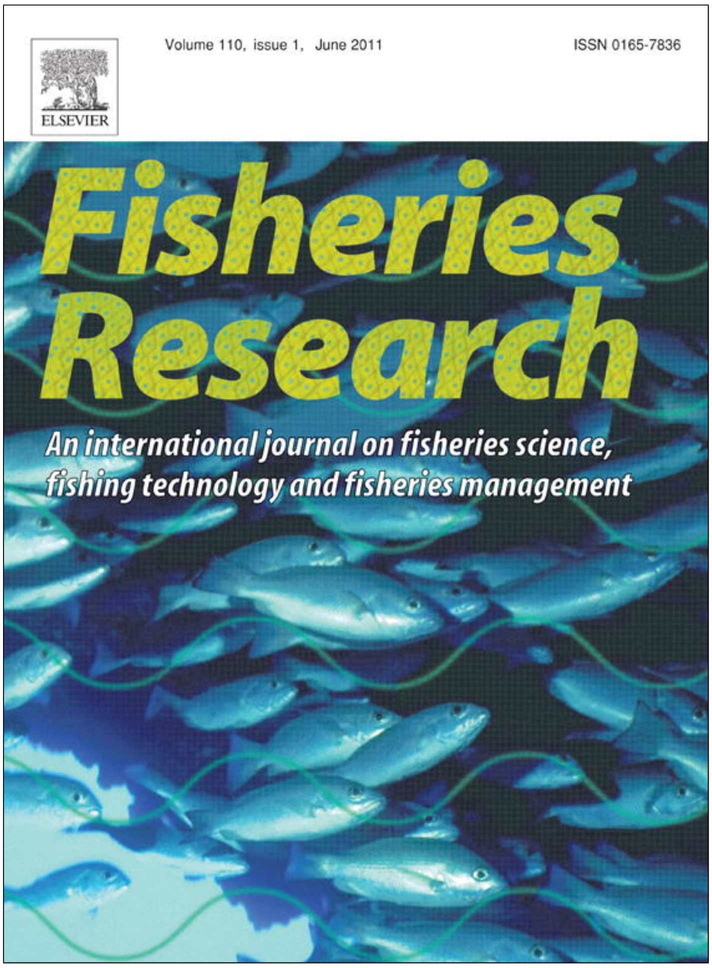
Volume 110, issue 1, June 2011
ISSN 0165-7836
ELSEVIER
Fisheries Research
An international journal on fisheries science, fishing technology and fisheries management

Fisheries Research 110 (2011) 120–127

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Using fisher local ecological knowledge to improve management: The Murray crayfish in Australia

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ARTICLE INFO

Article history:
Received 25 November 2010
Accepted 29 March 2011

Keywords:
Fisheries
Anglers
Sex ratios
Regulations
Recreational

ABSTRACT

The use of data provided by fishers is a contentious topic in fishery management. We compare fisher local ecological knowledge, fisher catch data and scientific data for Murray crayfish (*Euastacus armatus*) size and sex ratios in the River Murray, Australia, to determine if these data are consistent and if fisher knowledge can be a reliable input into fisheries management. Data were obtained through field surveys of crayfish populations, face-to-face fisher interviews and catch cards completed by fishers. All data sources indicated that there were higher numbers of crayfish <90 mm OCL compared to ≥90 mm OCL and the sex ratio of larger crayfish (≥90 mm OCL) was skewed towards females. Fisher catch card and scientific survey data showed the size frequencies of male and female crayfish were significantly different. Study results suggest that fisher local ecological knowledge can be a reliable source of information to improve fisheries management.

1. Introduction

Can recreational fishers provide a reliable source of knowledge for fisheries management? This question has long been debated between fishers, managers and scientists. Fishers often have a broad and detailed knowledge of fisheries stemming from ongoing and often extensive interactions with the environment in which they fish (Johannes, 1981; Ruddle, 1994) and through interactions with and observations of other fishers (Grant and Berkes, 2007). They can provide species specific information on population dynamics and biological and ecological aspects such as spawning grounds, juvenile habitat, migration patterns and habitat preferences (Ames, 2004; Hall-Arber and Pederson, 1999; Maurstad and Sundet, 1998; Neis et al., 1999) and about changes in stock and fishing pressure in response to regulatory changes (Neis and Felt, 2001). Furthermore, if scientific data about the past status of fish stocks or environmental conditions are nonexistent, older fishers can be the only source of information available (Johannes, 1998; Johannes et al., 2000).

This type of knowledge is often referred to as local ecological knowledge (LEK), where a group of individuals hold a cumulative body of knowledge, often site-specific, about an ecological system. LEK is based on the interactions of individuals, humans and animals, with the environment and with each other. LEK can be gained through a mixture of observations and practical experience and can be adapted over time and handed down through generations (Berkes, 1999).

On a global scale there are many animal populations where there is insufficient scientific information to make sound management recommendations that will ensure sustainable populations (Gilchrist et al., 2005). The value of fisher LEK has been widely documented (Baticados, 2004; Bergmann et al., 2004; Berkes and Folke, 1998; Johannes, 1998; Johannes et al., 2000; Maurstad, 2002; Silvano and Begossi, 2005) and there is increasing recognition that LEK can successfully complement scientific information to produce better management outputs (Chemilinsky, 1991; Mackinson and Nottestad, 1998). But, the inclusion of this knowledge into fisheries management remains the exception, rather than the rule. Alternative sources of information such as LEK need to be gathered, evaluated, and then tested through their application in management (Gilchrist et al., 2005).

Fisher LEK can be collected from fishers through a variety of methods including door-to-door, mail or telephone surveys, face-to-face interviews and logbooks and diaries which can occur at fishery access points (Pollock et al., 1994). LEK typically differs from scientifically generated data in that is it often qualitative and not quantitative (Mauro and Hardison, 2000); relates to different time periods and locations; and involves different collection methods (Huntington et al., 2004a). There is a only a small numbers of peer-reviewed articles drawing on LEK compared to the large number of scientific articles (Nadasdy, 2003).

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doi:10.1016/j.fishres.2011.03.020

Fishers often say that the value of their LEK is not recognised and challenge the scientific information that underpins fishery policy and management decisions (Delaney et al., 2007). On the other hand, scientists often mistrust the reliability of fisher LEK (Mackinson and Van der Kooij, 2006). The term 'anecdotal knowledge' is still widely applied to fisher knowledge and its translation into scientific knowledge and management remains limited (Neis et al., 1999; Palsson, 1998). Thus, the reliability of LEK is often questioned and this type of knowledge is not readily accepted as an input to management. Unreliable data, be it scientific or local, can result in mismanagement of resources (Ludwig et al., 1993; Walters and Hilborn, 1978). If fishery managers are to draw on fisher knowledge they need to be able to assess the reliability of LEK (Hamilton et al., 2005; Maynou and Sarda, 2001; Neis et al., 2007).

The comparison of LEK and scientific knowledge is one way of examining the reliability of both data sets, especially where the reliability of LEK is questioned. Comparing the independent outputs from these two methods can distinguish whether the two types of data corroborate (Rochet et al., 2008) or contradict (Degnbol, 2003) one another. To the extent that both types of data are consistent, then confidence in both is enhanced (Huntington et al., 2004a). To ascertain the reliability of fisher LEK, previous authors have compared data collected by fishers with data collected by scientists (Baigòn et al., 2006; Bergmann et al., 2004; Bray and Schramm, 2001; Ebbers, 1987; Maurstad, 2002; Maurstad and Sundet, 1998; Silvano and Begossi, 2002; Silvano et al., 2006; Silvano and Valbo-Jørgensen, 2008).

Ebbers (1987) compared data gathered using three methods (scientific electrofishing surveys, fishing tournaments, and fisher diaries) on the population structure of large-mouth bass (*Micropterus salmoides*) in Minnesota. The study found much of the population data was similar between the three data sources and thus the authors concluded that large amounts of data could be reliably collected by volunteer fishers (Ebbers, 1987). Similarly, in the Cabra Corral reservoir in Salta Province, northern Argentina, only small differences were found in the length of fish caught by fishers in tournaments, catamaran fishers and scientific gillnet captures (Baigòn et al., 2006). In Mississippi, Bray and Schramm (2001) found similarities in the length distribution of black bass *Micropterus* spp. (>250 mm) between angler reports and electrofishing samples (Bray and Schramm, 2001).

Bergmann et al. (2004) compared fisher surveys on the location of key habitat for gadoid fishes and whether the fishers had noticed features that might indicate the characteristics of essential fish habitat to that of standard groundfish surveys. The authors found that fisher information was not only broadly compatible with that gathered through scientific surveys, but fishers could also provide additional information (extra key fishing grounds/habitats) which was outside the scope of the scientific surveys (Bergmann et al., 2004). Similarly, Maurstad (2002) undertook interviews with fishers in Finnmark (Norway), to gain information about fished areas, species fished, gear used, people using the area, timing of fishing, and any changes in the fishery in the past few years. One of the outcomes of the study was a map (Maurstad and Sundet, 1998) in which fishers were able to identify 44 local spawning areas for cod whilst scientists knew of only four or five spawning areas (Maurstad and Sundet, 1998).

In this paper, we focus on the LEK of recreational fishers in a freshwater system. The majority of previous studies in this field have examined either commercial fisher LEK or marine systems or a combination of the two. In commercial fisheries, fishers are generally obliged to provide fishing and catch data to assist the monitoring of compliance with regulations, including quotas. These data are also used to monitor stock changes (Gerdeaux et al., 2006) and to facilitate the engagement of fishers in management and research. Until recently there has been little effort to gather data from recreational fishers to monitor the impact of fishing. Up to the 1970s it was generally perceived that commercial fisheries took the greater part of the total fishery catch and that recreational fishing did not make a large impact (Ramsay, 1991). It is now evident that the growth and impact of recreational fishing is greater than was previously anticipated (Ramsay, 1991).

Here, we discuss the findings of research that aimed to determine if freshwater recreational fisher LEK can be a reliable source of information for fisheries management. To do this, we tested two hypotheses (the catch is dominated by crayfish < 90 mm OCL (hypothesis one); and there is a skew in the sex ratios of larger crayfish (≥90 mm OCL) towards females (hypothesis two)), that explored whether fisher observations about the size and sex ratios of Murray crayfish (*Euastacus armatus*) in a recreationally fished section of the River Murray, NSW were consistent with data collected through fisher catch cards and scientific surveys.

Murray crayfish are an iconic and highly valued recreational fishing species in the southern Murray–Darling Basin of Australia. The current status of Murray crayfish is largely unknown, however reports by fishers of declines in abundance, range and size have been reported since the 1950s (Horwitz, 1990, 1995). The five key recreational fishing regulations for Murray crayfish in NSW are a minimum legal length (MLL) (90 mm occipital carapace length (OCL)), maximum slot limit where no more than one individual can exceed 120 mm OCL, restricted fishing season (open season May–August), protection of berried females, bag limit (5), and a restriction of the fishery to waters outside listed trout waters which represents a significant part of their range (Department of Industry and Investment, 2010). In 2007, a review of the fishing regulations for Murray crayfish in NSW was recommended (Gilligan et al., 2007). This recommendation and the limited published biological and local information about Murray crayfish make them an appropriate species for such a study. To the extent that the three data sources explored here showed consistency, there would be support for the use of fisher LEK to inform fisheries management.

2. Materials and methods

2.1. Participant selection

Participants for this study were identified during field site visits. Recreational fishers who were fishing for Murray crayfish at river reserves and fishing locations within a 230 km reach of the River Murray between Hume Weir (36°06′27.88″ S, 147°01′50.70″ E) and Yarrawonga Weir (36°00′30.87″ S, 145°59′58.42″ E), NSW (Fig. 1) were approached during the 2009 open crayfish fishing season (May–August). This river reach was used as it is a popular recreational crayfish fishing area. The sample of fisher informants was stratified to reflect the variation within the group (Seidman, 1998) and achieve representation across the range of river access points, jurisdictions, week/weekends and days/nights (time of fishery effort) (Pollock et al., 1994). Thirty recreational fishers were interviewed and 30 separate fishers were issued with catch cards.

2.2. Fisher interviews

Thirty interviews were undertaken to ascertain fisher knowledge of Murray crayfish population dynamics and associated fishing regulations. Semi-structured interviews (see explanation below) were used to facilitate a flexible approach that could explore viewpoints as raised by participants. This method enabled one-off interviews to be undertaken over a period of time and added depth and richness to the information obtained. The purpose of the research was described to all informants prior to interviews taking place. Consent for participation and tape recording was

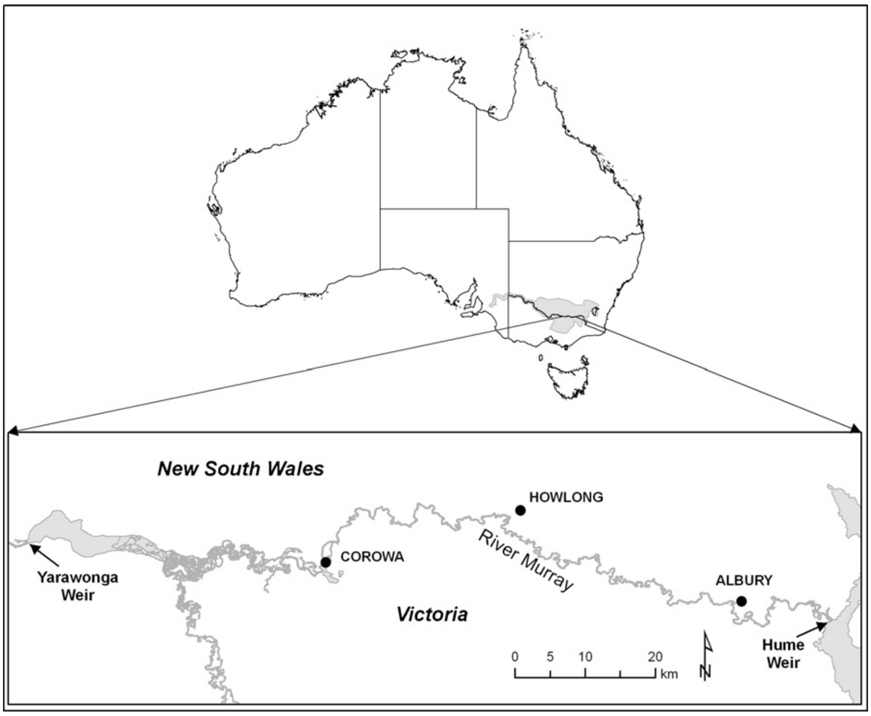

Fig. 1. Location of the likely natural distribution of Murray crayfish within Australia (Gilligan et al., 2007) and the reach of the River Murray between Hume Weir and Yarrawonga Weir in which fisher interviews, catch cards and scientific surveys were undertaken in 2009.

obtained before each interview. The duration of the interviews varied between 20 and 70 min. Where possible, interviews were taped and transcribed. Where informants preferred not to be recorded, extensive notes were taken during or immediately after the interview following the framework developed by Spradley (1980). An interview schedule was designed on the basis of six key questions (Table 1), as identified from issues prevalent in the research literature. The interviews were undertaken in a general conversation manner between the interviewer and informant. The interviewer attempted to gently guide the conversation rather than lead it and to incorporate the key questions, and where necessary, use probes (Table 1) to verify interpretations of responses provided by interviewees (Britten, 1995; Kvale, 1996).

Table 1
Summary of the fisher interview schedule.

Key points for fisher interview schedule	Probes
Fisher values	Why do you fish?
	What do you like about fishing?
	Views on fishing for future generations?
	Preferences for fishing?
	Where and how often do you fish?
Biological knowledge about Murray crayfish	Where found?
	Habitat and environmental preferences?
	Growth rates?
Knowledge and views on fishing regulations	What are current regulations?
	History of regulations?
	Views on current regulations?
Perceived compliance rates	Current compliance rates?
	Changes in compliance rates?
Sustainability of crayfish fishery	Is fishery sustainable?
	Why yes/no?
	How can it become sustainable?
Future management of crayfish fishery	Role of different stakeholders in management?
	Changes required? If yes, then detail?

2.3. Fisher catch cards

Thirty single-trip catch cards were issued at 22 sites to gather data on the size and sex ratios of Murray crayfish caught by fishers. On-site contact methods were used to decrease response errors (Pollock et al., 1994). For example, catch cards were explained and handed to fishers just before they began their crayfish fishing trip. Consent for participation was obtained before each catch card was handed out. As biases can result from misidentification of key species or misreporting length measurements, catch cards had in-depth information on how to identify and measure Murray crayfish (Pollock et al., 1994). Catch card data collection included the size, sex and number of crayfish caught and the date, time and location of the single fishing trip. Following the completion of the fishing trip, catch cards were collected from fishers or fishers returned the catch cards via mail.

2.4. Scientific field surveys

Scientific crayfish surveys were undertaken to obtain sex and size ratios for Murray crayfish. Crayfish surveys were carried out monthly from January 2009 to December 2009 in a 230 km fished reach of the River Murray between Hume Weir and Yarrawonga Weir, NSW (Fig. 1). Three fished river sites with easy boat and river access were sampled on three consecutive days at 9:00 (one site per day) each month. The sampling order of the three sites was randomised each month. These sites were located at Albury, Howlong and Corowa (Fig. 1). A standardised sampling protocol as recommended by Gilligan et al. (2007) was slightly modified and implemented as follows: single hoop nets of 700 mm diameter with a mesh size of 13 mm were used and baited with ox liver. The catch was recorded as catch-per-net-hour in order to standardise effort, with each net relocated after each haul. On each sampling day at each site twenty nets were set and checked hourly for a total of 3 h (60 hoop net hauls per site). Data recorded from each net set included date, position (latitude and longitude), flow, depth, distance from bank, time set, time retrieved and habitat characteristics. The catch data recorded included number of crayfish, occipital carapace length (OCL) (measured from the rear of the eye socket to the middle of the rear of the carapace) to the nearest 0.1 mm, sex, the maturity stage of adult females (stages 1–3) (Turvey and Merrick, 1997) and whether females were in berry (Gilligan et al., 2007).

2.5. Data analysis

For fisher interviews, the audio recordings and notes were transcribed verbatim to a spreadsheet. The interview transcripts were entered into and analysed using the software package QSR NVIVO 8. All data were thoroughly examined, and themes associated with crayfish biology (i.e. growth, size, sex, habitat) (Holdich, 2002) were identified and coded (King and Horrocks, 2010). These data were thoroughly searched for all divergent views to form a rich description of different factors related to Murray crayfish biology. The main themes relating to Murray crayfish biology which emerged were Murray crayfish size and sex ratios.

To compare the data collected through fisher interviews, fisher catch cards and scientific surveys on the size and sex ratios of Murray crayfish, two hypotheses were tested following the methods of Rochet et al. (2008). Using this method, fisher knowledge was assumed to be accurate and then compared against data obtained through the scientific surveys and catch cards. To make this comparison, fisher statements were coded to provide the input data for two testable hypotheses (Table 2). The hypotheses tested were true to fishers' statements and as such, alternative hypotheses were used (Rochet et al., 2008).

A two sample Kolmogorov–Smirnoff test (KS-test) was used to test whether there was a significant difference in the OCL frequencies between adult male and female crayfish in the data obtained through the fisher catch cards and scientific surveys. A KS-test was also used to analyse whether there were significant differences in the OCL for each sex in data from the fisher catch cards and scientific surveys. In each instance, the KS-test was used to determine if the two datasets differed significantly as this test does not make an assumption about the distribution of the data (non-parametric and distribution free). Size structure analysis (length-frequency histograms) was developed to determine Murray crayfish size and sex ratios in the data from the fishers catch data and scientific surveys. Chi-squared analysis was used to ascertain whether there was a difference between adult Murray crayfish sex ratios. Chi-square test for the comparison of two proportions (from independent samples) was used to determine whether sex ratios differed between fisher catch card and scientific survey data distributions. A *G*-test for goodness-of-fit was used to compare between the numbers of individuals found below and above 90 mm OCL in both the scientific and catch card data.

Table 2
Fishers' statements and associated hypotheses tested on Murray crayfish size and sex ratios in the River Murray in 2009.

H_o	
Catch dominated by crayfish < 90 mm OCL	Skew in sex ratio of larger crayfish (≥ 90 mm OCL) towards females
Fishers' statements	
We're only pulling up small crays under the limit now	*All been fished out, now nothing but small males and large females.*
Last year we got a whole heap of small crays but you never get the big males anymore	*25 years ago there were heaps of bigger crays, more bigger males, not as many big females as now*
Used to catch heaps around here, big ones too. Now there's only the small ones left that you can't take and not much of them around either	*25 years ago, we used to catch heaps of crayfish, day or night. There were a lot more large males and not so many large females, now there's many more large females than large males*
Have only caught two large males in the last two years	*There is definitely more larger females than males*
It's not sustainable, the big guys are getting wiped out and there are too many little guys	*Don't even get any larger males anymore, all that's left is the large females that you can't take anyway*
The numbers of crays has dropped heaps over the last 20 years and now we can't even catch one decent legally sized one	*Taking just the males could lead to problems. The number of large males has decreased and the large females increased*
There's not many of the big fellas around, need the bigger boys back in the river	*More big females than males, half females, half males when small, but the bigger ones almost always the females*
I have been catching Murray crayfish for over thirty years and the big hauls of legal sized crayfish are a thing of the past	*The current fishing regulations are not working, they're not sustainable. There's only large females and young ones left so people are now taking them*
Last year all we got was heaps of small ones, many of the size were 7–8 cm in length	*There are now a lot more bigger females than males. That can't last in the long term*
Legal sized males are hard to find as are legal females without eggs, very few large male crayfish caught	*These days we only catch small male crays and large berried females. Don't get any large males anymore*
Most of the males seem to be just under legal size	*There are only large females and small males left now*

3. Results

3.1. Fisher interviews

Of the fisher informants, 25 were male and five were female. The age of informants ranged from 25 to 65 years of age (mean 41 ± 7.1 S.E.). From the analysis of the interview data, the dominant themes relating to Murray crayfish population biology which emerged were the population size and sex ratios of Murray crayfish. These themes emerged from all interview topics including those related to values, biological knowledge, fishing regulations, perceived compliance rates, sustainability, and future management.

Under these main themes, two main observations were recorded by fishers in relation to their current catches: the majority of their catch comprised undersized (<90 mm OCL) crayfish; and there were more larger females (>90 mm OCL) than larger males (>90 mm OCL) caught under current fishing regulations (Table 2). These observations were rephrased as the catch is dominated by crayfish < 90 mm OCL (hypothesis one); and there is a skew in the sex ratios of larger crayfish (≥90 mm OCL) towards females (hypothesis two) and these new statements became the two hypotheses to be tested against fisher catch card data and scientific data (Table 2). Only one fisher commented that they had observed no difference in the abundance or sex ratios of males and female crayfish.

3.2. Fisher catch cards

Thirty fishers filled out individual catch cards (19 on site and 11 by mail returns). Of these, 23 were male fishers, seven were female fishers and the age of fishers ranged from 18 to 58 years of age (mean 34 ± 8.9 S.E.). Fisher catch cards reported a total of 198 Murray crayfish (115 females + 83 males) captured from May to August 2009. The OCL size frequencies of male and female crayfish were significantly different (KS-test, D = 0.21, P = 0.025) (Fig. 2). These differences stem from the significantly skewed male to female sex ratio (0.72:1) as revealed by chi-squared test of goodness-of-fit with Yates' continuity correction (only two cate-

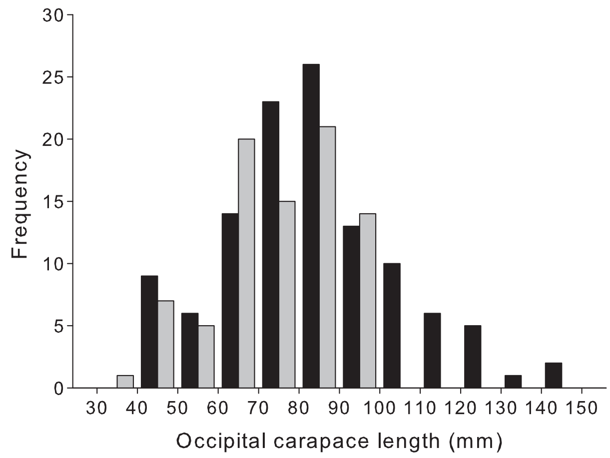

Fig. 2. Occipital carapace length (OCL) frequencies for male (grey bar) and female (black bar) Murray crayfish sampled by recreational fishers in 2009 in the River Murray, NSW (*N* = 198).

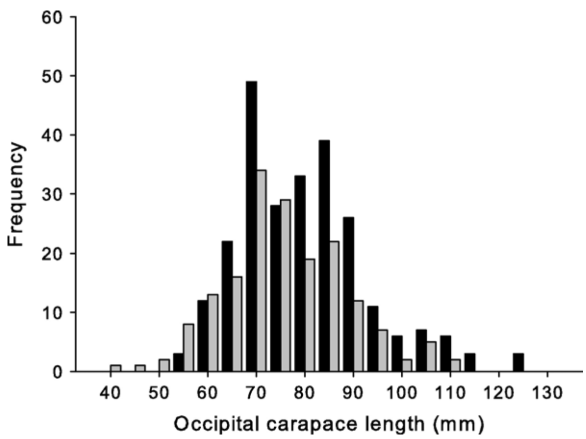

Fig. 3. Occipital carapace length (OCL) frequencies of male (grey bar) and female (black bar) Murray crayfish, from scientific field surveys in 2009 in the River Murray, NSW (*N* = 421).

gories present), (X^2 = 4.85, d.f. = 1, P = 0.028) and the significantly greater proportion of females greater than 90 mm OCL compared to males (male to female sex ratio is 0.36:1) (X^2 = 9.88, d.f. = 1, P = 0.001) (Table 3). From the total number of individuals captured (198), 75% of individuals were found to be <90 mm OCL (149 individuals). A significant difference was found between the number of individuals caught < 90 mm OCL and ≥90 mm OCL (*G*-test, *G* = 51.80, d.f. = 1, P < 0.0001).

3.3. Scientific field surveys

Totals of 421 crayfish (248 females + 173 males) were collected over 1280 fishing hours from January 2009 to December 2009. The OCL size frequencies of males and females were significantly different (KS-test, *D* = 0.15, P = 0.022) (Fig. 3). These differences stem from the significantly skewed male to female sex ratio (0.70:1) as revealed by chi-squared test of goodness-of-fit with Yates' continuity correction (only two categories present), (X^2 = 13.01, d.f. = 1, P = 0.0003) and the significantly greater proportion of females greater than 90 mm OCL compared to males (male to female sex ratio is 0.46:1) (X^2 = 7.35, d.f. = 1, P = 0.006), (Table 3). From the total number of individuals captured (421), 86% of individuals were found to be <90 mm OCL (361 individuals). A significant difference was found between the number of individuals caught <90 mm OCL and ≥90 mm OCL (*G*-test, *G* = 237.04, d.f. = 1, P < 0.0001).

Table 4
Hypotheses tested through scientific and fisher catch card data on Murray crayfish size and sex ratios in the River Murray in 2009.

	H_o supported by data	
H_o	Scientific data	Fisher catch cards
Catch dominated by crayfish < 90 mm OCL	Supported P < 0.0001	Supported P < 0.0001
Skew in sex ratio of larger crayfish (≥90 mm OCL) towards females	Supported P = 0.006	Supported P = 0.006

3.4. Fisher catch cards vs. scientific surveys

No significant difference was found between the OCL frequencies of either sex of crayfish recorded through fisher catch cards and scientific surveys (KS-test, males *D* = 0.17, P = 0.08, females *D* = 0.15, P = 0.057) (Table 3). No significant difference was found between sex ratios found through fisher or scientific surveys when all size classes were combined (X^2 = 0.17, d.f. = 1, P = 0.678) or in the crayfish size group ≥ 90 mm OCL (X^2 = 0.74, d.f. = 1, P = 0.391) (Chi-squared test for comparison of two proportions).

3.5. Fisher interviews vs. fisher catch cards and scientific surveys

Fisher observations that the catch is dominated by crayfish < 90 mm OCL (hypothesis one) and that there is a skew in the sex ratios of larger crayfish (≥90 mm OCL) towards females (hypothesis two), were supported by both fisher catch card and scientific data (Table 4). A significantly greater proportion of females ≥ 90 mm OCL compared to males was found through fisher catch cards (X^2 = 9.88, d.f. = 1, P = 0.001) and scientific surveys (X^2 = 7.35, d.f. = 1, P = 0.006), thus supporting hypothesis one (Table 4). Hypothesis two was also supported with a significantly greater number of crayfish found with <90 mm OCL as compared to with ≥90 mm OCL through fisher catch data (*G*-test, *G* = 51.80, d.f. = 1, P < 0.0001) and scientific data (*G*-test, *G* = 237.04, d.f. = 1, P < 0.0001) (Table 4).

4. Discussion

Our findings on fisher knowledge suggest that fishers recognised that the size structure of the population and the sex ratios were not as they would be naturally or as they had observed them to be in the past. Fishers suggested a skew in the sex ratios of larger crayfish (≥90 mm OCL) towards females from the normally expected 1:1 ratio (e.g. '*More big females than males, half females, half males when small, but the bigger ones almost always the females*', '*All been fished out, now nothing but small males and large females.*')

Table 3
Sex ratios of Murray crayfish obtained from fisher catch card results and scientific survey undertaken in 2009 the River Murray, NSW.

	Fisher catch cards				Scientific surveys				Fisher vs. scientific	
Sex ratio (OCL)	*M*	*F*	Ratio (*M*:*F*)		*M*	*F*	Ratio (*M*:*F*)		Difference	*P*-value
All size classes	83	115	0.72	1	173	248	0.70	1	2.00%	0.6781
≥90 mm	13	36	0.36	1	19	41	0.46	1	10.00%	0.3905

Previous studies have demonstrated that crayfish populations generally have an approximately even sex ratio. For example, *Astacus astacus* was found to have male to female sex ratios of 1.04:1 and 1:1 in Lake Gailintas (Lithuania) (Mackeviciene et al., 1999) and in L. Bronnen, Bavaria (Keller, 1999), respectively. Male to female 1:1 sex ratios were also found in Swiss populations of *Astacus leptodactylus* (Stucki, 1999) and in two native Mexican species, *Procambarus diguetti* and *P. bouvieri*, ratios were 1.04:1 and 0.99:1, respectively (Gutierrez-Yurrita and Latournerie-Cervera, 1999).

In Victorian river reaches where closures (1–7 years) to fishing had been introduced, the average sex ratios of Murray crayfish was 1:1 (49% females) in the Ovens River, 1:1.3 (56% females) at Lake Nagambie and 1:1.2 (55% females) at Wodonga Creek (Barker, 1992; Morison, 1988). Similarly, in Tasmania, a 1:1 sex ratio for an unfished population of Tasmanian giant freshwater crayfish (*Astacopsis gouldi*) was recorded (Horwitz, 1991).

Fishers also reported a tendency to now catch mainly undersized (<90 mm OCL) animals (e.g. '*The numbers of crays has dropped heaps over the last 20 years and now we can't even catch one decent legally sized one.*') Fishers observed that there was a difference between the current fished population dynamics and the population as it would be expected under natural unfished conditions. They based their expectations of a 'natural' population on what they had observed twenty to fifty years ago.

The main purpose of this paper was to determine whether recreational fisher LEK was a potentially reliable form of knowledge. To do this, we tested two hypotheses based on these fisher observations to ascertain the reliability of fisher LEK for Murray crayfish size and sex ratios in a recreationally fished reach of the River Murray, NSW. Past literature has shown that comparing LEK to scientific data can generally result in three possible results (Huntington et al., 2004a; Silvano et al., 2008). There could be significant differences between LEK and scientific data, the data between the two information sources may not be able to be compared, or a high comparability could be found between the two data sources confirming the reliability of the LEK (Silvano and Valbo-Jørgensen, 2008).

This study found no significant differences between the data obtained through fisher interviews and that obtained through fisher catch cards and scientific assessments. The two hypotheses tested based on fisher statements (the catch was dominated by crayfish < 90 mm OLC and there was a skew in the sex ratios of larger crayfish which are over the current minimum legal length (MLL) (90 mm OCL) towards females), were supported by both fisher catch cards and scientific data. There were also no significant differences found between fisher catch card data and scientific catch data on the sex and length distribution of Murray crayfish.

Previous studies have found conflicting results, with some studies finding a higher number of discrepancies between fisher and scientific perceptions (Ainsworth and Pitcher, 2005; Van Densen, 2001) and other studies finding fewer differences between the two data sources (Baigòn et al., 2006; Bergmann et al., 2004; Bray and Schramm, 2001; Ebbers, 1987; Maurstad, 2002; Maurstad and Sundet, 1998; Rochet et al., 2008). Conflicting results between fisher LEK and scientific studies do not however necessarily indicate a fault with either sources or a lack of reliability of fisher LEK. On the contrary, differences could provide two truthful but varied results. Such discrepancies between two sources of information can provide useful opportunities to investigate new biological data (Huntington et al., 2004a; Johannes, 1981; Johannes et al., 2000). The differences between the data sources could be a result from the differences in methods, time periods, experience and spatial scale from which each data source is collected. For example, whilst fisher LEK can be based on longer term local observations, acquired and strengthened by being passed down through generations, scientific data collection methods tend to cover a broader spatial scale, be of a shorter time frame and use a more systematic approach (Huntington et al., 2004b; Poizat and Baran, 1997).

Fisher catch cards have been used in previous studies to obtain data including catch per unit effort (*CPUE*), catch composition, and location and year round timing of catches by recreational anglers around the world (Mann et al., 2002). Indeed, Rochet et al. (2008) found that on some occasions, such as when acquiring information on yields or lengths of driftnets, gathering fisher LEK was easier and faster than gathering scientific data. However, in recreational fishing, the data feedback loop is often poor or non-existent. Catch rates and fisher observations of changes in populations are generally not recorded in an ongoing and systematic approach to inshore recreational fisheries management. This is in spite of the evidence in commercial fisheries that these data can provide important information on ecosystem changes and can provide early detection of system changes. Recreational fishers are seldom required to provide fishing trip reports or catch rates and generally do not have an opportunity to provide their catch data and observations into the management of fisheries. Occasionally this occurs through voluntary surveys (Gerdeaux and Janjua, 2009; Mann et al., 2002).

Fisher LEK can provide long term and up-to-date information (Rochet et al., 2008) and can often be the first to detect an environmental problem or change or suggest when regulations need to be introduced or changed (Alexander, 2008). Here we propose an integrated management approach where changes in fisheries could be detected through fishers in the first instance and passed onto management. Fisher LEK could be used to improve fishery management by helping to identify ecosystem changes, which can then be scientifically monitored and assessed and the data fed back into management to help enable proactive and efficient decisions. For example, from our study, the high compatibility of the data from fisher interviews, fisher catch cards and scientific surveys suggests that fisher information could be used as a reliable source of information to assist management. The changes in size and sex ratios in Murray crayfish as observed by fishers could be used as early indications which could guide specific scientific monitoring. Such monitoring could then be specifically tailored for management needs and would enable time and money savings and provide early indication to managers of changes in fisheries stocks or ecosystems and allow proactive management. This would be especially important in boom-and-bust fisheries where a fishing resource could be depleted within a couple of years without proper management intervention (Boyer et al., 2001).

5. Conclusion

The use of fisher knowledge in fisheries management has been long been debated, with scientists and managers concerned about the reliability of fisher LEK. This study tested the reliability of fisher LEK for Murray crayfish in the River Murray, Australia, by comparing data obtained through three different methods: fisher interviews, fisher catch cards and scientific surveys. The three data generating methods identified the same significant difference between the numbers of individuals found below 90 mm OCL and above 90 mm OCL; and significant skews in the size and sex ratios of larger crayfish towards females. The strong compatibility of the three data generating methods indicated that recreational fisher LEK could be a reliable data generating source which could detect population changes at an early stage and enable proactive and efficient management.

Acknowledgements

We are grateful to all the fishers who by willingly sharing their knowledge, views and catch data, made writing this paper possible. The Institute for Land Water and Society for financial support for this research. Nick Whiterod for technical and field assistance. Simon McDonald for technical assistance. Stacey Kopf, Rhonda Sinclair and Colin, Dot, Beck and Dave Whiterod and Calum Zukowski for field assistance. Our thanks also to two anonymous reviewers for comments on a draft manuscript. This work was conducted under a Charles Sturt University Wildlife Research Ethics Permit 07/142 and NSW Fisheries permit P08/0017. The Charles Sturt University Ethics in Human Research Committee in accordance with the National Statement on the Ethical Conduct in Human Research approved the interviews and fisher catch cards. Ethics number: 2007/322.

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