CHANGE OF FORM IN THE SPERM WHALE ACCOMPANIED WITH GROWTH

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It is already explained by many authors that in the mammals, all the portions of the body do not extend at the same rate as the length of the body. From this fact the following reversed consideration may be taken. Age may therefore be detected from the data on body proportions by measuring the parts in which growth is apparent. On the other hand, if there are differences in the body proportions of two groups of whales, these differences may be due to hereditary factors. These two groups may be considered to belong to two different populations. An analysis of the data accumulated from investigations carried out at various whaling stations has been made as follows. The ageal changes are given in the figure on relationship between the body length and age computed from teeth lamination reading is attached at the end of this paper.

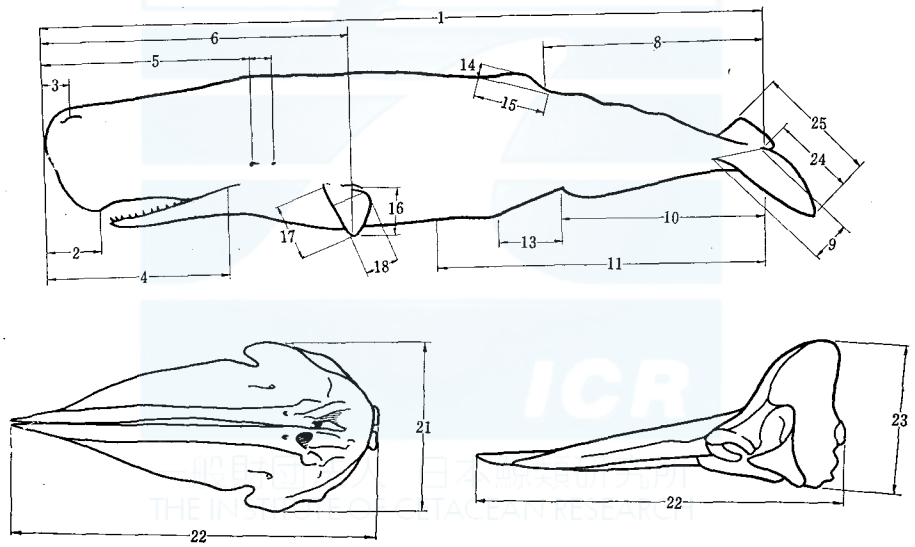

Fig. 1. Measurement points of body proportions of sperm whale.

MATERIALS AND BODY PARTS ON WHICH THE MEASUREMENT IS BASED

The measurements in this paper are based on the data on 227 individuals (199 males and 28 females) of the North Pacific sperm whale (including the data by

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Fujino, 1956), and have been compared with those obtained by Matthews (1938) on the Antractic sperm whale.

The data are obtained by measuring from the tip of snout or from the nocth of tailflukes along a straight line running parallel with the body axis to the objective point. The flippers and the tailflukes have been measured in a straight line at two points.

Fig. 1. outlines the above stated measuring method, and the measurements are numbered mainly in according with the Discovery Reports Vol. 1 (by Mackintosh and Wheeler, 1929) example.

SEXUAL DIFFERENCES IN BODY PROPORTIONS

The greatest sexual difference naturally is most apparent in the genital organs,

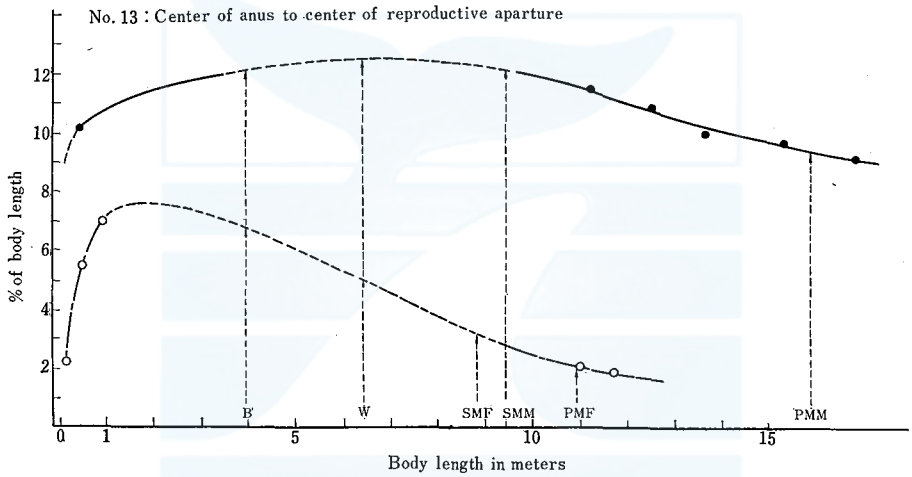

Fig. 2. Sexual difference in genitals.

EXPLANATION OF THE FOLLOWING FIGURES

The abscissa is the body length and the ordinate is the percentage of the body length In order to avoid complication, data on all the individual points have been eliminated, and have been confined to the indication of the average trend developed through growth of body according to the body length in curves. On the figures attached (2 through 9 and 12), the broken lines indicate facts on which data is scarce and the cross marks indicate the data obtained by Matthews (1938). The letters B, W, SMF, SMM, PMF and PMM in thefigures are represent the body length at birth, weaning, sexual maturity of female, sexual maturity of male, phisical maturiy of female and physical maturity of male, respectively.

that is, the values from the center of the anus to the center of the reproductive apertures are very different in the male and the female. A very interesting trend is noted in the changing of the body proportions according to the part especially in the female. During the period of its embryo, the distance from the anus to the opening of the vagina gradually grows, however, the proportion of the part becomes

gradually smaller from the later stage of its foetal life. In the male, the distance from the anus to the exposure hole of the penis keeps on gradually growing proportionally even after birth till it reaches sexual maturity, after which its growth declines. It is therefore considered that the above distance becomes stable even though the body length keeps on growing.

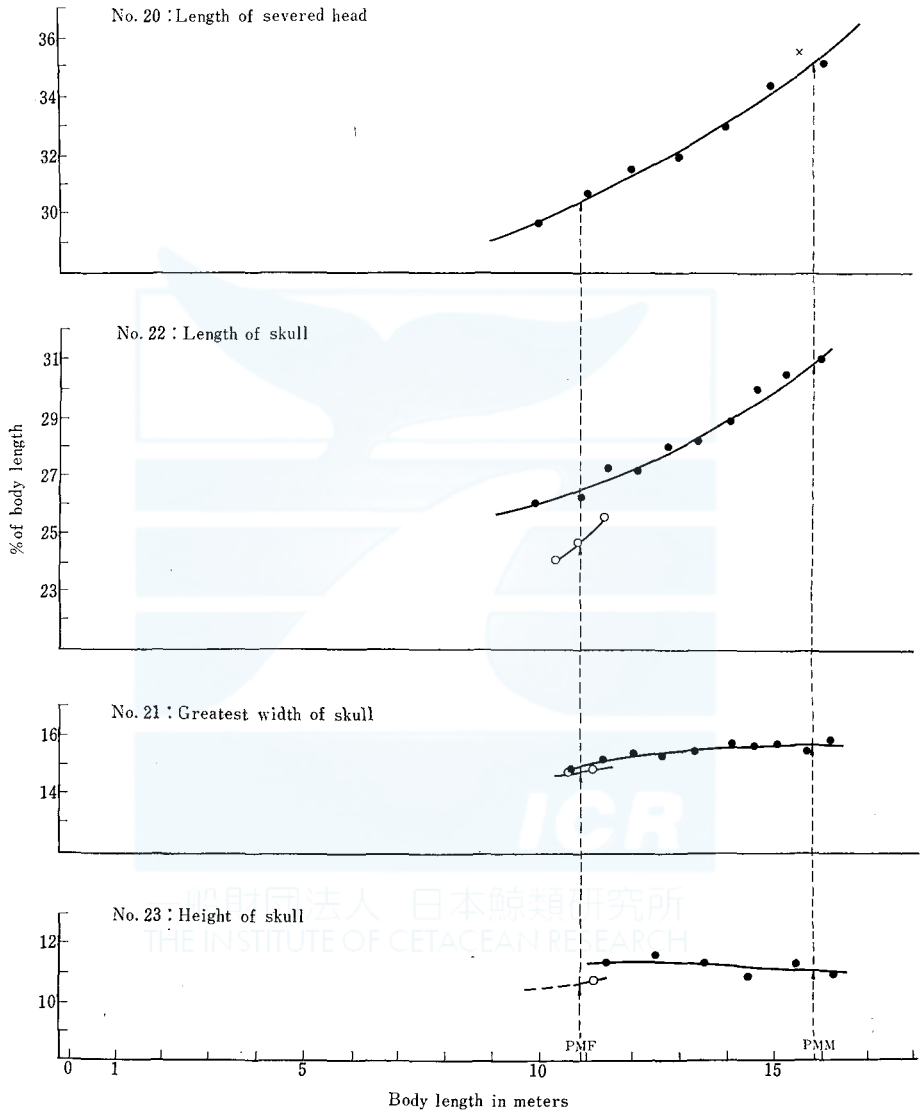

Fig. 3. Sexual differences in skull.

The difference between male and female can also be seen in the skull. The growth of the skull is more remarkable compared with the growth of the body in the male, especially in its length and height. The length of the severed head shows

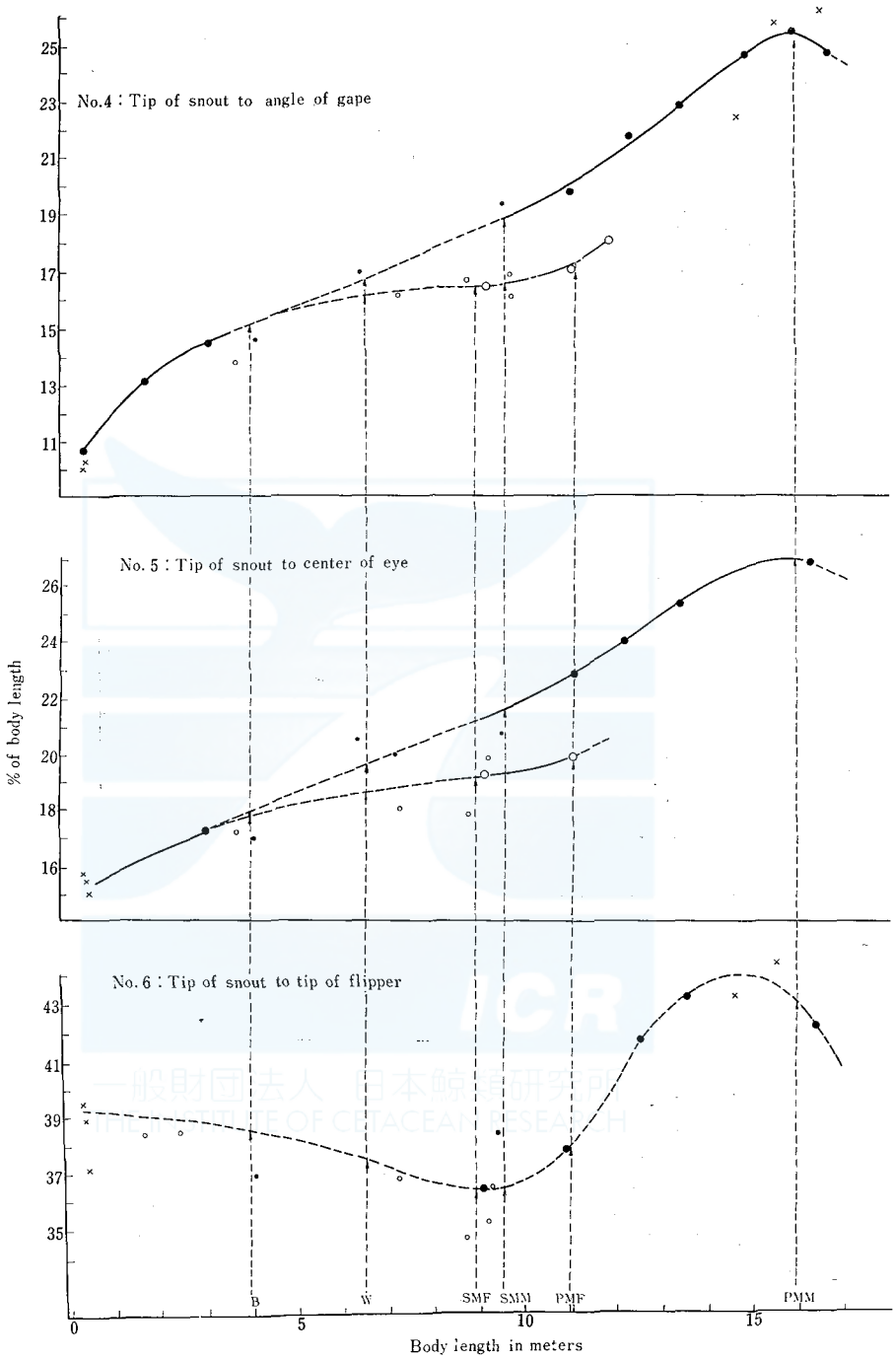

Fig. 4. Growth of forepart of body (1)

growth exceeding the length of the skull at the time of growth. In the male especially, the growth of the distance from the tip of snout to the angle of gape or to the center of eye is greater than that of the skull length, and this means that the soft tissue part in fromt of the skull grows more than the hard tissue. The consequent argument is that the melon in front of the skull, which not only plays a very important part in the fighting operation of the male to vercome the female but some undefined physical purpose enabling it to dive into the depths, grows at higher ratio than the skull, especially in the male.

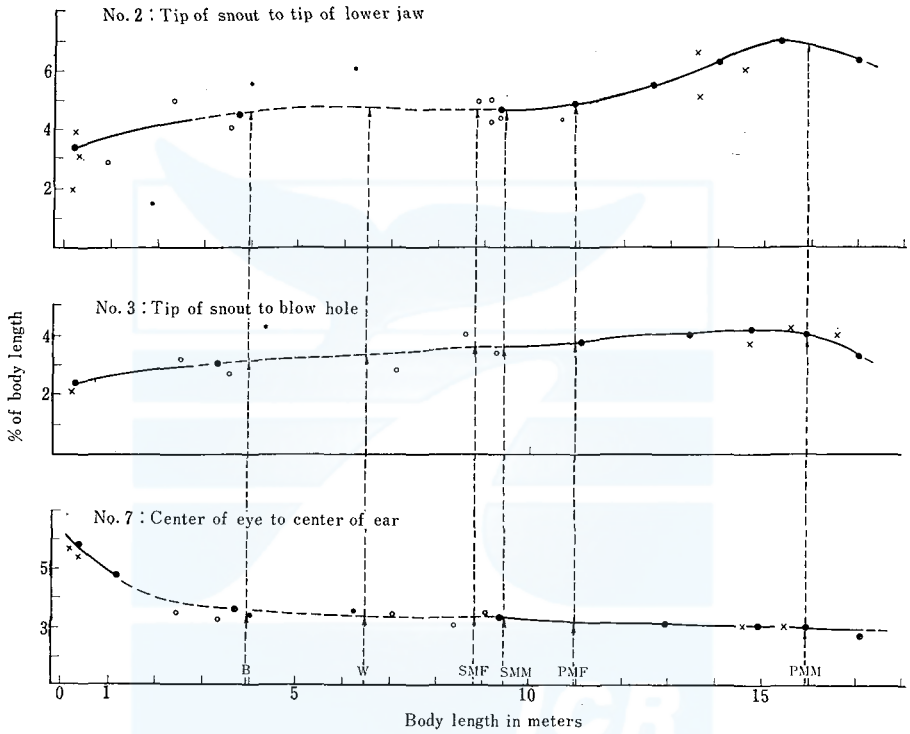

Fig. 5. Growth of forepart of body (2)

The sudden drop in the curves shown in most of the figures do not indicate that the distance between the parts of the body under discussion has become shorter but that this part of the curve is not too reliable due to the fact that data represented here is based on body length and not on age.

GROWTH OF FOREPART OF BODY

The features of the skull are explained in the following paragraph, therefore the other parts of the forepart of the body will be discussed here. As no sexual differences can be observed in these parts, the following changes according to growth are applicable to both male and female.

1. Tip of snout to tip of lower jaw.

Whether the measurements are taken with the lower jaw open or closed, technical errors are in suitable, therefore the actual measurement indicates the distance from the tip of snout to the fore end of the socket into which the lower jaw fits. This part of the head slowly but gradually changes with growth, and the growth of the part becomes proportionate with the growth of the body after sexual maturity is reached (mainly in the male).

2. Tip of snout to blow hole.

Measurements naturally change according to the stage of growth, but as it is well known, the blowhale of the sperm whale opens at a point very close to the tip of the snout, and changes in this particular case are of very little value. As also explained in the foregoing paragraphs, these changes are mainly due to characteristics ensuing from growth of the soft tissue in the forehead.

3. Tip of snout to tip of flipper.

These measurements were taken in accordance with the method employed by Mackintosh and Wheeler (1929). In spite of the fact that this part is considered very important in examining the middle of the body, measurements of this particular area contains considerable errors because the position of the tip of the flipper varies according to the freshness of the carcass as well as the position of the body itself, etc. These measurements therefore are not to reliable.

4. Center of eye to center of ear hole.

This is one of the parts which can be very easily measured. In the earlier stage of the foetal life, the distance between the two points is rather apart, but from the later stage of it this distance becomes very stable and proportionate with the growth of the body length.

GROWTH OF REARPART OF BODY

1. Notch of flukes to anus.

Compared with those of other land mammals, this part of the whale body is very large, and grows at the same ratio as the growth of the body length till it reaches at sexual maturity, however, after this stage is passed, the curve rapidly goes down. As it is well known, ossification advances from both ends of the vertebral column, till physical maturity is reached, but in the Cetacea, the ossification from the rear end advances at heigher speed than from the fore end, so that it may seem that ossification is completed entirely from the rear part of the body. The curve in the figure therefore shows that ossification which commences slightly after sexual maturity is reached advances smoothly.

2. Notch of flukes to posterior emargination of dorsal fin and to umbilicus.

The doral fin of the sperm whale is not conspicuous, moreover, it is accompa-

nied with dorsal humps, so taking measurements is made relatively difficult. The curve of this measurement, however, is comparatively smooth. The curve from the notch of flukes to umbilicus shows a fairly different from the two curves on the abovementioned. In the foetal stage the development of this part is very rapid,

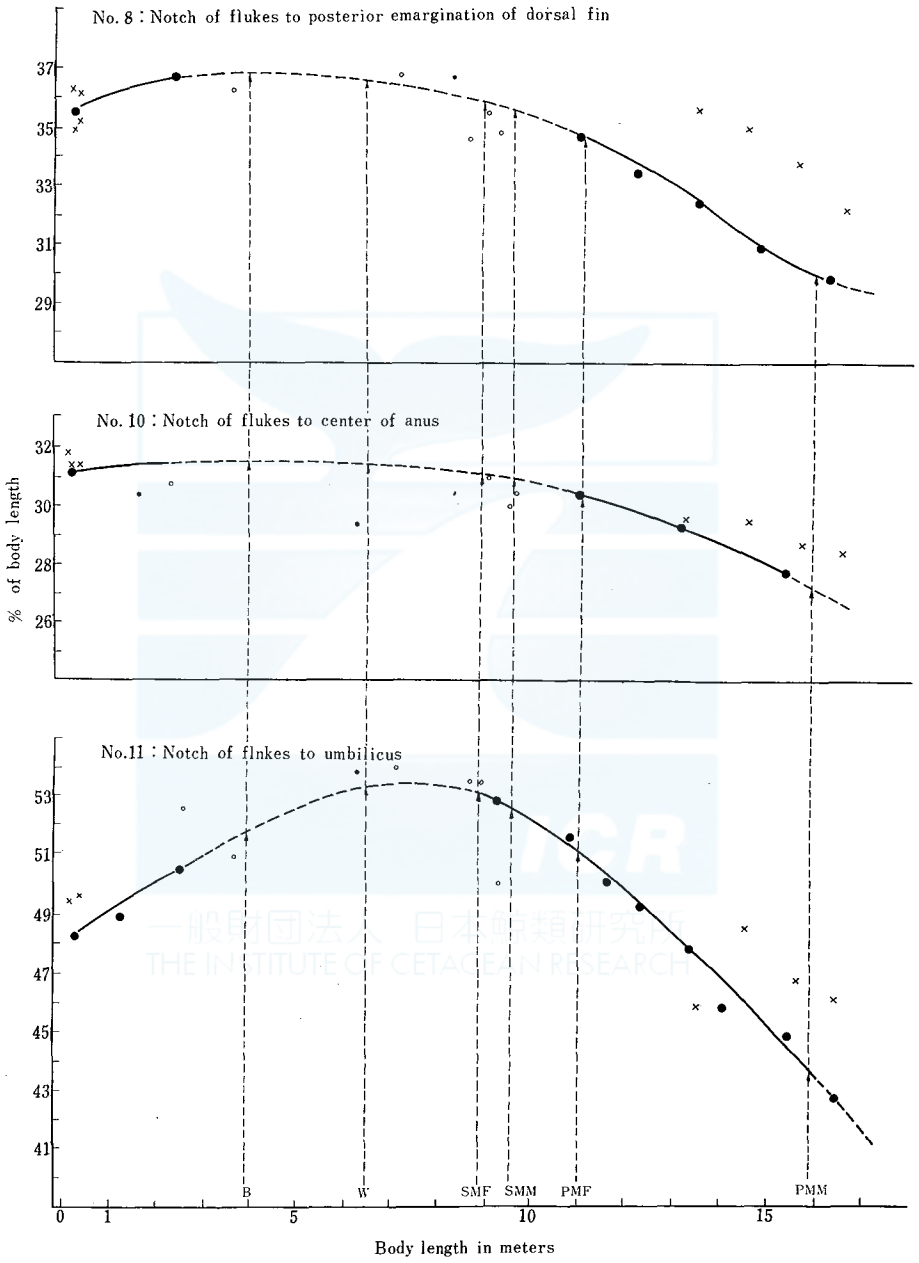

Fig. 6. Growth of rearpart of body.

and this growth continues till the stage slightly before sexual maturity. This is caused by the rapid development of the internal organs. This development stops at the stage of the sexual maturity, thereafter the curve goes drown at the same

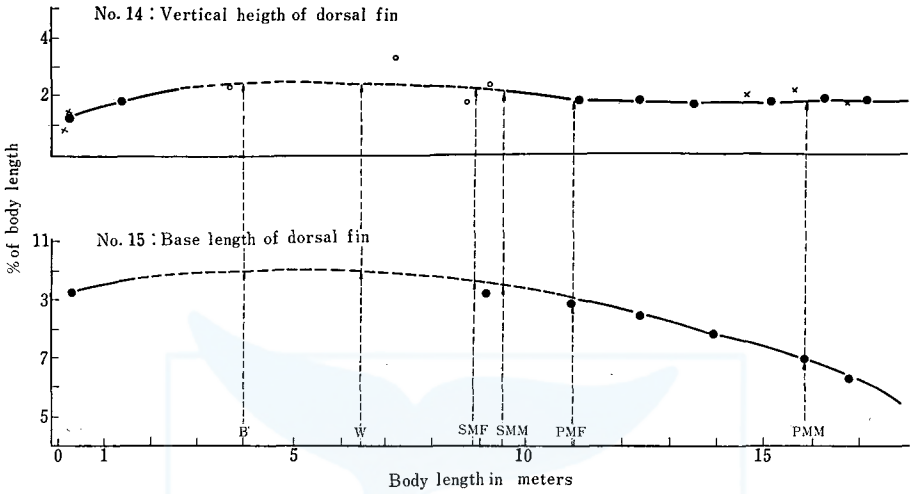

Fig. 7. Change of shape of dorsal fin.

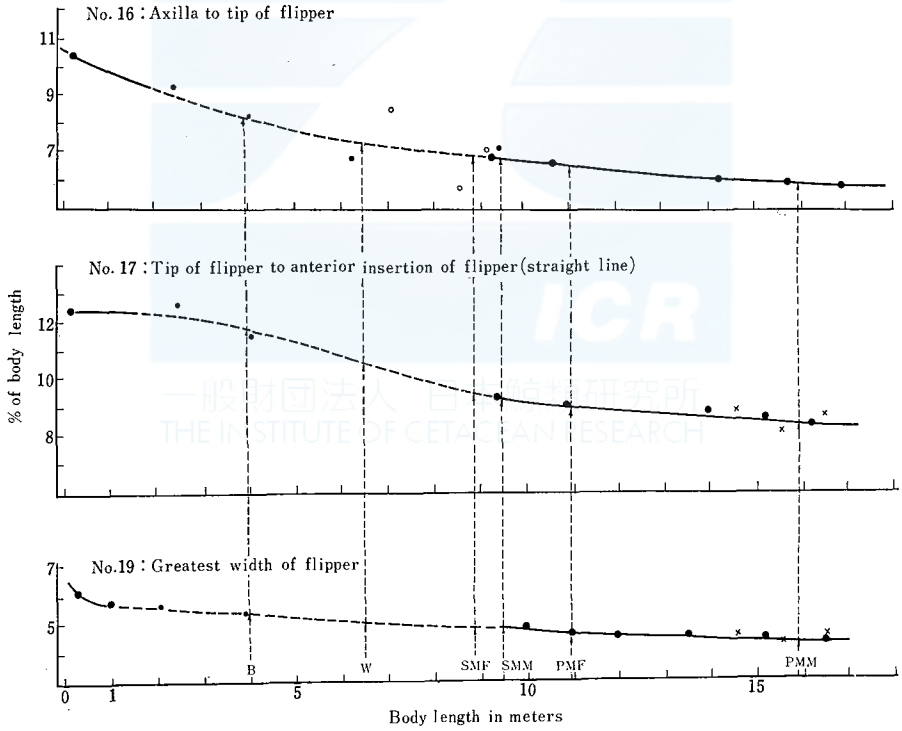

Fig. 8. Change of form of flipper.

rate as the abovementioned curves (from notch of flukes to anus as well as to anterior emargination of dorsal fin). It is understood that this declining tendency of the curves is due to the ossification of the vertebral column.

At the end of these curves, there are " X " marks which clearly disjoins the curves. These phenomena are only observed in the rear part of the body. It is considered from this fact that the tail part of the North Pacific sperm whale is shorter than that of the Antarctic sperm whale. Ivanova (1955) already described this fact.

3. Change of shape of dorsal fin.

The measurements of the dorsal fin had been shown in the figures, although the dorsal fin of sperm whale is very difficult to measure, and the curves are well proportionate with the growth of the body length. The basal length of the dorsal fin is naturally affected and regulated by the ossification of the vertebrae that is situated just under the dorsal fin.

4. Change of form of flipper.

With regard to the shape of the flipper, the distance from the tip to the anterior end of lower border, from the tip to the axilla and the greatest width were measured. The proportions of these lengths follow a fitted ratio in the earlier stage of the foetal life, but this ratio gradually drops in the later stage of it. This trend continues in the later stage of the foetal life till the animal reaches to the high age. From this fact it is considered that the flippers have never played an important role in the swimming life of the sperm whale. Furthermore the paleontological consideration in the long life history of the sperm whale, the foreleg was used in their land life and became atorophied gradually in the swimming life of the sea. The shape of the flipper became smaller and smaller, and the function of the foreleg also changed. This is a very interesting fact in the sperm whale, but is not common in all the species of whales. Though it must be recognized that there is some great difference between the change of the foreleg and the atorophy of the hind leg which does not appear on the outer surface of the body, this is considered as a new phylogenetical opinion.

5. Development of tail flukes.

The measurement of the tail flukes have been taken from the distance between the notch of flukes to the tip, the distance from tip to tip and the length of flukes at insertion.

The tail flukes are first formed at the stage of 3—5 cm body length. The edges of the early flukes rapidly develop to the natural shape. This however is folded in the ventral side of the body until the time of parturition. So it is fairly difficult to obtain accurate results when measuring from tip to tip of flukes in the foetal stage.

In the figure, the ratio of the length of the tail flukes at the insertion is larger in the earlier stage of the foetal life, and this is due to the sudden development.

When the later stage of the foetal life is reached the curve gradually becomes more stable, and the spread of the tail flukes gradually keeps on developing till sexual maturity is reached. This is the stage when the ratio of the spread is largest in the proportion, twice the distance from the notch of flukes to the tip. The ratio of the length of the side of the flukes remains stable while that of the spread becomes shorter, this means that the position of the tip of flukes has moved slightly forward. The figure 11 illustrates tail flukes in their natural shape with equal distance from tip to notch.

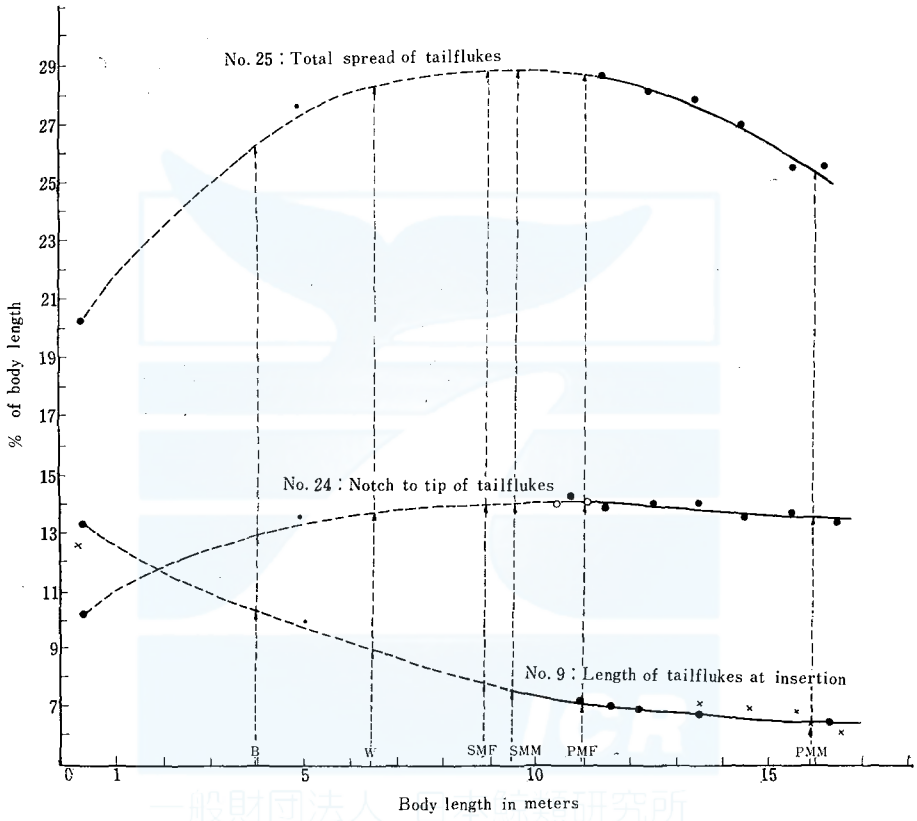

Fig. 9. Development of tail flukes.

RELATION BETWEEN BODY LENGTH AND AGE

It is natural that the body length increases according to age, and the body length of an individual whale is largest at the stage of attainment of physical maturity through sexual maturity. It however is considered recently that the body length decreases very slowly in the older stage. This is shown in Fig. 12 as the relationship between body length and lamination number in the teeth which is the most reliable basis for age determination. This is a general rule of physiological phenomena in the mammals, and can be found in other kinds of mammals including

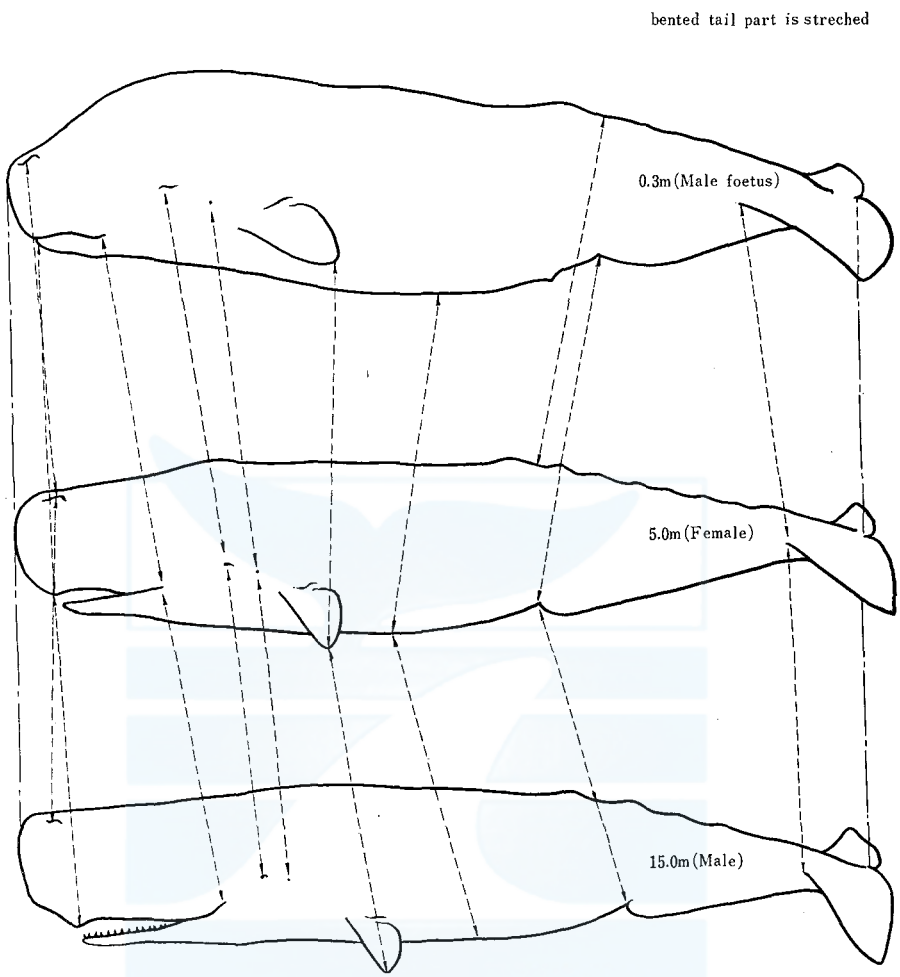

Fig. 10. Pictorial representation on change of body form in sperm whale drawn equal in length.

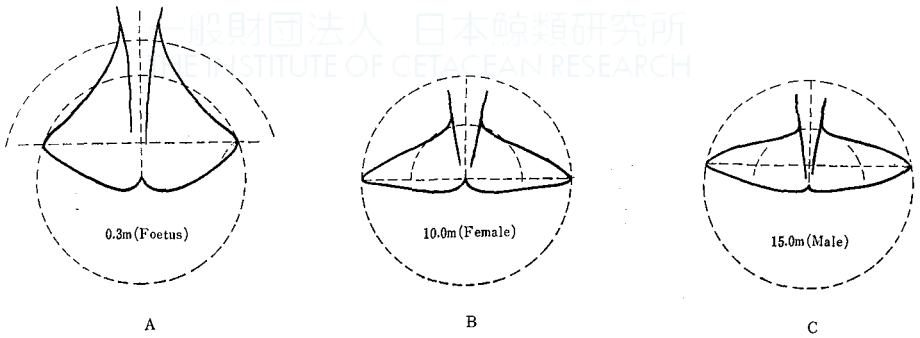

Fig. 11. Pictorial representation on change of tail flukes in sperm whale drawn equal in length.

mankind, which is caused through the contraction of the intervals between the vertebrae, and the bowing of the vertebral column due to age. The head or the skull which occupies a large proportion of the body length of the sperm whale,

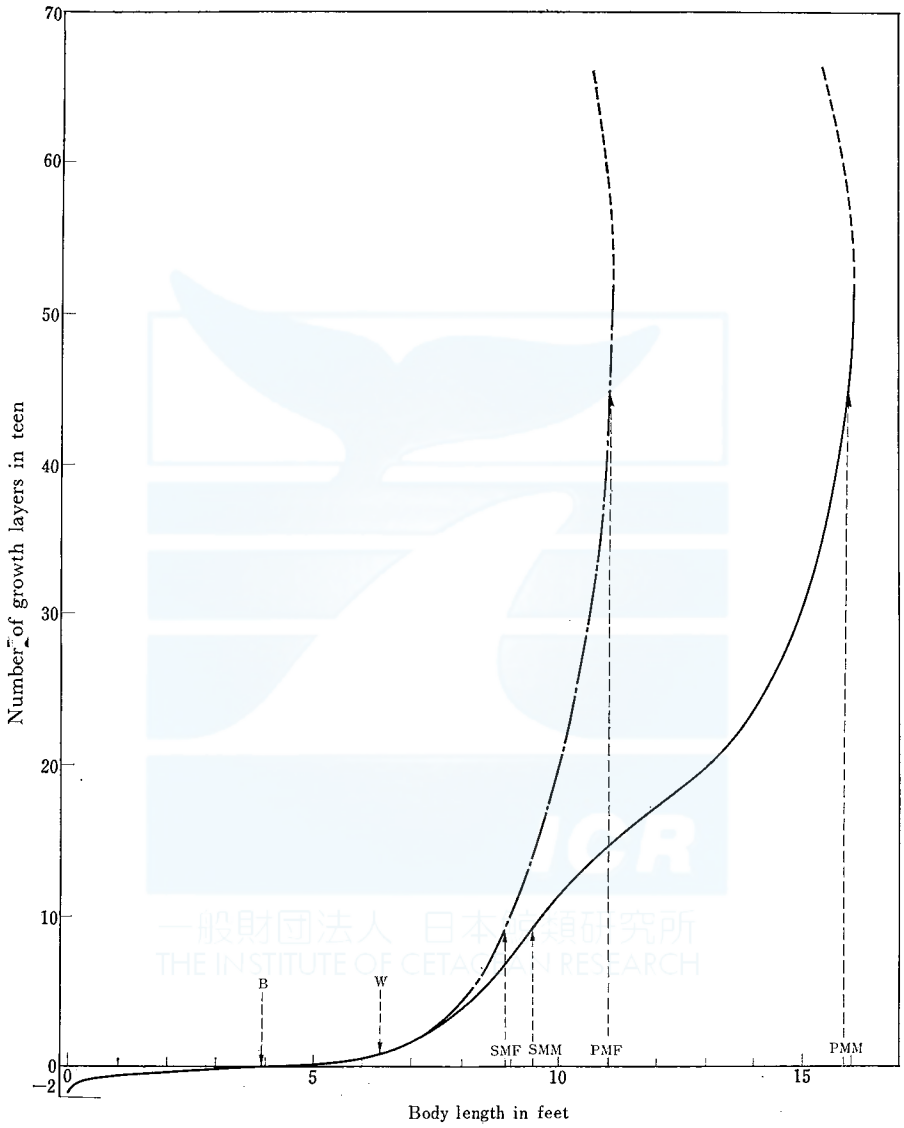

Fig. 12. Growth of body length according to age (represented by number of growth layers in teeth).

however, does not decrease at the same rate. The foregoing facts should not be forgotten when reading the abovementioned figures.

SUMMARY

The above mentioned discussions are summarized as follows.

1. The growth of the head is very remarkable, and it seems that it is continues after physical maturity is reached.
2. The sexual differences are naturally observed in the reproductive appertures, but it is interesting to note that it can also be observed in the development of the head part.
3. The phylogenetical data on the development of the shape of the flipper which is large in proportion in the earlier stage of the foetal life has been teken.
4. Some differences in the rear part of the body can be observed in the sperm whale from the North Pacific and the Antarctic, as for instance those from the North Pacific have shorther tail parts. Differences, if any occuring in sperm whales from the same waters, may be considered as technical errors in measurement, therefore such differehces are not suitable as data for separating them into groups.
5. The characteristics according to age were observed from body proportions, and they are comparative olderness and not showing the actual age. For more accurate data on age, it is necessary to combine the foregoing with other finding.

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EXPLANATION OF THE PLATES

(The figure number in the plate is given from upper to bottom.)

PLATE I

Fig. 1. A sperm whale embryo of 3.5 cm in body length, collected from a female caught in the South East off Hokkaido, Japan.

Fig. 2. A sperm whale embryo of 4.0 cm in body length, collected from a female caught in the South East off Hokkaido, Japan.

Fig. 3. A sperm whale embryo of 9.1 cm in body length, collected from a female caught in the South East off Hokkaido, Japan.

PLATE II

Fig. 1. A sperm whale embryo of 30.5 cm in body length, collected from a female caught in the East off Sanriku, Japan.

Fig. 2. A sperm whale embryo of 19.5 cm in body length, collected from a female caught in the East off Sanriku, Japan.

Fig. 3. A sperm whale embryo of 26.5 cm in body length, collected from a female caught in the East off Sanriku, Japan.

PLATE III

Fig. 1. A sperm whale embryo of 29.5 cm in body length, collected from a female caught in the South East off Hokkaido, Japan.

Fig. 2. A sperm whale embryo of 41.0 cm in body length, collected from a female caught in the East off Sanriku, Japan.

Fig. 3. A young female sperm whale of about 7.5 m in body length, caught in the East off Sanriku, Japan.