# Trends in abundance of Dall's porpoise 1979 to 1988

By

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ABSTRACT

Two density indexes of Dall's porpoise abundance were estimated for the western North Pacific Ocean area from 1979 to 1988. One index is density of animals (number of animals per $nm^2$) using line transect methods and the other is number of Dall's porpoise sighted per nautical mile. The number of Dall's porpoise sighted per nautical mile increases from 0.115 in 1979 to 0.232 in 1984, then declines to 0.142 in 1988. The density increases from 0.559 animals/$nm^2$ in 1979 to 1.01 animals/$nm^2$ in 1984, then declines to 0.365 animals/$nm^2$ in 1988. Some of the differences in the two indexes could be due to improvements in the estimation of distance to sightings in 1987 and 1988. The data indicate that abundance has declined in 1987 and 1988 from previous years, however, the low coverage of the area, and the large variability in the data confound any estimation of a statistically reliable trend.

INTRODUCTION

U.S. observers have collected data on marine mammal sightings using line transect methods from 1978 to 1988 in the North Pacific Ocean. Estimates of abundance of Dall's porpoise from line transect methods are biased by attraction of the animals to the survey vessel and by missing animals near the transect line (Turnock 1987, Turnock and Quinn in prep). An estimate of animal density without correction for these biases may be regarded as a density index for estimation of trends in abundance if biases in the sampling do not change over time. This paper will present

estimates of two density indexes from 1979 to 1988 for Dall's porpoise in the western North Pacific Ocean area (Figure 1)(see Jones, Breiwick, Bouchet and Turnock 1986 for details on area definition). Turnock (1988) presented trends in abundance for the period 1978 to 1984 for three areas: The western North Pacific Ocean area (excluding the Japanese salmon fishery area), the salmon fishery area and the Bering sea area (Figure 1). The western North Pacific Ocean area is regarded as the range of a single stock of Dall's porpoise (Jones et al 1986). This paper adds data from 1986 to 1988 using a weighted average estimate of the density indexes for the western North Pacific Ocean area (excluding the salmon fishery area) and the salmon fishery area, instead of presenting separate estimates for both areas. The 1978 data will not be included in this paper since sea state and weather conditions were not recorded for most of the data.

## METHODS

Two indexes of abundance were estimated: 1) the density of individual Dall's porpoise (animals per $nm^2$) using data from visibility codes 2 and 3 (see Turnock (1988) for description of visibility codes), and 2) the number of Dall's porpoise sighted per nautical mile of transect for visibility codes 2 and 3. Estimates of the first density index were made for 1979 to 1984 and 1987 to 1988. For 1985 and 1986 the sample size was too small to estimate density. However, in 1986 there was similar effort to other years so the second density index (number of porpoise sighted per nautical mile) was estimated.

The first density index was estimated by,

$$\hat{D}_1 = \frac{n\ \hat{G}\ \hat{f}(0)}{2\ L}$$

Where n is the number of groups of animals observed,

$\hat{G}$ is the average group size,

L is the transect length, and

$\hat{f}(0)$ is the inverse of the effective width of the transect.

The variance of density is estimated by (Burnham, et al 1980),

$$\hat{var}\ (\hat{D}_1) = \hat{D}_1^2\ [\ (cv\ n)^2 + (cv\ \hat{f}(0))^2 + (cv\ \hat{G})^2\ ]$$

The variance for n the number of groups sighted is estimated by ,

$$\hat{Var}\ (n) = \frac{\Sigma_{i=1}^{R}\ l_i\ [(n_i/l_i) - (n/L)]^2}{L\ (R-1)}$$ (Burnham, et al 1980).

Where n is the total number of observed groups,
$n_i$ is the number of observed groups in transect i,
$l_i$ is the length of transect i,
R is the number of transects, and
L is the sum of the $l_i$'s.

The number of Dall's porpoise sighted per nautical mile was estimated by,

$$\hat{D}_2 = \frac{n\ \hat{G}}{L}$$

The variance was estimated by,

$$\hat{var}\ (\hat{D}_2) = \hat{D}_2^2\ [\ (cv\ n)^2 + (cv\ \hat{G})^2\ ]$$

Data from visibility codes 2 and 3 only were used to reduce variability and bias that may occur from pooling data with different g(0) values (where g(0) is the probability of sighting a group given it is at zero perpendicular distance). The Hazard rate

model (Buckland 1985) was used to estimate f(0). All perpendicular distance data were analyzed grouped and truncated at 500 meters.

Data were stratified by area to reduce bias due to nonrandom effort. The density indexes were estimated separately for the area of the Japanese salmon fishery (Figure 1) due to the large amount of sighting effort collected on board the fishing vessels in this relatively small area. A weighted average density index was estimated weighting by the respective areas.

$$\hat{D} = \frac{A_f\hat{D}_f + A_n\hat{D}_n}{A_f + A_n}$$

Where, $A_f$ is the area of the salmon fishery area within the western North Pacific area (91,740 $nm^2$)

$A_n$ is the area of the western North Pacific excluding the salmon fishery area (1,036,354 $nm^2$)

$\hat{D}_f$ is the density index in the salmon fishery area

$\hat{D}_n$ is the density index in the western North Pacific Ocean area excluding the salmon fishery area

$\hat{D}$ is the density index for the western North Pacific area

## RESULTS

Tables 1 and 2 show the data and estimates of mean group size and f(0) by area and year. Table 3 shows the weighted average density indexes for the western North Pacific Ocean area. The number of Dall's porpoise sighted per nautical mile increases from 1979 to 1984, is lower in 1986, then increases from 1986 to 1988

(Table 3 and Figure 2). The range is 0.085 animals/nm in 1986 to 0.232 animals/nm in 1984. The estimated density shows similar trends for 1979 to 1984, but declines from 1987 to 1988 (Table 3 and Figure 3). The range is 0.365 animals/$nm^2$ in 1988 to 1.159 animals/$nm^2$ in 1982.

Straight line regression fits to the data showed slopes that were not significantly different from zero, however, a straight line does not appear to provide a good fit to the data. Due to the large variability from year to year in the estimated density indexes, statistical power of the regression is low.

## DISCUSSION

The level of effort in any one year is low (1300 to 2500 nm) for the western North Pacific Ocean area excluding the fishery area compared to the total area (1,036,054 $nm^2$) (Table 1). The low coverage of the area can result in biases due to spatial variability in density of animals. The indexes show large fluctuations from year to year which may be due to the low coverage of the area.

A polynomial regression may fit the data better than a straight line, however, due to the large variability in the data, fitting a more complicated shape may be misleading.

Binoculars with reticles were used in 1987 and 1988 by some observers to estimate distances to sightings. More observers used the binoculars in 1988 than in 1987. This may have resulted in larger estimated distances (the tendency is to underestimate distances by eye) and lower f(0) values, and consequently lower estimated density. The number of Dall's porpoise sighted per

nautical mile also was lower in 1987 and 1988 than most other years. However, the decrease in density from 1987 to 1988 is due to a lower f(0) value as the number of Dall's porpoise sighted per nautical mile increased from 1987 to 1988.

The weighted average density indexes presented here are similar to those in Turnock (1988) for 1980 to 1984 in the western North Pacific Ocean area outside the salmon fishery area. The more recent data (1986 to 1988) indicate density has declined from the earlier period (1979 to 1984). However, due to the large variability in the data no statistically significant trend can be found.

More effort is needed in a single year to obtain better coverage of the area. Stratification by smaller areas to reduce bias due to spatial variability of density would be desirable if more effort could be obtained. Due to improvements in estimation of distance to sightings in recent years, number of Dall's porpoise sighted per nautical mile may be a better indication of trends in abundance than the density. However, the density accounts for differences in distances at which observers sight animals, which means there may be biases due to pooling the data over different observers for the second density index (the number of Dall's porpoise sighted per nautical mile).

## REFERENCES

Buckland, S.T. 1985. Perpendicular distance models for line transect sampling. Biometrics 41, 177-195.

Burnham, K.P., Anderson, D.R. and Laake, J.L. 1980. Estimation of density from line transect sampling of biological populations. Wildlife Monographs Number 72, 1-202.

Jones, L.L., Breiwick, J., G.C. Bouchet, and B.J. Turnock. 1986. Report on the incidental take, biology and status of Dall's porpoise. National Marine Mammal Laboratory, Seattle, Washington. 55pp.

Turnock, B.J. 1987. Analysis of experiments to assess movement of Dall's porpoise in relation to survey vessels and population estimates corrected for movement and visibility bias for the North Pacific Ocean. Document submitted to the Scientific Subcommittee, Ad Hoc Committee on Marine Mammals, International North Pacific Fisheries Commission, March 11-15, 1987, Tokyo, Japan. 40pp.

Turnock, B.J. 1988. Trends in abundance of Dall's porpoise. Document submitted to the Scientific Meeting on Marine Mammals, International North Pacific Fisheries Commission, March 14-18, 1988, Tokyo, Japan. 20pp.

Turnock, B. J. and T. J. Quinn. In prep. The effect of responsive movement on abundance estimation using line transect sampling. Revised paper submitted to Biometrics. 30pp.

## Figure Titles

Figure 1. Areas used in density estimation. a is the Bering sea, b, the western North Pacific Ocean area excluding the fishzone, and c is the fishzone area within the western North Pacific Ocean area.

Figure 2. Weighted average number of Dall's porpoise sighted per nautical mile for the western North Pacific Ocean area 1979 to 1988 using visibility code 2 and 3 data (+ is the estimate minus 2 standard deviations, is the estimate plus two standard deviations).

Figure 3. Weighted average density for the western North Pacific Ocean area 1979 to 1988 using visibility code 2 and 3 data (+ is the estimate minus 2 standard deviations, is the estimate plus two standard deviations).

Table 1. Sightings data and estimates of f(0) for the western North Pacific Ocean area excluding the fishery area using data from visibility codes 2 and 3, for 1979 to 1988 (n is the number of groups sighted, L is the effort in nautical miles and G is the average group size).

| year | n | cv n | L | G | cv G | f(0) | cv f(0) |
|---|---|---|---|---|---|---|---|
| 79 | 56 | 0.199 | 1922 | 3.952 | 0.076 | 9.715 | 0.195 |
| 80 | 58 | 0.190 | 1737 | 4.148 | 0.081 | 10.320 | 0.149 |
| 81 | 105 | 0.145 | 2490 | 4.368 | 0.068 | 7.012 | 0.108 |
| 82 | 112 | 0.122 | 2215 | 3.478 | 0.053 | 13.989 | 0.136 |
| 83 | 59 | 0.192 | 1350 | 3.613 | 0.092 | 10.000 | 0.163 |
| 84 | 99 | 0.133 | 1537 | 3.776 | 0.053 | 8.795 | 0.268 |
| 85 | 4 | 0.474 | 342 | 3.500 | 0.247 | - | - |
| 86 | 22 | 0.250 | 1561 | 5.478 | 0.172 | - | - |
| 87 | 52 | 0.195 | 1337 | 3.136 | 0.066 | 7.816 | 0.183 |
| 88 | 41 | 0.163 | 1555 | 5.400 | 0.096 | 5.127 | 0.105 |

Table 2. Sightings data and estimates of f(0) for the fishery area using data from visibility codes 2 and 3, for 1979 to 1988 (n is the number of groups sighted, L is the effort in nautical miles and G is the average group size).

| year | n | cv n | L | G | cv G | f(0) | cv f(0) |
|---|---|---|---|---|---|---|---|
| 79 | 5 | 0.621 | 248 | 5.6 | 0.377 | - | - |
| 80 | 44 | 0.163 | 922 | 4.386 | 0.103 | 35.753 | 0.160 |
| 81 | 120 | 0.111 | 4410 | 3.758 | 0.058 | 10.074 | 0.093 |
| 82 | 107 | 0.105 | 5564 | 2.86 | 0.059 | 13.285 | 0.181 |
| 83 | 140 | 0.096 | 3727 | 3.542 | 0.054 | 9.136 | 0.093 |
| 84 | 76 | 0.181 | 2099 | 3.099 | 0.081 | 6.246 | 0.135 |
| 85 | 66 | 0.123 | 2691 | 3.147 | 0.061 | 20.540 | 0.745 |
| 86 | 137 | 0.156 | 2626 | 3.359 | 0.059 | 11.256 | 0.095 |
| 87 | 159 | 0.113 | 4360 | 3.284 | 0.046 | 7.235 | 0.088 |
| 88 | 0 | - | 0 | 0 | - | - | - |

Table 3. Weighted average density and number of animals observed per nautical mile for the western North Pacific Ocean area.

| year | weighted $\hat{G}n/L$ | cv $\hat{G}n/L$ | weighted density | cv density |
|---|---|---|---|---|
| 79 | 0.115 | 0.213 | 0.559 | 0.289 |
| 80 | 0.144 | 0.190 | 0.898 | 0.234 |
| 81 | 0.177 | 0.148 | 0.635 | 0.178 |
| 82 | 0.166 | 0.122 | 1.159 | 0.175 |
| 83 | 0.155 | 0.196 | 0.774 | 0.247 |
| 84 | 0.232 | 0.133 | 1.011 | 0.280 |
| 85 | - | - | - | - |
| 86 | 0.085 | 0.280 | - | - |
| 87 | 0.121 | 0.189 | 0.473 | 0.253 |
| 88 | 0.142 | 0.190 | 0.365 | 0.217 |

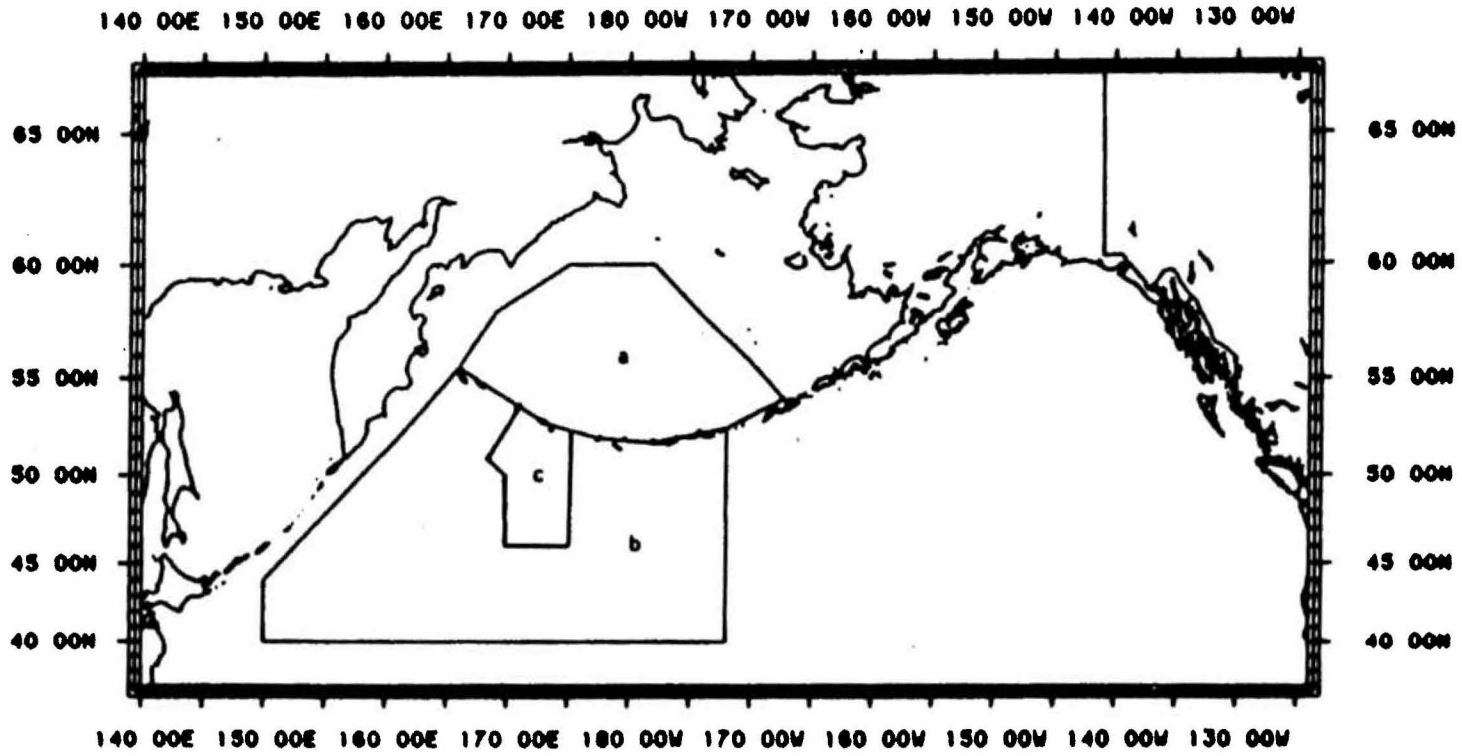
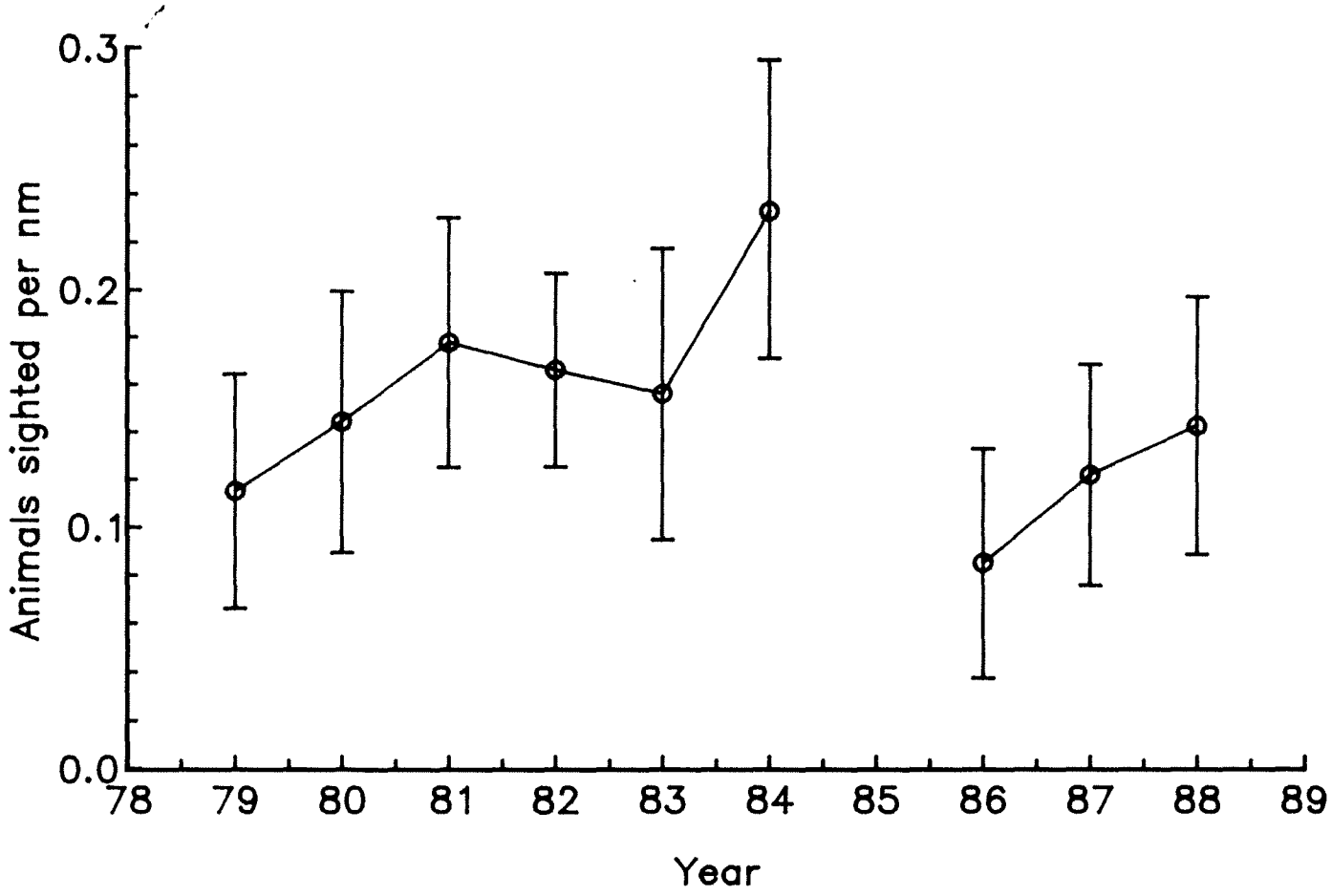
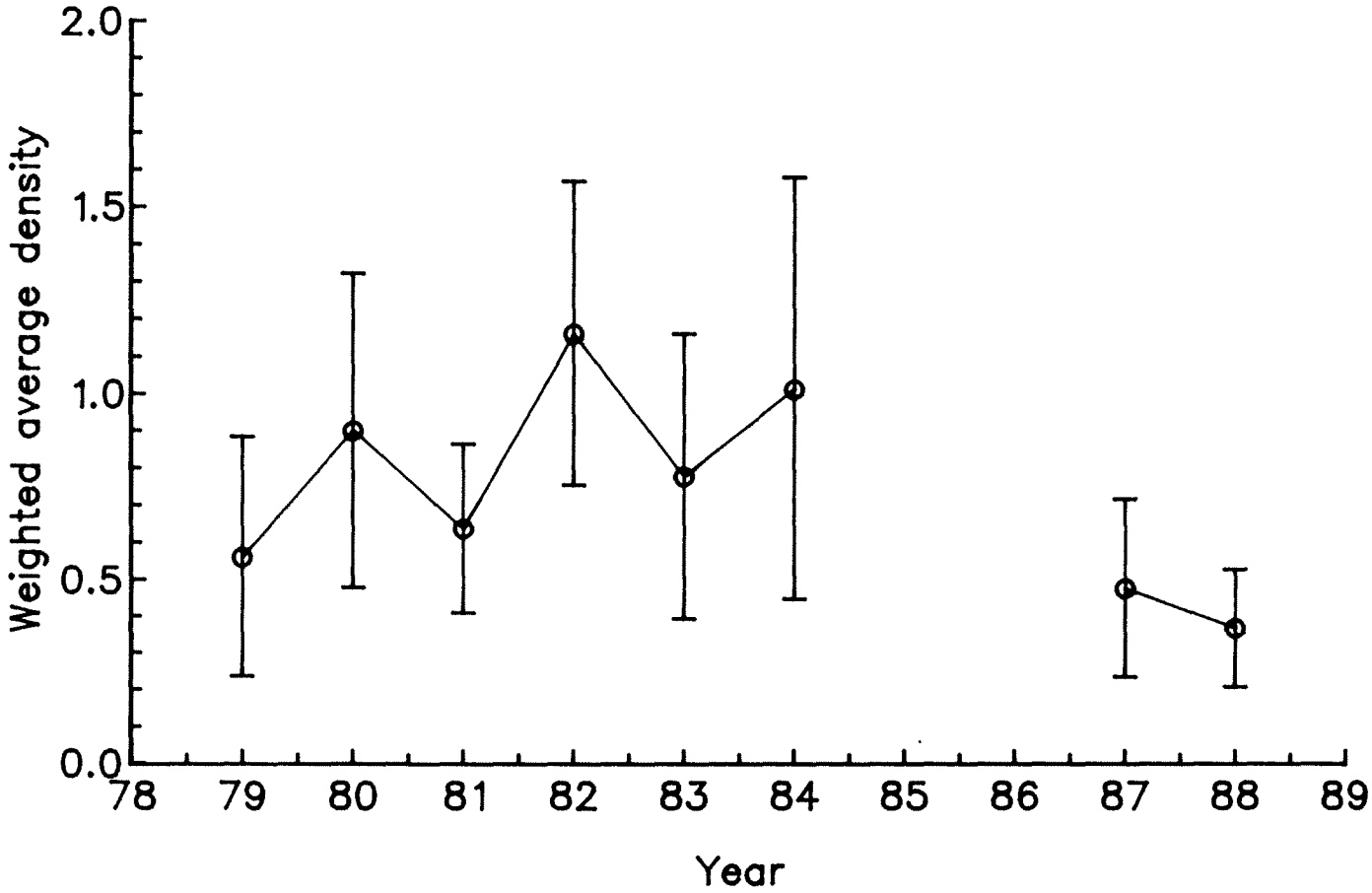



Figure 1. Areas used in density estimation. a is the Bering sea, b, the western North Pacific Ocean area excluding the fishzone, and c is the fishzone area within the western ~~central~~ North Pacific Ocean area.


0.3
0.2
0.1
0.0
Animals sighted per nm
78
79
80
81
82
83
84
85
86
87
88
89
Year


Weighted average density
2.0
1.5
1.0
0.5
0.0
78
79
80
81
82
83
84
85
86
87
88
89
Year