Trends in abundance of Dall's porpoise

By

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INTRODUCTION

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. An estimate of animal density without correction for these biases may be regarded as a density index for estimation of trends over time if these biases do not change over time. The ability to detect changes in population abundance is determined by the variance of the density estimates, the amount of change in the population abundance, the number of years of data, and the selected level of type I error. Estimates of a density index, a density index corrected for movement, and estimates of the number of Dall's porpoise sighted per nautical mile, will be presented in this paper by year for three areas: 1) the western North Pacific Ocean area excluding the area where the Japanese Salmon driftnet fishery occurs in the U.S. Exclusive Economic Zone (EEZ) (the fishzone). (This area will be abbreviated NPACNOF), 2) the fishzone area inside the western North Pacific Ocean area, and 3) the Bering Sea area (Figure 1)(see Jones, Breiwick, Bouchet and Turnock 1986 for details on area definitions). The amount of sighting effort needed for various coefficients of variation of density and corrected density will also be investigated.

width of the transect), the Fourier series (Crain, et al 1978), and the Hermite polynomial (Buckland 1985). The Hazard rate model (Buckland 1985) was also used to estimate f(0), but results will not be presented here because for several data sets the model did not converge. All data were analyzed grouped and truncated. The density index was estimated by,

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

Where n is the number of groups of animals observed,
G is the average group size,
L is the transect length, and
f(0) is the inverse of the effective width of the transect.

The variance of density is,

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

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.

Density corrected for movement is estimated by,

$$\hat{D}_c = \hat{D}\ \hat{C}$$

Where $\hat{C}$ is the correction for movement estimated by the ratio method (Cochran, 1970), using data from the 1984 and 1983 helicopter-ship surveys (Turnock, 1987),

$$\hat{C} = 2.479\ \hat{X}$$

The correction for movement tends to reduce the year to year fluctuations in the density index (Tables 8, 9 and 10, and Figures 5, 6 and 7). However, due to the large variance of the correction factors for movement, the corrected density indexes have large variances, precluding any conclusions being drawn from the data concerning trends in abundance. The changes in the corrected density index are similar to the density index for the fishzone and Bering sea areas. For the NPACNOF area, the corrected density index does not indicate an increasing trend as the uncorrected density index did.

The density index contains three variables, the number of groups sighted per nautical mile, the average group size, and the f(0) value. The f(0) value is affected by the searching process (i.e., at what distances the observer searches), the method of estimating or measuring distances and angles, and the effect of movement. In 1987, distance and angle estimates to stationary buoys by 3 U.S. observers were tested against radar measurements. The observers used eye estimates and binoculars with reticles to estimate distances, and angle boards for angles. The angle board consisted of a piece of plywood on a tripod with angles marked by one degree increments. A pointer was used to sight on the animal and the angle was read from the board. Results of the cruise indicate that distances may be underestimated by 50%, and that the amount of error in distance estimation may change with observer (unpub. NMML

The number of Dall's porpoise sighted per nautical mile shows similar trends as the density index (Tables 2, 3, and 4, and Figures 8, 9, and 10). A straight line regression was fit to the number of Dall's porpoise sighted per nautical mile by year for each of the 3 areas (Table 11). The slope for the NPACNOF area is significantly greater than zero($0.01 < p > 0.0025$, using a one-tailed t test) and indicates that the abundance has increased by about 87% from 1978 to 1984. The density index also indicates an increasing and slightly higher trend in abundance, however the corrected density index indicates no trend. Because the variance of the corrected density indexes are large, a trend would not be detectable using linear regression.

The slopes for the regressions in the fishzone and the Bering Sea were not significantly different than zero ($p > 0.25$ for the fishzone, and $0.1 < p < 0.25$ for the Bering Sea)(Table 11, Figures 9 and 10). This result of no trend is also indicated by both the density index and the corrected density indices for the Bering Sea and the fishzone. Gerrodette(1987) has investigated the power of detecting trends in abundance estimates. Using his equations for constant coefficient of variation and linear change in abundance, the power of detecting a trend in abundance can be estimated given the amount of decrease, the number of years of data, the coefficient of variation of the estimates, and the level of type I error. The average coefficient of variation for the fishzone estimates is 0.15, transect surveys for tropical porpoises. A straight line regression was fit to the data,

$$cv\ \hat{D} = 1.8265\ (1/\sqrt{n}) \qquad r^2 = 0.885.$$

From the regression above, and the average number of groups per nautical mile of transect, the coefficient of variation of density for various transect lengths can be estimated. The average number of groups sighted per line length for all years is 0.042 groups/nm in the NPACNOF area, 0.031 groups/nm for the fishzone, and 0.034 groups/nm for the Bering sea area. The other components of density, the g(0) value and the correction for movement will add variation to the density estimate.

Approximately 57% of the sightings effort from Japanese research vessels is during Beaufort 0 to 3 (Kato 1986a) which would be similar to visibility codes 1 through 4. Approximately 68 % of the sightings data during Beaufort 0 to 3 may be at visibility codes 1 through 3 (unpublished NMML sightings data). Japanese research vessels operating in the NPACNOF area covered an average of approximately 28,000 nm each year for 1980 to 1985 (Kato, 1986b). Observations are conducted during all daylight hours while the ship was in transit. To estimate the percent area covered by a certain amount of sighting effort, the effective width must first be estimated. The estimate of f(0) corrected for movement (i.e. $f_m(0)$) can be used to estimate the effective width. The estimate of $f_m(0)$ for the

1987, 1988). The coefficient of variation for the correction factors has a large influence on the coefficient of variation of the corrected density (Table 12). This indicates that better estimates of the correction factors are needed, especially the correction for movement, in order to reduce the variance in the corrected density.

Sighting surveys using independent observers are needed to improve estimates of g(0), and possibly to estimate a correction for movement (see Turnock 1988).

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.

Zar, J.H. 1974. Biostatistical Analysis. Prentice Hall, Inc., Englewood Cliffs, N.J., 620pp.

Table 2. Sightings data and estimates of the number of groups observed per nm (n/L) and of the number of individual Dall's porpoise observed per nm (Gn/L) for the fishzone area using data from visibility codes 2 and 3, for 1980 to 1987 (n is the number of groups of Dall's porpoise sighted used for estimation of Gn/L, n* is the number of groups after truncation that were used for estimation of f(0) and n/L, and G is the average group size).

Year	n	n*	L	G	cv G	n/L	cv n/L	Gn/L
80	41	32	912	4.29	0.107	0.045	0.160	0.1505
81	118	97	4385	3.80	0.058	0.027	0.111	0.0840
82	112	95	5487	2.84	0.061	0.020	0.108	0.0491
83	151	132	3543	3.55	0.054	0.043	0.097	0.1322
84	77	62	2065	3.06	0.083	0.037	0.186	0.0918
85	64	56	2354	3.16	0.064	0.027	0.128	0.0751
86	136	113	2479	3.38	0.061	0.055	0.162	0.1540
87	160	146	4009	3.21	0.045	0.040	0.119	0.1169

Table 3. Sightings data and estimates of the number of groups observed per nm (n/L) and of the number of individual Dall's porpoise observed per nm (Gn/L) for the NPACNOF area using data from visibility codes 2 and 3, for 1978 to 1984 (n is the number of groups of Dall's porpoise sighted used for estimation of Gn/L, n* is the number of groups after truncation that were used for estimation of f(0) and n/L, and G is the average group size).

Year	n	n*	L	G	cv G	n/L	cv n/L	Gn/L
78	237	186	6421	4.14	0.048	0.037	0.079	0.1199
79	55	51	1552	4.11	0.080	0.035	0.226	0.1350
80	61	54	1731	4.15	0.081	0.035	0.190	0.1294
81	116	110	2446	4.41	0.068	0.047	0.144	0.1983
82	112	107	2173	3.38	0.054	0.052	0.124	0.1664
83	57	53	1260	3.63	0.098	0.045	0.205	0.1526
84	103	100	1497	3.76	0.055	0.069	0.137	0.2511

Table 5. Density index (D) estimated using the Fourier series and Hermite Polynomial models for the Fishzone area from 1980 to 1987 (cv is the coefficient of variation).

Year	Fourier series f(0)	cv	D	cv D	Hermite Polynomial f(0)	cv	D	cv D
80	36.17	0.0652	2.7241	0.203	36.42	0.2293	2.74	0.299
81	17.06	0.1334	0.7165	0.183	17.46	0.1275	0.73	0.17
82	14.74	0.0824	0.3624	0.149	15.87	0.0899	0.43	0.153
83	9.49	0.0500	0.6277	0.122	10.28	0.1010	0.68	0.150
84	8.55	0.1250	0.3935	0.239	7.35	0.2009	0.34	0.286
85	14.93	0.1056	0.5604	0.178	16.22	0.1122	0.61	0.182
86	17.41	0.1058	1.3421	0.203	18.24	0.1043	1.41	0.202
87	7.99	0.0517	0.4675	0.137	7.89	0.1052	0.46	0.165

Table 6. Density index (D) estimated using the Fourier series and Hermite Polynomial models for the NPACNOF area from 1978 to 1984 (cv is the coefficient of variation).

Year	Fourier series f(0)	cv	D	cv D	Hermite Polynomial f(0)	cv	D	cv D
78	5.76	0.1023	0.3457	0.138	5.74	0.0982	0.34	0.135
79	7.9	0.0977	0.533	0.259	9.25	0.1003	0.62	0.260
80	10.95	0.0813	0.7081	0.222	12.14	0.1546	0.79	0.258
81	6.71	0.0390	0.5004	0.164	7.37	0.0772	0.73	0.177
82	18.63	0.0876	1.5523	0.161	17.91	0.0760	1.49	0.155
83	10.41	0.0946	0.7949	0.246	12.07	0.1497	0.92	0.272
84	5.82	0.0712	0.7298	0.164	7.18	0.1179	0.90	0.189

Table 7. Density index (D) estimated using the Fourier series and Hermite Polynomial models for the Bering sea area from 1978 to 1986 (cv is the coefficient of variation).

Year	Fourier series f(0)	cv	D	cv D	Hermite Polynomial f(0)	cv	D	cv D
78	5.176	0.0818	0.4743	0.181	4.16	0.1875	0.381	0.247
79	6.624	0.1031	0.3686	0.339	12.30	0.1483	0.684	0.355
80	8.451	0.1399	0.8306	0.295	9.47	0.1304	0.931	0.290
81	12.839	0.1063	0.8485	0.209	13.86	0.1973	0.916	0.267
82	11.212	0.1274	0.8786	0.260	12.49	0.1283	0.979	0.260
83	8.253	0.1045	0.5259	0.225	8.94	0.1786	0.570	0.268
84	6.417	0.1302	0.3866	0.317	7.04	0.2380	0.424	0.374
85	10.95	0.1156	0.6787	0.324	13.18	0.2062	0.817	0.366
86	10.05	0.1384	0.8256	0.263	9.43	0.2543	0.775	0.339

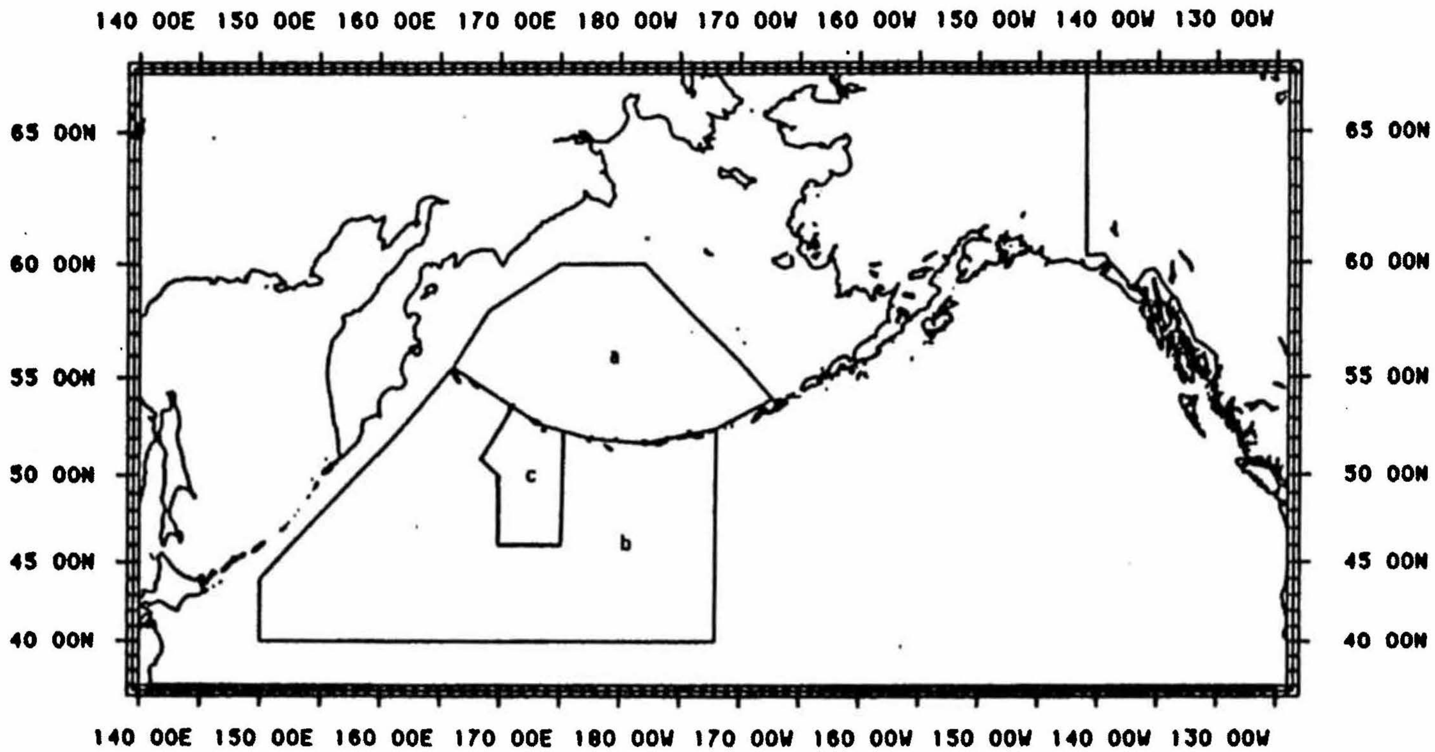

Figure 1. Areas used in density estimation. a is the Bering sea, b, the western North Pacific Ocean area excluding the fishzone, and c is the fishzone area within the western central North Pacific Ocean area.

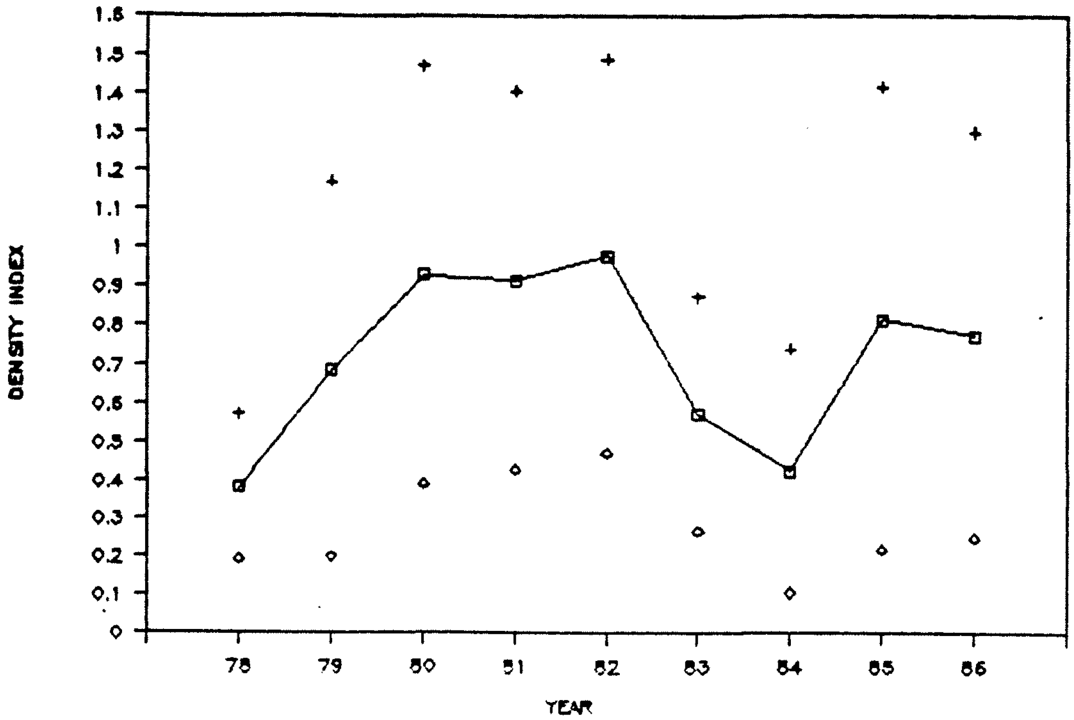

Figure 4. Density index for the Bering sea area for 1978 to 1986 using visibility code 2 and 3 data (+ is the estimate plus 2 standard deviations, ◊ is the estimate minus two standard deviations).

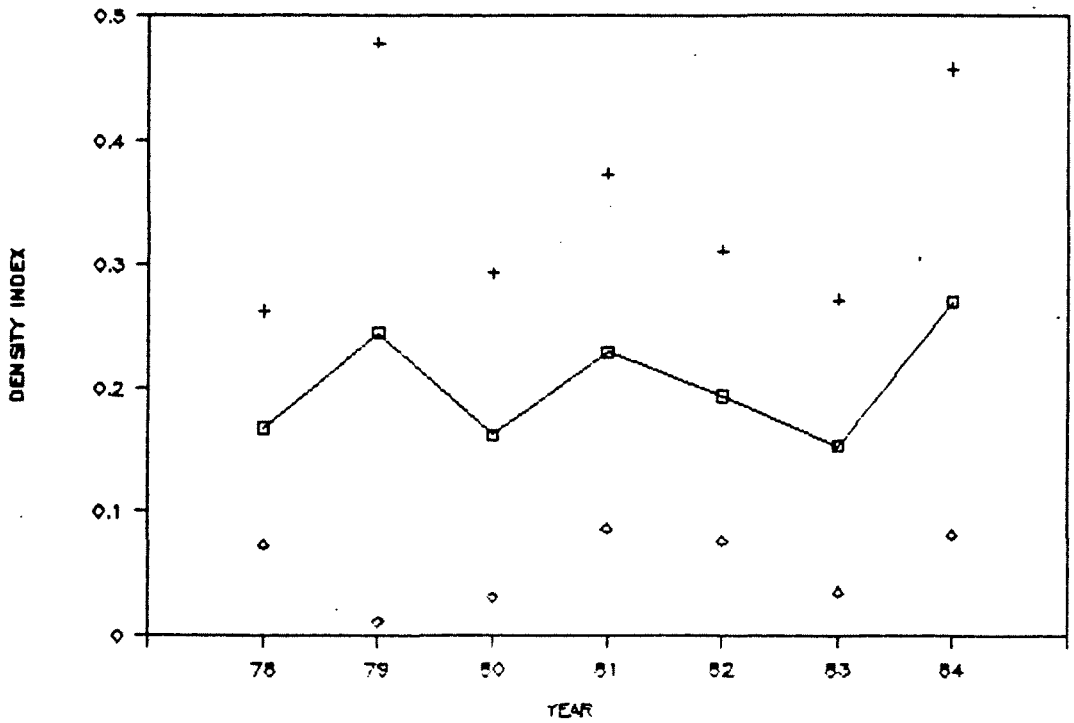

Figure 5. Density index corrected for movement for the western North Pacific Ocean area excluding the fishzone area for 1978 to 1984 using visibility code 2 and 3 data (+ is the estimate plus 2 standard deviations, ◊ is the estimate minus two standard deviations).

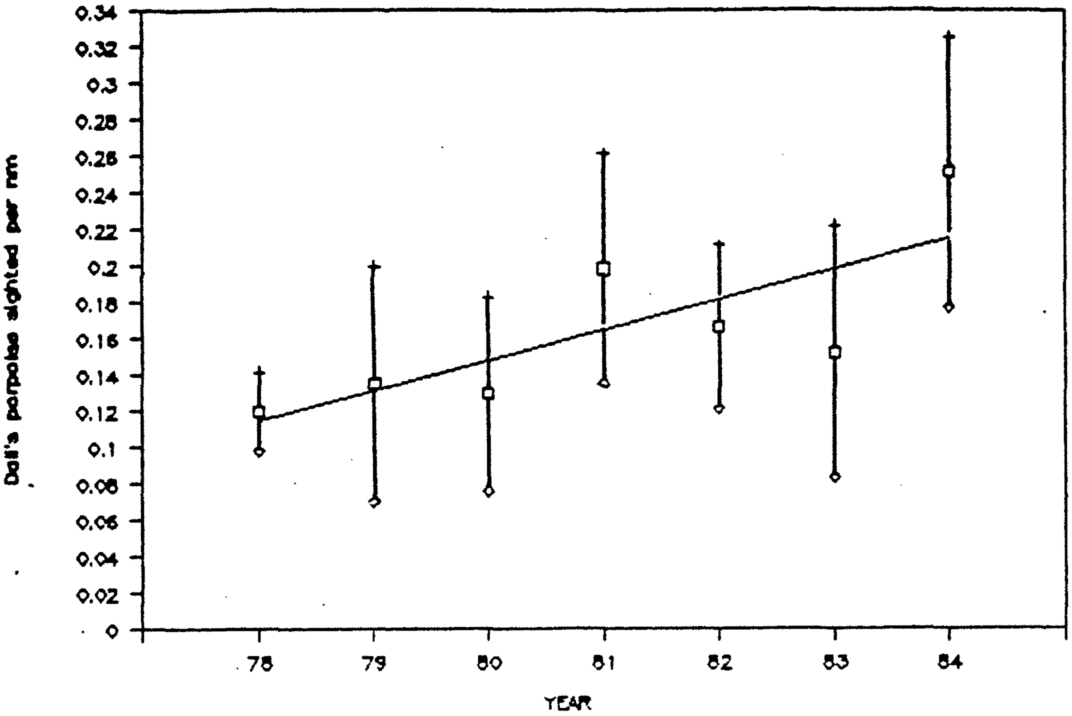

Figure 8. Straight line regression fit to the number of Dall's porpoise per nautical mile for the western North Pacific Ocean area excluding the fishzone area for 1978 to 1984 using visibility code 2 and 3 data (+ is the estimate plus 2 standard deviations, ◊ is the estimate minus two standard deviations).

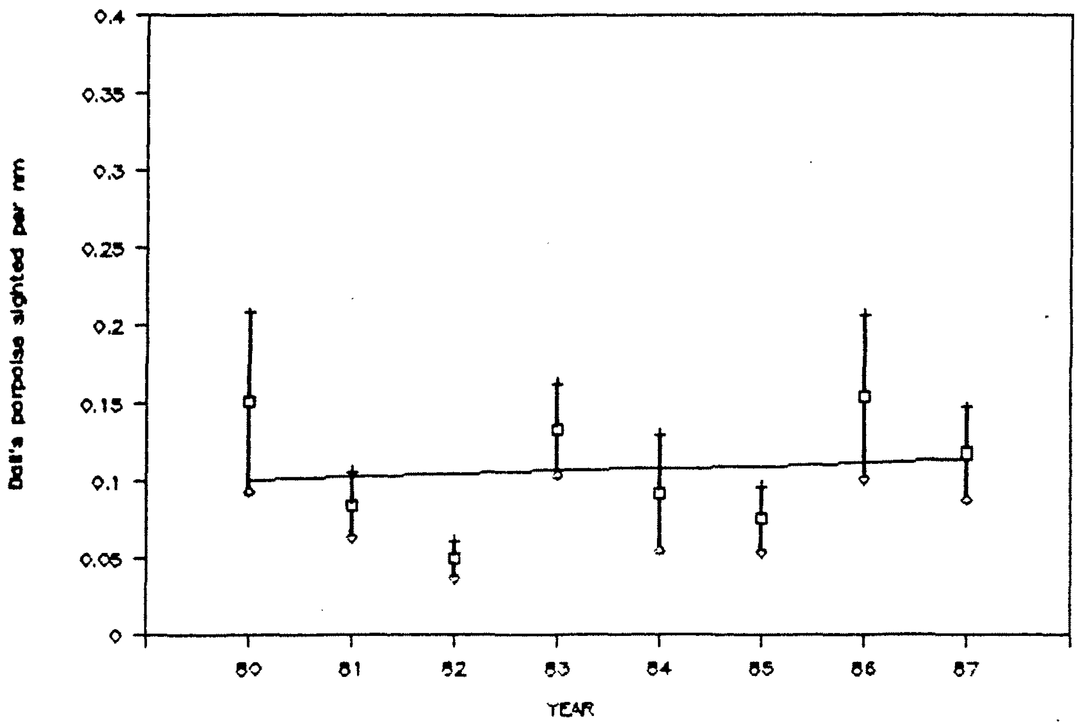

Figure 9. Straight line regression fit to the number of Dall's porpoise per nautical mile for the fishzone within the western North Pacific Ocean area for 1980 to 1987 using visibility code 2 and 3 data (+ is the estimate plus 2 standard deviations, ◊ is the estimate minus two standard deviations).

Table 11. Regression estimates for the number of Dall's porpoise sighted per nautical mile by year for the western North Pacific Ocean area excluding the fishzone, the fishzone area, and the Bering Sea area.

Area	Number of years	Constant	se Y	R^2	slope	se slope
NPACNOF	7	-1.183	0.032	0.60	0.0166	0.00605
Fishzone	8	-0.0446	0.040	0.01	0.0018	0.00624
Bering Sea	9	0.4141	0.031	0.09	-0.0033	0.00397

Table 12. Coefficients of variation of density corrected for movement and missed animals given various coefficients of variation of density, g(0) and C, the correction for movement. At cv D = 0.084, L = 11,200 nm, at cv D = 0.14, L = 4,053 nm, at cv D = 0.20, L = 1,986 nm, for the NPACNOF area.

cvD	cv g(0)	cv C	cv Dc
0.084	0.1	0.25	0.2821
0.140			0.3034
0.200			0.3354
0.084	0.075	0.15	0.1876
0.140			0.2184
0.200			0.2610
0.084	0.05	0.1	0.1398
0.140			0.1791
0.200			0.2291