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Some Problems in the Fishery for Deep Sea Prawns.

by

Birger Rasmussen

The biology of the deep sea prawn has been studied by many scientists as f. instance Wollebæk (1903), Wilhelm Bjørk (1911), Alfreda Berkely from British Columbia (1930), Leopoldseder (1934), Jägersten (1936). In 1938 Professor Johan Hjort and Johan T. Ruud published a comprehensive treatise on the deep sea prawn fishery in Norway and other countries, summarizing our previous knowledge of this crustacean and setting forth their own views on the biology of the prawn and on various practical problems connected with the prawn fishery. After 1940 the deep sea prawn at Spitsbergen and on the west coast of Norway has been treated by the present author, and in 1945 Erik M. Poulsen has published a treatise on the Danish prawn fishery in the Skagerak together with his biological observations on the same matter.

The chief result of the investigations on the deep sea prawn in 1930-36 was the discovery that this crustacean was a protandric hermaphrodite, i.e. that all individuals at first function as males and later in life become females. During this change from males to females certain transitory stages can be sorted out by studying the endopodite of the first pair of pleopods which function as copulatory organs.

The deep sea prawn has no visual body characters by which we can ascertain the age. The only method left is to use the "Petersen method": to measure a large number of individuals and study their grouping from time to time. The method of measuring the prawn has varied from author to author. The various methods have one thing in common, i.e. by multiplying the measurement with a certain factor, all can be converted to total length and thus made comparable.

The prawn in the Oslo Fjord has a comparatively rapid growth. According to Hjort and Ruud the berried females hatch their young in spring, and the size of the young is 5-6 mm. When 1/2 year old they measure 50 mm., 1 year old 78 mm. and 1 1/2 years old 93 mm. They are now functioning males. A year later the prawn has grown to 120 mm., and they are spawning as females in the autumn when 2 1/2 years old. Hjort and Ruud have followed the prawn till an age of 3 1/2 years when they have reached an average size of about 130 mm. Investigations of the prawn in other localities, for instance in the Gullmars Fjord, Sweden, in the open Skagerak, and on the Pacific coast off British Columbia - has shown a growth in agreement with that found in the Oslo Fjord.

When working on the prawn material from Spitsbergen it became apparent that we had to revise any conception that the growth and development of the deep sea prawn was largely universal in all areas of its distribution. The first thing noticed was that this arctic prawn population spawned 2 months earlier and that the eggs hatched 2 months later than what was the case in the Oslo Fjord. The growth rate proved to be extremely slow in comparison to that of the Oslo Fjord. Another feature worth noticing was, that the size of the prawn when becoming active males and females, was nearly the same in both localities in spite of the difference in age.

In the Mist Fjord in northern Norway has been found a prawn population which obviously constituted an intermediary growth type between that of Spitsbergen and that of the Oslo Fjord. The prawns in the Mist Fjord become ovigerous females at a later age than in the Oslo Fjord, but earlier than in Spitsbergen waters. Although the size of the prawns when reaching maturity respectively as males and females was about the same in all these localities, the age when reaching these stages varied.

We have here an example of variability in growth and maturing in one and same species quite noteworthy in marine biology. If we look for an explanation of this phenomenon it is quite natural to think of the surroundings - the millieu - as an influencing factor, as f. instance temperature, salinity, food supply and the topographical features of the sea bottom. In this connection some observations taken on these prawning grounds may be of interest.

The Mist Fjord has a threshold at its entrance with a saddle depth of 50 m. The warm Atlantic water outside the fjord cannot enter, and the bottom here is

covered with coastal water of about 3.5 - 4.0 °C.

At Spitsbergen we find temperatures between 0 - 3 °C. in summer on the prawning grounds, but we may also find temperatures below 0°C. With other words, in the north colder surroundings apparently cause a slow growth and maturing. In the Oslo Fjord the temperature varies between 6 - 8°C. during the year. We may say that a prawn population from a locality in northern waters has a slower rate of renewal and recuperation than what is the case in more southerly grounds, and that a northerly population hardly will stand the same intensive fishery and taxation as a southerly one.

In western and southern Norway have been found prawn populations which show that all individuals belonging to a year class do not become ovigerous females at the same age, and that the sexual development is closely connected with the local rate of growth. As an example we may take the prawns from the Torungen ground in the Skagerak area. Figure 1 shows the growth and development of the prawn from this locality. The height of the columns gives the numbers of individuals expressed as percentages of the total sample. The numbers at the bottom express the total length in mm. after conversion of the original measurements.

On the bottom left we have 1/2 year old prawns measuring 52 mm. They grow rather fast, and 1 year later they measure averagely 89 mm. They are now active males. But there are some few individuals which do not develop in the usual way, but instead become berried females 1 1/2 years old. On the average we may say that it is only about 1% of the year class which behaves in this way. These young females we find on the right hand side of the age group. In other words, it seems to be larger individuals within the age group which have the tendency to become females at an early stage.

A couple of months after spawning we find that the males behave rather curiously. In January the male group splits into 2 fractions, one retaining the male characters, the other changing into females. This is still more pronounced in April. It is again the largest individuals of the age group which become females, while the smaller ones remain males. The female fraction become ovigerous when 2 1/2 years old at a size of 120 mm., the same length as found by Hjort and Ruud for the prawn in the Oslo Fjord. The rest of the age-group function as males for the second time in their life. We may say that probably between 60-70% of a year-class become females at this age, while 30-40% remain males.

After functioning as males for the second time also these last individuals enters the transitional stages and become females. They seem to have a rather rapid growth after leaving the male stage. They become berried females for the first time 3 1/2 years old, in size intermingling with the second time female spawners.

The composition of the catches.

From the Torungen material it is possible to study the composition of the catches. The prawn samples are about 3-4 litres each, and are taken directly from the commercial trawl before any sorting of the catch has taken place. The samples are all taken by a commercial fisherman while carrying out his ordinary work of prawn trawling off Torungen. We may assume that the samples give an adequate picture of the composition of commercial catches.

As regards the age composition (Fig. 2) we find in December 1945 4 year-classes represented. During the year 1946 the number of the oldest and largest prawns decreases, the group 1942 disappearing completely. At the same time the youngest age group (1945) rapidly rises to dominating strength. This year-class reaches its maximum strength in the catches when 1 1/2 years old when it constitutes about 70% of the catch. In January 1947 the 1945-class begins to lose its dominancy and a new year-class (1946) enters into the catches.

The sex composition varies with the season. Without going into details the figure shows that the major part of the catches is composed of males and youngs, while the most valuable part of the catch from a commercial point of view - the large females - are the least numerous.

In Figure 3 is shown the strength of a year-class in the trawl catches with increasing age of the prawn. When about 1/2 year old a few individuals of a year-class enter into the catches. The number caught increases rapidly as the prawn grows in size, and before the prawns are 1 1/2 years old they constitute about 70% of the catch. The year-class is now functioning with a few primary females. From now on the numerical strength of the year-class decreases rapidly. When 2 years old they

constitute only 40% of the catch. By now a part of the year-class is in the transitional stage. When 2 1/2 years old about 23% of the year-class is left, being composed of berried females and large males. When 3 years old the year-class constitute only about 10% of the catch, and from now on the year-class is no longer of any significance in the catch.

In another investigation of a prawn ground on the west coast of Norway a similar curve has been constructed, and in that case the point of maximum taxation was fixed at the age of 1 3/4 years. However, the prawns of that locality had a slower rate of growth. We may say that the age of maximum taxation is determined by the local rate of growth and by the selective action of the trawl. We may further assume that mortality due to natural causes is great after a life-span of 1 1/2 years on the Torungen ground.

In the Torungen material we find that the mortality of a year class during the 1 year from the age of 1 1/2 to 2 1/2 years to be about 67%. On the ground on the west coast of Norway where the prawn has a similar development, the mortality within the same space of time was found to be about 68%. The age from 1 1/2 to 2 1/2 years is apparently the critical period when the prawns in these particular areas show a most rapid decline.

The fishery for deep sea prawns in Norway started about 50 years ago. In 1898 investigations carried out by Professor Johan Hjort and Professor Johs. Petersen disclosed the fact that deep sea prawns were abundant in some fjords on the Norwegian and Swedish Skagerak coast. A commercial fishery on a small scale started immediately. From this small beginning the trawling for deep sea prawns has grown to be a fishery of comparatively great economic importance.

We have many trawling grounds in the Skagerak area, most of them small, lying near the coast or in inshore waters. But there is also a regular deep sea fishery going on on the large and continuous trawling ground stretching from Færder southwards to Skagen in Denmark and from here westwards towards the mouth of the Skagerak. This extensive trawl area has been known for a long time, but it was not till 1930 that "the bank" south of Færder was exploited by the fishermen from Norway, and the fishery has steadily been continued in that locality. Prawn trawling on "the Reef" south of Kristiansand started in 1929. The Norwegian fishery here has given very rich and steady catches up to the last world war.

The prawn fishery on the west coast and in northern Norway has expanded greatly during the last 20 years. The fishery is carried on in fjords and off the coast where suitable grounds are found. Particularly in the northernmost part of the country the prawn fishery at present is of increasing economic importance.

In the practical fishery the prawns are sorted according to size into 2 categories, small prawns and large prawns. It is practically only large prawns which form the basis for the Norwegian export trade. The sorting of prawns is done by hand or by the aid of a sieve. On the average we may say that the sieve sorts out as small prawns those below 10 cm. (according to experiments carried out by Hjort and Ruud). While fishing in inshore waters the undersized prawns may be sold to canning factories or sold for bait. On distant grounds, as in central Skagerak, the small prawns will have small value. During and after the war the prize of small prawns have been increasing.

In Figure 4 is set up the percentage of small prawns in catches from Torungen, and for comparison catches from the Oslo Fjord in identical months. The figures for Torungen show that during the whole year, but mainly in spring and summer considerable quantities of valueless prawns are destroyed. The catches in the Oslo Fjord have in comparison yielded very little of the small prawns. The two fishermen have used identical trawls with same mesh-width, but the fisherman in the Oslo Fjord had tied the trawl's cod-end in a different manner.

We may assume that a great part of the escaping small prawns are sifted through the meshes of the cod-end. How much, and what size of prawns shall escape, depends to a certain extent on the mesh-size in the cod-end. But at the same time it is equally, if not more, important how the meshes are distended during the trawling operation. Generally when fishing the cod-end is pursed together at the center end or tied up with a knot. By this procedure the net will lie in folds, the meshes cannot distend properly, with the result that the small prawns escape only with difficulty. This is the method used on the Torungen grounds. In the Oslo Fjord the cod-end is laced together and tied up in one corner permitting the meshes and the net to be fully extended when fishing.

The difference in the composition of the catches as shown in Figure 4 may most probably be attributed to the different methods of tying up the cod-end.

In Norway we have had regulations since 1926 determining the lawful mesh size and dimensions of the prawn trawl. These regulations have been changed several times, and the regulation in force at present is from 1941.

The present regulations are in two parts, one pertaining to the Skagerak area, the second part regulating the prawn fishery on the rest of the Norwegian coast. In the Skagerak area the prawn trawl cannot be used in shallower water than 60 m. The maximum length of footrope is 35 m., the bridles 50 m., the trawlbag 15 m., the circumference of the trawl bag at the center of footrope 800 meshes. The mesh size in the cod-end shall be between 32 and 36 knots per Norw. ell (62.75cm.)

As previously shown the catch of small and unmarketable prawns can be very large and presumably prove a heavy taxation on the prawn population on limited prawning grounds.

In the international co-operation on fisheries problems it has been shown that a saving of small sized fish can be brought into effect by means of mesh regulations. This is based on the experience that a great number of small fish escape from the trawl without reducing the catch of large and edible fish in any great degree. A similar solution in the case of the prawn trawl should seem obvious.

Hjort and Ruud have more fully investigated the problem to find a mesh size which does not give much smaller catches of large prawns while at the same time the undersized prawns have a better opportunity to escape. But it is not only the mesh which determines the size of prawns in the catch. Also the relative quantity of large and small prawns on the ground, the size of the stock, and - as we have seen - the way of tying up the cod-end play a part as well. Bjerkan (1939) indicates the possible use of a special fishnet flapper in the cod-end as possible means for saving the small prawns.

Hjort and Ruud in their investigations proposed for the Norwegian fishery a minimum mesh of 36 knots, and a maximum mesh of 32 knots per ell, a proposal taken due regard to in the last Norwegian regulations. They obtained their best results with a mesh of 36 knots, a mesh which also has been found satisfactory by most fishermen in Norway.

The term used in Norway "knots per ell" is an inexact way of stating the effective size of the mesh. A number of 36 knots to the ell should theoretically give a 35 mm. mesh in new net when stretched. However, measurements carried out on several prawn trawls have shown that a used net of 36 knots may have an effective mesh size, or lumen, anywhere between 26 and 35 mm. when the net is stretched. The effective mesh size relative to the number of knots is determined by the thickness of twine, the quality and the shrinking ability of the material used. On the average we can say that the stretched mesh corresponding to 36 knots is about 30 mm.

Besides the regulation of the mesh size, the question of a closed season has been mentioned. From a biological point of view a closed season would be of great benefit if it was made effective somewhere between January and April. In January-February we get a comparative high percentage of small softshelled males and transitionals. In March- April the prawn eggs are ready for hatching in the females. On the other hand, during the winter the large prawns are of excellent quality, demanding high prizes for export and inland consumption.

Johan Hjort has ascertained that a heavy decline of the prawn stock has taken place on the grounds which he was able to investigate 40 years ago. A similar decline on the offshore Skagerak grounds has not been detected as yet, although great variations in catches are reported from one season to another, and from year to year.

The question of protecting the deep sea prawn and other shellfish in the Skagerak area has been taken up by the International Council for the Exploration of the Sea. The Transition Area Committee has recommended that the countries interested in the deep sea prawn fishery in the Skagerak adopt identical measures in regard to mesh size and manner of tying up the cod-end of the prawn trawl.

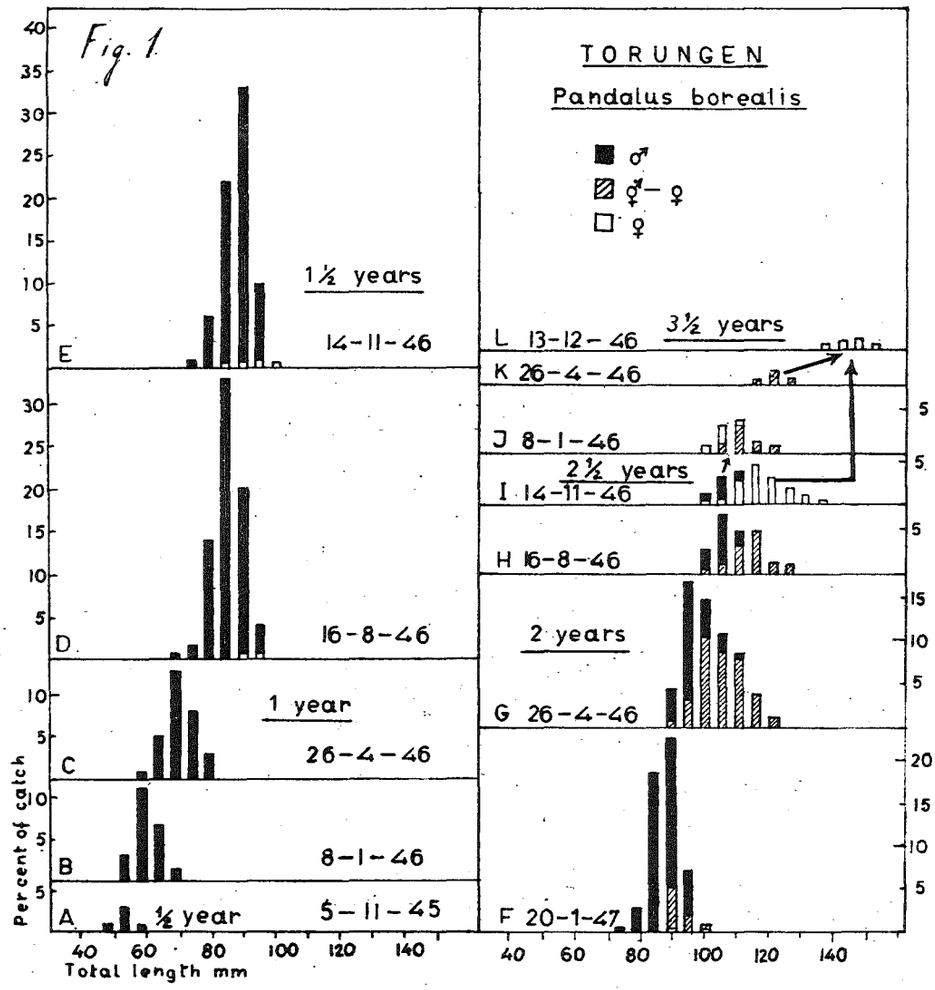
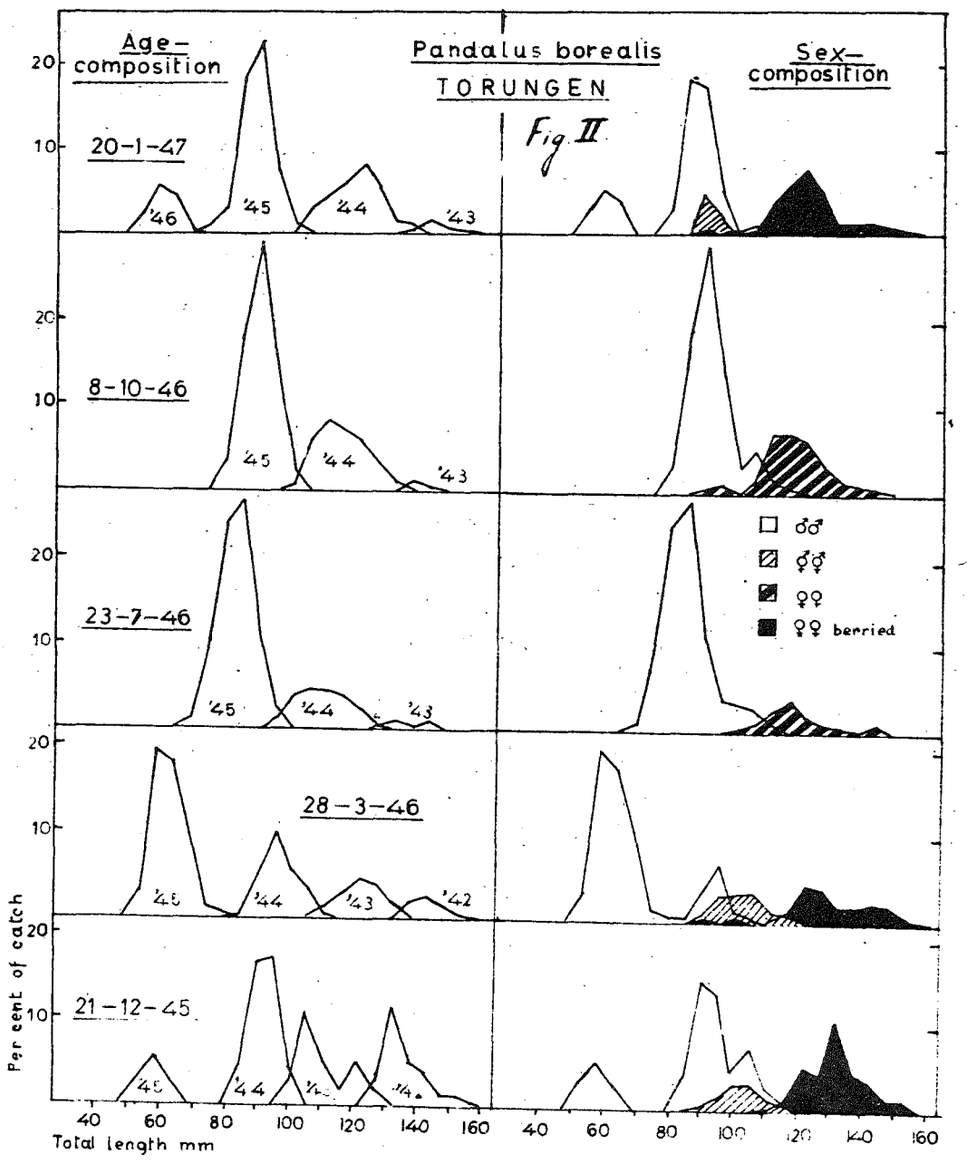


Fig. 1
TORUNGEN
Pandalus borealis
♂
♂–♀
♀
1½ years
E 14-11-46
D 16-8-46
1 year
C 26-4-46
B 8-1-46
A ½ year 5-11-45
L 13-12-46
3½ years
K 26-4-46
J 8-1-46
2½ years
I 14-11-46
H 16-8-46
2 years
G 26-4-46
F 20-1-47
Percent of catch
Total length mm


Age-composition
Pandalus borealis
TORUNGEN
Fig. II
Sex-composition
20-1-47
8-10-46
23-7-46
28-3-46
21-12-45
♂♂
♂♀
♀♀
♀♀ berried
Per cent of catch
Total length mm

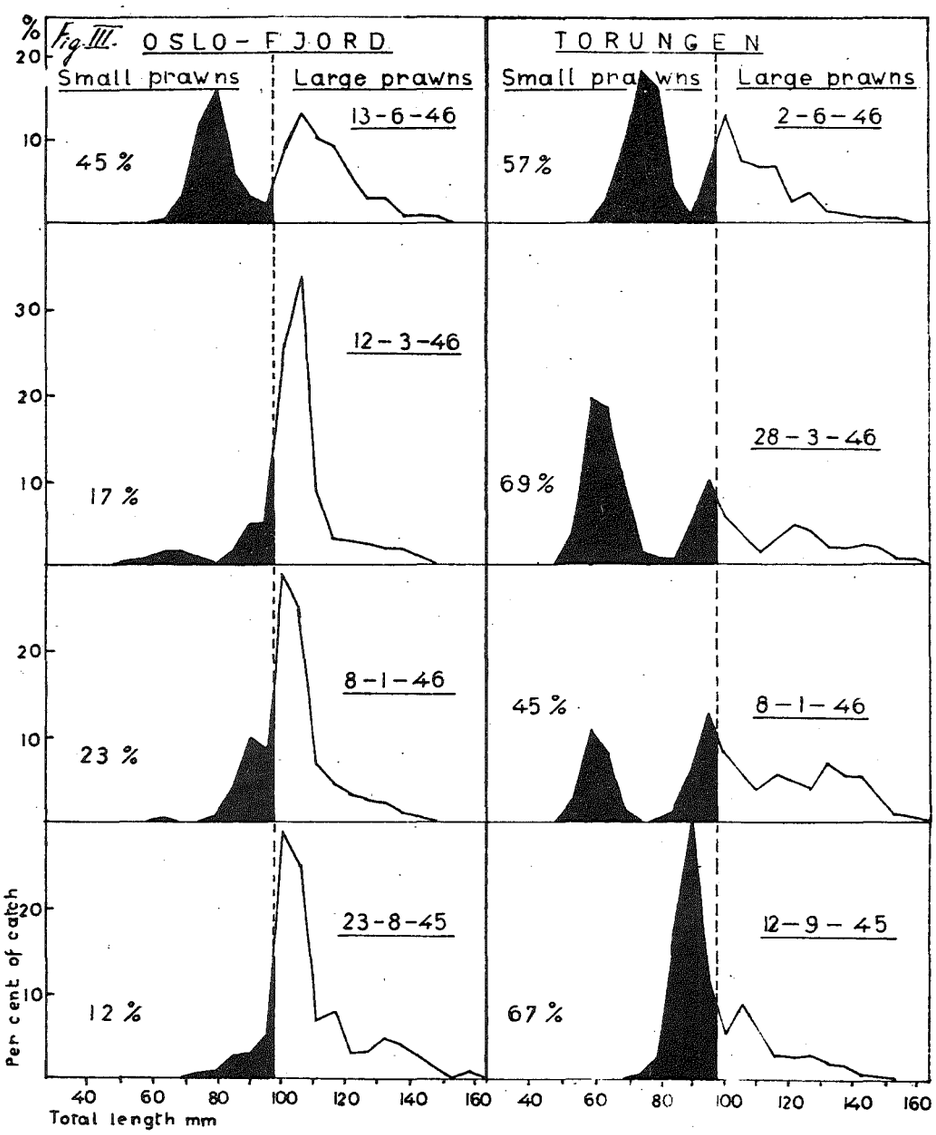


Fig. III.
OSLO-FJORD
TORUNGEN
Small prawns
Large prawns
13-6-46
2-6-46
45 %
57 %
12-3-46
28-3-46
17 %
69 %
8-1-46
8-1-46
23 %
45 %
23-8-45
12-9-45
12 %
67 %
Per cent of catch
Total length mm

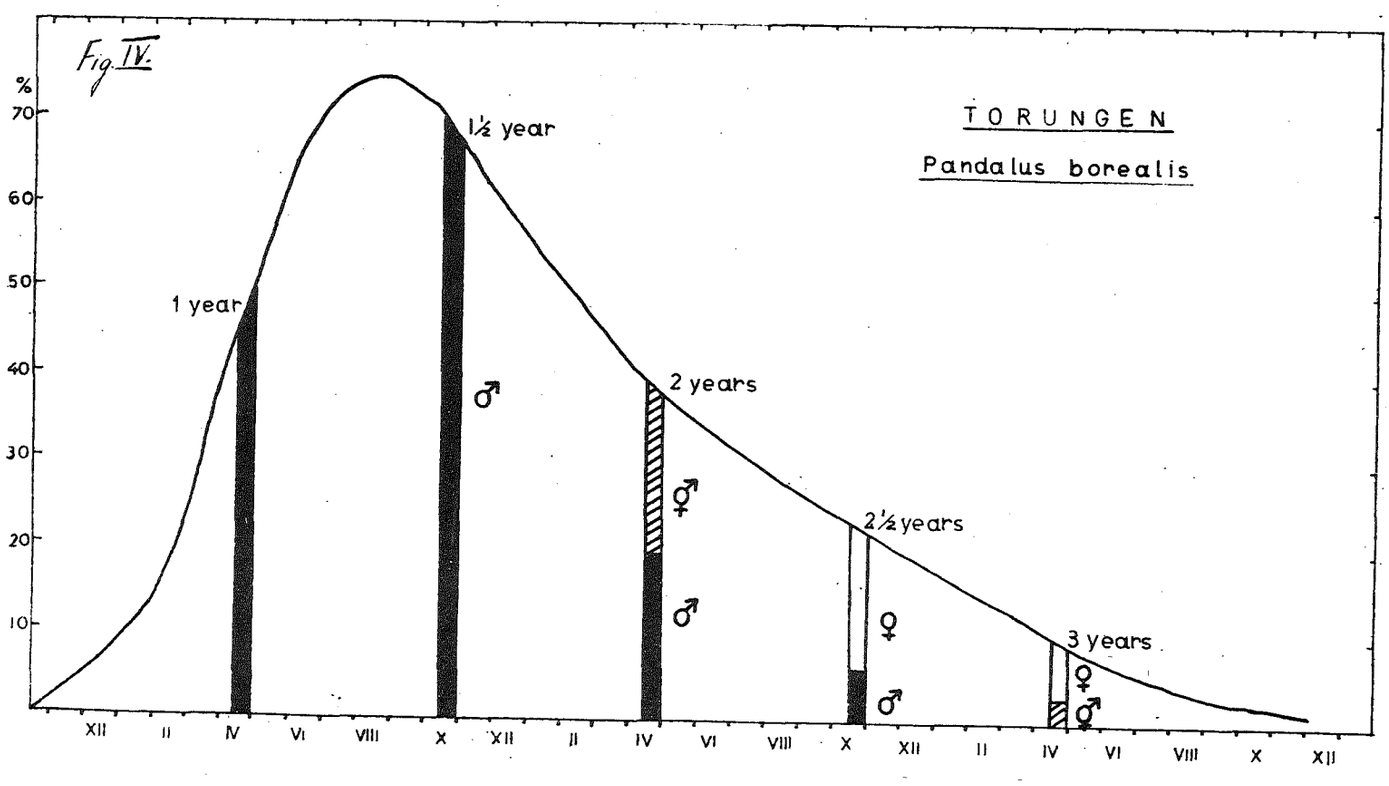


Fig. IV.
TORUNGEN
Pandalus borealis
1 year
1½ year
2 years
2½ years
3 years
♂
♀