International Council for
the Exploration of the Sea

C.M.1971/N:6
Marine Mammals Committee

SPERM WHALE BIOLOGY RELATED TO STOCK ASSESSMENT

by

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Introduction

More sperm whales are now caught throughout the world than any other species of large whale, as shown in Table 1. Successive reductions in the catches of baleen whales (chiefly fin and sei) in the major whaling grounds of the North Pacific and Antarctic to bring the yields to their maximum sustainable levels are causing the commercial whaling concerns to take an increasing interest in the apparently large stocks of sperm whales available for exploitation. Unfortunately there are still considerable gaps in our knowledge of the biology and the structure and sizes of the sperm whale stocks to fill before adequate regulations for rational harvesting of the resource can be formulated. The whale fishery off Durban, South Africa, has provided excellent opportunities for studying many of the critical biological parameters required for population models, and the following is an outline of the main results obtained (see Gambell, in press, for full details).

Sperm Whales off Durban

Sperm whales, hunted in the Indian Ocean off Durban since 1908, have been exploited more intensively from 1960 onwards. Analyses of catch and aircraft sighting data per unit of effort since 1954 (Fig. 1) suggest little significant change in real annual abundance when allowance is made for selective catching policies. The sightings records are unbiassed by species or size selection.

Seasonally, females and small males are most abundant in the early months of the year, the medium and big bulls in the winter months (Fig. 2). Most sperm whales are seen moving up the coast throughout the whaling season from February or March to September, although this trend slackens in winter (Fig. 3). The numbers of whales commonly found are single big bulls, up to half a dozen medium-sized males and ten to twenty small sperm whales (Figs. 4 and 5). There are on average ten mature females per big bull in mixed size groups, and the sexual classes of females are not segregated.

Histological investigation of the testes confirms that they mature slowly from the centre outwards. Testis tubule diameters and the weight and volume of the organ show no seasonal fluctuations, suggesting the absence of a male sexual cycle. The rate of growth of the testes relative to body length increases in males over 45ft (Fig, 6), a length which corresponds with the stage at which changes occur in the behaviour patterns of the whales associated with the attainment of social maturity and the potential to achieve harem-master status.

Dated foetal length records point to a constant growth rate of 0.99 ± 0.01 cm per day for most of the 449 day gestation period (Fig. 7). Referring the foetal records to their estimated dates of conception and birth defines the limited breeding season which reaches a peak in December, with calving at a maximum in March (Fig. 8) when equal numbers of males and females are born at a mean length of 4.05m and a mean weight of 1054kg.

A detailed study of variations in mammary gland thickness, uterus diameters, Graafian follicle size and abundance, and the sizes and numbers of corpora lutea, albicantia and aberrantia in the ovaries during their respective development and throughout the reproductive period points to a typical four year breeding cycle made up of $14\frac{3}{4}$ months gestation, 24-25 months lactation and 8-9 months resting periods. The average ovulation rate, allowing for the varying proportions of the female population which ovulate and conceive at the main, post-partum, mid- and end-of-lactation oestrous cycles is calculated

as 0.43 per year. The average pregnancy rate is 19%, but newly mature and older females are less fertile than those with 3-7 ovarian corpora.

Estimates of age are based on the annual dentinal growth layers counted in bisected, acid digested teeth. From these counts length-at-age curves for the catches can be erected (Fig. 9), which although much affected by the minimum size limit, do show a reduced rate of growth in the older males over 45ft long and 26 years old. Physical maturity is estimated at 50ft and age 40 years in males and 36ft and 45 years in females. Sexual maturity in females occurs at a length of 29ft and age 7 years. The attainment of harem-master status by the bulls at a length of 45ft and an age of 26 years is associated with the reduced growth rate of the body and the continuing enlargement of the testes after this stage.

The age composition of the catches show that the females are fully recruited to the fishery at about age 18 years, but the males enter more gradually from ages 14 to 23 years. Estimated instantaneous mortality rates are 0.08 for females and 0.20 for males, and natural mortality is considered to be 0.06 in both sexes.

External characters and morphometry are little help in defining stock limits; but a recovered whale mark shows a link between the males in Antarctic Area III (0°-70°E) and those off Durban, which are considered to be part of a local stock from recaptures in the same area a year after marking. The limits of this stock are set at 20° and 70°E longitude from a consideration of pelagic catch density data. Estimates of exploitable stock size from catches and fishing mortalities, mark recoveries, and comparisons with the densities of the fin and sei whale stocks in the area, give a range from 20 to 49 thousand sperm whales, with equal numbers of males and females. The number of mature females is calculated as 18-50 thousand, with a more probable narrower range from 18 to 30 thousand. This in turn leads to estimates for the sustainable yield of females of 430-2765 (430-1659 narrow range) and of males 500-2435 (500-1461 narrow range). The present catch of females off Durban averages 877 whales per year and is within the sustainable yield range, but the combined Durban and pelagic catches from the male stock of about 2000 per year are near the upper limit for a sustainable yield,

as is the fishing mortality calculated. The optimum yield in weight of males would be obtained from animals of length 45ft and age 26 years.

Parameters

A number of relatively simple models have been developed for stock assessment purposes so far, and the critical parameters from the available biological studies carried out to date have been identified (International Whaling Commission, 1969, 1971).

The Scientific Committee of the International Whaling Commission is promoting a sperm whale stock assessment meeting to be held in Vancouver, Canada, in April 1972 to carry forward this work. Many of the difficulties encountered in developing suitable models are associated with charges which might be expected but have not yet been observed in the various factors resulting from exploitation and associated stock density changes.

Ovulation and pregnancy rates

The ovulation and pregnancy rates might be expected to increase in an exploited sperm whale stock as they appear to have done in the Antarctic fin whales (Laws, 1961). It is unexpected to find in a polygynous species such as the sperm whale that the pregnancy rate off Durban, for example, is only 19% when the four year breeding cycle suggests a rate of at least 25%. The evidence from Durban shows that only 69% of the ovulations during the main winter oestrus are fertilised, so the pregnancy rate could well be increased by a higher conception success at this oestrous period. A greater proportion than the present 0.8%, 9.3% and 52.3% of the female stock estimated at Durban to ovulate post-partum, at mid- and end-of-lactation respectively would also raise the level of reproduction.

Sexual maturity

In female sperm whales the age at sexual maturity may be lowered with a corresponding increase in the growth rate under exploitation, as occurred in the Antarctic fin whales (Laws, 1962; Lockyer, in press). For the male sperm whales however, because of the slow maturation of the testis tissue resulting

in lower concentrations of spermatozoa in smaller animals, and the need for a bull to be socially acceptable as well as sexually capable before reaching harem-master status, there is some doubt if the age at which this can be achieved will be reduced in an exploited population.

Harem size

The number of females per breeding bull can be varied according to the catching policy adopted; as the males grow so much larger than the females more or less selective exploitation of the sexes can be practised. The effect that such variations in harem size may have on the reproductive potential of the population is not known. For example, there may be a maximum number of females which a bull can successfully impregnate and this could become particularly important if sub-fertile younger bulls become harem-masters as a result of the over-cropping of the biggest animals.

Natural mortality

It is generally assumed that the natural mortality rate of a virgin population will decrease when exploitation occurs. The precise extent to which this change will progress, and the form of the reduction, still have to be determined. Since the natural mortality rate in sperm whales is relatively low at about 0.06, the amount of change will inevitably be rather small.

Patterns of exploitation

At the present time there are prohibitions on the capture of lactating females and animals of less than 35ft length from land stations and 38ft in pelagic whaling operations. These restrictions give a degree of protection to the females in particular, because animals of this sex seldom grow larger than 38ft. The effect has been to direct a considerable part of the catching effort on the male component of the stock. It now seems from analyses of the sperm whales in the North Pacific and off both coasts of South Africa that a change is required to achieve the most effective harvests. Because the bulls reach harem-master status at a relatively advanced age, the numbers surviving to this point are not very large and there is not really such a surplus of males available for

capture as first appears. It might be much better management policy to ration the catches by number of each sex, with no minimum size limit but rather a maximum above which only a certain quota can be taken annually. In this way the breeding bulls could be given sufficient protection to maintain the full reproductive potential of the stocks. As the industry is likely to catch the largest whales it can of the remainder, the juvenile part of the populations should not be exposed to a so much greater fishing effort than at present.

Stock limits

All of the foregoing discussion assumes that the unit stocks of sperm whales are known and distinguishable. This is not the case, and a prime subject for research is the de-lineation of independant sperm whale populations which can be individually managed. At the moment the divisions into separate stocks are largely a matter of practical convenience based on the geography of the whale fisheries. More precise definitions must be achieved by means of whale marking, blood typing, genetic studies and any other practicable techniques.

Summary

Sperm whales are now caught in greater numbers than any other species of large whales. Knowledge of their basic biology as it relates to stock assessments is illustrated by recent work on the stock fished off Durban, South Africa. The main parameters required are indicated, and changes which may occur in response to exploitation discussed.

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Table 1. Whales killed in the years 1956/57 - 1968/69, by species(from IWS).

Season	Blue	Fin	Hump.	Sei	Sperm	Other	Total
1956-57	1,775	31,626	3,196	3,138	19,156	99	58,990
1957-58	1,995	31,587	2,923	5,670	21,846	54	64,075
1958-59	1,442	30,942	5,055	5,539	21,298	97	64,373
1959-60	1,465	30,985	3,576	7,035	20,344	84	63,489
1960-61	1,987	31,790	2,840	7,785	21,130	109	65,641
1961-62	1,255	30,178	2,436	8,804	23,316	101	66,090
1962-63	1,429	21,916	2,758	9,549	27,858	69	63,579
1963-64	372	19,182	318	13,690	29,255	184	63,001
1964-65	613	12,317	452	25,453	25,548	297	64,680
1965-66	243	6,882	59	23,067	27,378	262	57,891
1966-67	70	6,458	4	19,016	26,424	266	52,238
1967-68	-	5,268	2	16,960	24,080	335	46,645
1968-69	-	5,320	5	11,980	24,142	288	41,735

1956-57=Antarctic season 1956/57 and summer 1957 etc.

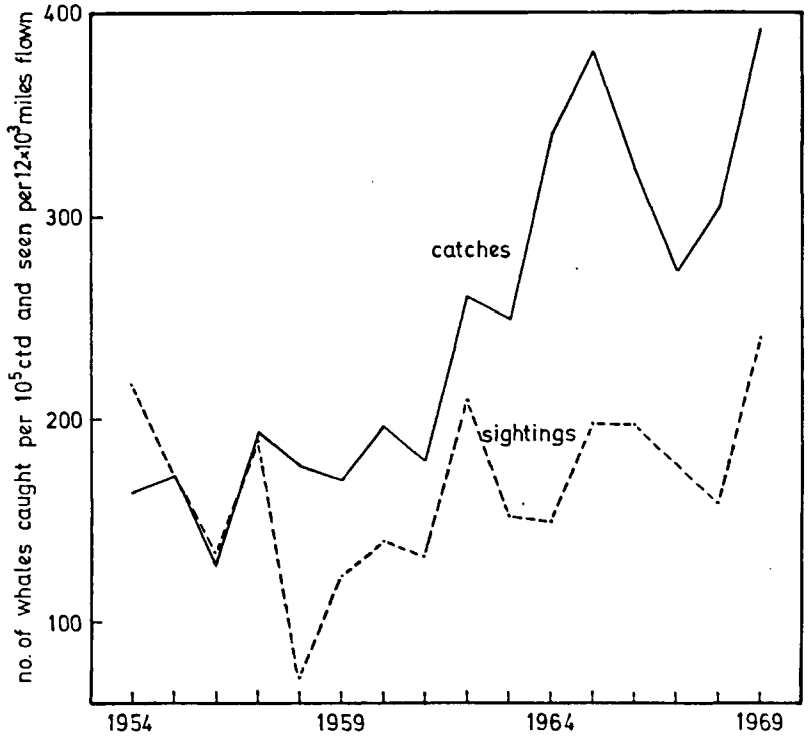

Fig. 1. Annual catches and sightings per unit of effort of sperm whales off Durban.

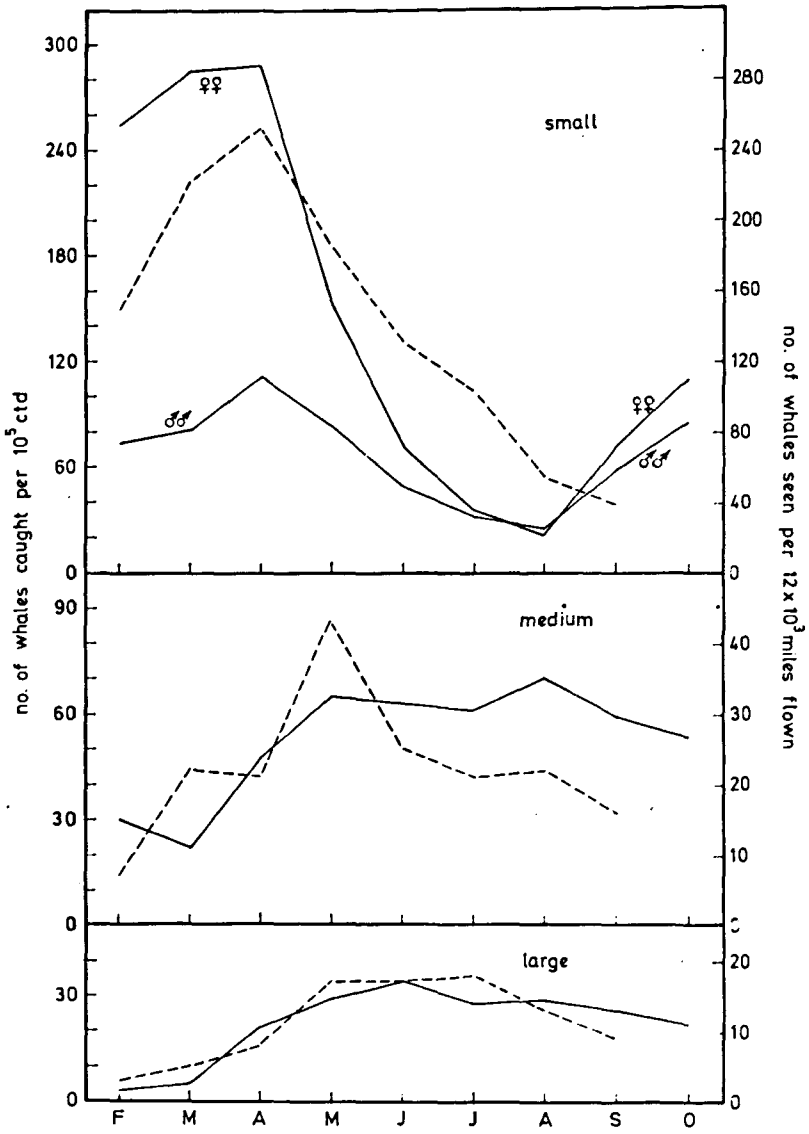

Fig. 2. Average monthly catches (solid line) 1954-69 and sightings (broken line) 1961-69 per unit of effort of various size groups of sperm whales off Durban.

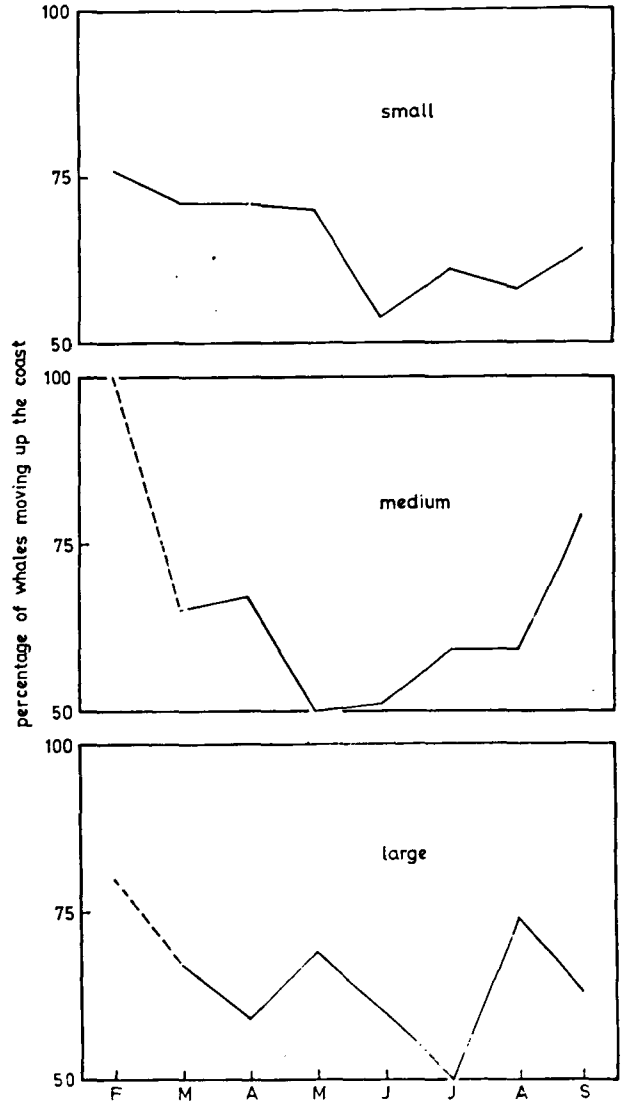

Fig. 3. Percentage of three size groups of sperm whales seen moving up the coast, 1961-69.

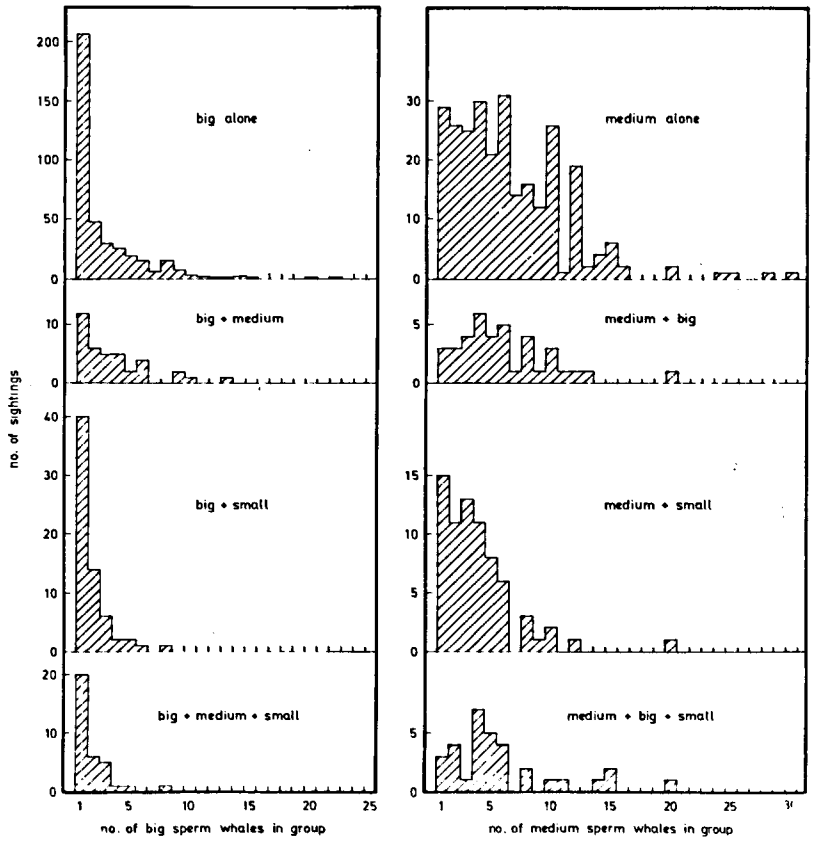

Fig. 4. Frequency distributions of numbers of big and medium-sized sperm whales in the aircraft sightings off Durban.

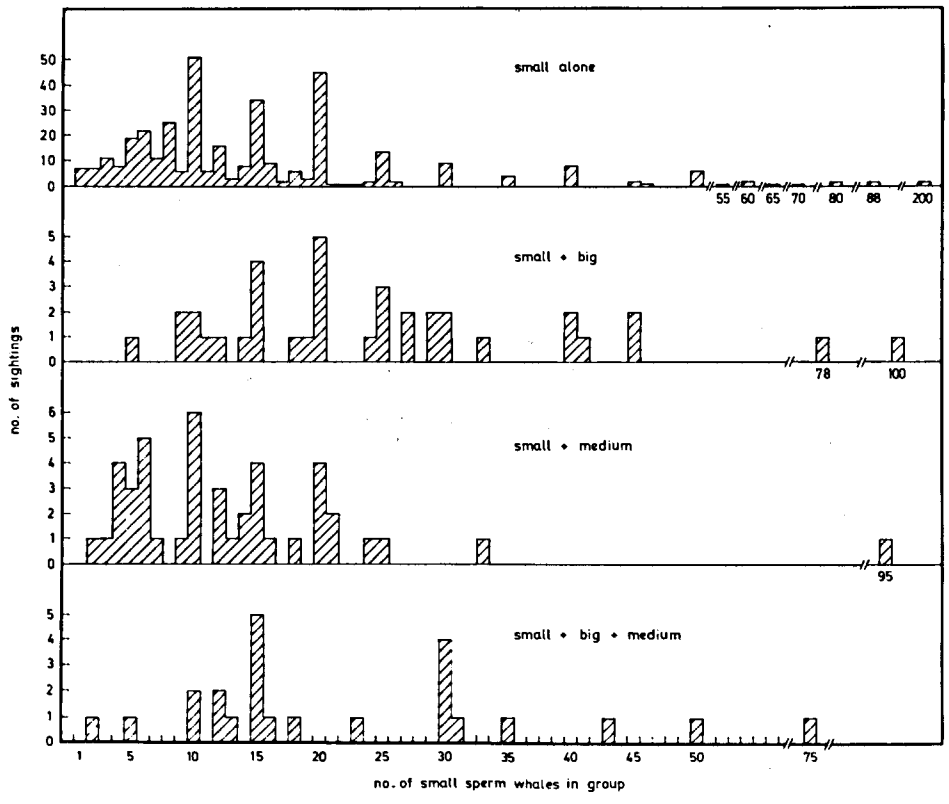

Fig. 5. Frequency distributions of numbers of small sperm whales in aircraft sightings off Durban.

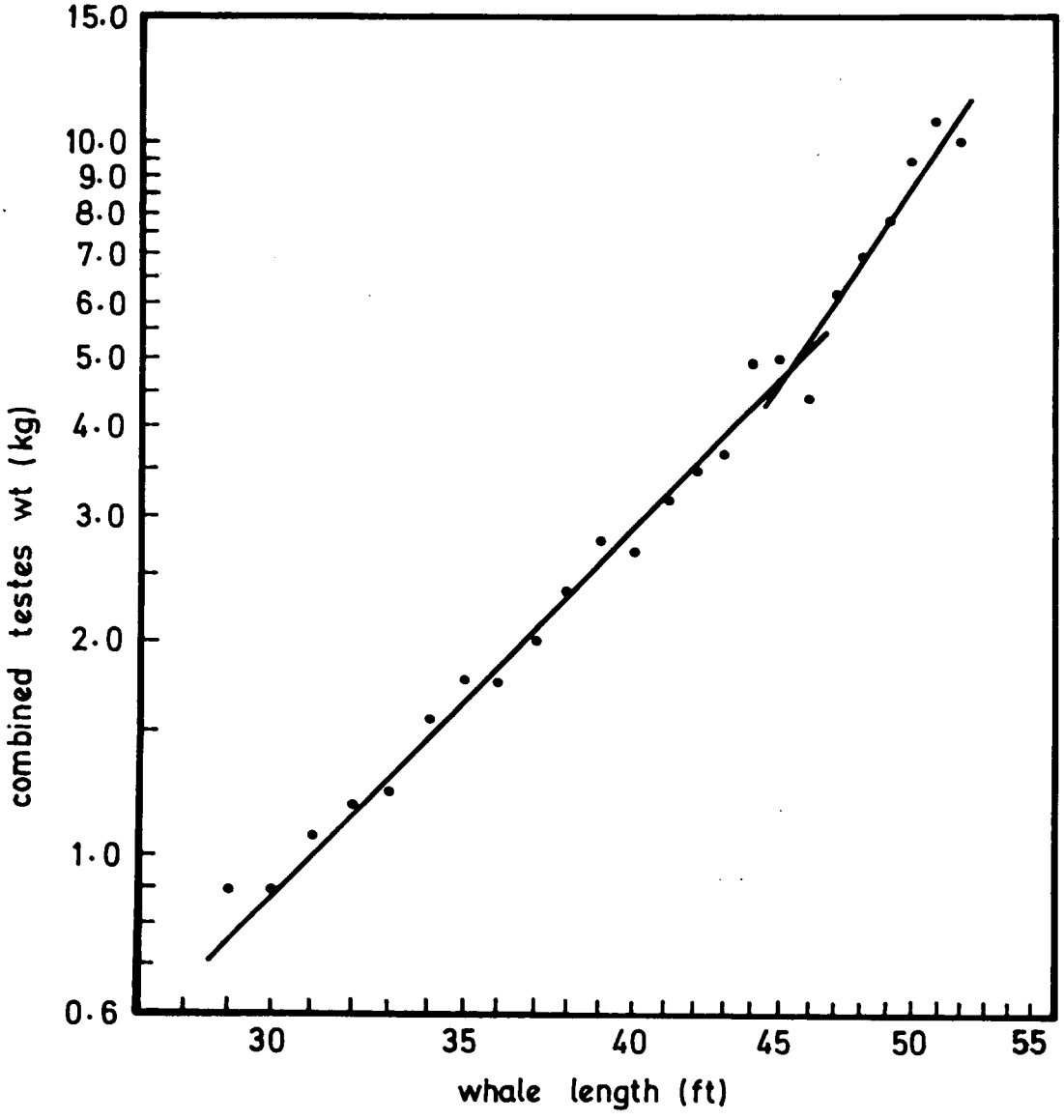

Fig. 6. Geometric mean weights of the combined testes at each body length of sperm whales classified as mature at Durban, and the fitted regressions.

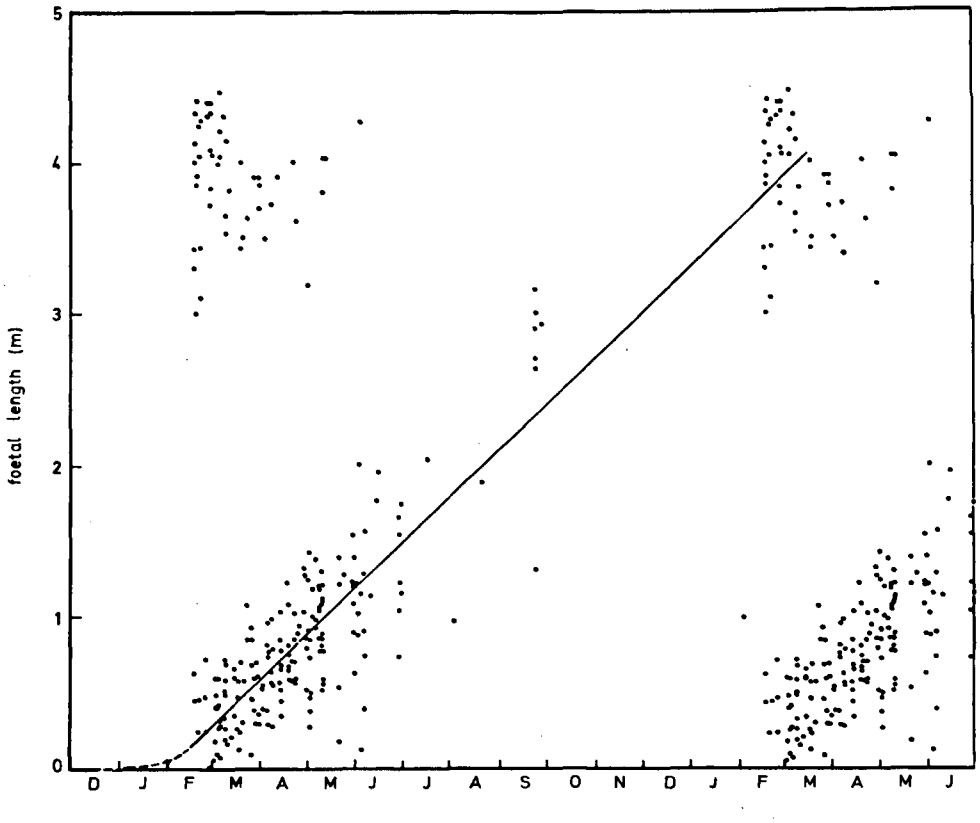

Fig. 7. Foetal sperm whale records at Durban and the calculated mean growth line.

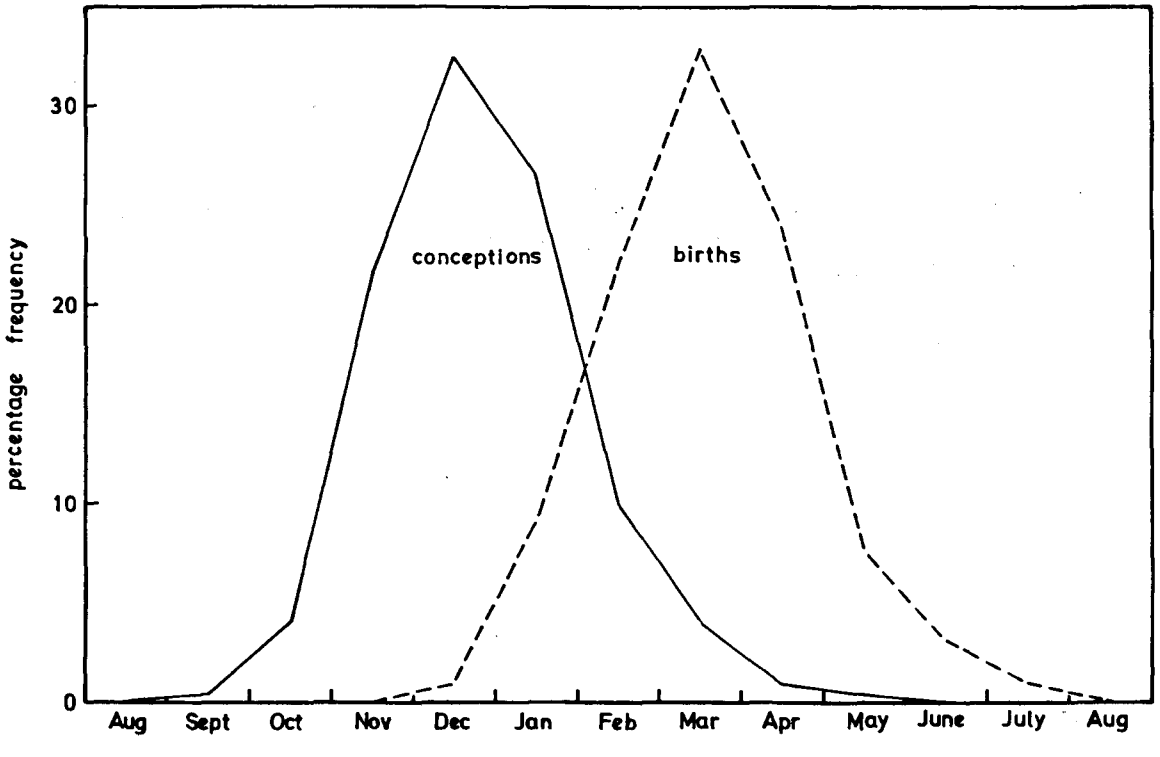

Fig. 8. Monthly frequencies of conceptions and births in sperm whales off Durban.

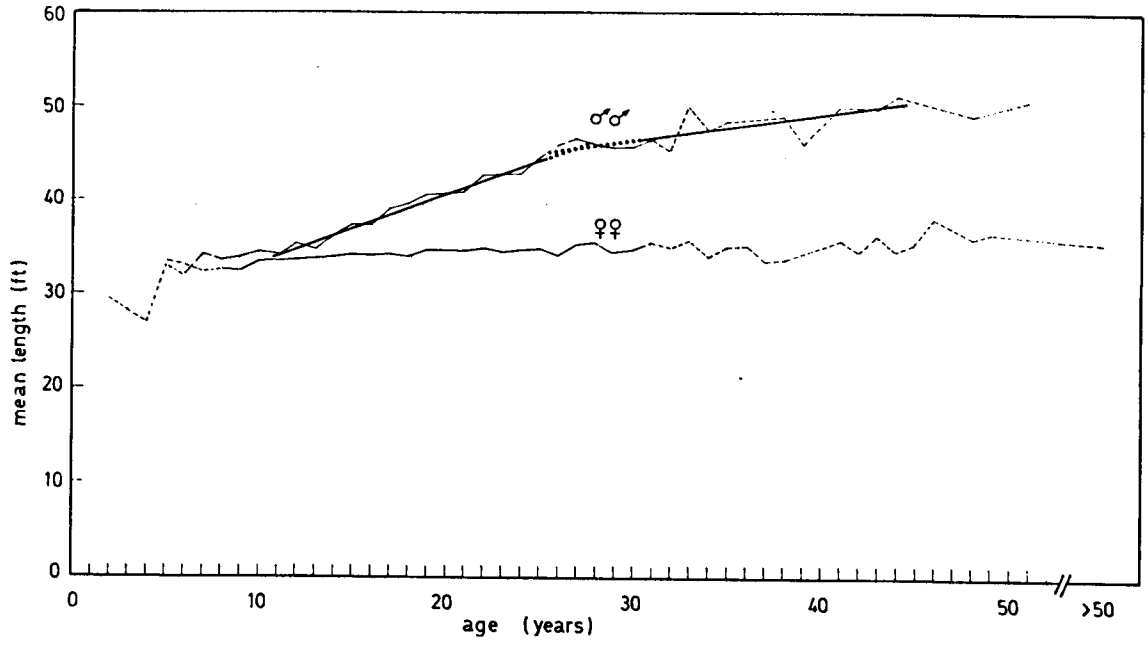

Fig. 9. Mean body length at each age of male and female sperm whales caught off Durban (points representing fewer than ten observations joined by broken lines).