Management of Biological Invasions (2015) Volume 6, Issue 3: 303–306
doi: http://dx.doi.org/10.3391/mbi.2015.6.3.09
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Short Communication

Optimizing sampling effort to detect rusty crayfish (*Orconectes rusticus*) in southern Ontario rivers

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Received: 21 October 2014 / Accepted: 16 March 2015 / Published online: 25 March 2015

Handling editor: Vadim Panov

Abstract

The distribution and status of native and non-native crayfish are monitored across hundreds of lakes in Ontario (Canada). However, a corresponding effort has not been undertaken in flowing waters. Reliable and efficient sampling methods are essential for the detection of new aquatic invaders and tracking the spread of existing invasive species. In this study, a recent dataset for the invasive rusty crayfish (*Orconectes rusticus*) was used to determine whether the detection probability associated with intensive sampling by hand-capture (20 minutes) of 10 transects could be achieved with fewer transects. Results indicate that sampling more than three transects does not improve rusty crayfish detection. Monitoring designs based on three transects would reduce search effort by 140 minutes at each site; permitting greater spatial coverage or more frequent sampling.

Key words: monitoring, invasive species, hand-capture, crayfish, rivers

Introduction

The detection of new aquatic invaders and tracking the spread and impact of existing invasive species is a resource management priority in Ontario (Canada) (OMNR 2012). Rusty crayfish [*Orconectes rusticus* (Girard, 1852)] is one of three crayfish species thought to be introduced into Canada from the United States (Hamr 2010). Where introduced, rusty crayfish has caused dramatic changes to aquatic ecosystems, including: the replacement of native crayfishes, damage to macrophyte beds, and shifts in macroinvertebrate and fish assemblages (Phillips et al. 2009). Rusty crayfish was first reported in Canada during the 1960s from Lake of the Woods in Northwestern Ontario and a small number of south-central Ontario lakes (Crocker and Barr 1968). The species has subsequently been captured from numerous lakes and rivers in other regions of the province (Berrill 1978; Momot 1996; Edwards et al. 2009). While trends in the status of native and invasive crayfish have been monitored across hundreds of Ontario lakes (Edwards et al. 2009; Somers and Reid 2010), a corresponding effort has not been undertaken in streams and rivers.

A recent study of rusty crayfish distribution and associated impacts on native crayfishes used a time-intensive sampling design at 99 southern Ontario river sites (Reid and Nocera 2015). At each site, sampling by hand-capture required 200 minutes of search effort distributed across 10 systematically placed transects. However, monitoring programs require sampling designs that balance data quality and quantity requirements with practical and economic constraints (Field et al. 2005; Legg and Nagy 2006). Improving the allocation of sampling effort may reduce sampling requirements without affecting data completeness (Smith and Jones 2005), and permit monitoring to occur over greater spatial scales. If the monitoring objective is to track changes in species distribution, effort required to reliably detect a species may also be substantially less than tracking changes in abundance (Gibbs et al. 1998). In this study, I used the aforementioned dataset to determine whether or not the probability of rusty crayfish detection associated with sampling 10

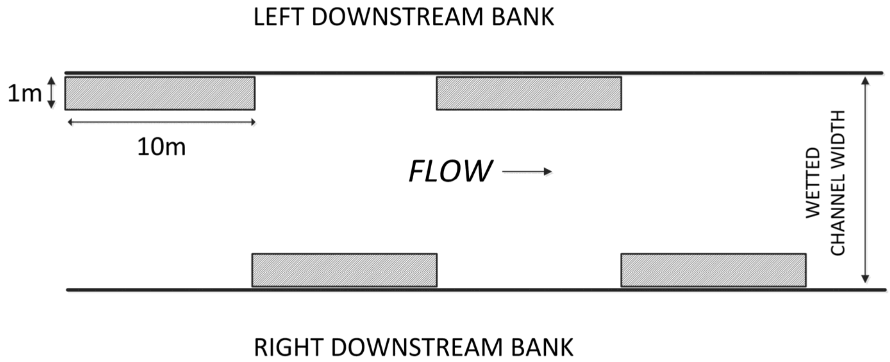

Figure 1. Plan view of generalized river channel, showing a representative distribution of sampled transects arranged in an alternating sequence along the margins of the wetted channel.

transects could be achieved, more efficiently, with fewer transects at a site. Estimates of sampling effort required to detect rusty crayfish will inform the design of monitoring programs in Ontario streams and rivers.

Methods

Crayfish sampling occurred from July 25th to October 5th, 2011, and May 30th to October 16th, 2012. Sampling sites were located in the following Laurentian Great Lake watersheds: Grand River and Nanticoke Creek (Lake Erie); Ausable and Maitland rivers (Lake Huron); Don River, Duffins Creek, Ganaraska River, Highland Creek, Moira River, Oshawa Creek, Otonabee-Trent River, and Rouge River (Lake Ontario); and, Thames River (Lake St. Clair). These watersheds differ in surficial geology, intensity of agriculture practice and/or suburban/urban development, and degree of fragmentation by dams. Wetted channel width at sites ranged from 2.8 to 125 m (median: 17).

At each site, 10 shoreline transects were evenly spaced, in alternating fashion, along both banks (Figure 1). Transects were 10 m long and 1 m wide. The length of habitat sampled at each site was defined as 15 times channel width; with a maximum of 500 m. For most sites, a variety of habitats types (*i.e.* pool, riffle and run) were sampled. A 20 minute search was completed at each transect. Crayfish were caught by hand or scooped with flat bottom dip nets. Rocks were overturned to flush specimens out from their refuges. Baited traps are often used to sample crayfishes in Ontario (Guiasu et al. 1996; Somers and Reid 2010), but were not used as they require repeat site visits, are vulnerable to vandalism or theft (Bernardo et al. 2011), and deployment may be impractical in very shallow, or fast-flowing habitats. Hand-capture has been effective at collecting rusty crayfish and other native crayfishes in wadeable stream and river habitats (Hamr and Sit 2011; Reid and Devlin 2014), and avoids potential harm to non-target species that may be associated with electrofishing. Rusty crayfish was detected at 40 of the 99 sites sampled. Collection data from the 40 rusty crayfish sites were used to model detection probabilities.

Re-sampling methods were used to generate rusty crayfish detection probability curves (Jackson and Harvey 1997). First, transect-sampling data were randomly split into re-sampling, and validation datasets. Each dataset included all ten transects associated with 20 rusty crayfish collection sites. A summary of collection data associated with each dataset is presented in Table 1. For samples sizes of 1 to 9 transect, sets of rusty crayfish presence/absence data were generated from pooled transect data. For a given site, each sample size was assigned a value of 1 if rusty crayfish was detected and a value of 0 if it was not. A bootstrap re-sampling procedure (sampling with replacement and 5 000 randomizations) was used to calculate mean (and 95% confidence limits, CL) detection probabilities for each sample size (Manly 2007). Based on a probability of detecting rusty crayfish equal to 0.95 (Garrard et al. 2014), three levels of reduced sampling effort (*i.e.* number of transects) were identified using mean, upper CL and lower CL probabilities. Data were simulated using Excel Add-in: PopTools Version 3.2.5 (Hood 2010).

Validation of sampling effort predictions with independent data is an important step towards quantifying confidence in future site classifications (*i.e.* rusty crayfish presence or absence) (Olden et al. 2002). The validation dataset was used to compare the accuracy of site classifications associated with the three levels of reduced sampling

Table 1. Comparison of rusty crayfish hand-capture data associated with re-sampling and validation datasets. Each dataset included transect data from 20 rusty crayfish collection sites.

	Re-sampling	Validation
Number collected at each site, median (range)	49 (6-324)	56 (1-239)
Number of occupied transects at each site, median (range)	8 (3-10)	9 (1-10)
Sampling effort (transects) until first detection, median (range)	1 (1-5)	1 (1-7)
Overall percentage of each life-stage		
Females (%)	40.5	35.3
Form I[a] Males (%)	13.3	21.8
Form II[b] Males (%)	22.2	20.3
Juvenile	24	22.6

a: sexually active, b: sexually inactive

effort, relative to 10 transects. Accuracy was assessed by calculating the correct classification rate (CCR) and Cohen's Kappa statistic; an index of agreement between classification methods (Agresti 2013).

Results and discussion

Sampling effort at a site required to obtain a mean probability of rusty crayfish detection equal to 0.95 was three transects (Figure 2). Effort associated with upper and lower CLs were one and six transects. When applied to the validation dataset, sampling only one transect resulted in a CCR of 75% and a Kappa statistic of 0.75, which is considered 'substantial' agreement (Landis and Koch 1977). There was no difference in accuracy between three and six transects. When three or six transects were sampled, CCR equalled 95% and the Kappa statistic was 0.95, which is considered 'almost perfect' agreement (Landis and Koch 1977).

Results from this study indicate that sampling more than three transects at each site by hand-capture does not improve rusty crayfish detection. The result is not surprising given that rusty crayfish were typically encountered early during sampling, and were widely distributed across transects within sites (Table 1). Monitoring programs using three transects would reduce search effort by 140 minutes at each site. If monitoring objectives are limited to documenting species occurrence, further reductions in time spent searching could be achieved by stopping once rusty crayfish is collected. These efficiencies would permit sampling of a greater number of sites across watersheds, or more frequent sampling at sites identified as a high risk for introduction.

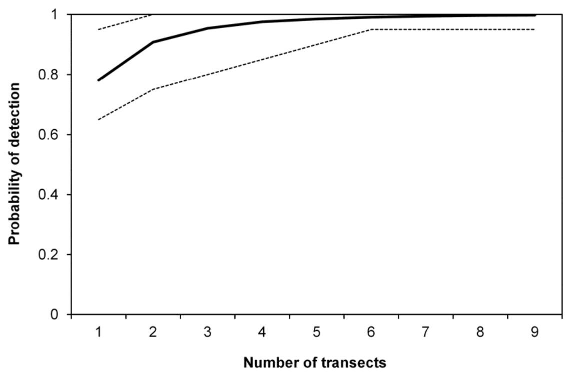

Figure 2. Influence of sampling effort on rusty crayfish detection by hand-capture at southern Ontario river sites. Probabilities associated with mean values (solid line) and upper and lower 95% CLs (dashed lines) are presented. Detection probabilities were estimated using re-sampling methods (5 000 randomizations) and transect data from 20 sites.

Currently, the distribution of rusty crayfish is expanding into the rivers of southwestern Ontario (Hamr 2010). The risk of direct impacts to native crayfish and indirect impacts to the federally endangered queensnake (*Regina septemvittata* Say, 1825), an obligate feeder of freshly molted crayfish, has been recognized for these rivers (Gillingwater 2011). Accordingly, tracking rusty crayfish invasions is a priority conservation action. The leading edges of rusty crayfish invasions are characterized by low population densities (Jansen et al. 2009) and, therefore, may be more difficult to detect than established populations. In this study, data used to generate detection probabilities included both low density and long-established, high density populations. As the probability of detecting a species is positively correlated to local abundance (Royle and Nichols 2003), sampling effort recommendations presented here may be insufficient to detect new or advancing rusty crayfish populations. In the absence of a robust dataset from low density populations, alternative recommendations for sampling Ontario rivers could be developed by computer simulation (Morrison et al. 2008).

Acknowledgements

Research was supported by Invasive Species Centre, and Ontario Ministry of Natural Resources and Forestry species at risk program funding. The manuscript was greatly improved by suggestions provided by two anonymous reviewers.

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