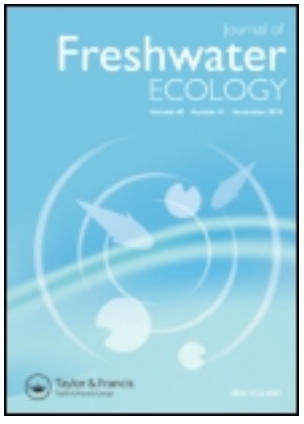

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Evaluating the physical removal of ruffe (*Gymnocephalus cernuus*) with bottom trawling

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NOTE

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The ability to reduce a population of ruffe (*Gymnocephalus cernuus*) with intense repeated bottom trawling was examined at two locations in Chequamegon Bay of Lake Superior. Trawling significantly depleted the population at the Kakagon River site but not at the Second Landing site. At least 93% of the estimated population of ruffe was removed from the Kakagon River site, but ruffe re-established in the area within 1 year. The relative success of short-term reduction at the Kakagon River site was likely due to habitat and biological characteristics that led ruffe to congregate in large numbers. Physical removal does not appear to be an effective way to effect long-term removal of ruffe.

Keywords: invasive; control; Lake Superior; ruffe; removal

Ruffe (*Gymnocephalus cernuus*), an invasive percid, is native to Europe and Asia and was first found in Lake Superior in 1986 (Ogle 1998). Since then, numerous methods have been proposed to control, if not eradicate, this invasive fish. We evaluated an attempt to physically remove ruffe from two distinct locations within Chequamegon Bay, southwestern Lake Superior.

The two locations – Kakagon River and Second Landing – were chosen because previous trawling observations showed that ruffe were caught only within specific areas at each location, and repeated trawling through these areas resulted in reduced catch rates. These observations suggested that ruffe were concentrated in defined areas and were thus susceptible to physical removal.

The Kakagon River is a tributary on the east side of Chequamegon Bay. At the mouth, it forms a narrow channel 30 m wide by 3–5 m deep and decreases in depth to <2 m in the transition from mouth to bay. Trawling occurred in a $\sim$10,000 m^2 area of the channel, extending from the mouth/bay transition to 335 m upriver. The Second Landing site covered a nearshore area of $\sim$4000 m^2 in southeastern Chequamegon Bay. Depth ranged from 1.5 to 2.5 m, with a gradually sloping gradient. Trawling occurred adjacent to a pondweed (*Potamogeton* spp.) bed and covered the entire 4000 m^2 area.

During August of 1998, bottom trawling was conducted with a 4.9 m wide trawl at each location on each day for a total of $\sim$3 h or until ruffe were no longer caught.

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The number of ruffe captured in each trawl tow was recorded. The Leslie depletion estimator method (Seber 1991), using the Ricker (1975) modification implemented in the FSA package (Ogle 2009) for the R environment (R Development Core Team 2009) was used to estimate the initial population size (N), with associated confidence interval, at each location in 1998 from the daily catch-per-unit-effort (CPUE; number per hour of trawling) data. The percentage of the population removed was estimated by dividing the total catch of ruffe in all trawl tows by N. Approximate confidence ranges for the percentage removed were estimated by dividing the total catch of ruffe by the endpoints of the confidence intervals for N.

A total of 4.9 h of trawling at the Kakagon River site resulted in the removal of 700 ruffe. Daily CPUE of ruffe ranged from 891/h on day 1 to zero on day 10 (Table 1). The initial ruffe population size was estimated at 700 (95% CI: 651–749), with at least 93% removed by trawling effort. One year later in August, we conducted trawling at the Kakagon River site to identify the long-term impact of the 1998 trawling. The daily CPUE for 0.52 h of trawling on 3 days in 1999 ranged from 1080/h on day 2 to 524/h on day 3. These results suggest that the substantial reduction in the ruffe population in the Kakagon River in 1998 was not sustained into 1999.

A total of 3.45 h of trawling effort at Second Landing in 1998 resulted in the removal of 547 ruffe. Daily CPUE of ruffe ranged from 685/h on day 5 to 4/h on day 9, but did not show a consistent decreasing trend (Table 1). Daily CPUE was not significantly related to prior cumulative catch ($p = 0.07$); thus, the population of ruffe at Second Landing was, statistically, not depleted. The initial ruffe population size was estimated at 552 (95% CI: 270–834) with at least 66% removed by trawling.

The results of this study suggest that a short-term reduction in a ruffe population may be achieved in some areas. A significant reduction in ruffe occurred at the Kakagon River site but not at the Second Landing site. We hypothesize that this difference is likely due to the physical and biological characteristics of the two sites. Trawling at the Kakagon River site occurred in a readily defined channel. Downstream and lateral to this site, the shallower water was unlikely to be inhabited by ruffe during the day (Ogle et al. 1995). Areas adjacent to the trawling site at Second Landing had similar habitats and depths or were heavily vegetated, which may have provided cover during the day for ruffe. Thus, ruffe likely congregated in the channel at the Kakagon River site and were, therefore, more vulnerable to removal by bottom trawling.

However, at least a 93% short-term reduction in the ruffe population at the Kakagon River site did not result in a long-term reduction in the ruffe population. A long-term reduction in the ruffe population is likely only if that population congregates in well-defined areas, is located at the periphery of the range of the fish, and is widely separated from the next nearest population. A widely separated and

Table 1. Ruffe CPUE (number per hour) during August 1998.

Date	3	4	5	6	7	17	18	19	20	21
Kakagon River	891	694	52	12	18	38	7	0	2	0
Second Landing	–	–	320	685	126	74	30	144	4	140

peripheral ruffe population is likely to have a lower rate of restocking than an interior range population that is surrounded by other ruffe populations.

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