Collaborating with recreational fishers to inform fisheries management: Estimating population abundance for an iconic freshwater crayfish

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Summary

Can the abundance of fish populations be effectively determined by the collection of scientific research with support from recreational fishers? Collecting and analysing fishing data from recreational fishers to aid management are not new; however, engaging fishers in a scientific survey design to produce specific population estimates is rarely undertaken. We engaged recreational fishers to assist with field sampling to provide an estimate Murray Crayfish (*Euastacus armatus* von Martens, 1866) abundance at three sites on the Edward River which were recently impacted by an extreme blackwater disturbance. Employing mark-resight models, fishers undertook crayfish surveys and produced research data which estimated adult population sizes of Murray Crayfish in the studied reaches ranging between 94.27 ± 24.72 individuals (Below Stevens) and 450.01 ± 175.30 individuals (Twin Rivers). Both the effective undertaking of the mark-resight designs in collaboration with fishers and acquiring population abundance estimates for Murray Crayfish in a river reach are concepts which have not previously been published and are important attributes for the management of aquatic species.

Introduction

Recreational fisheries

With many variables at play, the best management of recreational fisheries would rely on robust scientific data and fisher knowledge to guide fishery regulations and help ensure high compliance rates. Previous studies have shown that fisher input and local ecological knowledge can not only provide a reliable source of fishery information but can also provide new information that might not be captured by scientific research (Macdonald *et al.* 2014; Marin *et al.* 2017). Importantly, researchers have demonstrated that the comparison of this data collected through interviews and questionnaires, catch cards, catch rates, fishing effort data and fishery-independent surveys can have similar results (Zukowski *et al.* 2011; Macdonald *et al.* 2014).

Gathering population-level data on individual species is an important, but time-consuming and expensive task, the burden of which can be eased through obtaining data from fishers (Santos *et al.* 2017). When engaging fishers in scientific data collection, it is important to use a robust design to provide credible information which can be used in management of the resource. Nowicki *et al.* (2008) showed that the robust design of mark-recapture can be an easy to use and reliable tool for determining population abundances and temporal trends for the White-clawed Crayfish (*Austropotamobius pallipes*) complex. Freshwater crayfish, such as Murray Crayfish (*Euastacus armatus* von Martens, 1866), is well suited to meet the assumption of these designs (Nowicki *et al.* 2008).

The Murray Crayfish is the second largest freshwater crayfish in the world and a recreationally fished species in the southern Murray-Darling Basin (MDB), Australia. The species has experienced declines in distribution and abundance and most recently over 2010–11, significant population loss was experienced in areas subject to a hypoxic blackwater disturbance (McCarthy *et al.* 2014). This disturbance resulted in the closure of extensive areas to recreational fishing, but recreational fishing remains an important pastime in a limited section of the species range.

In this study, we engaged recreational fishers to assist with field sampling to shed light on the status of populations of Murray Crayfish impacted by this hypoxic blackwater disturbance. Specifically, we undertook a pilot mark-resight study to estimate population abundance with marking undertaken by ecologists and resight events conducted by recreational fishers but supported by ecologists. The aims were twofold: (i) to provide the first estimate of population abundance for the species and (ii) demonstrate that recreational fishers, with training and guidance, can assist with collecting data to provide these estimates. Future studies investigating possible differences in population abundance estimates between research data collected by fishers alone and ecologists could provide evidence to allow fishers to undertake crayfishing in the closed areas for obtaining vital scientific data. It is also hoped that the study will form the basis of a local long-term monitoring programme for this iconic native species.

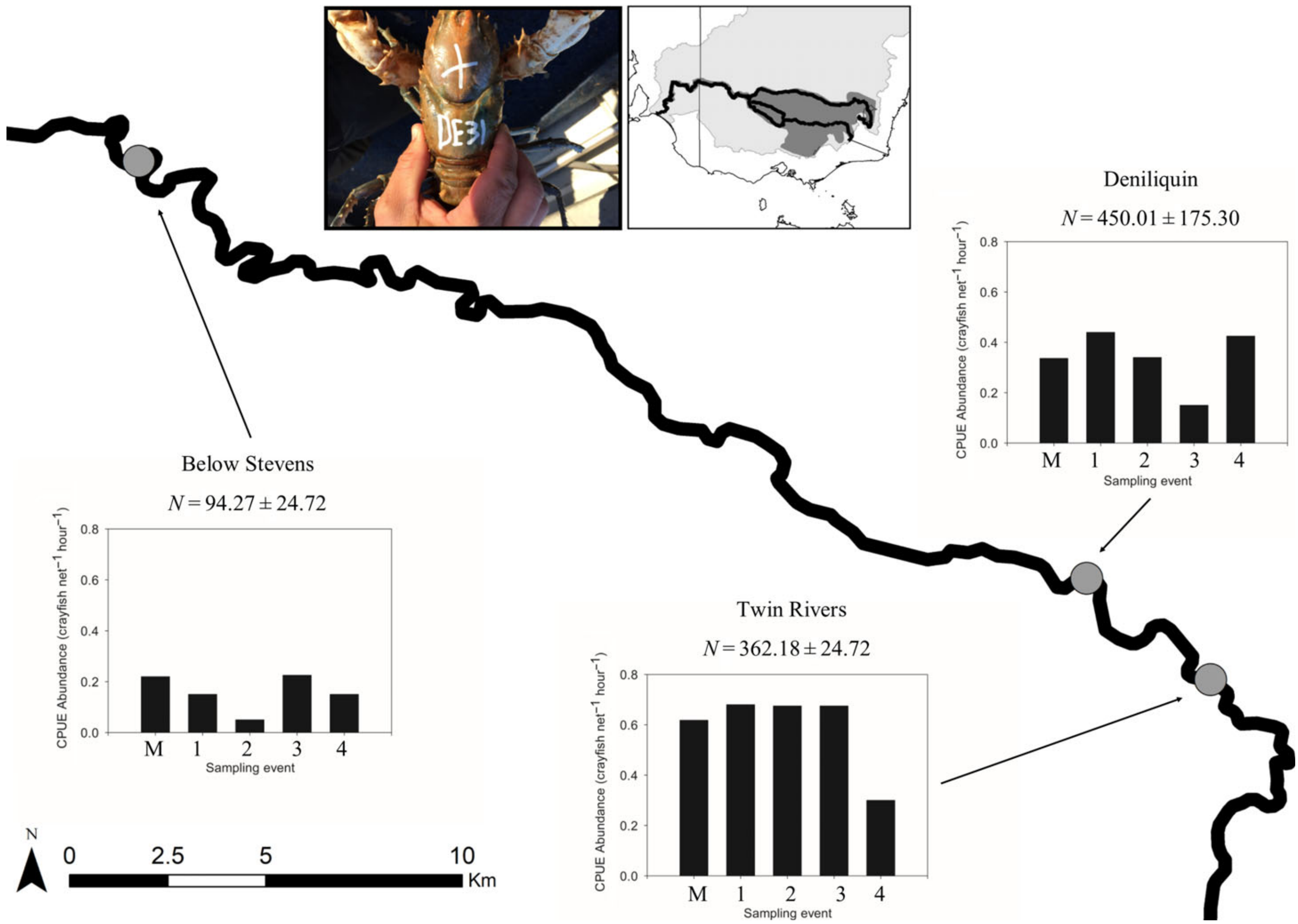

Figure 1. Changes in relative abundance (individuals/net/hour) over time and an estimate of population abundance (number of individuals ± standard error) of Murray crayfish at three Edward River sites (collectively denoted by * on insert) in its natural range (dark grey on insert) across the southern Murray-Darling Basin (light grey on insert). Also shown is a marked Murray crayfish. [Colour figure can be viewed at wileyonlinelibrary.com]

Materials and Methods

Study region and field sampling

The study focused on three sites (Below Stevens: −35.4457, 144.7975; Deniliquin: −35.5173; 144.9616; Twin Rivers: −35.5990, 144.9918) on the Edward River, a 383-km regulated turbid and low gradient anabranch of the Murray River in the southern MDB (Fig. 1). The study region was impacted by the 2010–11 blackwater disturbance, and recreational fishing was totally prohibited at the time of sampling (McCarthy *et al.* 2014). Each site was approximately 2-km long with the river varying between 60- and 100-m wide and surface areas of 0.073 km^2 (Below Stevens), 0.113 km^2 (Deniliquin) and 0.092 km^2 (Twin Rivers).

At each site, a mark-resight design, with a single marking event (conducted by ecologists) followed by four resight occasions (conducted by recreational fishers and supported by ecologists) (McClintock & White 2009, 2012), was employed to estimate population abundance across the 2-km river stretch. The advantage of this design over others where individuals are not marked during each sampling event (i.e. mark-recapture) is that data collection is easier for recreational fishers participating in the study and can lessen the possibility of data error. During the marking event, all sampled Murray Crayfish were individually marked (site and unique number) with a permanent waterproof paint marker (Fig. 1) (Ramalho *et al.* 2010). On subsequent resight occasions marked crayfish as well as unmarked individuals were recorded. All sampled crayfish were measured for length (occipital carapace length, OCL, mm), weighed (g, marking event only) and sexed (based on position of gonopores) with females in berry recorded.

Sampling across the 2-km stretch at each site was achieved using single hoop nets [800 mm diameter, 13 mm stretch mesh size, 0.3 m drop, baited with Common Carp (*Cyprinus carpio*)] deployed and checked hourly (over five rounds; five hours; marking: 20 nets per site; each resight occasion: 10 nets per site) during daylight (08:00–17:00). Sampling events were separated by 2-week intervals to avoid any short-term recapture bias (Nowicki *et al.* 2008) and all sampling was conducted during winter months when the species is most active and the likelihood of moulting is low (between June to August: Zukowski *et al.* 2012).

Data analysis

The number of sampled crayfish was divided by the total net hours at each site for each sampling event to estimate relative abundance, expressed as individuals/net/hour to estimate Murray Crayfish population abundance (N) at each site. The closed resight zero-truncated Poisson log-normal (zPNE) mark-resight estimator was used, given there was only one primary sampling interval and sampling was with replacement (McClintock & White 2009, 2012). As such, the distinct resight occasions were not delineated but rather marked and unmarked individuals were combined and population abundance was model-averaged over the study period. The estimate of population abundance was divided by area (km^2) to provide a measure of density at each site. The analysis was conducted using mark-resight modelling in Programme MARK v.8 (White & Burnham 1999).

Results

In total, 20 individual recreational fishers were involved over the four resight occasions. Almost all (90%) of the recreational fishers involved had either previous experience with the species, undertook a prior training session or sampled under the guidance of a trained participant, or both, with only two participants considered inexperienced (only involving one occasion at one site). The number of recreational fishers participating remained relatively consistent across each resight occasion (two fishers per sampling trip).

Across the study period (marking and four resight occasions), 319 Murray Crayfish were sampled, including 134 individuals that were initially marked and the detection of 39 of these marked crayfish (Fig. 1). Sampled Murray Crayfish ranged between 65.7–147 mm OCL and 150–1245 g (based on marking event only) with an overall sex ratio 0.78:1 (males:females) and 34% of all females carrying eggs. For the 39 recaptures, there was a 2.4 ± 0.3% discrepancy between length OCL recorded by ecologists (during initial marking) to that obtained from recreational fishers (over the four occasions). Relative abundance ranged from 0.05 to 0.68 crayfish/net/hour, with mean relative abundance highest at Twin Rivers (0.59 ± 0.07 crayfish/net/hour) followed by Deniliquin (0.34 ± 0.05 crayfish/net/hour) and the Below Stevens site (0.16 ± 0.03 crayfish/net/hour) (Fig. 1). Despite this, a larger, although less precise, estimate of population abundance at Deniliquin (N = 450.01 ± 175.30) compared to Twin Rivers (N = 362.18 ± 68.03) was achieved, with a considerably lower estimate revealed at Below Stevens (N = 94.27 ± 24.72). These estimates correspond to densities of 3986.71 individuals/km^2 (Deniliquin), 3934.39 individuals/km^2 (Twin Rivers) and 1287.45 individuals/km^2 (Below Stevens), respectively. The resighting rate was lowest at Deniliquin (σ = 0.15 ± 0.07) compared to the other two sites (Twin Rivers: σ = 0.33 ± 0.07; Below Stevens: σ = 0.34 ± 0.11).

Discussion

Understanding changes in population abundance over time and space helps to assess the status of recreational fisheries (Berkeley *et al.* 2004) and aids the conservation of threatened species (Lintermans 2013). The present study has provided the first estimate of population abundance for a large recreationally fished freshwater crayfish, achieved through collaboration with recreational fishers. The findings offer useful insight into the status of Murray Crayfish populations as well as the engagement of recreational fishers in fisheries management.

The present study revealed that fewer than 500 (and possibly < 100) individuals may persist across 2-km stretches of the river impacted by the 2010–11 blackwater disturbance. Given the length of individuals sampled (e.g. >65.7 mm), these estimates relate to the advanced juvenile and adult proportion of the population, so the total population is anticipated to be much larger – with possibly up to 5000 juveniles present (estimated from population modelling of C. Todd *et al.*). Regardless, based on the estimates of population abundance, the viability of populations sampled in the Edward River requires further study. Relative abundance and length structure (c.f. McCarthy *et al.* 2014) infer larger, and more sustainable, populations in other regions of the range of the species. Further investigation will be necessary as the present study revealed that relative abundance alone may not be a reliable indicator to identify such populations.

Collaboration with recreational fishers to determine population parameters of fish species can provide additional data in an often data-limited industry. Previous studies have shown that this data can also be a reliable source of information when examining data generating methods such as questionnaires or catch diaries (Zukowski *et al.* 2011; Macdonald *et al.* 2014). By utilising the simple yet robust sampling design in this study, it was evident that fishers can effectively assist with research sampling procedures that help acquire species population-specific information. Contributing to this is the use of survey gear (i.e. hoop nets), that is consistent across recreational fishing and scientific research, thus being familiar and easily accessible to participants. However, it should be noted that proper training and guidance in research methods for fishers should complement field participation projects otherwise large discrepancies in data may result. For instance, during our study, one participant who had not undergone training was recording all crayfish without eggs as males, when in fact some were nonberried females. The accompanying ecologist quickly identified and resolved this issue. However, without ongoing training and communication, errors may occur that lessen the usability of the data.

The present study confirms the capacity for recreational fishers to assist in monitoring to provide important ecological information (Zukowski *et al.* 2011). The present small-scale, short-term study could be repeated to assess the impact of a blackwater disturbance that was experienced over the wider study region during late 2016 (MDBA 2016). More broadly, it could be expanded to greater spatial (including open and closed areas to harvest) and temporal (e.g. seasonally, but also multiyear) scales. This expansion would require new engagement (e.g. additional fishing groups) and tagging methods (e.g. pit tags) that persist across years (and in the case of freshwater crayfish, through moults). Further, mark-recapture designs should be considered to provide more comprehensive, robust and longer term estimates to inform management (Nowicki *et al.* 2008).

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Chemical options for the control of Siam Weed (*Chromolaena odorata*) in natural ecosystems

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Summary

The perennial shrub Siam Weed (*Chromolaena odorata* (L.) R. M. King & H. Rob.), a native of the rainforests of central and southern America, is predicted to invade most countries between the Tropics of Cancer and Capricorn. Subsequent to its discovery in northern Queensland, Australia in 1994, it was unsuccessfully targeted for eradication, with early control efforts restricted to manual removal and foliar spraying with triclopyr/picloram. A chemical trial involving five herbicides and three

