An assessment of the 'bus-route' method for estimating angler effort

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Introduction

In 1989, Robson and Jones published a paper describing a new survey method designed to estimate recreational fishing effort on large bodies of water having a high number of access sites. They called their survey design the 'bus-route' method and its advantages are its logistic ease and relatively low cost, since only limited personnel and equipment are required for its implementation.

The basic idea of the bus-route method is for a survey agent to travel by car around the body of water in a cyclic manner, stopping at all fishing access sites along the way. The agent remains at each access site for a predetermined amount of time and, while there, records the length of time that each boat trailer (i.e fishing trip) is present (Figure 1). If a fishing party returns during the waiting time, an interview with the returning fishers is conducted to estimate such things as species composition and catch rate. The amounts of time that trailers are observed are then used to obtain an estimate of total fishing effort on that day.

The purpose of this paper is firstly to provide a simple example to show how this estimator for total fishing effort is derived, and then to look at one way in which the bus-route method is being applied in a South Australian fishery. For a more detailed explanation of the bus-route survey method see Robson and Jones (1989).

Simplest case

Here we just observe if a trailer is present or not when our observation point is chosen at random in [0,T] (Figure 2). We define Y_i to be a random variable such that

$$Y_i = \begin{cases} 1 & \textit{observe boat trailer} \\ 0 & \textit{otherwise} \end{cases}$$

and thus arrive at the following probability distribution:

Y_i	1	0
$Pr(Y_i)$	$\frac{D_i}{T}$	$\frac{T-D_i}{T}$

From the above probability distribution, the survey agent's expectation of observing an angler's trailer will be:

$$E(Y_i) = 1 \star \frac{D_i}{T} + 0 \star \frac{T+D_i}{T}$$
$$= \frac{D_i}{T}$$

Hence, the length of a given fisher's trip, D_i, can be arrived at through the expected value of observing this trip multiplied by the length of the fishing day:

$$E[TY_i] = D_i$$

We have now arrived at a probability of observing a boat trailer which relates to the length of the fishing trip, D_i.

Waiting times

This theory may now be extended to include the survey agent not only observing whether or not a boat trailer is present, but remaining at the access site for a certain length of time and recording the period of observation of each boat trailer (Figure 3).

Let X_i = length of time that angler's trailer is observed

and w = waiting time for survey agent at ramp.

Suppose that the survey agent arrives at a random time $t \in [0,T]$, then X_i will vary according to the time that the survey agent arrives at the access site:

$$\begin{aligned} t = 1 \quad & E[X_i | 0 < t < a_i - w] = 0 \\ 2 \quad & E[X_i | a_i - w < t < a_i] = \frac{w}{2} \\ 3 \quad & E[X_i | a_i < t < d_i - w] = w \\ 4 \quad & E[X_i | d_i - w < t - d_i] = \frac{w}{2} \\ 5 \quad & E[X_i | d_i < t < T] = 0 \end{aligned}$$

Associated with each of these expected values of the length of observed time, is a probability that the agent will be at that access site at time t:

$$\begin{aligned} t = 1 \quad & Pr(0 < t < a_i - w) = \frac{a_i - w}{T} \\ 2 \quad & Pr(a_i - w < t < a_i) = \frac{w}{T} \\ 3 \quad & Pr(a_i < t < d_i - w) = \frac{D_i - w}{T} \\ 4 \quad & Pr(d_i - w < t < d_i) = \frac{w}{T} \\ 5 \quad & Pr(d_i < t < T) = \frac{T - d_i}{T} \end{aligned}$$

Combining these probabilities and expected values, we arrive at the expected length of observation of a trailer, $E[X_i]$, given a fisher's trip of duration D_i:

$E[X_i]$ = Pr (agent at site) * E [X_i | angler at site]

$$= \left(0 \star \frac{a_i - w}{T}\right) + \left(\frac{w}{2} \star \frac{w}{T}\right) + \left(w \star \frac{D_i - w}{T}\right) + \left(\frac{w}{2} \star \frac{w}{T}\right) + \left(0 \star \frac{T - d_i - w}{T}\right)$$

$$= \frac{w}{T}\left(\frac{w}{2} + D_i - w + \frac{w}{2}\right)$$

$$= \frac{w}{T} D_i$$

Hence:

$$E\left(\frac{T}{w}X_i\right) = D_i$$

The D_i and its associated X_i relates to a particular fishing party utilising a particular access site. To arrive at the total angler effort for the sampling day, it is necessary to sum up all lengths of time that trailers are observed at all access sites within the survey area. If waiting times (w) at all access sites are the same, then total angler effort is given by:

$$TE = \frac{T}{w}\sum X_w$$

A practical example

The bus-route method is currently being applied in South Australia to undertake a roving creel survey of the recreational boat fishery in Gulf St Vincent and the adjacent waters of Investigator Strait and Backstairs Passage (Figure 4).

This represents a body of water of approximately 7000 square kilometres accessed by about 20 major and 35 minor boat ramps. The total perimeter of the fishery, and thus distance to be covered by survey agents, is roughly 500km.

It was therefore necessary to subdivide this area into more manageable units by grouping the boat ramps into a number of individual bus-routes such that a circuit of each route could be covered in a working day. The particular geography and distribution of ramps around Gulf St Vincent allowed the delineation of four routes containing five to seven ramps each. Each complete circuit is, on average, 200 km long (Figure 5).

Next, it was necessary to define Δ or the length of the fishing day. This will obviously vary depending on the time of year. In summer, when the days are finer and longer, people will stay out fishing later. The distribution of fishing effort throughout the day was known from a pilot study undertaken the previous year, so fishing day lengths were selected such that no more than 5% of effort was missed completely. This led to the selection of a 9 hour fishing day in winter (0900–1800) and a 12-hour fishing day in summer (0700–1900). This was divided into two shifts (δ) of six hours or eight hours respectively with an overlap period in the middle of the day. These shift times corresponded to the amount of time taken to accomplish a complete circuit of one 'bus-route', thus, for our purposes, $T = \delta$ (symbols from Robson and Jones 1989).

With these shift lengths fixed, the four routes were driven in order to ascertain precise travelling times between ramps. The remainder of the shift time was distributed as waiting times at ramps. As an example, for Route 2 in summer (T = 480 minutes), the total travelling time is 150 minutes and waiting times, which range from 30–80 minutes depending on the importance of the ramp, sum to 330 minutes (Figure 6).

The survey is to be carried out over a full year and this period has been divided into six temporal strata. Sampling frequencies within each stratum were calculated according to pilot data estimates of means and standard deviations for harvest such that coefficients of variance (CVs) were less than 10%. This resulted in 12 survey days per month in winter rising to a maximum of 26 days per month during autumn (April and May) for all four routes combined.

The accuracy of the method was tested using a set of census data of *known* fishing effort collected at a number of boat ramps which were kept under 24-hour surveillance. These data were used in 12 000 computer simulation trials which generated estimates of effort using the bus-route method of sampling under a variety of combinations of Δ, δ and T at different sampling frequencies.

Results showed that the method yielded estimates that were within 10% of the actual value using sampling frequencies as low as 10 days per stratum. The method was also shown to be precise and unbiased.

The cost of the survey is in the region of $12–14 000 per month. This covers salaries for four staff (1 research officer and 3 technical services officers), vehicle hire and travel expenses. In 1995 the survey will continue into Spencer Gulf which is approximately half as big again as Gulf St Vincent. Preliminary reconnaissance suggests that this area can be covered by six individual bus routes and that costs should be only slightly higher.

Reference

Robson, D. and C. M. Jones (1989). The Theoretical Basis of an Access Site Angler Survey Design. *Biometrics* 45, 83–98.

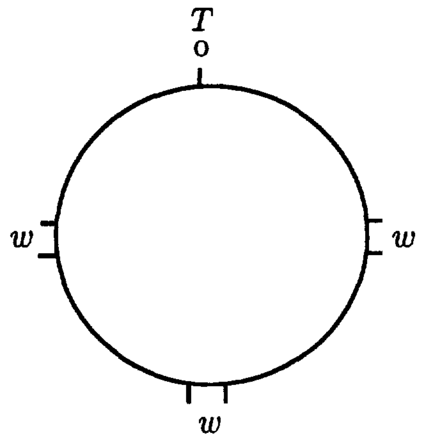

Figure 1. A pictorial representation of a circuit around a fishery which takes time T to travel and consists of three access sites with equal waiting time, w.

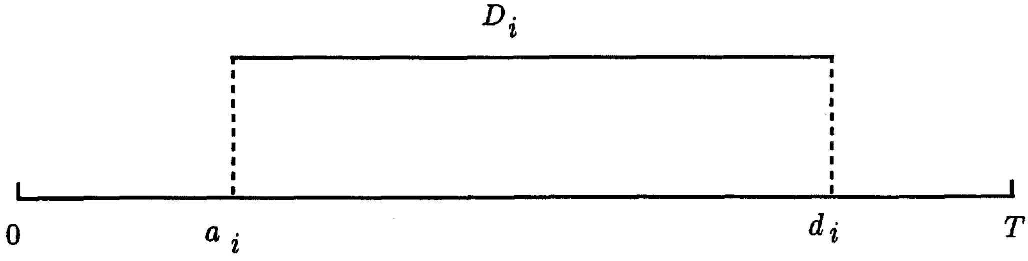

Figure 2. Instantaneous waiting time selected at random in [0,T].

In this example

T = length of fishing day ≡ length of survey day

D_i = length of fisher's trip

a_i = arrival of fisher i

d_i = departure of fisher i

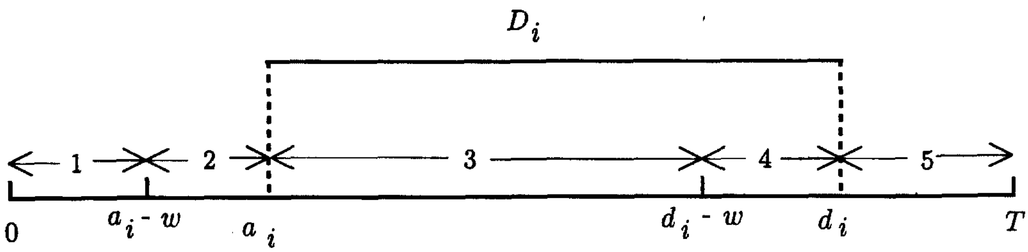

Figure 3. Effect of a randomly located waiting time on the duration of the agent's encounter with the trailer.

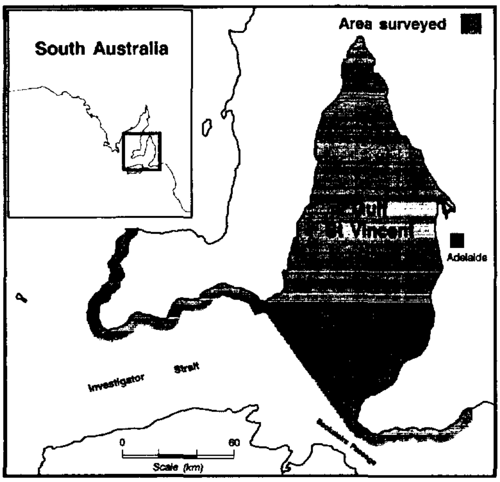

Figure 4. Location of the fishery being surveyed by means of the 'bus-route' method in South Australia.

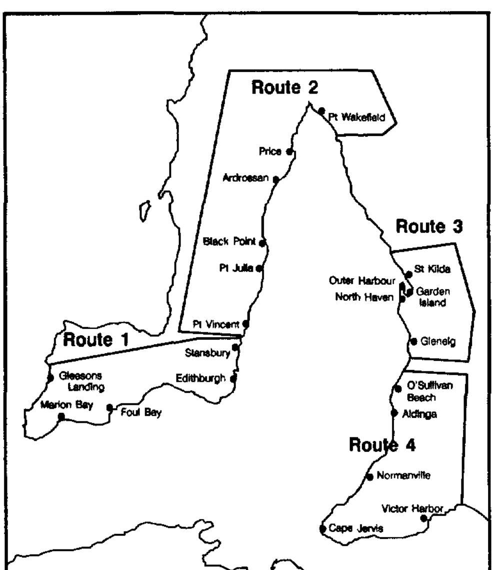

Figure 5. Subdivision of Gulf St Vincent fishery into individual 'bus-routes'.

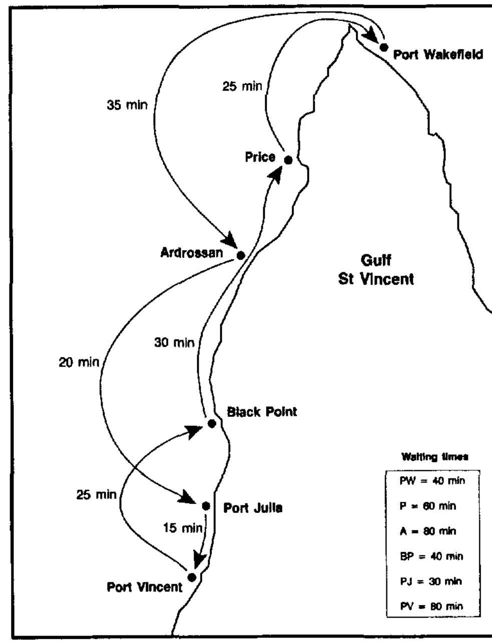

Figure 6. 'Bus-route' 2 showing circuit design, waiting times at ramps and travel times when T = 8 hours.