Hook learning and fishing vulnerability in Arctic grayling and implications for the development of catch-and-release fishing in Mongolia

Introduction:

Fisheries are important as a source of protein, economic revenue, and outdoor recreation (Ommer et al. 2011).They are also complex social-ecological systems in which human actions, species behavior, and ecosystem traits can interact to create emergent dynamics and unexpected feedbacks. Studies of these interactions usually assume that fishers' catch per unit effort (CPUE) and fish population size are linearly related such that $CPUE = qN$, where N is abundance and q is a coefficient representing the catchability of fish by fishing gear. However, certain interactions between fish behavior and fishing gear can cause non-linear effects where catchability remains high even as populations decline, known as hyperstability, or where catchability declines rapidly even at high population sizes, known as hyperdepletion (Harley, Myers, and Dunn 2001). Both of these effects can alter the response of fishermen to the perceived status of the resource and complicate the management of fisheries.

Changes in catchability at the population level are often driven by fish behavior at the individual level. In fish populations targeted by recreational hook-and-line fisheries, for instance, individual fish vary in their vulnerability to angling, partly because of variations in their behavioral phenotype (Härkönen et al. 2014). This behavioral variation within a population can also be induced by fishing, in that fish learn from their encounters with fishing gear and become invulnerable to further attempts for some period of time afterward (Lennox et al. 2017). This can result in a population-level hyperdeplete effect because a subset of the population will be invulnerable to fishing due to this learning process. Hyperdeplete effects caused by hook learning are particularly concerning in catch-and-release fisheries, which depend on fish being accessible to anglers repeatedly, even after multiple capture events. Catch-and-release regulations can be a powerful tool for conserving fish while encouraging anglers' participation as active stewards of fish and ecosystems (Cooke et al. 2016). However, if hook learning leads to hyperdepletion, anglers could see their conservation-oriented release practices rewarded with lower-than-expected catch rates, especially of highly desired trophy-sized fish (Arlinghaus et al. 2017). This could have the paradoxical effect of discouraging fishery participation and make it harder to assess the status of fish populations accurately.

Mongolia is a developing country that has historically had little culture of fishing (Chandra, et al. 2005). However, this is changing rapidly, with fishing becoming an increasingly popular hobby among the growing urban middle class. Most of these anglers fish consumptively using spinning gear, but Mongolian conservation activists are advocating for a shift to catch-and-release fly fishing, and catch and release is becoming more widespread (A. Golden, unpublished data). Despite this shift, fishing effort in the remote Hövsgöl and Bulgan provinces of northern Mongolia is still low, making it a good region in which to study potential behavior-related hyperdepletion in fish populations that have not yet been exposed to fishing pressure. This project will investigate hook learning using standardized experimental fishing in semi-natural enclosures of Arctic grayling (*Thymallus arcticus* Pallas 1776), a popular recreational fishing target in Mongolia, on the Eg and Uur rivers in northern Mongolia.

Questions:

1) Do Arctic grayling become less vulnerable to fishing effort with increasing exposure to fishing gear over time?

2) Does the degree of hook learning in grayling depend on the type of fishing gear they are exposed to?
3) Is there significant individual variation in hook vulnerability within grayling populations, and is it correlated with life-history traits like body condition, observed feeding behavior, and diet?

Methods:

Research will be conducted in July and August 2019 at two sites in the Eg-Selenge watershed of northern Mongolia. At each site, two semi-natural enclosures will be created by blocking the outlet(s) of shallow side channels or tributaries with fine-mesh seining nets. The enclosures will be swept with seine nets to remove existing fish populations. They will then be stocked with grayling caught on spinning gear, fly fishing gear, and by seining in the mainstem to ensure the sample contains a variety of behavioral phenotypes. A target sample size of 25 fish will be added to each enclosure. Individual fish will be weighed, measured, and tagged with Peterson disc tags color-coded by method and date of capture. Visual deterrents will be placed around and above each enclosure to discourage predation by birds.

Following a two-day acclimation period, one of the enclosures at each site will be fished with standardized effort every other day for two weeks. The pool will be fished simultaneously by two anglers for four hours, for a total per-day effort of eight angler-hours. One angler will fish with standardized spinning gear and the other will use standardized fly-fishing gear. The second enclosure, the control, will not be fished until the end of the two-week study period, when it will be fished for eight angler-hours with both methods. Detailed effort data will be recorded for all fishing bouts, including casts per bout, strikes, and fish that are hooked but not landed. Landed fish will be identified to the individual level. On days when fishing does not occur, four-hour bouts of visual observation will be conducted at each pool to record fish habitat use and feeding behavior. If water conditions permit (i.e. turbidity is low), behavior will be recorded at the individual level; if not, observers will record number of surface-feeding episodes and time spent in pool edge versus center habitat. At the end of the study period, each enclosure will be swept with seine nets again to determine the total number of grayling remaining and all fish will be weighed, measured, and fin clipped for DNA analysis.

Materials needed

- 5 fine-mesh seine nets (two for each pool at each site, plus one backup)
- Tools and materials for constructing enclosures
- 2 seine nets with mesh sized to capture medium-length grayling
- 1 lightweight spinning rod
- 1 lightweight fly rod
- 2 dozen small spinning lures
- 2 dozen mayfly pattern fly fishing lures
- Approx. 200 Peterson disc tags
- Rite-in-the-Rain notebooks, pencils, etc.

References

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