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Anthropogenic Associated Mortality in the Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*)

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Abstract - Anthropogenic disturbance to natural habitats has been identified as a major threat to freshwater biodiversity. Human activities can destroy critical habitat of aquatic species by altering hydrodynamic stream characteristics. Movement and removal of shelter rocks within and along streams has been postulated to be detrimental to survival of aquatic salamanders; however, empirical data are lacking. *Cryptobranchus alleganiensis alleganiensis* (Eastern Hellbender) is a fully aquatic salamander species that shelters under cobble and boulder as both a juvenile and as an adult. Herein, we document mortality of both adult and larval Eastern Hellbender salamanders associated with anthropogenic habitat disturbance (i.e., moving and stacking of rocks to build small dams). To our knowledge, these observations are the first of their kind in the scientific literature. Given the high number of visitors to and increasing recreational use of rivers on public lands in the southeastern US, managers should consider implementing outreach education programs and monitoring popular recreation areas to deter in-stream habitat alteration.

Anthropogenic disturbance is a major threat to the biodiversity of freshwater ecosystems (Brown et al. 1998, Lake et al. 2000) and can alter in-stream habitat and flow regime, disrupt animal behavior, modify water-quality parameters, increase sediment deposition, and ultimately result in direct displacement and mortality of individuals (Bunn and Arthington 2002, Cole and Landres 1995, Lessard and Hayes 2003, Watters 1999). Specifically, the removal of cobble shelter can greatly alter habitat characteristics required by aquatic organisms, including fish, macro-invertebrates, and aquatic salamanders (Diaz et al. 2015, Kondolf 2000, Milner and Piorkowski 2004).

Salamanders play a vital role in many ecosystem processes either through direct (predation) or indirect (energy transfer between aquatic and terrestrial landscapes) ecological food webs (Davic and Welsh 2004). *Cryptobranchus alleganiensis alleganiensis* Daudin (Eastern Hellbender) is a cryptic, fully aquatic salamander, sensitive to silt and sediment pollution, and historically found throughout the Appalachian and Allegheny Mountains, upper Midwest, and part of Missouri (Phillips and Humphries 2005). Eastern Hellbenders are experiencing declines in populations across their geographic range (Burgmeier et al. 2011, Wheeler et al. 2003). Hellbenders rely on an assortment of shelter rocks as larvae (gravel/cobble) and as adults (larger cobble/boulder) (Nickerson and Mays 1973, Petranka 1998). There is a dearth of information on anthropogenic stressors associated with in-stream alteration of shelter rocks for this species. We report on the first observation of human-induced mortality associated with in-stream habitat alteration for this species.

On 4 September 2012, we observed a recently deceased adult Eastern Hellbender directly under a recently constructed rock stack that included large, flat boulders (potential adult shelters) in a tributary of the French Broad River Basin in Pisgah National Forest, western North Carolina (site information on file with the North Carolina Wildlife Resources

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Commission and withheld to protect the specific location; Fig. 1a). On 22 July 2016, we observed a recently deceased, first-year larva (total length = 6.2 cm, snout–vent length = 4.1

Figure 1. (a) Adult *Cryptobranchus a. alleganiensis* (Eastern Hellbender) mortality observed near stacked shelter rocks in a western North Carolina stream. (photograph © David Herasimtschuk/*Freshwaters Illustrated*), and (b) Eastern Hellbender larval mortality under cobble at the base of an artificial dam (photograph © Lori A. Williams/NCWRC).

cm) directly under freshly moved cobble (intermediate and longest axis measurements: 25.5 cm by 63.5 cm; Fig. 1b) at the base of a small, artificial dam that spanned the entire width of the stream (10.0 m length). The larva was observed on its side, freely floating immediately under the cobble in slow-moving water. In surveys here one month earlier, we detected 2 larvae utilizing similar cobble structures (authors, unpubl. data). Upon inspection, the larva exhibited a severe hematoma in the thoracic cavity and upper abdominal area from apparent blunt force trauma, as well as lacerations or abrasions on top of the head and snout. The extent of injuries and lack of any other stream events (such as flooding, which has been implicated in previous mortality events; Neto et al. 2016) indicate this deceased larva likely sustained a fatal injury as a direct result of recent rock piling and small-dam construction that occurred in the interim since our surveys the previous month.

Both these mortalities occurred in a small, heavily used headwater stream where daily visitation can total hundreds of people (USFS 2016). Moreover, we have documented displacement of in-stream rocks by the public to create temporary wading pools throughout the year and river tube chutes in the summer months. In this same stream reach, most recently in August 2015, June 2016, and again in July 2016, we observed 2 different small artificial dams (upper dam = 11.5 m long, lower dam = 10.0 m long) built repeatedly by recreational visitors at this same site and within 3 m of each other, even after dams were dismantled and rock dispersed each time. These dams included both larval and adult Eastern Hellbender shelter rocks (cobble and boulders), and photos indicate several of the exact same boulders were used both in 2015 and 2016 each time to form the base of the dam, increasing the cumulative impact of habitat disturbance at this site. We measured the intermediate axis to determine the Wentworth size classification of shelters (Harrelson et al. 1994), and report on both the intermediate and longest axis measurements for rock shelter size. The upstream dam included at least 3 flat boulders and 1 cobble (intermediate and longest axis measurements: 46.3 cm by 50.1 cm; 61.9 cm by 80.5 cm; 49.8 cm by 105.5 cm; and 98.4 cm by 25.5 cm) large enough to serve as typical adult Eastern Hellbender shelters (Rossell et al. 2013). The downstream dam and the site of the dead Hellbender larva contained at least 5 potential adult shelters (intermediate and longest axis measurements: 36.0 cm by 77.0 cm, 62.0 cm by 79.8 cm, 62.5 cm by 77.6 cm, 71.0 cm by 86.3 cm, and 39.5 cm by 53.9 cm). Further, we observed that 1 of the shelter rocks (intermediate and longest axis measurements: 50.0 cm by 106.0 cm) was an active adult Eastern Hellbender nest in previous years.

We report 2 localized events of Eastern Hellbender mortality associated with in-stream rock moving and stacking, but we speculate that this occurrence is widespread in streams across the range of the species, particularly in popular and easy-to-access recreational areas on National Forests and other public lands. This observation of stream alteration involving both large boulders and cobble (adult shelters and possible nest rocks) and smaller cobble (larval shelters) indicates the potential detriment to local breeding populations across life-history stages. Larval salamanders may not only prefer cobble habitat as cover (Nickerson et al. 2003), but cobble may also harbor a high diversity of macroinvertebrates (Suriyawong et al. 2015), food sources for Hellbenders (Pitt and Nickerson 2006). Therefore, displacement of cobble for rock structures and small, artificial dams can have detrimental effects on crucial larval life stages. The rock stacks and dams and associated mortalities we report in this note, when taken together, demonstrate the potential for these activities to negatively impact Eastern Hellbender populations and modify in-stream habitat at a local scale.

These observations provide the first documentation of direct mortality associated with recreational movement of shelter rocks for a state-designated species of greatest conservation need in North Carolina (NCWRC 2015). Further, Eastern Hellbenders have been petitioned for federal listing under the Endangered Species Act and are currently in status review (J. Applegate, US Fish and Wildlife Service-Ohio Ecological Services Field Office, Columbus, OH, pers. comm). Eastern Hellbender management should focus on preventing people from disturbing and moving shelter rocks of all sizes for building stacked piles or cairns, dams, wading pools, or chutes for river tubes, as rock cover is important across multiple age classes from larvae to adults. We recommend natural resource managers implement strategies such as outreach education and continued monitoring of recreational stream use to minimize displacement and destruction of cobble and boulder shelter rocks to reduce Eastern Hellbender mortality. More frequent monitoring of heavily used, easily accessible sites is needed particularly during busy summer holidays and the peak tourist season.

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