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Radio-tagged, hatchery-reared guide fish: a method for uncovering information about rare or cryptic fishes

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The behaviour and habitat selection of many fish species render them cryptic, difficult to observe, capture or study, and ultimately, poorly known (Bruton 1995). The cryptic nature of such species leads to uncertainty as to the status of local populations or even whether a population is present within a system. This uncertainty imposes difficult challenges on resource management agencies tasked with managing such species in the face of continued anthropogenic alteration and destruction of aquatic habitats (Bruton 1995; McKinney 1999). Often, data on which to base management or conservation efforts or to determine critical habitat for protection are non-existent, and generating these data can be expensive and time consuming. Occasional serendipitous discoveries can help inform this process, but this approach is unreliable.

Robust redhorse, *Moxostoma robustum* (Cope), offers an excellent example of the difficulties uncertainty imposes on conservation of cryptic species. Robust redhorse is a large catostomid native to medium to large rivers along the south Atlantic coast but is currently known only from three drainages in North Carolina, South Carolina and Georgia (Cooke, Bunt, Hamilton, Jennings, Pearson, Cooperman & Markle 2005). Stocked populations have been established both in additional drainages and in other portions of the Altamaha and Savannah. This species was first described by Cope (1869), but the description and the fish were 'lost to science' for 121 years until the fish was rediscovered in the Oconee River in central Georgia in 1991 (Ruetz & Jennings 2000; Cooke *et al*. 2005). Robust redhorse probably went unnoticed for such a long time because of a combination of habitat selection (viz. robust redhorse occupying difficult-to-sample riverine habitats; Grabowski & Isely 2006), restricted range because of dam construction, population decline and a historic neglect on the part of fisheries agencies towards non-game species such as suckers (Cooke *et al*. 2005). Robust redhorse spends most of its time in deep (> 2 m) water in association with large woody debris along the outer edge of riverbends (Grabowski & Isely 2006). This habitat is difficult to sample effectively with standard methods such as electric fishing (Bayley & Austen 2002). As a result, early efforts to determine the status of this species in its historic range were hampered, and new data about the species habitat use and distribution were acquired with the occasional capture of one or two individuals (DeMeo 1997, 1998, 1999, 2000, 2001).

Radio-telemetry of wild individuals played a major role in assessing the movement patterns and habitat use of known populations of robust redhorse in the Savannah River (Grabowski & Isely 2006) and the Pee Dee River (R.J. Heise, personal communication). Further, telemetry has been instrumental in locating previously unknown populations by successfully directing sampling efforts to locations occupied by this species and allowing for the identification of spawning aggregations. In this paper, the use of radio-tagged hatchery-reared 'guide fish' to direct sampling efforts to capture resident fish and to identify

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the timing and location of spawning is described. The effectiveness of this technique was evaluated as part of a larger study examining the movement patterns and habitat use of robust redhorse stocked into the Ocmulgee River, Georgia (Grabowski & Jennings *in press*).

A total of 30 robust redhorse were captured, tagged with radio transmitters, transplanted to the Ocmulgee River and tracked for 13 months. The study fish were collected from refugial populations established with progeny from Oconee River broodstock. These fish originating from Oconee River broodstock exhibit no genetic differentiation from those in the Ocmulgee River and are considered to be part of the same evolutionarily significant unit (Wirgin, Oppermann & Stabile 2001). The individuals from these refugial populations were of hatchery origin but they had been at liberty for at least 3 years prior to capture. Radio transmitters with a trailing wire antenna were surgically implanted into the abdominal cavity. A lopher needle was used to create a small secondary opening in the body wall and served as a conduit for the trailing whip antennae to exit. These fish were maintained in holding tanks for 10 days after surgery before they were transported to and released in the Ocmulgee River in April 2006. Location of each fish was determined weekly through May 2007 (Grabowski & Jennings in press).

Toward the end of the life of the transmitters, the locations of radio-tagged fish were used in conjunction with electricfishing surveys to determine the detection probability of robust redhorse when employing the survey criteria recommended by the Robust Redhorse Conservation Committee (2002). A total of five transects, each ~1.5 km long, were sampled by boat-mounted electric fishing on 23 February, 2 March, 8 March, 5 April and 19 June 2007. One transect was sampled on each date and each transect had at least two (range 2–6) radio-tagged, hatchery-reared individuals. The electric fishing boat crew was aware that tagged individuals were present in the transect but were unaware of their locations (T.B. Grabowski, T.D. Ferguson, J.T. Peterson and C.A. Jennings, unpublished data). Untagged, resident robust redhorse were captured while sampling the specific locations (i.e. the same piece of large woody debris) occupied by radio-tagged fish during three of the five sampling events [23 February (n = 2), 2 March (n = 2) and 19 June (n = 2)]. Untagged robust redhorse were not encountered in areas not occupied by the radio-tagged fish. Only one of the radio-tagged fish was captured during 7.5 h of electricfishing effort (Grabowski, Ferguson, Peterson & Jennings, unpublished data). Mean (±SE) catch-per-unit-effort (CPUE) of untagged fish for these five sampling events was 1.32 ± 0.59 fish h^{-1}. In comparison, CPUE of robust redhorse during survey efforts on the Ocmulgee River without the benefit of radio-tagged, hatchery-reared guide fish was low (0.15, J.W. Evans, personal communication.; 0.0, C.A. Jennings, unpublished data).

In this study, sampling in areas occupied by radio-tagged, hatchery-reared fish yielded a higher CPUE than when sampling was conducted without such knowledge. The use of radio-tagged wild fish to guide sampling efforts also has proven to be effective in the Savannah River (Grabowski & Isely 2006) and the Pee Dee River (R.J. Heise, personal communication). No examples of radio-tagged, hatchery-reared fish employed in the same role were found in the literature. However, a similar approach was suggested by Baras & Lagardere (1995) and employed by Diggle, Day & Bax (2004), who used radio-tagged wild common carp, *Cyprinus carpio* Linneaus, as 'Judas fish' to increase the effectiveness of eradication efforts in Tasmania. The use of radio-tagged individuals of wild or hatchery origin may assist researchers who have been unsuccessful or met only with limited success when trying to locate and monitor populations of rare or cryptic fishes.

In addition to helping to find untagged resident fish, radio-tagged, hatchery-reared guide fish in this study helped identify a previously unknown spawning location. On 8 May and 10 May 2007, two radio-tagged male robust redhorse (453 mm TL, 1276 g; 447 mm TL, 1332 g) relocated at a site in the Ocmulgee River were part of a group of at least 10 individuals spawning in shoals at 362.5 rkm. Although spawning was suspected in the Ocmulgee River, the spawning location was not known to researchers. Both of these fish were located over substrate composed of loose gravel similar to that reported to be used by robust redhorse for spawning in other rivers (Freeman & Freeman 2001; Grabowski & Isely 2007) but in deeper water.

The likelihood of finding this aggregation without a radio-tagged individual acting as a guide would have been very low. Conventional wisdom about where robust redhorse spawn has limited sampling efforts to surveying large, mid-channel gravel bars, similar to known robust redhorse spawning sites in other systems (Freeman & Freeman 2001; Grabowski & Isely 2007). The present surveys for robust redhorse spawning aggregations in the Ocmulgee River followed similar search patterns. Additionally, the portion of the river where the spawning aggregation was found is navigable only by canoe. The locality was only surveyed because the ratio-tagged fish could not be found during our standard telemetry transects in the more easily accessible portions of the river. Finally, the habitat occupied by this spawning aggregation was not conducive to a thorough visual examination because of the speed with which a canoe is carried through it and the occupants of the canoe being focused on avoiding boulders. The spawning aggregation was discovered when the surveyors stopped to record tracking data. Wild radio-tagged robust redhorse in both the Savannah and Pee Dee rivers have been used to determine the timing and location of spawning aggregations (e.g., Grabowski & Isely 2006). The use of wild, radio-tagged guide fish to locate spawning habitat has also been successfully applied to both white sturgeon, *Acipenser transmontanus* Richardson, in the Kootenai River (Paragamian, Wakkinen & Kruse 2002) and Gulf sturgeon, *Acipenser oxyrinchus desotoi* Vladykov, in the Pascagoula River system (Heise, Slack, Ross & Dugo 2004) and to common carp (Diggle *et al*. 2004). Radio-tagged, hatchery-reared razorback sucker, *Xyrauchen texanus* (Abbott), released into the Green River, Utah were relocated at a known spawning area with wild fish (Modde, Bowen & Kitcheyan 2005). However, no other examples where radio-tagged, hatchery-reared individuals were used for the express purpose of locating previously unknown spawning aggregations of resident fish are known.

The results of these observations indicate that hatchery-reared individuals can be useful guide fish for finding wild individuals in situations where wild individuals are unavailable for use as guide fish. There are two considerations that should be made prior to employing hatchery-reared individuals as guide fish. Hatchery-reared individuals frequently demonstrate behaviours that are markedly different from their wild counterparts (Huntingford 2004) and, as a result, may suffer elevated levels of mortality. These behavioural differences tend to become less pronounced as individuals become naturalised (Huntingford 2004). Researchers attempting to use hatchery-reared guide fish that have not acclimatised to life outside of a hatchery should be prepared for possible high levels of mortality and allow time for the newly released fish to adjust. A second consideration is avoiding potential genetic consequences of the introduced guide fish. In the Ocmulgee River, such concerns were not an issue because the transplanted individuals originated from the same evolutionary significant unit as the resident population (Wirgin *et al*. 2001). However, using such genetically similar individuals may not always be possible and evaluating both the methods of surgically sterilising guide fish prior to release and the migratory behaviour relative to unaltered native or naturalised fish after release may be necessary (Collins, Smith, Mudrak, Bakal & Ware 2004).

The implicit assumption of almost all telemetry studies is that tagged individuals do not differ in their behaviour or habitat selection from untagged fish. Although this assumption may not always hold true, it was not a concern in this study (Grabowski & Jennings in press). The use of radio-tagged hatchery-reared guide fish appears to be a tool to fishery managers and researchers can use to direct sampling, survey and observation efforts to locations and times that offer a high probability of success.

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