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(Gunnerus), 1765

By Olav Aasen

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The Basking Shark, *Cetorhinus maximus* (Gunnerus), 1765

By

Olav Aasen

Directorate of Fisheries
Institute for Marine Research

p 909

Introduction.

The basking shark was first described by bishop Gunnerus in the year 1765 under the name of *Squalus maximus* from a specimen caught in the Tronheims Fjord (Gunnerus 1765). Although the description is somewhat faulty and the drawing of the shark lacking in accuracy the work is remarkably good when one consider the early period it was done (Fig.1).

The basking shark has, however, been known and caught in Norway at a much earlier stage. In the collection of writings by Peder Claussøn Friis the following remarks about the shark can be found: " In Nordland (county in north. Norway) a large fish is also caught, the length of which is 8-9 ell¹. or more. This fish, when cut into strips and dried, is good

1. One ell is equivalent to 0.627 meter

Comments by scientist who requested
this translation.

"The family Isuridae are the mackerel
sharks, not the Greenland sharks.
(these are the Dalatiidae and ~~mak~~ are
not the group referred to here)

food for the working people, and such a fish was caught in this district in 1596" (Friis 1881)..

The basking shark is also mentioned in Hans Ström's description of the district of Sunnmøre. A dried up tail fin seen by Mr. Ström measured $2\frac{1}{2}$ ell across the tips (Ström 1762).

A work by Pennant from about 200 years ago contains a short note of an embryo or fetus found in a basking shark (Pennant 1769). This is quite extraordinary as the next known observation was not made until 1936 (Sund 1943). Another observation of a fetus was made shortly afterwards by a Scottish fisherman (Matthews 1950).

Early mention of the basking shark and the shark fisheries was made by O.N. Löberg. Mr. Löberg (1864) reports some figures pertaining to length and liver content, but his reports contain very little information beyond what was already known through the works of Ström and especially Gunnerus 100 years before.

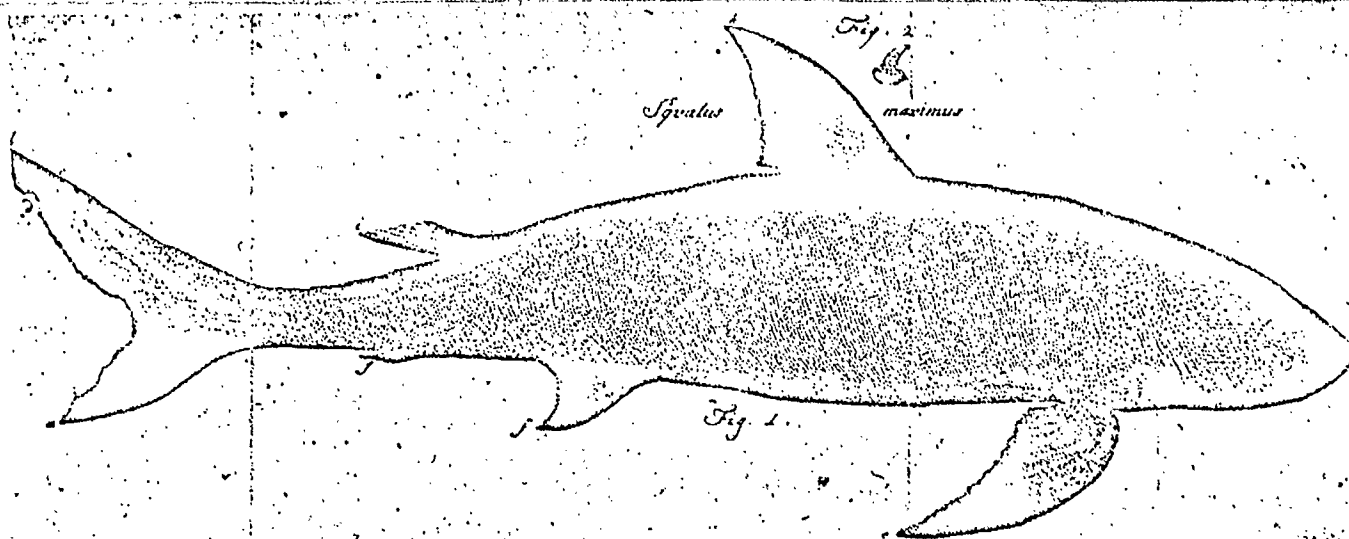


Fig.1 Sketch of the basking shark by Gunnerus (1765).

Robert Collett states quite rightfully(1874) in "Norges Fiske"(Norway's Fishes) that Gunnerus "is the one person who so far has made the most comprehensive study of the natural life and the catching of the basking shark , (Collett 1875). Mr. Collett later on gives a thorough description of the shark and also relates some data on catches during the period 1884-1905 (Collett 1905).

The shark fishery has been of little importance , and this fact no doubt accounts for the lack of interest shown by Norwegians during this century in the field of research concerning this branch of the fisheries. Among Norwegians who lately have written about the basking shark are the following: Thor Iversen(1937) in "Utviklingen av fiske og fiskemetoder i Norge"(The development of fisheries and fishing methods in Norway), Paul Bjerkan (1947) in "Norges Dyreliv"(Norway's Animal Life),and Hans Thams-Lyche (1962) in "Havet og vaare fisker"(The Sea and our Fishes).

The interest in the fishery is growing and the necessity for a more detailed biological study of the basking shark is apparent.This paper is a collection of information from older as well as more recent works on the subject.

It is felt that a summary of the present knowledge of the basking shark is in place.This can then be used as a basis for further investigations which are being planned.

General Description

Classification

p.910

The basking shark is now classed as a separate family, Cetorhinidae, in the zoological system. It was earlier included in the family Isuridae (Greenland shark etc.). The two families have many similarities and the former seems to have developed from the latter. The peculiar gill-rakers sets the basking shark apart from other present-day sharks and justifies its being classed as a distinct family.

There is a general acceptance of the presence of only one genus within the family, Cethorinus Blainville, 1816. The family was over a period of time considered to be monotypic, but some research by Australians around 1940 indicate that this may not be definite and the discontinuity of existence seems to bear this out. It is assumed, however, that in the North-Atlantic waters only one species is present.

Peculiar features

According to Bigelow and Schroeder (1948) the most characteristic marks of the basking shark are its large curved tail fin, enormous gill slits, long comb-like gill rakers, large number of small teeth and the nostrils located relatively far from the mouth.

Body shape

Fig. 2 shows an outline drawing of the basking shark by Bigelow and Schroeder. The shark is torpedo shaped and

the body is at its thickest from the shoulders to the first dorsal fin. From here it tapers off towards the fairly thick base of the tail. This portion is dorsoventrally flattened with well developed side keels, which start in the area of the second dorsal fin and the anal fin, terminating somewhat beyond the start of the tail fin proper. Just in front of the tail fin are two well defined, crescent-shaped notches, one on top and one on the bottom part of the body.

Head

The head is somewhat flattened from the sides in the mouth region on older sharks and more pronounced on the younger ones, who also have longer snouts. It has been suggested that this longer projection on younger sharks, with a sudden increase of the circumference at the throat, may be explained by a post-mortem shrinking of the porous tissue covering the cartilage of the nose.

Eyes and nasal openings

The eyes are small and almost circular without a nictitating membrane. The diameter equals approximately one eighth of the distance between the eyes. The nasal openings are widely separated, and located on the snout slightly in front of the mouth in a lateral arrangement. Spray holes are described as small openings (1.5 mm) with the opening inside the mouth cavity in the shape of a cleft or slit of a fair width (30 cm). Their location is somewhere in the area above the corners of the mouth.

Gill slits

The gill slits are of a considerable size. The first pair of openings are separated by only some 10 cm for a 6 m long shark, both on top and bottom. The slits taper off in length toward the rear and the distance between them has increased to approximately 25 cm for the fifth pair on a fish of equal size. The length of the openings inside the mouth cavity is more of the same order for all pairs.

Mouth and teeth

The mouth is large, rounded and traverses almost the entire width of the head. The lower jaw shows short lip folds at the corners of the mouth. The numerous teeth are very small. It is not too surprising that Gunnerus[^] believed that the basking shark was without teeth altogether. The devout bishop considered it fortunate that Providence had not equipped the basking shark with teeth like those of the Greenland shark. Bigelow and Schroeder indicate a size of 6 mm for a

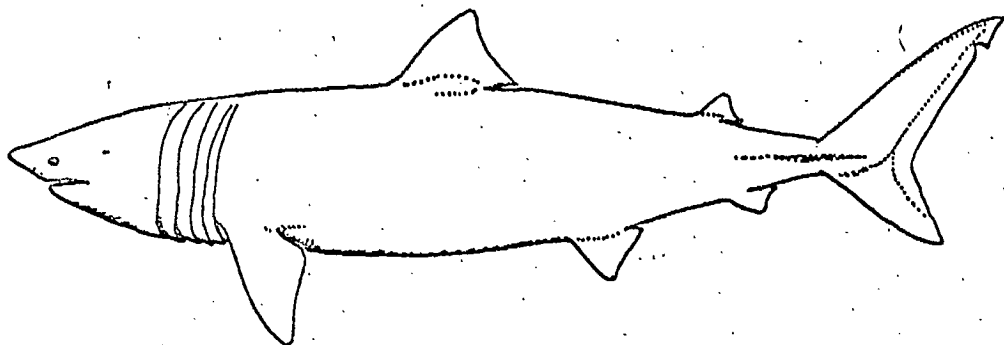


Fig.2. Sketch of the basking shark
by Bigelow and Schroeder(1948).

thirty ft. (abt. 9 m) long shark. There are 4 to 7 functional rows of 100 or more teeth both in the upper and lower jaw, p.911 totaling several thousand. The teeth are short and triangular in shape in the middle, changing to a conical and slightly curved appearance toward the sides of the jaws. The teeth are modified placoid or skin teeth.

Skin

The skin is thick and tough. Gunnerus[^] mentions a thickness of two fingers and adds that the skin was used for harness and soles for footwear. The skin is covered with numerous skin teeth, more or less evenly distributed. There is, however, an indication of or tendency toward grooves arranged laterally without any teeth. These furrows, which are about 2 mm deep, seems to correspond to wrinkles in the skin. Longitudinal furrows are prevalent on the head and particularly in the throat region. These furrows appear also around the anus and partly on the abdomen and along the sides, so that, together with the transverse pattern, the skin gives the appearance of consisting of rectangular blocks, (Matthews and Parker, 1950). These teeth are in general of a fairly equal size over the greater part of the body, but the size is definitely smaller under the snout, in the mouth and on the claspers. The apex is inclined toward the rear so that the skin feels smooth when stroked in this direction while it feels more like sandpaper the opposite way. A multitude of glands are located in the skin and a layer of slime covers the body. This layer, which on a live shark all

but cover the teeth, may after death increase, to the extent that the teeth are completely hidden (Matthews and Parker):

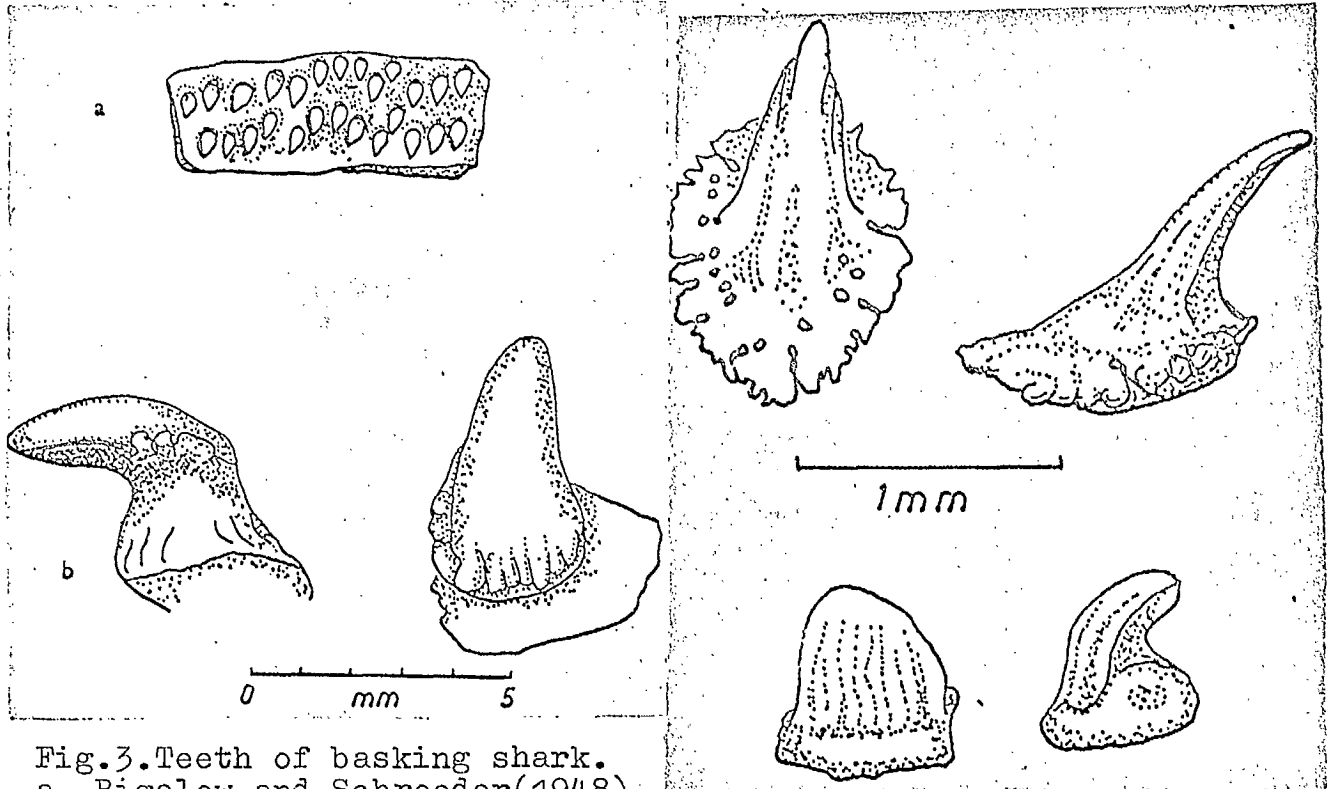


Fig. 3. Teeth of basking shark.
a. Bigelow and Schroeder (1948)
b. Matthews and Parker (1950)

Fig. 4. Skin teeth of basking shark. Matthews and Parker (1950)

Fins

The first dorsal fin is shaped somewhat like an equilateral triangle. The front edge is reasonably straight, while the rear edge generally is concave although a straight or convex shape occur as a rare exception. Apex is slightly rounded. The rear, free corner extends only a little beyond the base of the fin. The length of the front edge amounts to 11-14 % of the overall length. The base of the first dorsal fin is located midway between the snout and the tail cleft, with its front part starting well behind the rear of

the pectoral fins's base. The length of the second dorsal fin's leading edge is about a quarter of that of the first. Apex is rounded and the free rear portion is approximately of the same length as the base. The upper leading edge of the tail is about $1/5$ as long as the over-all length of the shark, and the axis is very steep as with Isuridae. The rear edge is fairly straight, but there is a well defined notch below apex, the angle of which is acute. The size of the bottom part of the tail fin is about $2/3$ of the top, both of them being measured from the cleft immediately in front of the tail. The anal fin is in shape and size very much the same as the second dorsal fin, and its base starts below the point where that of the dorsal fin ends. The pelvic fins are about $2/3$ of the size of the first dorsal fin, measured along the leading edge. The claspers are described as being approximately 1 m long for a 9 m long fish. The pectoral fins are fairly straight or slightly concave along the rear rims with well rounded inside corners.

Colour

p.912

The colour of the basking shark is generally dark gray to black with a varying range of lighter gray along the middle of the bottom side. The dark colour is, however, not always uniform and many sharks show darker and lighter areas. The degree of gray is marked by darker areas on light background, with the darker portions sharply defined. Whenever such a colour pattern is present, the dark spots are generally

arranged in longitudinal zones. In these cases a dark band along the center line of the back will be flanked by brighter stripes. A dark and then a light zone follows with the latter ending close to the side keel on the rear portion of the shark. Below this line is again a dark and a light band. Small light gray or white spots are prevalent in the throat region and these spots may, where the quantity is large, form larger patches. Most sharks have a brighter stripe going from the throat area to anal region and this stripe tends to be dark when narrow, while a wider stripe would seem to be lighter in colour. This stripe widens mostly to a marked, well defined white area between the pectoral fins. This lighter stripe is again noticeable under the snout. The upper lip is nearly always covered by light spots and an appearance of a wide white zone is not uncommon.

Internal anatomy

Matthews and Parker (1950) have given a detailed description of the basking shark's internal anatomy. Only a few characteristic features will be dealt with in this paper and reference is made to the above mentioned work for any further information.

Mouth

The skin of the mouth and throat, which is smooth up front but covered with a multitude of papillae further back. The size of these projections increases towards the gullet where they develop into ramified structures penetrating even further down the throat.

Esophagus

The gullet is quite narrow for such a big fish. This was already pointed out by Gunnerus, and one of the conclusions drawn by Gunnerus was that this kind of fish could not be the one which swallowed the prophet Jonah.

Stomach and Bursa Entiana

p.913

The stomach itself is of course spacious enough to hold a prophet. The thick "plankton soup" which is present in the cardiac portion of the stomach weighs about half a ton, depending of course on the size of the fish. The separation of water from the pylorus portion of the stomach is rapid as the remainder is in the form of a thick, red paste. A small sac, the bursa entiana, is located just where the gut content is leaving the pyloric loop. Here, a clear, red oil is separated and probably absorbed by the cells of the lining.

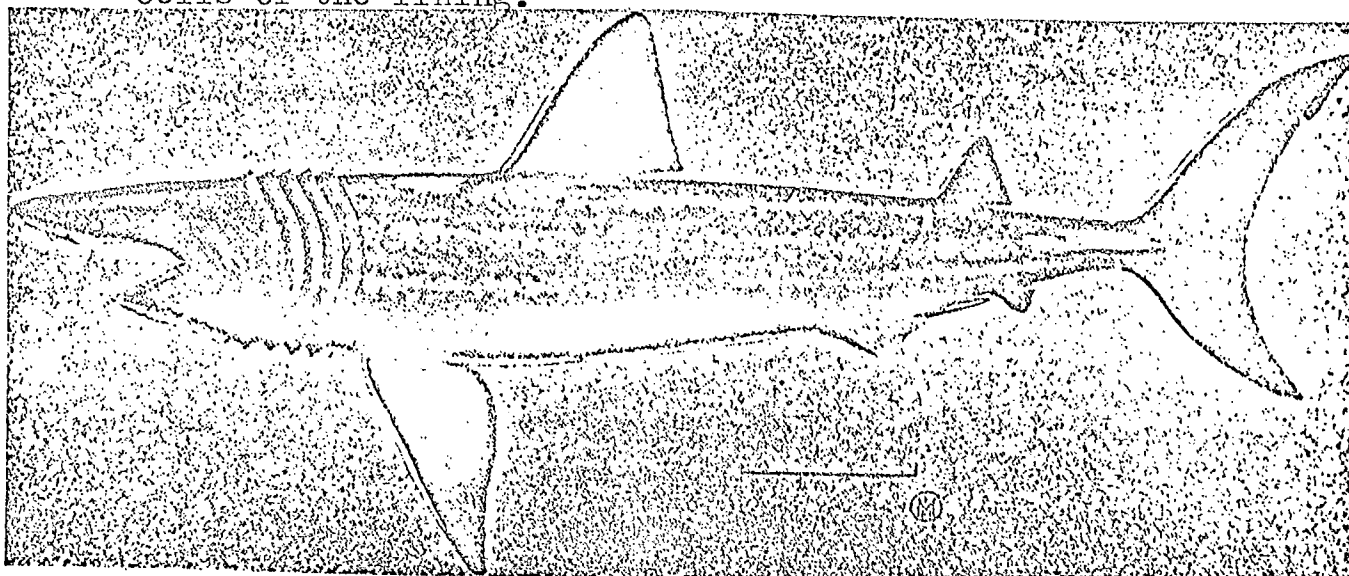


Fig.5. Colour pattern of basking shark. The shades are not always this well defined. Matthews and Parker(1950).

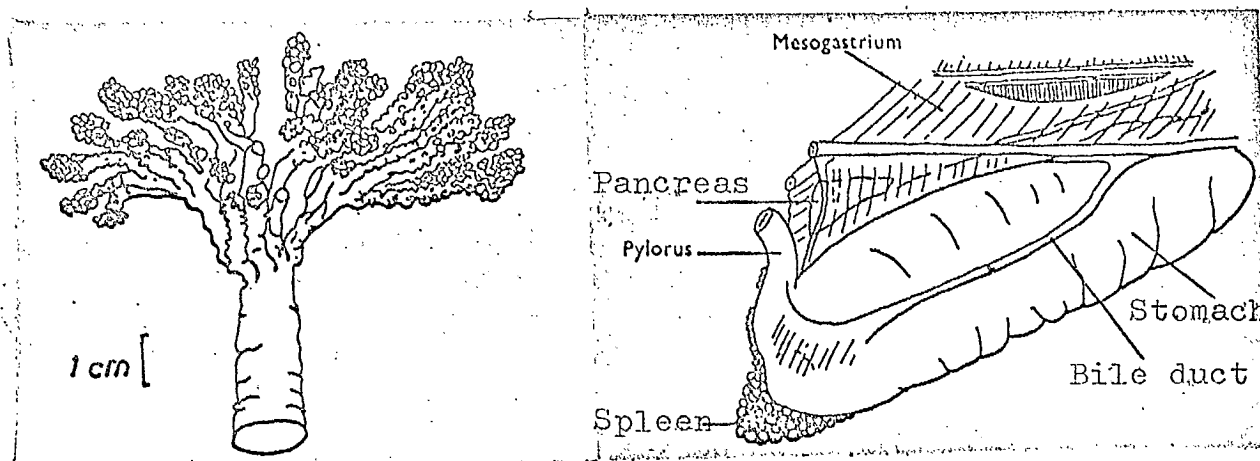


Fig. 6. Papillae in throat re-
gion. Matthews and Parker (1950)

Fig. 7. Stomach of basking shark.
Matthews and Parker (1950)

Duodenum and spiral valve

The bile and gastric juice ducts have openings into the duodenum, a chamber just ahead of the spiral valve. This latter is a rather strange device, built somewhat like the interior of a meat grinder. This arrangement increases the surface of the mucosal lining, which has numerous papillae and glands.

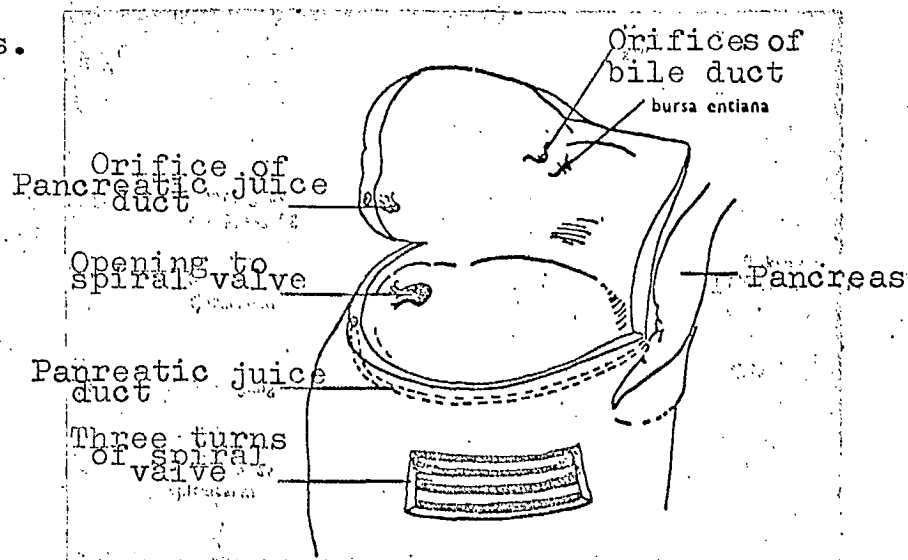


Fig. 8. Duodenum and spiral valve. Matthews and Parker (1950)

Colon and rectum

Both the colon and the rectum are relatively short, but there is a well developed anal gland which opens into the junction of the two. For a 7 m long shark the over-all length of colon and rectum is approximately 25 cm, while the anal gland is about 40 cm long. Highly differentiated opinions as to the function of the anal gland exist, and, for the time being, the problem seems to be unsolved.

Liver

The liver consists of two lobes which extends throughout the abdominal cavity. The lobes tend to fill the surrounding space and are therefor rounded on the outside and flattened on the side adjoining the digestive system. The lobes of the liver are joined in front and there is no gall bladder. The liver, which is the main purpose of catching the basking shark, is well known to the fishermen. They estimate that the average weight of the liver is about 500 kg, but, as the fish itself is never weighed, we have no knowledge of the percentage of the total weight the liver accounts for. Some idea as to this percentage was arrived at after the capture of a shark north of the Viking bank in May this year (1966). The fish measured 6.80 m and the liver weighed 560 kg. According to the length/weight formula the weight of the shark would be 1600 kg and the liver would account for 35% or approximately one third of the total weight. Not too much importance should be placed on this isolated case as quite a

p.914

number of observations are required to arrive at a reliable ratio figure.

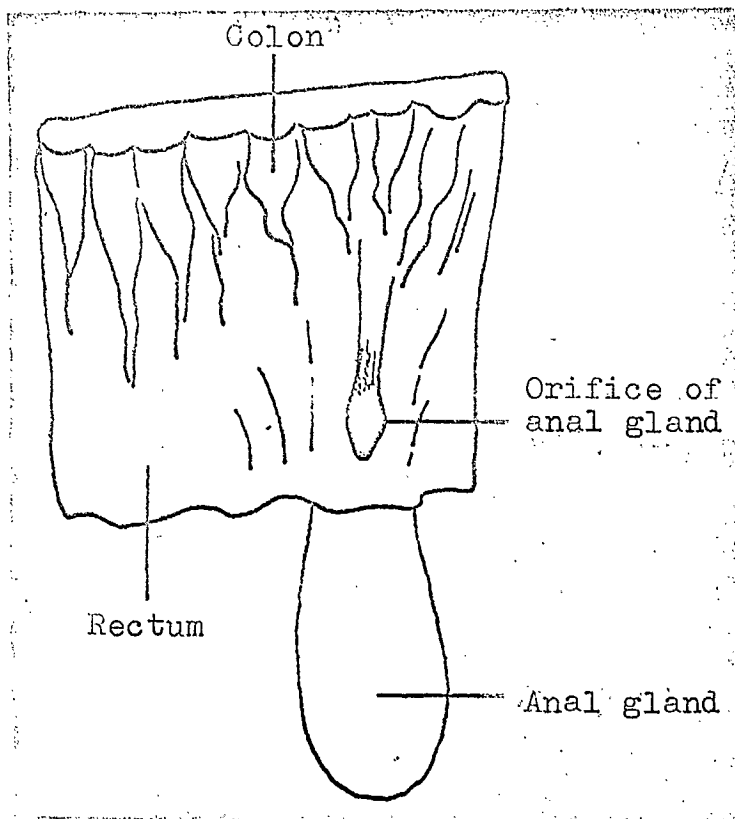


Fig.9. Colon and rectum.
Matthews and Parker
(1950)

Spleen and pancreas

Both the spleen and the pancreas are relatively large organs. The locations are shown on Fig.'s 7 and 8. No further discussion of their structure or function will be undertaken in this paper, nor will the heart and circulatory system be considered.

Gills and gill rakers

It will, however, be of some importance to take a closer look at the gill organization which with its rakers

sets the basking shark apart from all other sharks(cf.p.4). The bristles of the gill rakers are arranged in single rows on both sides of the gill slits with the free end pointing toward the mouth cavity. The bristles are lying flattened against the gill arches when the gill slits are closed, but with the mouth and the slits open the bristles will be in an upright position. The bristles are longer in the middle of the arches, about 10 cm and their density is some 13/cm. The foremost arches hold about 12-1300 while the corresponding figure for the rear arches is 10-1100. The mucus glands are more prominent around the attachment of the bristles to the arches, and it is assumed that a large portion of the mucus present in the stomach has its origin here. It has been indicated that the mass of plankton sifted by the rakers is being mixed with this mucus and the mixture pushed into the mouth cavity when the rakers become prostrate. According to recent observations it seems certain that the rakers are lost in the fall and that a new set appears again in the spring(Parker and Boeseman 1955). Except for the size, there is not much to be mentioned about the gills. It has been calculated that the respiratory surface for a 7 m long shark is about 270 m^2 . It must be kept in mind that while the quantity of blood increases with the third power of the increase in length, the surface of the gills is only growing with the square. A disproportionately bigger gill

surface would therefor be required. It is implied that this mechanical necessity, together with the reduction of metabolic activity, both resulting from an increase in size, caused the development of microphagy as evident with the two largest sharks.

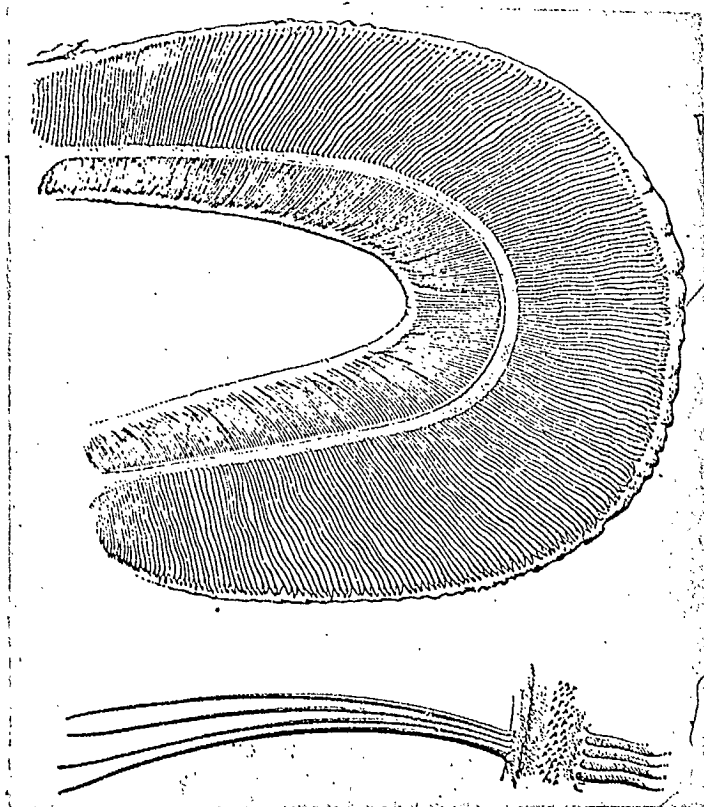


Fig.10. Gills and gill rakers of basking shark. Bigelow and Schroeder, (1948).

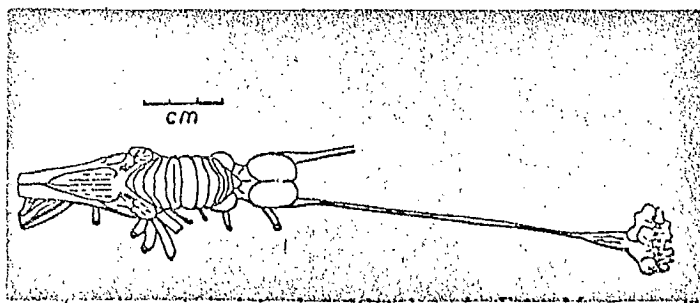


Fig.11. Brain and olfactory organ of basking shark. Matthews and Parker(1950)

Brain and sensing organs

Brain

The brain cavity is much larger than the brain. To prevent any "bouncing"-if one can express it this way- a multitude of filaments gives the appearance of the brain being suspended in a mass of cobwebs. The brain itself is only about 10 cm long, not considering the greatly elongated olfactory organs which measure some 15 cm.

Olfactory organs

An interesting feature is the comparatively well developed thalamencephalon where the olfactory nerves originate. It seems therefore that these organs are of great importance to the fish. Fig.12 (top) shows a front view and (bottom) a cross sectional view of a nostril. The flow of water is indicated by arrows.

Eye

The eye has been studied in detail by Franz(1905). His sketches are based on specimens conserved in formalin at Bergen. As can be seen from Fig,13 a strong cartilaginous socket surrounds the eye. The lens is quite small and the pupil is narrow(lateral). The bulb support is rudimentary and there is a massive fibrous layer between it and the eye ball. The muscles of the eye are strongly developed. p.915

Lateral line

Matthews and Parker give no description of the basking shark's ear and it is doubtful that it has ever been

examined. The lateral lines have, however, been briefly mentioned. These are longitudinal ducts about 2 cm below the surface. These ducts branch out into a complex system in the head region. The diameter of a duct is some 2.5 mm, and the connection to the outside is through smaller canals, the openings of which are 1.5 mm pores spaced approximately 3 cm apart. The lateral-line nerve is a different system to any other nerve organs. The belief is that the function of the lateral line is to sense any pressure changes such as a splash in the water.

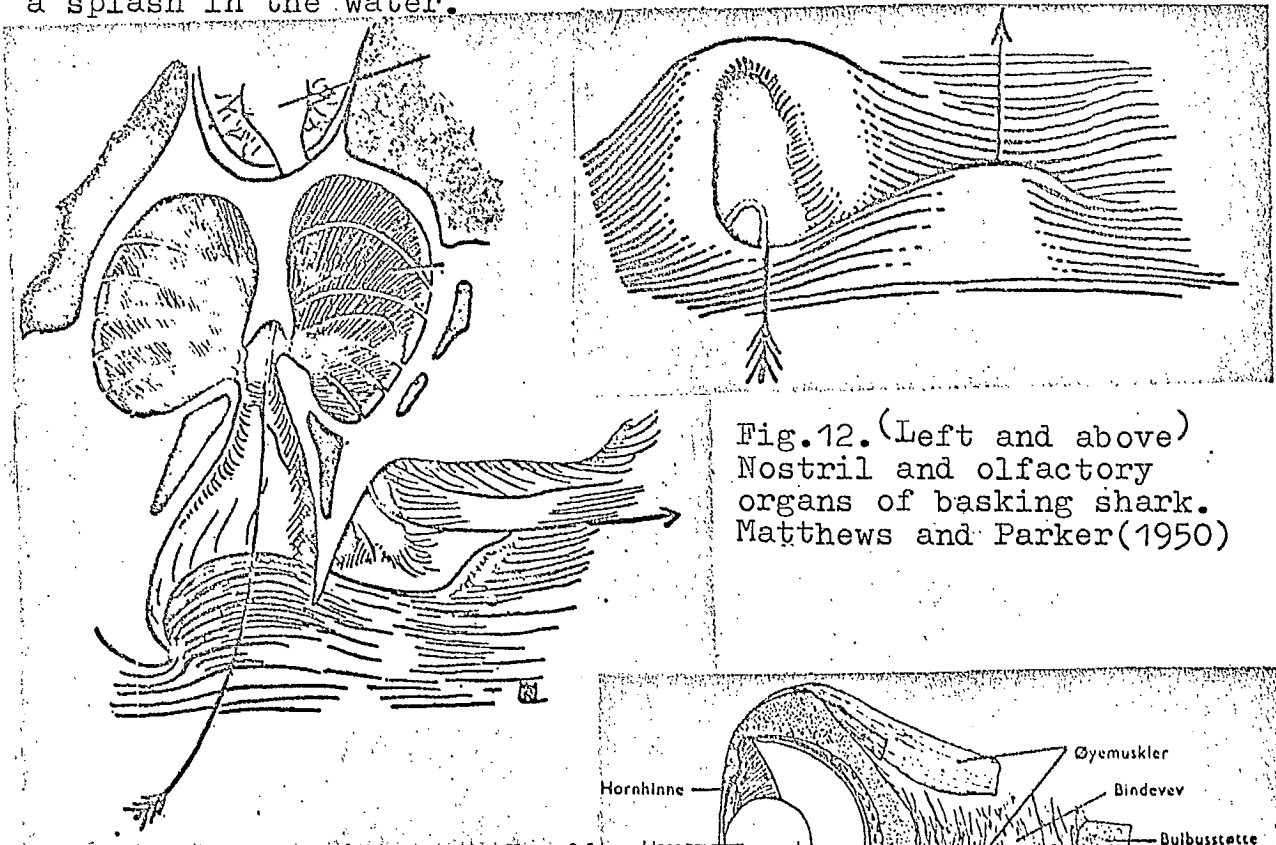
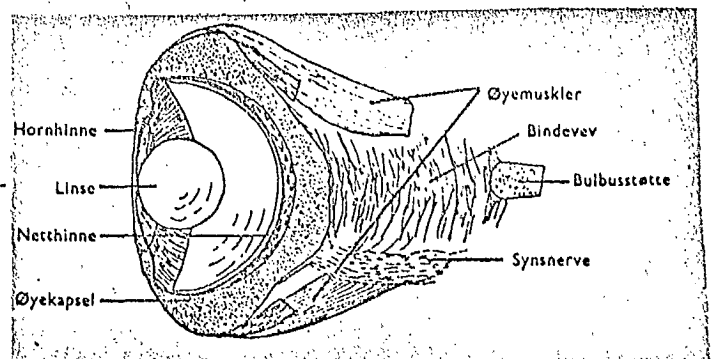


Fig.12. (Left and above)
Nostril and olfactory
organs of basking shark.
Matthews and Parker(1950)

Fig.13. (Right)
Eye of basking shark.
By Franz(1905).



Reproduction

Male

A representation of the urogenital system of the basking shark by Matthews[^] is shown in Fig. 14. Testes are located in the upper part of the body on either side of the anterior portion of the stomach. They are surrounded by the so called epigonal organs. These consist of lymphoid tissue. They are the centers for the formation of red and white blood cells. The length of a testis is about 70 cm including the epinogal organ, the diameter is 20 cm in a fish of 7 m length and the weight is approximately 8 kg. This seems like "big stuff", but in relation to the size of the fish it is quite moderate.

From the testes the vasa efferentia leads to the epididymis which consists of complicated windings convoluted as a large semicircular body with curved ends.

Ductus deferens is a passage from epididymis and which expands to an ampulla of almost 2 m length and a diameter of about 25 cm. The inside of this ampulla is partitioned by dividers which have an opening placed somewhat excentric. In the compartments which are formed the sperms are concentrated into spermatophores, which consist of an inner core of sperms and an outer, transparent shell. The diameter of the spermatophores is about 3 cm, and they are suspended in a clear liquid of which each ampulla contains about 20 liters. The two ampullae are joined together

about 2 cm prior to the outlet into the urogenital sinus.

The location of the kidneys is also shown in Fig.14. The external reproductive organs, claspers, of the basking shark are close to 1 m long. The build of the claspers is p.916

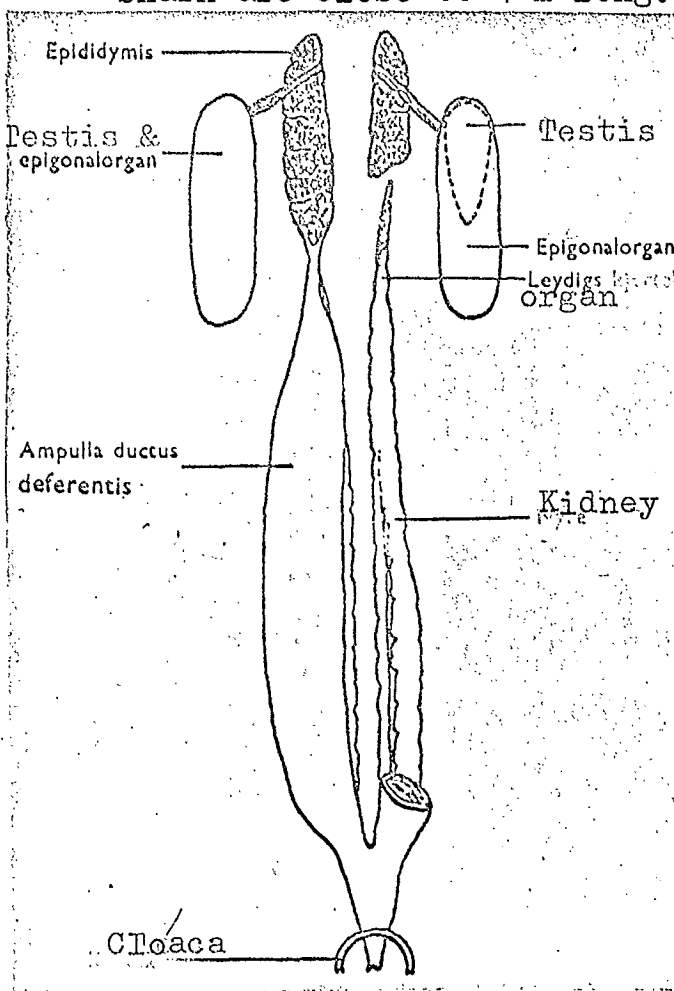


Fig.14. The urogenital system of the male. Matthews(1950).

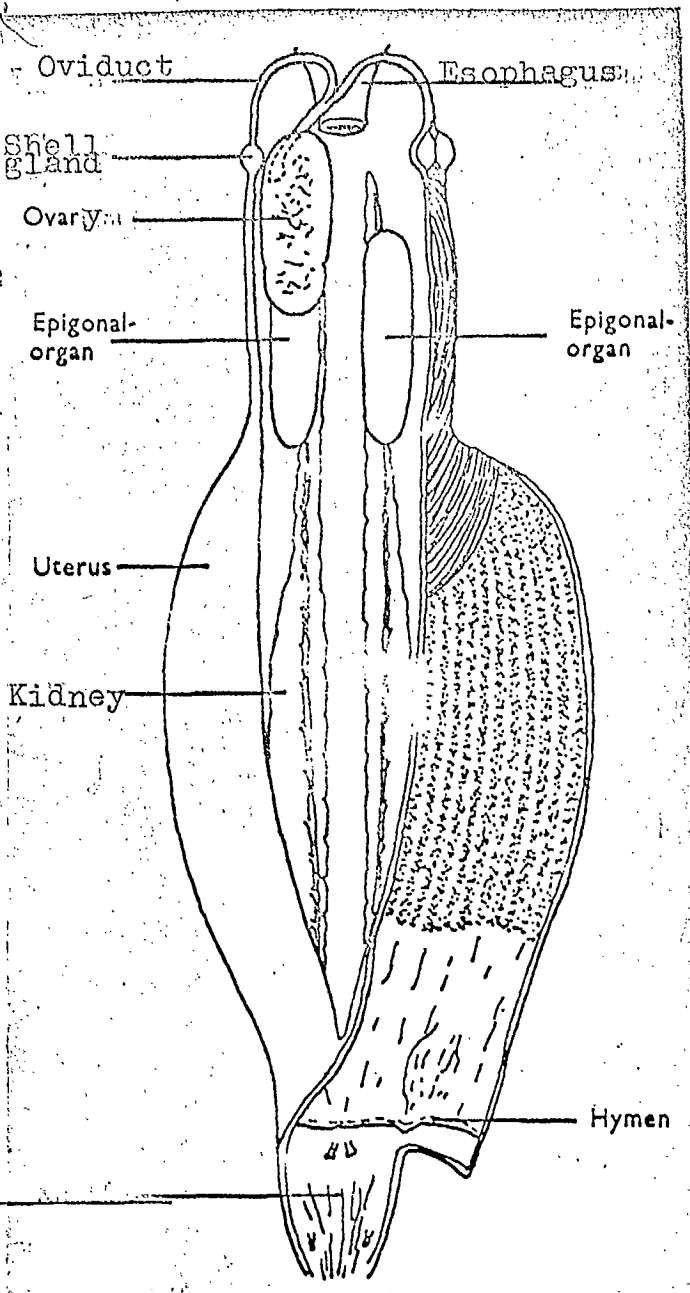


Fig.15. The female urogenital system. Matthews(1950).

somewhat complex, but it consists mainly of overlapping cartilaginous members forming a tubular skeleton. Approximately at the half-way area is a hook or claw which can be erected crosswise.

The reproductive organs of the basking shark will, as is the case with other sharks, show a tendency toward faster growth than the rest of the fish when it is reaching maturity. These observations indicate that maturity is reached when the fish is 5-6 m long or at an age of 4-5 years.

Female

The reproductive organs of the female are shown in Fig. 15. Only the right ovary is developed. It is located on the right side of the stomach and the posterior one third of it is joined to the (matching) epigonal organ. In general there is a similarity between the ovary and a common ovary of the oviparous type. It contains at least six million quite small eggs, about 0.5 mm in diameter. Most of these degenerate and are replaced by bodies similar to corpora lutea (yellow corpuscles). The eggs are developed when they are some 5 mm as the first part of the oviduct is rigid and anything bigger will not pass through. The oviduct branches out to the two uteri (womb). Just ahead of their entrance into the uteri, each branch of the oviduct is provided with a shell gland. The inside of the uterus is folded to begin with but further on this changes into vascular processes

of about 1 cm length(trophonemata)¹. The structure of the basking shark's ovary indicate that it is oviparous, but the build of the uterus points clearly towards a viviparous fish. The length of the uterus in a sexually mature fish is something more than 1 m. The length and age at which a female shark can be considered mature is unknown.

Mating

p.917

The posterior portion of each uterus(vagina) combine to form one common vagina. The inside is here covered with thick layers of fibrous tissue. These tissues are, in full-grown sharks, marked by scars or wounds caused by the claw of the male's claspers. From the appearance of these damages it seems conclusive that only one clasper is introduced at a time during the mating. Approximately 15 liters of spermatophores has been found in a just previously mated female. The mating takes place in the spring.

Embryonic development

There is no awareness of what takes place after the mating. Pennant does mention the observation of an embryo found in a shark, but there is no description and the report dates back more than 200 years. Oscar Sund's short reference to the calving by a shark in "Naturen"(The Nature) is consequently of great interest(Sund). He reports that a basking shark, which had been caught NNW of Geitmaren, late in August of 1936, during towing to Teigebogen threw one dead and five live young ones in Breisundet. Jonas Sördal caught one of

¹ The spelling of "trophonemata" in original is assumed to be wrong. Transl.'s note.

these and upon request he wrote to Sund: "It was a young basking shark I caught and its length was about $1\frac{1}{2}$ m. It had neither an umbilical cord nor an embryonal yolk sac. The front of the snout was narrow and had a slight downward inclination. The liver content was 8 l. It was swimming with wide open mouth as is the habit of the basking shark when feeding". However unsatisfying these data may be from a scientific viewpoint, one will have to accept their correctness. Accordingly, it can be concluded that the basking shark is viviparous, it calves during August, and the throwing may take place along the Norwegian coast.

The length/weight formula would indicate a weight of 20 kg for $1\frac{1}{2}$ m long fish. The liver content of the captured shark amounted to 8 l, and, by assuming sp.gr. of 0.9, the liver would account for 36% of the total weight. This is in accord with what has been found for the fully grown fish (p.13). The length at birth is also in agreement with theoretical calculations (p.26).

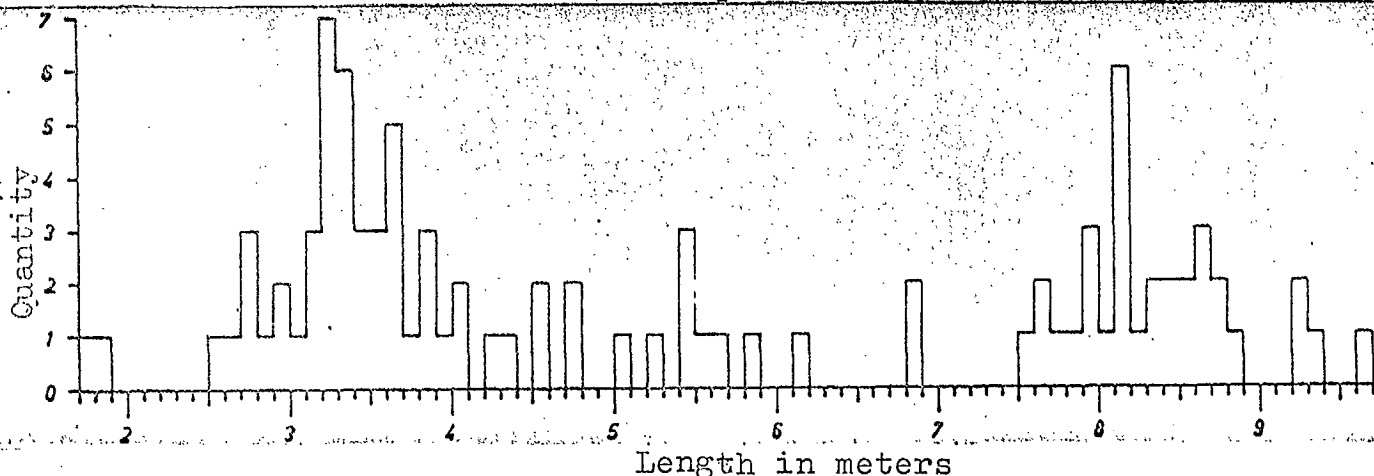


Fig.16. Graph showing size distribution among 93 basking sharks captured and measured in the eastern Atlantic area.
By Parker and Stott(1965)

Nutrition

Stomach content

Quite a few observations of the stomach content of the basking shark have been made; but anything larger than the red feed (plankton) has not been found. Some of the food has been identified as: Oithona, Calanus, Pseudocalanus, some decapod larvae, fish eggs and larvae of cirripeds. Generally speaking it is very difficult or next to impossible to determine the quantity of the different types of plankton, as the food is torn or partly digested. To investigate this in detail would, of course, not serve any purpose, as the fish most certainly filter out whatever plankton is available and the composition of the food surely changes with the time of year and also the locality. The tomato-red thick soup is usually characteristic of the stomach content (Matthews and Parker). The enormous dimensions of the stomach does impede any close scrutiny and pity the poor scientist who accidentally cuts a hole in the stomach and finds himself covered with close to half a ton of partly digested plankton and mucus (Matthews). In spite of the size of the stomach, which holds an average of half a ton, one gets an exaggerated impression of the actual nutritional value of its content. It is estimated that the solids account for only about 30% of the total weight and the mucus constitutes a large portion of this.

Feeding habits

p.918

While the shark is feeding close to the surface, it moves at a speed of about 2 nautical miles per hour. The mouth is wide open and the gill rakers removes the plankton from the sea water, which passes out through the expanded gill slits. The mouth opening of a 7 m long shark is about 0.4 m^2 , and it has been calculated that 0.33 hp is required to propel the fish through the water at 2 knots. The equivalent to this is 212 kilogram-calories per hour. By estimating the effectivity of the tail of the shark at 80%, the fish will need 265 kilocalories per hour. The metabolism, however, consumes some energy and the conversion losses may be evaluated as 60%. The energy required to collect the food consequently amounts to 663 kilocalories/hour. It is well known that the feeding conditions undergo seasonal changes. Calculations show that for the North Sea area, the basking shark may be able to collect plankton equivalent to 410 kilocalories/hour under favourable conditions. The feeding would consequently be carried out at a loss during the winter months as the above mentioned figure of 410 applies to the month of November. This is used as an argument for the theory that the basking shark has a period of rest during the winter, and the shedding of the gill rakers points in the same direction. It is not known where the shark is located during this time, and its migratory habits are also still unknown. This is a field where further investigations by

Norwegians can contribute greatly toward the knowledge of the shark. Marking of the fish is considered to be technically feasible, but the research will be a relatively expensive venture.

Length, weight and age

Length

It is generally accepted that the basking shark is one of the largest fishes in existence. Its length is only surpassed by that of the whale-shark (*Rhineodon typus* Smith). There is no agreement about how large it will actually grow. Most of the more recent writers are sceptical regarding the largest sizes reported in earlier literature on the subject.

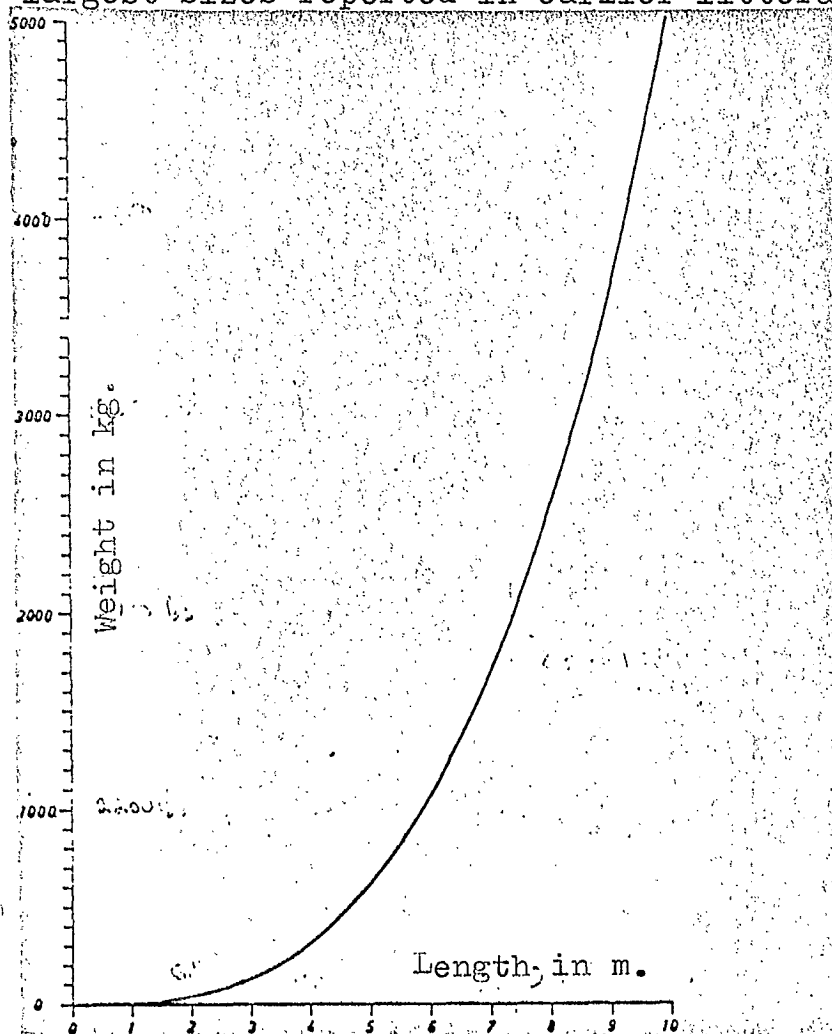


Fig. 17.
Length/weight ratio
for basking shark.

It is apparent that a large portion of the stated figures are based on estimates. It is obviously quite a task to measure the lengths of these enormous fishes. The problem can, however, be solved and quite a number of actual measurements have been undertaken. According to these it seems that a length of 30 ft (about 9 m) is very seldom reached. Larger fishes do exist and the most reliable figure for the largest measured shark available from papers on the subject is 9.83 m (Bigelow and Schroeder). This report is based on findings in the western Atlantic, but actual measurements from the eastern Atlantic indicate sizes of the same order. The graph by Parker and Stott (1965) showing the size distribution among 93 basking sharks captured in eastern Atlantic waters is supplemented by a measurement undertaken 13 May 1966 aboard a Norwegian ship.

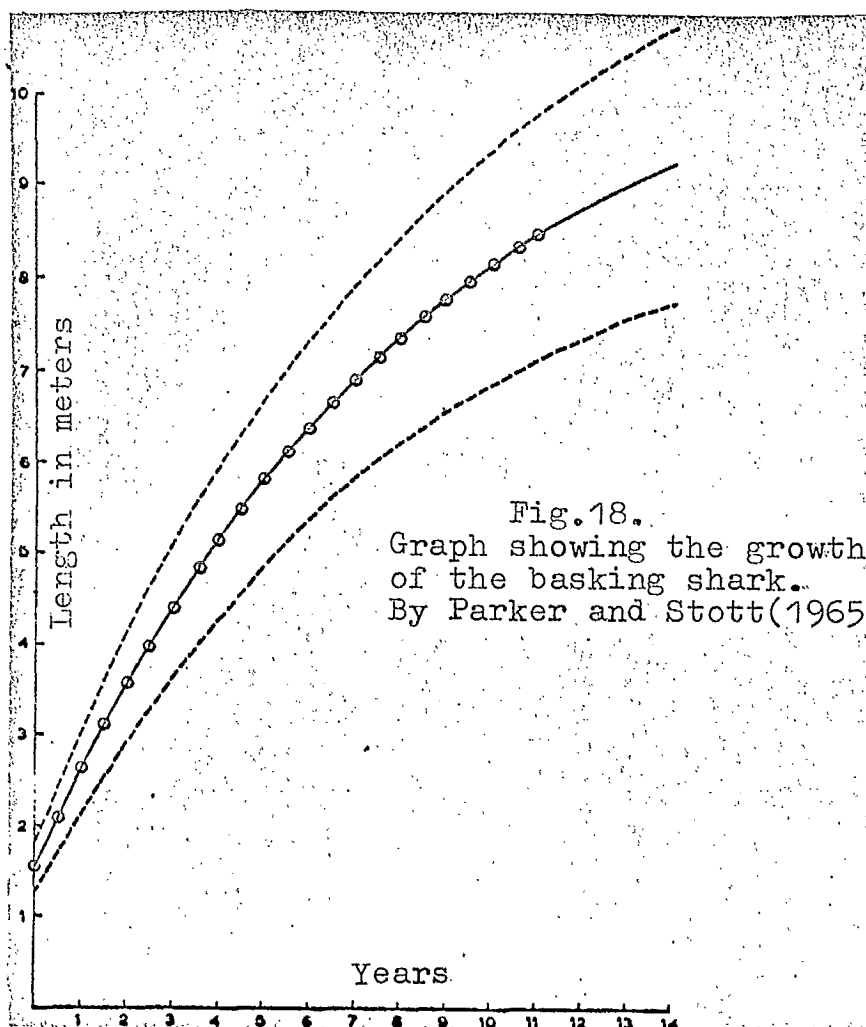
It would appear natural for the Norwegian research to collect as much information as possible with respect to the size of the basking shark. The task could be accomplished through the cooperation of the fishermen.

Weight

The size of the fish makes the measurement of length rather difficult, and the weighing of these giants will of course present an even bigger problem. The scarcity of data on weights is apparent. According to Bigelow and Schroeder the weights of two sharks were established at Monterey in California. The measurements are given as 6850 and 8600 lbs for the sharks with respective lengths of 28 and 30 ft. As

far as is known no other accurate length/weight data are available. This is another area of the study of the shark where norwegian scientists could make valuable contributions with a minimum of effort.

The generally accepted formula for length/weight ratio of fishes is: $P = KL^3 \times 10^{-5}$, where P is the weight in kg, L is the length in cm, and K is a constant which can be calculated from available length and weight data for a specific type of fish. The constant K varies generally to



a certain degree for the same type of fish, and as this change depends on the condition of the fish with K for this reason being called the condition factor. With a sufficient number of measurements of lengths and weights, average values of K can be established and the equation will give us the unknown when either P or L is available. This could probably be developed into a system where measurements are taken between the dorsal fins or other conveniently accessible locations, but any further reflection on this will not be attempted here.

It is only reasonable to assume that the basking shark of the Pacific is not very different from the one of the Atlantic. Based on the above mentioned two measurements a K factor of 0.5 has been calculated. Fig. 17 gives the length/weight curve and from this the weight of the largest shark measured for length would be some 5 tons. Informations as to the average length of basking sharks caught on our waters are lacking, but if we assume 6-7 m as a reasonable figure the weight of the fishes would be approximately 1.5 tons.

Age

The basking shark belong to the cartilaginous fishes. This means there is no general ossification of the vertebrae. During the growth, however, a certain amount of calcified particles is deposited between the layers of cartilage and appears as concentric circles (tubes) in the vertebrae. This has been known for a long time and it has been compared to

annual rings of trees indicating the yearly growth. The vertebrae of the basking shark is a fairly soft substance and when withered takes on the appearance of the leaves of a (circular) book- if such an analogy may be used.

The vertebrae of the tail portion have fewer rings and therefor do not lend themselves to the determination of age. Anterior to the tail cleft and posterior to the same the number of vertebrae are 50 and 60 respectively, for a total quantity of 110 (Springer and Garrick 1964).

There are differences of opinions as to the relationship between these growth zones and the age. The latest investigations indicate that there are two growth zones per year and that the basking shark has seven of these at birth, (Parker and Stott). This points to a development period, from fertilization to the calving, of $3\frac{1}{2}$ years. The theoretical length at birth should be 1.53 m, and this is in accord with the data given by Oscar Sund in his "basking-shark calving" (Sund). Providing the interpretation by Parker and Stott holds true, the maximum age of the shark should be in close proximity to 20 years. The shark's growth rate as indicated in Fig. 18 is taken from the same source. From this graph a 7 year old shark would be about 7 m long. However, the same graph gives widely separated upper and lower limits and the length would therefor not be an accurate indication of the age.

Habitat

The basking shark can be found in temperate waters of the southern and northern hemisphere, while it is totally lacking in the tropical region in between. It can be found along the coasts of California and British Columbia in the northern Pacific as well as in Japanese and Chinese waters. It is, however, not quite clear whether we are dealing with the same species. It appears along the coasts of Peru and Ecuador in the southern Pacific and also in the waters south of Australia and New Zealand. The Australians have expressed doubts about the family being monotypic. The shark appears in the Atlantic waters of South Africa, Argentina, and the Falkland Islands. It can be found from North Carolina to the southern part of Newfoundland of the western Atlantic, and from Morocco to North Cape in the eastern Atlantic with sporadic sightings as far east as Murmansk. It appears that the main habitat is in the area west and south of Iceland, in the coastal waters west of Ireland, the Hebrides, Orkney Islands, Shetland, Tampen (NE of Shetland) and along the west coast of Norway. The shark's movements within this area are, as mentioned earlier, unknown; but one knows for a fact that the fishery starts earlier in the more southern region (Ireland) than further north. p.920

Resources and yields

One of the questions of great interest from a fishing industry's viewpoint is about the basking shark's abundance. The general opinion among norwegian fishermen is that there is "plenty to take from". From time to time there have been reports of schools "covering the whole ocean". These, somewhat vague, reports are unfortunately not good enough when trying to estimate how large a yield the shark population can support. It is well known that the stock of basking sharks in norwegian waters has varied in the course of time; this, strictly speaking, does not necessarily mean changes in the size of the shark population.

The fastest and most accurate way of estimating the stock and taxation of same will be through a program of marking the fish. Such a program would serve a threefold purpose: migratory habits, size of resources and taxation. Experiments with marking would only be successful if proper statistics over the number of fish captured are established and marked fish be reported with accurate data on the recapture.

Based on fishery-statistical reports on the liver quantities, the graph in Fig. 19 shows the yearly yield of the basking shark fishery over the last 30 years (1934-1965). The number of fishes caught has been arrived at by fixing the average weight of the liver at 500 kg. Nothing in this graph indicates that the stock has been overtaxed. The ups

and downs of the curve more likely present a picture of the changes in fishing conditions and also the interest shown by the industry, the latter of course taking into account price and market situation.

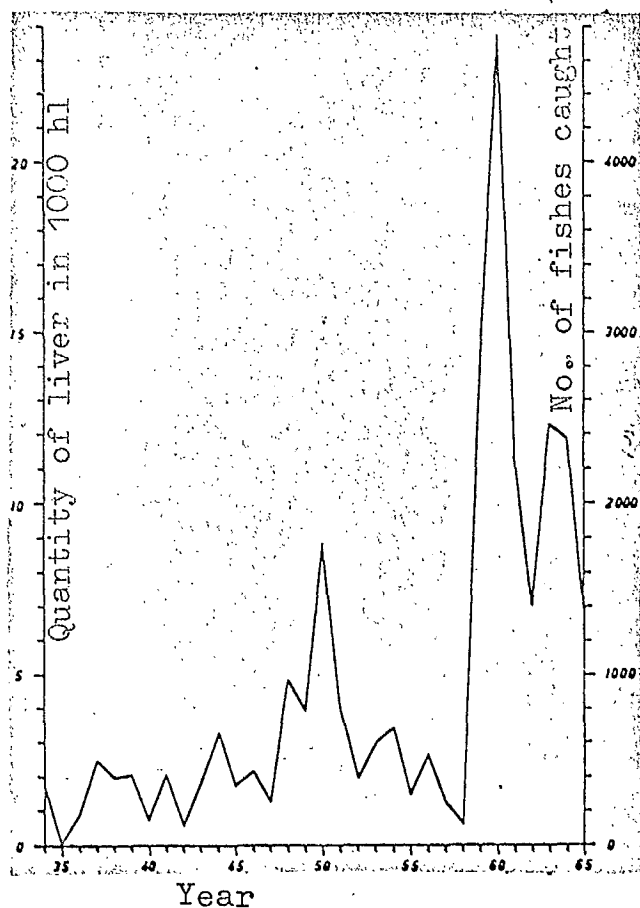


Fig.19. Yield of the basking-shark fishery for the period 1934-65.

Translator's note: All references in this paper which are marked ^ are loc.cit.

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