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Assessing the cost-effectiveness of a fish stocking program in a culture-based recreational fishery

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ABSTRACT

Fish stocking is commonly used to enhance, create and maintain recreational fisheries that typically generate significant economic activity. As fish stocking can be highly popular with stakeholders and is often a large economic investment, it should be evaluated to ensure it provides adequate return and is an effective use of fisheries management funds. In this study we evaluated the cost-effectiveness of a fish stocking program for non-native salmonid species of brown trout, rainbow trout and Chinook salmon at Lake Purrumbete, south-western Victoria, Australia. As Lake Purrumbete has no natural recruitment of these stocked species, it is described as a culture-based or put-grow-and-take recreational fishery. The average annual cost of the stocking program between 2007 and 2014 was estimated at $86,646 (2014 $AUD) per year including aquaculture production and transport of fish to release. A stratified random angler creel survey between December 2013 and 2014 was used to estimate visitation to the stocked fishery at 5447 fishing days, with average observed angler expenditure of $72 per person per day and the percentage of anglers satisfied with their fishing experience at 76%. The observed economic expenditure (market value) associated with the stocking program was estimated to be $351,741 with a 1:4 cost-benefit ratio return on stocking investment. The additional willingness to pay, or non-market recreational value of the stocked fishery, was estimated using the travel cost method to be an additional $84 – $291 per person per day with a 1:5 to 1:16 cost-benefit ratio return on stocking investment. This study demonstrates that fish stocking can provide a substantial return on investment, yielding significant economic and social benefits, and we recommend evaluations be conducted independently for stocking programs to assist in the responsible management of resources, maximise our understanding and subsequent benefits.

1. Introduction

Recreational fishing can have multiple benefits, co-benefits and effects on the socioecological system. It has been demonstrated to be culturally significant and a generator of considerable social, ecological and economic values (Arlinghaus et al., 2002, 2015; Cowx et al., 2010). For recreational fisheries to best provide these benefits, fisheries managers require an understanding of angler behaviour and fisheries management tools (Arlinghaus et al., 2013; Cooke et al., 2014). Studies that evaluate the cost-effectiveness of fisheries management tools are essential for optimising fisheries management outcomes and understanding the benefits derived from recreational fishing.

Fish stocking is a fisheries management tool that particularly requires cost-effectiveness evaluation, due to its common application and heavy investment both economically and socially. Economic investment is seen in the large sums of often public money used to annually stock billions of fish worldwide (Welcomme and Bartley, 1998; Halverson, 2008; Lorenzen, 2014). In some cases, stocking programs are reported to constitute the

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majority of fisheries management expenditure over other management tools (Epifanio 2000). Social investment is seen in the incredible popularity of fish stocking with key stakeholders and the belief that stocking fish is a 'fix all' or panacea of fisheries management (Hilborn, 1999; Hasler et al., 2011; Van Poorten et al., 2011). The considerable investment in fish stocking requires stocking practices to be evaluated to ensure they provide acceptable return on investment of fisheries management funding.

Key papers on responsible fish stocking highlight the need for stocking programs to demonstrate cost-effectiveness. Cowx (1994) and Welcomme and Bartley (1998) stated that the economic influence of stocking programs must be evaluated to justify expenditure. Lorenzen et al. (2010) provided an update to the responsible approach to stock enhancement first published by Blankenship and Leber (1995) and included the additional element to assess both the economic and social benefits and expenditure of enhancement to decide whether stocking programs should commence or continue, and how they should be operated. The need to evaluate cost-effectiveness of fish stocking has also been advocated in government stocking policies (Leber et al., 2005). Economic benefits can be defined in terms of market and non-market values, however considering satisfaction is the ultimate product of the recreational fishing experience (Holland and Ditton 1992; Miko et al., 1995; Arlinghaus 2006), it is important that fish stocking is also assessed for social benefits in angler satisfaction. Despite the generally accepted requirement for cost-effectiveness evaluation of fish stocking and the long history of recreational fish stocking worldwide, examples of rigorous evaluations are rare in the literature. Such knowledge could inform whether fish stocking is an economically and socially effective fisheries management tool.

The travel cost method is a well-established technique that enables the estimation of the value of non-market-related goods such as fishing (Bateman 1993; Pollock et al., 1994). It is based on the premise that the costs incurred in visiting a site reflect the utility or expected satisfaction gained from visiting the site, allowing the recreational value of the site to be measured in dollars as a proxy for utility (Whitten and Bennett 2002; Perloff et al., 2014). Increasingly, this method is being used to estimate the recreational value of fisheries (Shrestha et al., 2002; Ezzy et al., 2012; Pascoe et al., 2014), including stocked inland fisheries (Rolfe and Prayaga 2007; Lothrop et al., 2014). Providing the value of the recreational fishing experience can be attributed to stocking, the travel cost method may also provide a potentially useful alternative method to determine the benefits of stocking and assist with assessing it's cost-effectiveness.

The objective of this study was to evaluate the cost-effectiveness of a fish stocking program in a culture-based recreational fishery for non-native salmonid species of brown trout, rainbow trout and Chinook salmon at Lake Purrumbete, south-western Victoria, Australia. We defined a 'cost-effective' stocking program as one having the combined or individual benefits from the stocking program, exceed the costs required to operate the stocking program. Thus to address our objective, we compared the costs of stocking in hatchery production and transport to release, with both the market and non-market benefits of the stocking program, measured using the travel cost method and an angler creel survey. This study will be of use to fisheries managers and fishers in guiding effective use of funds to enhance recreational fishing, given limited resources.

2. Material and methods

2.1. Study system

Lake Purrumbete is a freshwater lake located in south-western Victoria, Australia (Timms, 1976; Fig. 1). It is one of a series of highly productive volcanic maar lakes in the area (Ollier and Joyce 1964; Laurensen et al., 2012). Since at least 1879, non-native salmonid species such as rainbow trout (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*), brown trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*) have been annually stocked into Lake Purrumbete creating a popular and productive recreational fishery (Barnham 1997; Department of Primary Industries, 2008; Hunt et al., 2014). As there is no known natural reproduction of salmonid species in the fishery, Lake Purrumbete is described as a culture-based or put-grow-and-take recreational fishery (Hunt et al., 2014).

2.2. Stocking costs

Whilst fish stocked into Lake Purrumbete are usually derived from the Victorian State Government owned Snobs Creek hatchery, due to the difficulty in estimating the cost of assets such as land, water, buildings, facilities and machinery (Johnson et al., 1995), cost of fish production was determined by gaining purchase price quotes from 16 local commercial salmonid hatchery producers who commonly supply fish for stocking in Victoria. All monetary figures referred to from hereafter are in 2014 Australian dollars (AUD), assuming a constant 3% annual price increase over the time period. Quotes were obtained to encompass the four different species of salmonids stocked and the variety of sizes at release. These price quotes were assumed to cover costs of facilities, electricity, feeding, disease treatment, staff labour time and return on equity. Cost of transport to release was calculated by adding distance travelled, overnight stay accommodation, staff hours, meals and expense expenditure. As the stocked salmonid species in Lake Purrumbete can have variable longevity in the fishery of up to seven years (T. Hunt unpublished data) and thus the benefits of stocking can persist over this time, to compare the total annual costs with benefits of stocking, the average cost of stocking per year was calculated for seven years between 2007 and 2014 leading up to the 2013/14 angler creel survey.

2.3. Angler creel survey

Recreational angling expenditure data were collected from an access point (*on-site*) creel survey, whereby anglers were intercepted and interviewed as they embarked or returned from their fishing trip at Lake Purrumbete. Considering Lake Purrumbete has just one major access point (southern boat ramp), a standard access point creel survey was applied with survey days stratified using a two stage stratified random sampling strategy (Robson, 1991; Malvestuto, 1996). Data of ninety-one survey days were collected between 1 December 2013 and 30 November 2014, equating to approximately 25% coverage of the one year (365 days) sampling frame. Days were primary sampling units (PSUs) and were stratified into weekdays and weekend/public holidays. Days within a strata were selected randomly with equal probability and without replacement (same day cannot be selected twice for sampling). Morning and afternoon interview sessions (shifts) within a day were secondary sampling units (SSUs). Only one shift (either morning or afternoon) was selected randomly within a day. Strata effort proportions (sampling intensity within strata) were determined based on local knowledge interviews with two fisheries compliance staff, two regular anglers of Lake Purrumbete and the owners of the local caravan park and tackle store. Each interviewee was asked what they believed was the recreational fishing effort distribution between weekdays and weekends/public holidays, morning and afternoon. The interviews found that effort was considerably more on weekends than weekdays, which is consistent with effort proportions found in other recreational fishing studies (Hoenig et al., 1989; Pollock et al., 1994). Thus in order to improve the precision of the total effort estimates, our weekend strata was sampled more frequently (70% of the sampling days were allocated for weekend

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