Population Estimate for the Right Whales off Peninsula Valdes, Argentina, 1971–1976

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ABSTRACT

Identifications of right whales from photographs of their callosity patterns were used to make mark-recapture estimates of the population wintering off Peninsula Valdes, Argentina. Between 1971 and 1976 there were an estimated 450–600 individuals coming to Valdes, of which 120–220 were known females. The population is estimated to have been increasing at 6.8% per year (95% CL 0.0–13.6%). For the total population, the estimates may be biased to the low side because of a tendency for some individual whales to be more frequently photographed than others.

INTRODUCTION

Over the past 12 years the right whales (*Eubalaena australis*) which winter off Peninsula Valdes, Argentina (42.5° S, 64° W) have been the subjects of an extended study (Payne, 1972; 1976). One of the techniques developed during this research has been the individual identification of living right whales from photographs of their callosities (Payne, Brazier, Dorsey, Perkins, Rowntree and Titus, 1983). These callosities, which have proved to remain sufficiently constant for reliable identifications over periods of years, are a useful tool for the study of right whale behaviour and population biology (Payne *et al.*, 1983).

Photographic identifications of humpback whales (*Megaptera novaeangliae*) from fluke photographs have been used to make population estimates for the humpback whales in the northwest Atlantic, by the application of mark-recapture methods (e.g. Whitehead, 1982).

In this paper we present a mark-recapture analysis of the identifications of the right whales off Peninsula Valdes.

METHODS

The right whales occupying the waters near Peninsula Valdes were identified from photographs of their callosity patterns taken from a fixed-wing aircraft between June and December each year from 1970 to 1977. Each flight, or group of flights, was planned to cover all the major areas of whale distribution off Peninsula Valdes, and identifying photographs were taken in each area. A total of 52 airflights was made, 44 between September and November. The number of right whales at Peninsula Valdes builds up slowly from May until mid-August, and then stays fairly constant until early October, after which it drops suddenly (Payne, 1986). A detailed description of the flights, equipment used, and identification techniques is given by Payne *et al.* (1983).

First-year right whale calves, although often identifiable, were not considered for this analysis. Females could often be distinguished from the consistent presence of a calf, or, occasionally, from behavioural characteristics (Payne and Dorsey, 1983). Because of the consistency with which calves were seen close to their mothers, and the rate at which mother-calf pairs were resighted (Payne and Dorsey, 1983), it seems likely that a large proportion of the calf-bearing females present at Peninsula Valdes in the years 1971–1977 are included in the category of known females. However there are also immature females included, especially during the earlier part of the study.

The numbers of whales (calves excepted) and known females identified during each year are given in Tables 1

Table 1

Mark recapture estimates for all whales (except calves). N = number of whales photographically identified in each year. M = whales photographed in a given year and a previous year. Z = whales photographed in a previous year and a later year, but not in the given year. R = whales photographed in a given year and a later year. P = population estimate by Seber-Jolly method. SE = estimated standard error of population estimate.

Year	N	M	Z	R	P	SE
1970	9	0	0	9		
1971	177	3	6	154	583.8	285.6
1972	182	75	85	139	452.1	35.8
1973	196	120	104	126	460.2	28.8
1974	85	63	167	51	460.5	46.4
1975	140	99	119	52	593.1	66.0
1976	121	88	83	31	566.5	85.6
1977	180	114	0	0		

Table 2.
Mark-recapture estimates for known females (except calves). Notation as in Table 1.

Year	N	M	Z	R	P	SE
1970	2	0	0	2		
1971	60	1	1	59	121.0	85.6
1972	54	24	36	50	141.5	17.7
1973	65	41	45	56	147.8	12.2
1974	23	21	80	17	141.5	18.2
1975	50	44	53	18	217.3	37.8
1976	45	42	29	9	200.4	53.5
1977	42	38	0	0		

and 2. As can be seen, most animals were photographed in two or more years.

All the airflights within a year constituted a sampling period. For any year an individual was considered marked if one or more clear photographs of its callosity pattern were taken.

For the total population (except calves), and for the population of known females, mark-recapture analyses were carried out using the Seber-Jolly method (Jolly, 1965; Seber, 1965). This computes estimates of the size of the population being studied at each sampling period, together with immigration/birth numbers, and emigration/death rates, and their estimated standard errors, assuming (assumptions from Seber (1973) rephrased):

(1) Each living animal in the population, whether previously photographed or not, had the same probability of being photographed in each year.

(2) At any time, mortality/emigration rates were the same for each previously photographed living animal in the population.

(3) No animals lost their identifying marks.

(4) No animals left the population to later return.

(5) There was no substantial immigration/birth or emigration/death within a sampling period.

Little mortality would be expected over three months for animals which live tens of years, and in twelve years of study only two adult right whale corpses have been found at Peninsula Valdes. As calves were not considered part of the population, birth within a sampling period can be ignored. Thus, defining an animal as being within the population from the time that it first came to Peninsula Valdes until the time it last left, assumptions 4 and 5 are reasonably valid. Payne *et al.* (1983) have shown that assumption 3 is tenable, and, given the low rates of annual natural mortality in baleen whales, and protected status of the Peninsula Valdes right whales, any failures in assumption 2 would not be expected to much influence population estimates.

In order to check assumption 1 and the underlying validity of the model, we performed the two tests suggested by Seber (1973) which seemed most likely to detect any shortcomings that there might be in the data. The two data sets (for known females and the whole population, excluding calves) were tested for the validity of the underlying model using the method of Leslie, Chitty and Chitty (1953), as described by Seber (1973, pp. 224–5). There were no significant differences between the estimated numbers of identified animals in the population, from calculations using the entire data set, and just the previously photographed animals. There were also no significant differences between the actual number of animals photographed for the first time in any season, and the estimated numbers from calculations using just the identified population.

The two data sets were also subjected to Leslie's (1958) test for equal catchability as described by Seber (1973, pp. 161, 226–8). The whales photographed over five or more years were grouped by their first and last sighting years. These groups were then combined to produce sets each containing more than 20 animals (Seber, 1973), and the actual and expected numbers photographed once, twice, etc. in the intermediate years were calculated and compared. For the females there was no significant indication that some whales were more likely to be photographed than others ($\chi^2 = 65.16$, with 61 d.f., $P > 0.25$). However for the total population (excluding calves) there was significantly greater variance in the number of intermediate seasons in which animals were photographed than would be expected were all animals present equally likely to be photographed in any season ($\chi^2 = 216.9$, with 167 d.f., $P = 0.02$). Thus there were some animals in the population which were more likely to be photographed than others. This will tend to have depressed the estimates of the total population.

In order to test whether the non-calf population size changed significantly between 1971 and 1976, regression lines were fitted to the population estimates, weighted by the inverses of their estimated variances. This was done in two ways:

(1) Linear regression. This assumed that the population changed by a constant number each year.

(2) Logarithmic regression. This assumed that the population changed by a constant proportion each year.

RESULTS

Tables 1 and 2 give the estimated population sizes, with their estimated standard errors, and the data needed to compute the estimates, for all whales (excluding calves) and the known females, during the sampling years. The method does not give estimates for the first and last years – 1970 and 1977. The point estimates of female population size ranged from about 120–220 for the females, and 450–600 for the entire population (excluding calves). However these latter estimates may have been biased to the low side because of the failure of assumption 1 mentioned above.

The estimates of emigration/death rates, and immigration/birth numbers have considerable variance, as is usual in Jolly-Seber analyses (e.g. the example in Jolly (1965)), and are not presented here.

The results of the regressions for examining changes in the whole population (excluding calves), and for the females are given in Table 3. Both populations appear to have been increasing, but the increases are only significant at $P < 0.10$. The estimated intrinsic rate of increase of the population is 6.8% per annum (95% CL

Table 3.
Results of weighted regressions of population estimates on year. Levels at which the increases (linear regression) and rates of increase (logarithmic regression) are significantly different from zero are marked.

	Linear regression Increase per year	Logarithmic regression Rate of increase per year
All whales	30.0 animals ($P < 0.1$)	0.068 ($P < 0.1$)
Known females	12.7 animals ($P < 0.2$)	0.104 ($P < 0.1$)

0.0–13.6%). However these estimates should be treated cautiously as the population estimates from which they are derived are probably underestimates.

DISCUSSION

The finding that some whales were more photographable than others agrees with a behavioural analysis by one of us (R.P.) of these and other data collected on the right whales off Peninsula Valdes. The implication is that the area was more of a 'home' to some whales than others. A portion of the whales tended to be present most years and/or to stay in residence for a long time, thus increasing their probability of being photographed, whereas others appeared only rarely and/or for short periods. Our estimates can be considered to be principally representing the 'core' population, but with a reasonable representation of the more 'transient' members. (Excluding those animals photographed during only one season from the analysis reduced the population estimates by 20–35%).

As can be seen by comparing the rates of return in Tables 1 and 2, the females were more prone to be photographed repeatedly at Peninsula Valdes. (However the difference between the rates of return of known females and other whales was not the only reason for the differential rate at which whales were photographed – with the known females excluded there was still a significantly different rate at which individual whales were photographed.) There appear to have been proportionally fewer 'transient' females, although this may have been due to the fact that animals photographed only a very few times will have been less likely to be positively recognized as females. The known females in our population estimates are principally sexually mature animals, with a few immatures, especially in the earlier years. Payne (1986) found that female right whales tended not to appear at Peninsula Valdes in the years between calvings (which usually happened every three years). However this did not appear as a detrimental factor for the population estimates of known females, according to the tests that we performed. The greater availability of females to photographers in the years when they visit Peninsula Valdes seems to outweigh these periodic effects, leading to an overall greater catchability of females.

The estimated intrinsic rate of increase of the population of 6.8% per annum is in close agreement with the estimated rate of increase of the population of right whales off South Africa of 7% (Best, 1981). The South African and Argentinian right whales are apparently from distinct stocks (Payne *et al.*, 1983). Our calculated rates of increase should be treated cautiously given the uncertainty in the underlying estimates.

We believe that we have produced useful estimates of the number of right whales off Peninsula Valdes in the early 1970s, the numbers of mature females, and the rate of increase of the population. The accuracy and relevance of these estimates will be increased when identifications from subsequent years are processed.

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