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# Sampling Effects on the Estimation of Life History Parameters for Eastern Tropical Pacific Dolphins

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ABSTRACT

Specifications for the collection of life history data from eastern tropical Pacific (ETP) dolphins have recently changed. Specimens are now only collected if a total of more than six animals are killed. For a one-year trial period, a monetary reward system was offered for each specimen with life history data collected. The effect of these changes are examined to determine whether the resultant life history data are biased – a concern expressed at the 1989 International Whaling Commission's Scientific Committee meeting. The collected data are stratified by the new requirements, and the representation of females by reproductive condition, and calves is examined for each strata. Few statistically significant differences between the strata in the representation of animals in the sample were found, and no systematic biases were detected in the representation of specimens in the collection. The monetary reward system resulted in a significant increase in the number of specimens collected.

## INTRODUCTION

In order to accurately estimate life history parameters for a population, identification of biases in the data collected is critical. In addition to sampling methods, physiological or behavioral characteristics of the animals themselves, such as segregation by age and sex, reproductive seasonality or geographic variation in the species, may contribute to collection bias (for discussion, see Perrin and Reilly, 1984). The Southwest Fisheries Science Center has been collecting data on dolphin specimens from the eastern tropical Pacific (ETP) for 18 years (for documentation on the collection of life history data see Perrin *et al.*, 1976; Smith, 1979; Perrin and Oliver, 1982). Recently, two changes were implemented in the established sampling protocols in an attempt to improve the quality and quantity of data collected for the estimation of age and reproductive condition by observers on the purse-seine vessels: (1) after June 1987, specimen collection was restricted to sets with more than six animals observed killed (prior to that, observers had been instructed to sample every set, selecting the first animals available); and (2) on 1 October 1988, a monetary reward system was implemented for a one-year trial period. Observers were given bonuses for all specimens with minimum life history data collected (i.e., species identification, sex and total body length); a larger bonus was given if the observer returned gonad and teeth samples for the same specimen.

The IWC Scientific Committee (IWC, 1989) questioned whether the first change in collection criteria might introduce a bias in the estimation of life history parameters. This paper addresses this question and tests whether the introduction of a monetary reward system increased the quantity of data collected.

## METHODS

Observers placed aboard US tuna purse-seine vessels by both the US National Marine Fisheries Service (NMFS) and the Inter-American Tropical Tuna Commission (IATTC) collect mortality data on the dolphin species incidentally killed in the yellowfin tuna purse-seine fishery in the ETP. Data collected includes the number of dolphins killed by species for each set and the geographic location of the set. The life history data collected from individual dead animals includes the species, sex, total body length and reproductive condition, if female. Gonads and teeth of both sexes are returned to the laboratory for state of sexual maturity and age to be determined.

Spotted (*Stenella attenuata*), spinner (*S. longirostris*), striped (*S. coeruleoalba*), and common dolphins (*Delphinus delphis*) are the primary target species of the ETP yellowfin tuna purse-seine fishery, and, consequently, the species for which we have most data. For spotted and spinner dolphins, sufficient data are available to analyze the data by geographic stocks (Table 1; for descriptions of stocks, see Perrin *et al.*, 1985).

The fraction of females that were sexually mature and the fraction of mature females that were pregnant, lactating and simultaneously pregnant and lactating for each species were first stratified by kill-per-set (KPS) to reflect the new collection protocol of only sampling sets with more than six animals killed. The first KPS stratum included data from purse-seine sets with 1–6 animals killed, ('small-kill' sets) between 1974 and 1987, the last year 'small-kill' sets were sampled. The second stratum included life history data from sets with $\geq 7$ animals killed ('large-kill' sets) collected between 1974 and 1989.

The null hypotheses of no significant temporal trend in the fraction of females in each reproductive state (i.e. mature, pregnant, lactating, and simultaneously pregnant and lactating) were tested for each species, or stock, in small- and large-kill sets ($\alpha=0.05$; linear trends for proportions, Snedecor and Cochran, 1973). If the temporal trend was significant, the null hypotheses of no difference between the regression coefficients for each KPS stratum was tested using a bootstrap procedure. The bootstrap was performed by resampling the raw data and comparing the regression coefficients generated. The null hypothesis was rejected if the observed difference in the regression coefficients was not within the 95% confidence interval. If the temporal trend was not significant for either KPS stratum, the annual data were pooled and the null

Table 1

The statistically significant (S) temporal trends, 1974-89, are indicated in the corresponding cell. The sample sizes are given for each species and stock examined and for each strata of kill-per-set. The column headings for the strata are '< 7' for sets with 1-6 animals killed and '> = 7' for large-kill sets. The fraction mature is calculated as the fraction of all females that are mature from all females for which sexual maturity is known. The fraction pregnant, lactating and simultaneously pregnant and lactating are calculated as the fraction of mature females in each condition. The fraction pregnant and the fraction lactating do not include the simulataneously pregnant and lactating females. Blank cells were tested but the results were not statistically significant.

| | Sample size | | Fraction mature | | Fraction pregnant | | Fraction lactating | | Fraction pregnant & lactating | |
|---|---|---|---|---|---|---|---|---|---|---|
| Species + Stock | < 7 | > = 7 | < 7 | > = 7 | < 7 | > = 7 | < 7 | > = 7 | < 7 | > = 7 |
| Spotted | | | | | | | | | | |
| N. Offshore | 1,208 | 3545 | | S | | | | | | S |
| S. Offshore | 84 | 333 | | S | | S | | | | S |
| Spinner | | | | | | | | | | |
| Eastern | 174 | 989 | | S | | | | | * | S |
| Whitebelly | 231 | 986 | | | S | S | | S | | |
| Common | | | | | | | | | | |
| All stocks | 114 | 548 | | | | | | | | S |
| Striped | | | | | | | | | | |
| All stocks | 18 | 44 | | | | insufficient data | | | | |

* There were no eastern spinners that were recorded to be simulatneously pregnant and lactating in sets with fewer than seven animals killed.

hypothesis of equal mean proportions for each stratum was tested ($\alpha$=0.05; Fleiss, 1981).

The proportion of calves in the sample was examined by the same two KPS strata. Male and female calves were summed and the proportion calculated on the basis of all male and female specimens collected with total body length (TBL) recorded; TBL is used as the criteria to define a calf. Animals with a TBL $\leq$130cm are considered to be calves. This is the approximate length at one year of age and the beginning of weaning (Perrin *et al.*, 1976). When sufficient data were available, the species were analyzed by geographic stock as detailed previously.

Data collected for years 1979 through 1989 were used to evaluate the effectiveness of the monetary incentive program. Both the NMFS and the IATTC participated in the sampling program during these years. To correspond with the trial period for the incentive plan, each year is defined to begin on 1 October and end on 30 September the following year. The first year of IATTC data collection is 1979, thus 'collection year' 1980 (1 October 1979 – 30 September 1980) is the first year used for the analyses. The collection of minimum life history data, for both male and female specimens, was calculated as a percentage of the total observed kill for each year.

## RESULTS

Table 1 summarises the results of the test for temporal trends in the data by species and stock. The life history data for spotted (northern offshore, southern offshore and coastal) and spinner dolphin stocks (eastern, northern whitebelly, southern whitebelly and Costa Rican) were examined separately. Sample sizes were too small for analyses of data on coastal spotted and Costa Rican spinner dolphins. The data for southern whitebelly spinner dolphins were also too few and were combined with the data for northern whitebelly spinner dolphins.

None of the tests to compare regression coefficients rejected the null hypotheses of equal slopes. Of the pooled annual data comparisons conducted when there was no significant temporal trend in the data, only the mean proportions for the fraction of lactating eastern spinner dolphin females were significantly different between the large- and small-kill sets.

With respect to the representation of calves in small- versus large-kill sets, significant differences were found only for northern offshore and eastern spinner dolphins (Table 2). A greater fraction of calves were present in the large-kill set samples.

Observer collection rates of both minimum and full life history data increased significantly in 1989 over the 1988 rate and the mean rate for the 1980s (Table 3; Chi-square, $p<0.001$; Snedecor and Cochran, 1973). The fraction of the observed kill collected with full life history data increased significantly to 0.455 in 1989 from a mean for the 1980s of 0.379 (Chi-square, $p<0.001$; Snedecor and Cochran, 1973).

## DISCUSSION

The results indicate that there is no significant effect on the representation of female dolphins by reproductive state in the life history sample when the data were stratified by small- and large-kill sets. Although temporal trends in the fraction of females in each reproductive state were significant for some stocks and species examined, the number of animals killed in the set was not a significant factor in the analytical estimation of life history parameters. Although there was a significant difference in the representation of calves between small- and large-kill sets for both northern offshore spotted dolphins and eastern spinner dolphins, this may be due to the increased power of the trend analyses when the proportions are near 0 or 1 (Nam, 1987).

Table 2

The statistically significant (S) temporal trends, 1974-89, are indicated in the corresponding cell. The sample sizes are given for each species and stock examined and for each strata of kill-per-set. The column headings for the strata are '< 7' for sets with 1-6 animals killed and '> = 7' for large-kill sets. The fraction calves is calculated as the fraction of the total sample of male and female specimens collected with length was recorded. Specimens with length < = 130cm are calves.

| | Sample size | | Fraction calves | |
|---|---|---|---|---|
| Species + Stock | < 7 | > = 7 | < 7 | > = 7 |
| Spotted | | | | |
| N. Offshore | 9,498 | 15,244 | | S* |
| S. Offshore | 1,246 | 1,781 | | S |
| Spinner | | | | |
| Eastern | 2,227 | 3,884 | | S* |
| Whitebelly | 2,474 | 4,180 | | |
| Common | | | | |
| All stocks | 1,135 | 2,054 | | |
| Striped | | | | |
| All stocks | 201 | 287 | | |

* Indicates that the regression lines for the two groups are significantly different, $\alpha = 0.05$.

Table 3

Fraction of the total observed kill sampled as life history data. The life history data collection includes both male and female specimens with minimum data collected, i.e., species, sex and total body length. The 'full' category is minimum data plus gonads. Data in table is for 'collection' years 1980-89. For example, collection year 1980 is October 1, 1979-September 30, 1980.

| Collection year | Observed kill | Life history specimens | | Fraction of kill collected as life history | |
|---|---|---|---|---|---|
| | | Min. | Full | Min. | Full |
| 1980 | 5,747 | 1,417 | 865 | 0.25 | 0.15 |
| 1981 | 7,731 | 1,380 | 757 | 0.18 | 0.10 |
| 1982 | 8,205 | 1,459 | 703 | 0.18 | 0.09 |
| 1983 | 5,702 | 1,305 | 748 | 0.23 | 0.13 |
| 1984 | 3,236 | 1,019 | 317 | 0.32 | 0.10 |
| 1985 | 8,546 | 2,107 | 1,026 | 0.25 | 0.12 |
| 1986 | 12,883 | 1,756 | 996 | 0.14 | 0.08 |
| 1987 | 9,852 | 2,226 | 1,286 | 0.23 | 0.13 |
| 1988 | 12,366 | 1,990 | 1,515 | 0.16 | 0.12 |
| 1989 | 11,490 | 3,224 | 2,695 | 0.28 | 0.23 |
| Total | 85,758 | 17,883 | 10,908 | 0.21 | 0.13 |

The low collection rates of life history data from ETP dolphin species during the 1980s has been discussed by the IWC Scientific Committee (IWC, 1989). Besides the incentive of the collection bonuses, the increased collection rate for collection year 1989 may also have been due to the concentration of effort resulting from the instruction to sample only from sets with ≥7 animals killed. However small-kill sets accounted for an average of 30% of the observed kill during 1979 to 1989 and dropping the latter sampling requirement while keeping the bonus system would probably further increase the life history data sampling rate.

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