhere. However, the loss of two decades of recovery work reinforces the point that proper identification of broodstock using an array of techniques, including genetic screening, is a vital part of every PTRA project.

—ALG

Greenback cutthroat trout, a species that has had its recovery hampered by the propagation and introduction of misidentified Colorado River cutthroat trout into its range.

Illustration: Joe Tomelleri

RULE 4: PROPAGATE NATURALLY AND CAREFULLY

Propagation facilities devoted to spawning and/or rearing of fishes will vary in size and design, largely based on the requirements of the propagated species. Common to all, though, is the need to make every reasonable effort to minimize risks associated with captive propagation. The first goal is to naturalize the captive environment as much as possible to reduce artificial selection and maximize survival of released fishes (Maynard et al. 1995; Miller and Kapuscinski 2003; Fraser 2008). In addition, captive propagation facilities should prevent harm to the target community by preventing the export of diseases or parasites with the propagated fishes. Finally, protocols need to be developed that reduce security and equipment failure risks and replicate programs at multiple facilities where appropriate.

Incorporating knowledge of natural habitat preferences and behaviors will often improve fish health, both in captivity and upon reintroduction. Appropriate flow regimes, which may vary widely for different life stages, can be critical. Substrates and cover objects may be important, but bare tank bottoms might be preferable for feeding and waste removal, particularly at early life stages. Providing options, from woody debris to artificial cover, is often the best solution until observations guide refinement. Foods not only must be nutritionally appropriate but should stimulate natural feeding behavior. Food selection is a major challenge for rearing smaller non-game stream fishes, which are often sight feeders that prey primarily on live, moving aquatic insect larvae. Larval and juvenile fish usually have vastly different dietary needs from adults. Providing natural wild prey items is difficult but important so that fish learn natural feeding behaviors. Exposure to artificial predator stimuli may prevent behaviors that might reduce fish survival in the wild (Brown and Laland 2005).

Propagation of fish in artificial conditions, particularly in closed systems, can greatly increase the risk and rate of transmission and export of disease and parasites, requiring precautions to minimize risks. Standard protocols should be in place for quarantine procedures, water treatment, contamination control, and recognition and treatment of disease (see USFWS 2003). Open systems utilizing surface waters for supply and discharge are at less risk for disease but require redundant precautionary pre- and post-use water treatment protocols to prevent escape of propagated fishes, introduction of exotic species and disease organisms, or changes in local water chemistry. Closed systems using treated drinking water and sewage systems offer far less risk of escape but should never be considered risk-free. Propagation facilities should have access to fish health specialists and/or veterinarians for disease diagnosis and treatment. Culture systems should be constructed to allow for isolation of all or portions of captive populations for quarantine and therapeutic treatments.

Unauthorized human access should be controlled with perimeter fencing or screens and motion-detecting lights if fish are held outdoors. Monitored security systems for indoor facilities should be installed to detect criminal trespass, vandalism, fire, floods, and heating or cooling system failures. Culture systems should be designed with multiple redundancies to ensure life support, such as a back-up power system for power outages. Tanks and systems should be designed to prevent unnecessary handling of fish or unwanted mixing of stocks. Protocols should be established to deal with escapees of uncertain origin, such as permanent isolation or euthanasia. Euthanasia protocols must be humane (AFS 2004) and should be appropriate for post-mortem preservation of specimens for subsequent genetic or other research. At a minimum, all mortalities should be catalogued and frozen prior to transfer and archiving at a research museum or repository. Along with mortalities, all individuals contributing to the propagation effort should be fin clipped for genetic analysis. Propagation projects should allot funding for genetic sampling for a randomly selected subset of the released fish in order to screen for genetic diversity and check against the existence of hybrids or incorrectly identified fish. Protocol manuals should be developed to document standard operating procedures.

Rush darters in yarn, an artificial substrate for spawning and hiding.
Photo: Conservation Fisheries, Inc.

Redundancy in systems by replicating programs at multiple facilities can greatly benefit PTRA programs and safeguard critically imperiled species. Maintaining the total population as an effectively single random mating population by regular translocation of animals among institutions will lower the risks of artificial selection (Frankham 2008). This also minimizes the chances of losing entire captive populations due to system failure or disease at one facility.

RULE 5: PREPARE FOR RELEASE!

Prior to Release. Before propagated or translocated individuals can be released, appropriate habitat, natural or restored, must be present (USFWS 2000; Jones et al. 2006). In some cases, such as the loss of a population due to a catastrophic event (Box 1) or by acute point-source pollution that has been mitigated (Box 4), additional habitat restoration may not be necessary. Other scenarios generally involve recovery through improved land use practices that lead to conditions favorable for restoring the native fauna. Reintroducing small numbers of individuals (pilot population) can determine if habitat restoration is sufficient for survival of the species and a continuation of reintroduction efforts, but only if habitat improvement is evident.

Tagging is one method to assess the success of the PTRA project by demonstrating survival, movement, or in-stream reproduction through detection of untagged progeny. Several options exist for tagging that vary widely in cost, time, and invasiveness (Guy et al. 1996; Jepsen et al. 2002; Gibbons and Andrews 2004). If tagging is used as part of the PTRA monitoring protocol, it likely needs to be completed prior to release. Disease screening of a subset of the captive individuals should also be conducted prior to release or whenever fish are moved from one facility to another (USFWS 2003). Screening fishes for a translocation project is nearly impossible without a mobile fish lab, but a randomly selected sample from the source population can be assessed a few weeks prior to translocation to help prevent transfer of unusual parasites or diseases to other native fishes at the release site. In general, fish should be fasted for at least 48 hours prior to transportation for the release, which minimizes mortality or stress with less fouling of the water during transport (Piper et al. 1982).

When to release. Determining the size and/or age at which fish should be released depends on a number of factors. Returning offspring to the wild at the earliest possible life stage reduces costs to the propagation facility, frees up space for the grow-out of other fishes and reduces the threat of domestication (Jones et al. 2006). However, survival may be higher when fish are stocked at a larger size (Szendrey and Wahl 1996). A short-lived fish, especially an annual species, under ideal conditions will grow quickly and can often be released within the same year they are spawned. Fishes that live for several to many years must be evaluated on a species by species basis. A combined approach, where randomly selected groups are either released early or left to grow longer in the propagation facility, may also be considered (Donovan et al. 1997). The life-history traits and post-release monitoring will reveal which stocking approach is most appropriate.

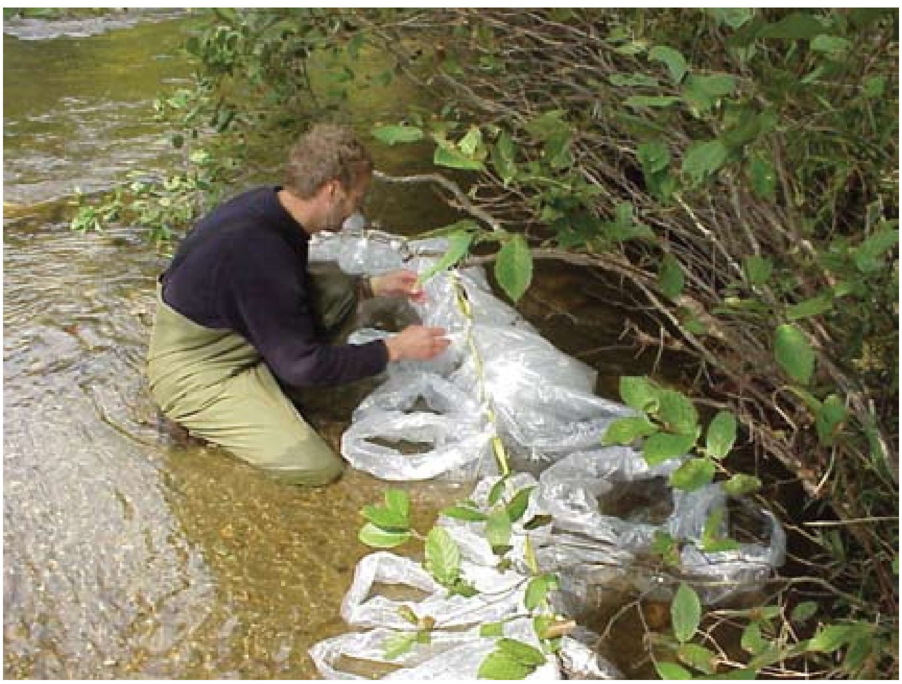
In addition to size(s) at release, the season and time of day when fishes are stocked may affect their survival. Available food items, growth, and activity increase in the warmer waters of spring/summer, often providing fishes with more resources to succeed (Garvey et al. 1998; Sutton and Ney 2001). Reproductive considerations may also determine release timing. Little is known of the "imprinting" of non-game species and this may be important to fishes that participate in runs as a part of their reproductive strategy (e.g., some catostomids). Night releases may be important for nocturnal fishes, but may be even more beneficial for small fishes (e.g., minnows) to avoid diurnal predators. Time should be allotted for acclimating fishes prior to release.

Release site considerations. The best habitats for reintroduction or restoration are protected public lands or private sites with limited public access. Establishing good relationships with managing agency personnel and/or landowners is essential to long-term recovery projects. Both should be made aware that species recovery projects can be long-term and usually require periodic return visits to assess the success of the project. Access to private lands is a privilege requiring consideration of and effective communication with the landowner.

Many factors come into play when considering how many individuals to release at a particular site. A delicate balance exists between releasing enough individuals to sustain a population without overstocking a particular site, reducing genetic variability, stressing donor populations, or exceeding carrying capacity of a site (Kelly-Quinn and Bracken 1989; Flagg et al. 1995). Fishes that are poor dispersers (e.g., darters, madtoms) will likely not travel far from the release site if appropriate habitat is available. Therefore, releasing smaller numbers in adjacent sites will likely populate suitable habitat across a larger area. On the other extreme, strong dispersers (e.g., darters with larval or juvenile drift, most minnows) may require larger numbers of individuals at a single site to compensate for the probability that most will disperse over a larger area.

Disposition of excess broodstock and progeny. Following propagation, excess broodstock or progeny should be disposed of following guidelines set in the PTRA plan. Because of the risk of harming the source population, returning broodstock to the wild population is rarely appropriate. Other options include use in toxicity studies, euthanasia and archival for future research, accessioning into teaching collections, or donation to zoos, aquariums, and nature centers for public displays. Euthanasia protocols must be approved by an IACUC committee (OLAW 2002; AFS 2004). Some of these same options are available for propagated individuals. Though a typical goal of propagation is to maximize numbers of progeny, the total number of released individuals must be controlled to maintain genetic diversity, which can result in surplus progeny. Institutions that maintain ark populations may also be burdened with too many offspring. Although it is tempting to reintroduce surplus progeny, particularly with extremely imperiled species, releases should be limited to the numbers recommended by the PTRA plan and approved by the advisory committee.

Acclimation of spotfin chubs in the Tellico River prior to release. The use of plastic bags lets water temperature slowly adjust to the river temperatures, reducing stress on fish.
Photo: Conservation Fisheries, Inc.



RULE 6: EVALUATE AND ADAPT

Monitoring of a reintroduced or augmented population is critical for evaluating the success of a PTRA project (Box 9; Lowe et al. 2008). PTRA protocols should be adaptive with improvement or changes based in part on feedback from regular monitoring of the population (Armstrong et al. 2007). Evaluation of PTRA populations should consist of more than just noting the presence of or an increase in the numbers of the target species at the site (Ostermann et al. 2001). Other useful data include growth and condition, movement of tagged individuals (especially for species that migrate), and the genetic diversity of surviving individuals. As with sampling efforts prior to PTRA projects, long-term monitoring includes consideration of detection probability, surveys for evidence of recruitment, range extension from stocking sites into distant suitable habitats, and any positive (or negative) changes in the aquatic community at and near the reintroduction site (Shute et al. 2005). For long-lived species, monitoring could last for more than a decade.

PTRA is not intended to be a continuous effort but rather a tool to reestablish a self-sustaining population represented by spawning-age adults and younger age classes at appropriate densities over a prescribed area (USFWS 2000). Specific milestones, set by the advisory committee, assist in determining when a PTRA program should cease (Armstrong and Seddon 2008). Even after the completion of a PTRA project, some long-term monitoring of the target population's status should be performed.

RULE 7: THE PUBLIC NEEDS TO KNOW

The impacts of PTRA programs can reach beyond the target species if the public is informed of projects and how they can be beneficial. This is accomplished by raising awareness of the program in the affected community through outreach (Box 10; Newton 2001). Formal and informal education programs in primary and secondary schools are obvious choices for outreach; students can visit a propagation facility, assist in releases, and learn more about their watersheds. Scout troops are excellent targets for outreach as their service projects can become a resource for PTRA programs. Educational opportunities for the general public should also be considered. Many nature centers, zoos, and aquariums display imperiled fishes, inform members and visitors about the ongoing conservation projects in their communities, and hold programs that include presentations by experts. Finally, live streaming video of fish behaviors uploaded to educational Internet sites can provide unique insights into the invisible underwater lives of fish.

Outreach efforts to key stakeholders affected by PTRA programs are also crucial if the species resides largely on private lands. One important element of cooperation with landowners is a conservation easement, a legal agreement between a landowner and a land trust or government agency that permanently limits certain uses of land in order to protect its conservation values (Rissman et al. 2007). Easements can be flexible, but landowners essentially forfeit some land rights in exchange for tax benefits. Conservation easements are an important tool in helping to preserve critical habitat for PTRA programs.

Both commercial and recreational anglers can be strong allies in PTRA programs and aid monitoring by reporting catches (Cowx and Gerdeaux 2004). Anglers can be made aware of PTRA programs by including information on the

Box 9.
How Are The Fish Doing Now?

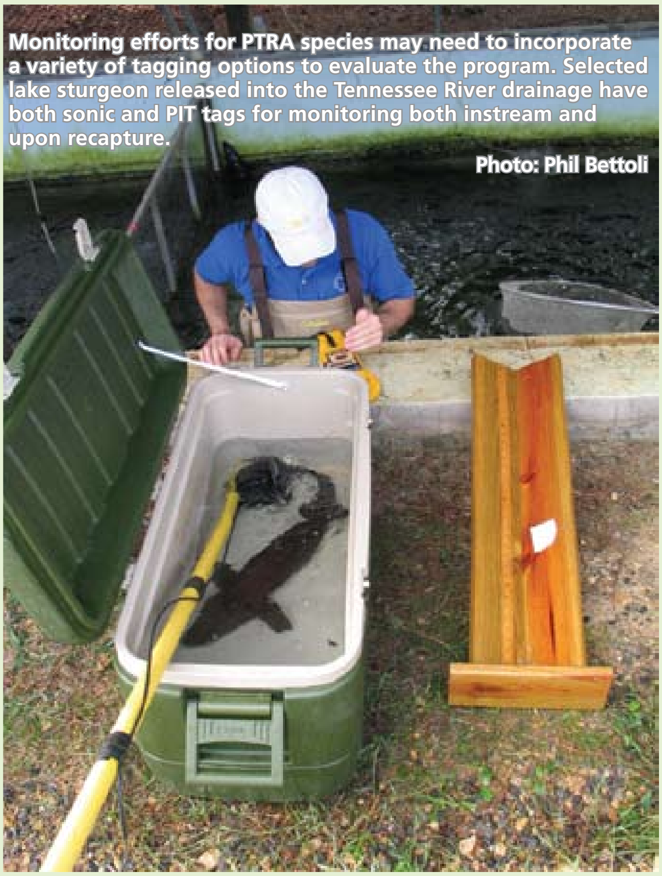
One of the most common questions asked about a PTRA project is, "How are the fish doing now?" One answer comes from the food chain; a desiccated sturgeon skull was found below an osprey nest, indicating that at least one individual successfully entered the "circle of life" from stocking efforts by the Tennessee Lake Sturgeon Restoration Working Group (TLSRWG), a multi-agency partnership led by the Tennessee Aquarium in the Tennessee River drainage. Monitoring efforts, a necessity for any PTRA project, should include regular status surveys, tracking of reintroduced individuals, and impact on the human community, which can all be used to evaluate the success of the program.

Status surveys should be conducted at every stage of a PTRA project, rigorously testing the current hypotheses concerning the status of a population. In addition, any source populations should be surveyed to ensure that the removal of individuals is not negatively impacting its persistence. Status surveys may require very different equipment and techniques depending upon the species and habitat.

A variety of tagging options exists, and different combinations may be incorporated into the program where appropriate. For example, all lake sturgeon (*Acipenser fulvescens*) released in Tennessee as young-of-year are tagged by a system of scute removal. Fish that are held more than a year are tagged with a passive integrated transponder (PIT) tag as well, but both of these methods require recapture. A smaller subset of these have been implanted with either radio or sonic transmitters for more detailed studies on their movement in the river and habitat use, which can be conducted by boat or stationary receivers.

Not all monitoring efforts have to be done by biologists; both commercial and recreational anglers have aided the TLSRWG in monitoring. Commercial partners with the TLSRWG have been given PIT tag scanners, PIT tags to implant in untagged sturgeon, and vials for fin clips from each fish caught. Recreational anglers have been encouraged to report sturgeon catches to the state agency. Monitoring programs are not only useful for determining the status of the species in the wild, they can also increase community awareness and help determine the extent of public involvement in the PTRA project.

—*ALG*



Monitoring efforts for PTRA species may need to incorporate a variety of tagging options to evaluate the program. Selected lake sturgeon released into the Tennessee River drainage have both sonic and PIT tags for monitoring both instream and upon recapture.

Photo: Phil Bettoli

Box 10.
Saving the Sturgeon: Educating Those Who Use the River

Since 1998, the Tennessee River Lake Sturgeon Working Group has worked to restore a wild breeding population of lake sturgeon (*Acipenser fulvescens*). In 8 years of releases, over 60,000 lake sturgeon have been reintroduced to the upper Tennessee River drainage. The most significant public impact of the Saving the Sturgeon program, however, has been to educate the regional community about the overall health of their ecosystem and how their actions impact imperiled aquatic species like the lake sturgeon. Public outreach has been accomplished through classroom education, raising awareness among anglers, and displays at the Tennessee Aquarium. Inviting the media to attend major events helps the message reach beyond the specific audience targeted by the program.

The classroom education component takes place at an elementary school located three miles from the release site on the French Broad River. The fifth-grade students participate in a range of activities, including research projects, interactive lessons in river ecology, raising a lake sturgeon in their classroom, and visiting the Tennessee Aquarium. This culminates with the class participating in a release of lake sturgeon into the French Broad River at the Seven Islands Wildlife Refuge. Sturgeon Preservation Cards are distributed with fishing licenses throughout the east Tennessee region where the lake sturgeon release program occurs to raise angler awareness. The wallet-size cards depict a lake sturgeon, and include instructions on what to do if one is caught (i.e., release and notify the state agency) and what other steps anglers may take to help preserve the species and its habitat. The Tennessee Valley Authority has also posted signs about lake sturgeon at boat ramps in the upper Tennessee River drainage.

Finally, a lake sturgeon touch tank at the Tennessee Aquarium ensures that every visitor has the chance to interact with a sturgeon, talk to docents about the program, and learn about conservation in their backyard. One family was so excited about what they had learned at the sturgeon touch tank that they attended a summer release to get involved with the program. Now, their Girl Scout troop is developing a coloring book on lake sturgeon that will be distributed to kindergarten through second-grade students across Knoxville. A multi-faceted outreach plan can engage the entire community, encouraging them to protect their river.

—*ALG*

Lake sturgeon are released into the French Broad River with the assistance of fifth grade students from nearby Gap Creek Elementary School. The sturgeon release is part of a year-long immersive program about watershed conservation led by educators from the Tennessee Aquarium.

Photo: Julia Gregory.

species in fishing regulations, posting information at nearby boat docks, or setting up phone lines for reporting catches.

The last group of key stakeholders includes elected and non-elected officials. Informing elected officials of the conservation activities in their constituencies helps promote environmental awareness in the government, increasing the likelihood of further habitat improvement. Including public utilities and other resource managers in these educational efforts may help minimize their impacts on PTRA species.

Throughout PTRA programs, the media can be used to build general awareness of imperiled species and their conservation needs, especially in conjunction with outreach efforts that raise attention (Allen 2001). A simple event, such as staging a fish release with schoolchildren, can spread a remarkably strong conservation message to a wider community. However, some recovery projects can be controversial and undue attention to the project may be problematic. If a species' locality information is sensitive, some federal agencies may have non-disclosure clauses included in their contracts. In these cases, written permission from that agency would be necessary before media notification or the agency would have to make the media contacts. But in general, public recognition of the plight and recovery efforts of these imperiled species usually works to their benefit.

RULE 8: RECORD IT AND SHARE IT

A critical need in captive propagation and translocation projects is the maintenance of detailed records of the activity, beginning with broodstock collection and ending with evaluation of the program. During the past four decades there have been numerous reintroductions, augmentations, and even a case of introduction using both translocated and propagated imperiled fishes by state and federal agencies and non-governmental organizations. Though there is some documentation of these early movements of imperiled fishes, too often records are almost impossible to locate, are of variable quality, or simply do not exist (Seddon et al. 2007).

In the past 15 years progress has been made in documenting the release of propagated and translocated imperiled fishes. Reporting requirements associated with permits and contracts require much of the data needed for thorough documentation of these projects. Publications of PTRA projects in the scientific literature have also increased (Seddon et al. 2007). An example of this improvement can be seen in projects conducted by Conservation Fisheries, Inc., in Knoxville, Tennessee, which have maintained records of their PTRA activities via contractual reports, website updates, and some publications (Rakes et al. 1999; Shute et al. 2005).

However, there is still no single repository for data and documentation of captive propagation and translocation of imperiled fishes for reintroduction or augmentation. There is also no mechanism to retrieve and standardize these data and make them available for planning future projects or informing researchers. Written documentation of the rationale and sites selected for broodstock and release, as well as methods used in transportation and captive settings, makes this work replicable. Without these data, it is impossible for resource managers and scientists to understand changes in the population dynamics, infer population genetics results, or properly manage the recovery of a species or a system. These data are needed not only for current and future projects, but also for past projects, which will require a considerable effort on the part of those involved in PTRA activities. A critical need is a standardized database to capture information on captive propagation and translocation projects involving imperiled fishes. We suggest that the appropriate agency to manage this database is the USFWS. This effort needs to be initiated immediately as information is being lost as agency and university biologists involved in some of the early projects retire. Scientific publications of large projects and results are also essential to documenting successes and failures of PTRA projects.

As the number of imperiled fishes continues to climb (Jelks et al. 2008), PTRA will likely continue to be an integral part of their recovery. Having the results of previous propagation and translocation efforts available would provide valuable insights to partners planning similar projects and would allow researchers studying genetics, morphology, and biogeography of fishes to know where fish distribution patterns have been artificially altered. Documentation of the outcome of captive propagation and translocation efforts will also permit agencies and PTRA managers to better evaluate the outcome of these projects and identify areas for improvement.

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