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Investigating bias in recreational fishing surveys: Fishers listed in public telephone directories fish similarly to their unlisted counterparts

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ABSTRACT

Several recent offsite recreational fishing surveys have used public landline telephone directories as a sampling frame. Sampling biases inherent in this method are recognised, but are assumed to be corrected through demographic data expansion. However, the rising prevalence of mobile-only households has potentially increased these biases by skewing raw samples towards households that maintain relatively high levels of coverage in telephone directories. For biases to be corrected through demographic expansion, both the fishing participation rate and fishing activity must be similar among listed and unlisted fishers within each demographic group. In this study, we tested for a difference in the fishing activity of listed and unlisted fishers within demographic groups by comparing their avidity (number of fishing trips per year), as well as the platform used (boat or shore) and species targeted on their most recent fishing trip. 3062 recreational fishers were interviewed at 34 tackle stores across 12 residential regions of Queensland, Australia. For each fisher, data collected included their fishing avidity, the platform used and species targeted on their most recent trip, their gender, age, residential region, and whether their household had a listed telephone number. Although the most avid fishers were younger and less likely to have a listed phone number, cumulative link models revealed that avidity was not affected by an interaction of phone listing status, age group and residential region ($p > 0.05$). Likewise, binomial generalized linear models revealed that there was no interaction between phone listing, age group and avidity acting on platform ($p > 0.05$), and platform was not affected by an interaction of phone listing status, age group, and residential region ($p > 0.05$). Ordination of target species using Bray-Curtis dissimilarity indices found a significant but irrelevant difference (i.e. small effect size) between listed and unlisted fishers (ANOSIM $R < 0.05$, $p < 0.05$). These results suggest that, at this time, the fishing activity of listed and unlisted fishers in Queensland is similar within demographic groups. Future research seeking to validate the assumptions of recreational fishing telephone surveys should investigate fishing participation rates of listed and unlisted fishers within demographic groups.

1. Introduction

The need for robust methods of monitoring recreational fisheries is increasing, as their contribution to global catch faces growing scrutiny (McPhee et al., 2002; Coleman et al., 2004; Cooke and Cowx, 2006). Offsite methods, those that survey the recreational fishing population through offsite sampling frames, are considered the most feasible and cost-effective for fisheries that are diverse and operate over large spatial areas (Hartill et al., 2012). Registries of fishing licence holders are a preferred sampling frame when available, either on their own or, if some population sectors are excluded from licensing, as part of a dual-frame approach (NRC, 2006; ICES, 2010). Licence registries have been utilised in many surveys worldwide, including in Denmark (Sparrevohn and Storr-Paulsen, 2012), Germany (Strehlow et al., 2012), the Basque Country (Zarauz et al., 2015), Canada (Fisheries and Oceans Canada, 2012), and Australia (Lyle, 1999; Melville-Smith and Anderton, 2000; Lyle et al., 2005; Currie et al., 2006; de Lestang et al., 2012; Ryan et al., 2013; Ryan et al., 2015). For unlicenced populations, surveys can use various methods to probabilistically sample recreational fishers. Postal area mail-outs were used in recent surveys in Finland (ICES, 2010) and England (Armstrong et al., 2013),

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while New Zealand opted for a meshblock door-knocking approach (Wynne-Jones et al., 2014). Other countries, including Denmark (Sparrevohn and Storr-Paulsen, 2012), France (Herfaut et al., 2013; Rocklin et al., 2014), the United States (NOAA Fisheries, 2015a), and Australia (Henry and Lyle, 2003; Lyle et al., 2005; Jones, 2009; Lyle et al., 2009; Taylor et al., 2012; West et al., 2012; Lyle et al., 2014; Webley et al., 2015), have used telephone directories as the sampling frame in recreational fishing surveys.

The choice of sampling frame depends on various factors, with coverage arguably the most important. Unlike licence registries which, generally speaking, provide high levels of coverage of the recreational fishing population, the coverage provided by alternative frames for unlicensed populations is more problematic. Historically, telephone directories have provided good coverage of populations, but the rising prevalence of mobile-only households has tended to reduce coverage because mobile phone listings are often unavailable, uncommon, or cost-prohibitive (Ehlen and Ehlen, 2007; Link et al., 2007; Lee et al., 2010; Busse and Fuchs, 2012). This has raised valid concerns about 'coverage bias', which refers collectively to the biases associated with total coverage rate (i.e. proportion of the population covered by the sampling frame) and differences in the variables of interest between covered and non-covered populations (Blumberg and Luke, 2009; Lee et al., 2010). With regards to coverage rate, Australian telephone users are rapidly shifting towards mobile-only; the number of mobile-only adults (18+ years) increased by 33.2% in the 12 months prior to June 2014, representing 27% of the adult population (ACMA, 2014). In the United States, the coverage rate is even lower, with almost half of all adults serviced only by mobile phones (Blumberg and Luke, 2015). This poor coverage has, in part, initiated the transition of NOAA's Marine Recreational Information Program away from its long-running Coastal Household Telephone Survey in favour of postal surveys, which are thought to be less subject to coverage bias due to higher response rates (NRC, 2006; Andrews et al., 2014; NOAA Fisheries, 2015b).

An important consideration in coverage bias is that coverage rates differ among socio-demographic groups, giving rise to the distinct traits of covered and non-covered populations (Blumberg and Luke, 2007; Link et al., 2007; Blumberg and Luke, 2009; Shebl et al., 2009; Hu et al., 2011; Busse and Fuchs, 2012). Age is one indicator strongly associated with telephone services, with younger people more likely to be mobile-only. As at June 2014, 51% of Australians aged 25–34 years lived in a household without a landline, compared with just 16% of people aged 55–64 years and 7% of people aged 65+ years (ACMA, 2014). Moreover, there is evidence from the state of South Australia that telephone listing is less common in urban areas (Dal Grande and Taylor, 2010). Likewise, mobile-only Europeans are more likely to be young, high earning city dwellers, although coverage biases appear to differ somewhat among countries (Busse and Fuchs, 2012; Mohorko et al., 2013). In the United States, low-income adults are more likely than higher-income adults to be mobile-only (Hu et al., 2011; Blumberg and Luke, 2015), whilst in California specifically, the mobile-only population disproportionately comprises young, single males relative to the landline population (Lee et al., 2010). Evidently, raw samples collected in telephone surveys will be inherently biased towards certain population sectors and their characteristics. Adopting a dual-frame approach (i.e. incorporating both landline and mobile phone listings) is one mechanism to potentially reduce these biases, but its costs and logistics, such as accounting for households that have both landline and mobile phones, have to date made the approach difficult to implement (Link et al., 2007; Georgeson et al., 2015). Moreover, mobile phone surveys may have lower response rates, possibly due to call screening, and participants are more likely to be distracted during interview (Hu et al., 2011). It is necessary, therefore, that the biases associated with landline telephone surveys are appropriately recognised and adjusted during data analysis.

As applied in Australia, telephone surveys of recreational fishing typically employ a two phase process, combining estimates of fishing participation rates (phase 1) with quantitative catch data of fishers recruited into the survey (phase 2). Phase 1 sampling is stratified regionally, and households listed in a public directory are telephoned at random and, if eligible (i.e. a household intending to fish during the survey period), recruited into the survey. The operation of phase 2 has seen amendments since the method's inception in New Zealand in the early 1990s (Hartill et al., 2012). Today it involves a telephone-diary method where trained interviewers telephone the recruited fishers regularly to record data. Based on an earlier survey in the Northern Territory, this approach was refined for Australia's first nationwide survey of recreational fishing in 2000–2001 (Lyle et al., 2002). Its major benefits come as a result of frequent interviewer contact, such as improved data precision, lowered recall bias, and higher participant retention rates.

After a telephone survey's completion, data from phases 1 (participation rate) and 2 (fishing activity) are expanded to make population-wide estimates of fishing catch and effort using peer-reviewed statistical techniques (Lumley, 2004; Lyle et al., 2010; Lumley, 2014). This expansion is based on known demographic benchmarks (e.g. national censuses), whereby a weighting is applied to each fisher or fishing household according to their demography (age, gender and residential region). Implicit in the validity of the expansion process is that coverage bias is corrected. It is assumed that, within their demographic group, households with a listed phone number (listed fishers) are representative of all households in the population, including those without a listed phone number (unlisted fishers), with regards to the variables of interest, namely recreational fishing participation rate and fishing activity. Testing for a difference in these variables between listed and unlisted fishers is important for ensuring the validity of offsite recreational fishing surveys (Georgeson et al., 2015).

The validity of the assumption about fishing activity was investigated in two onsite (boat ramp) surveys in Australia wherein the fishing activities of listed and unlisted fishers were compared. In the state of Victoria, Ryan et al. (2009) found no difference in the catch rate of snapper (*Pagrus auratus*) among listed and unlisted licenced fishers. Similarly, in Queensland, Taylor et al. (2012) found no difference in recalled fishing avidity (number of annual fishing trips) between listed and unlisted fishers. These studies did not test the assumption that fishing participation rate was similar among listed and unlisted households, possibly because they sampled at boat ramps which would not provide adequate access to non-fishers. Whilst these studies provide preliminary support for the assumption that fishing activity is similar among listed and unlisted fishers, these results are limited because they focused only on a single species or population sector (i.e. boat-based fishers), and did not compare within demographic groups.

Recreational fisheries in Queensland, Australia have for several years been monitored through telephone surveys that use landline telephone directories as a sampling frame (Henry and Lyle, 2003; McInnes, 2006, 2008; Taylor et al., 2012; Webley et al., 2015). The aim of this study was to test the hypothesis that, within demographic groups, phone listing status has no effect on fishing activity, i.e. that there is no coverage bias. We tested coverage bias by comparing, within demographic groups, the fishing activities of listed and unlisted fishers interviewed at tackle stores across the state of Queensland. Our primary measure of fishing activity was stated (recalled) fishing avidity, in addition to the platform use (boat/kayak or shore) and target species of each fisher's most recent fishing trip.