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The squid *Todarodes sagittatus* (Lamarck). Norwegian
investigations in the Norwegian Sea and North Atlantic
waters 1970-1972.

by

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INTRODUCTION

Todarodes sagittatus is the only squid of commercial importance in the Norwegian fisheries, with yearly catches up to 11 000 tons and a first hand value up to 3 million N.kr. The squids are mainly used for meal and oil, some also for bait, and a small quantity for human consumption.

The species is pelagic, occurring from the surface to a depth of about 1000 m. The main area of distribution is the Northeast Atlantic and adjacent waters from Dakar in the south to the Kara Sea in the north, at Iceland, the Faroes, in the North Sea and western Baltic, and in the Mediterranean. The main habitat and breeding area is probably in the Northeast Atlantic south and

southwest of Ireland.

The biology of T.sagittatus has been described e.g. by JAECKEL (1958), CLARKE (1966) and ZUEV & NESIS (1971).

During the summer and autumn T.sagittatus invades the coastal areas of the Faroes and southwestern Iceland; some migrate into the North Sea both from the north and from the south, others pass into the Norwegian Sea, invading the western and northern coasts of Norway. The first shoals may appear in June, but the main immigration usually takes place from August-September to December. During the winter the squids descend to the deeper water of the fjords, and may stay there until January-April the next year, when they disappear.

The fishery in Norway takes place from small boats with hand lines and special hooks, sometimes combined with the use of light. The catches were formerly dried or salted, but are now mainly deep-frozen.

MATERIAL AND METHODS

The Norwegian investigations of T.sagittatus started in December 1970. Squids were collected from research ships and from the commercial fishery and kept deep-frozen until investigation (Table 1). Material from the Zoological Museum at the University of Bergen has also been included.

After thawing, the mantle length was measured to the nearest cm, and the animals weighed to the nearest 10 g. One sample was measured fresh. Squids preserved in alcohol, were also measured and weighed, and reservations are taken that these figures are somewhat too low, owing to shrinking and dehydration.

Sex, stage of maturity and egg size were determined macroscopically or under microscope.

Stomach contents were determined under microscope and stomach

filling estimated in a five degree scale.

RESULTS

Size (Table 1, Fig. 1)

At the Norwegian coast the mantle length of single squids taken in June was 41 cm, in August 19 and 41 cm respectively; in October the mean size was 28-30 cm and in November about 31 cm (Fig. 1); the range in this period was 23-35 cm.

In February single individuals measured 30 and 32 cm and in April 37 cm (Table 1).

In the Faroe-Shetland area the squids measured 23-29 cm in September and 19-37 cm in October-November. Single specimens of 46 cm were taken in November and December. In this area the size distributions were similar to those in Icelandic areas at the same time of the year (FRIDRIKSSON 1943). West of Ireland, squids taken in March measured 23-29 cm.

The males of T.sagittatus are on an average a little smaller than the females, as also mentioned by ZUEV & NESIS (1971). In three samples from the Norwegian coast the average lengths of males and females respectively were 26.2 and 28.0 cm, 28.5 and 29.7 cm, and 28.1 and 30.9 cm; off Western Ireland the figures were 24.7 and 26.0 cm.

Weight (Fig. 2)

Specimens taken in September ranged from 200 to 500 g, mean 325 g (preserved in alcohol); in October 300-800 g, mean 420-530 g; in November 350-900 g, mean 570 g. A squid with a mantle length of 46 cm weighed about 2200 g.

The relation between mantle length and weight is shown in Fig. 3.

Sex ratio

Males of T.sagittatus are usually in minority, at Iceland, the Faroes, and at the Norwegian coast amounting to from one per cent (CLARKE 1966) to 10 per cent of the stock (ZUEV & NESIS 1971).

At the Norwegian coast the percentage of males in October-November varied from 10 to 5, near the Faroes in September it was about 10, in the Faroe-Shetland area in October-November about 18, and at Ireland in March the sexes were equal in number (Table 1).

Maturation

The majority of the individuals investigated were immature. The males had gonads 30-40 mm in length, and the females ovaries about 100 mm long, with oocytes 0.1-0.2 mm in diameter. A male taken in February off Vesterålen at the northwestern coast of Norway had a mantle length of 32 cm and a gonad with a length of 135 mm, weighing 10 g. The left ventral arm was partly hectocotylized.

In a female, 46 cm mantle length, caught in November at the Faroes, the ovary was in a developing stage (Fig. 4) weighing 15 g. The eggs were pear-shaped, length 1 mm, corresponding to "small eggs" in the scale of MANGOLD-WIRZ (1963). The nidamental glands measured 10 cm.

CLARKE (1966) among more than 600 females caught in March, mean mantle length 43 cm, found only two mature specimens in spawning condition. Six males, mantle length 30-40 cm, caught simultaneously, were all mature, with spermatophores.

Spawning

In North European waters, T.sagittatus is believed to spawn in late winter or early spring, at the west coast of France in March-April (CLARKE 1966). ZUEV & NESIS (1971) infer that the spawning takes place in March-April in deep water in the Northeast Atlantic. In the Mediterranean, the species spawns in September-

November (MANGOLD-WIRZ 1963).

As mentioned earlier, the smallest individuals taken in the Faroes and Norwegian waters in June, were 19 cm in mantle length, and FRIDRIKSSON (1943) at Iceland found a specimen of 17.5 cm in July. At Madeira, REES & MAUL (1956) caught two specimens of 8-9 cm in April. Fitting these length data into a curve in relation to time, hatching might be calculated to occur in December-January (Fig. 5). The squids caught west of Ireland in March do not fit very well into this scheme. Near the Azores JOUBIN (1924) in August caught a specimen of T.sagittatus with a total length of 5 cm, and rhynchoteuthion larvae possibly belonging to this species. It is therefore to be expected that T.sagittatus may have both summer-spawning and winter-spawning populations, similar to what is the case in Todarodes pacificus (ZUEV & NESIS 1971).

Growth

T.sagittatus of 32-41 cm mantle length have been found in Norwegian waters in April-June, 43-45 cm in Scottish waters (?) in March, (CLARKE 1966), 64 cm near Iceland in January (FRIDRIKSSON 1943), and 46 cm in the Faroe-Shetland area in November-December. It seems likely, that individuals with more than 40 cm mantle length are 1½-2 year old, although CLARKE (1966) suggests a more rapid growth. ZUEV & NESIS (1971) assume that T.sagittatus attains an age of two years, maturing in its second year, and dying after spawning.

Food

T.sagittatus has been reported to chase herring in Norwegian fjords and in the Norwegian Sea. It also takes Ammodytes sp., small cod, crustaceans and polychaetes (ZUEV & NESIS 1971).

The frequency of occurrence of various food items in stomachs of T.sagittatus from the Norwegian coast and the Faroe-Shetland area in September-November 1971 is shown in Fig. 6. Empty stomachs are excluded.

Fish is very important, occurring in up to 70 per cent of the stomachs. At the coast of Norway small Sebastes sp. dominate. Other species identified were: Pollachius virens, Maurolicus muelleri, Trisopterus esmarki, Gadiculus thori and Clupea harengus. In the Faroe-Shetland area most of the squid had taken T.esmarki, next M.muelleri, Benthoosema glaciale, and possibly Sprattus sprattus.

North of Shetland one specimen taken in February, had eaten Belone belone, T.esmarki and M.muelleri.

Squid as food is at times as important as fish, and both the same kind and other species are eaten. At Senja in North Norway the frequency of squid in the stomachs increased strongly from October to November, while that of fish decreased. It is supposed that when the squids have entered a fjord, the fish available is eaten first, and when the shoals of squid are dense, and food is getting scarce, they change to cannibalism. Off Vesterålen, a squid taken in February, had eaten a number of Gonatus fabricii, mantle lengths up to 60 mm.

Euphausiids or krill are important as food, in frequencies up to 70 per cent. Meganyctiphanes norvegica was identified.

Polychaetes, amphipods and copepods were only found in T.sagittatus from the Norwegian coast. Nereis pelagica, Themisto sp., Gammarellus sp. and Pareuchaeta norvegica were identified.

Krill was abundant in stomachs of squids taken near the Faroes in September. Of 14 T.sagittatus caught off western Ireland in March, eight had eaten fish, mainly M.muelleri, five krill, two squid, and one amphipods. Some of the specimens had two or three food species in the stomach.

The degree of fullness has been estimated subjectively in a scale of five:

0- empty, I- little, II- moderately full, III- full, IV-distended.

At the Faroes the number of stomachs of T.sagittatus in the various degrees in 1971 were:

	0	I	II	III	IV
September	0	5	5	3	2
November	3	11	1	0	6

The weight of the contents in the distended stomachs varied between 10 and 35 g, from 1.1 to 11 per cent of the total weight, mainly consisting of M.muelleri. Stomachs in degree III contained 1-2 g, and in I-II below 1 g. A squid with mantle length of 36 cm, taken near Shetland in January 1972 had a stomach content constituting 12 per cent of the total weight, mainly of T.esmarki and M.muelleri. In T.sagittatus from the Norwegian coast, the distribution of stomachs in various degrees of fullness were:

	0	I	II	III	IV
Sandnessjøen October	11.8	57.0	19.4	9.0	2.8 %
Senja October	10.2	55.5	36.0	3.4	0.0 %
Senja November	8.9	70.6	12.1	2.6	5.7 %

Those with full or distended stomachs had eaten squid or krill.

In the choice of food, T.sagittatus has much in common with the Pacific relative, T.pacificus. The latter feeds mainly on fish, Maurollicus muelleri japonicus and anchovies, next squid of its own kind, amphipods, crab larvae, copepods, chaetognaths, polychaetes and krill (CLARKE 1966).

Migrations

The migrations of T.sagittatus are very incompletely known. The immigrations in the autumn to the Faroes, Southwest Iceland, and the Norwegian coast evidently follow the branches of the North Atlantic current (FRIDRIKSSON 1943).

Nearly all T.sagittatus found in northern waters are immature and

probably in their first year of life. It is to be expected that they would migrate in the direction of the supposed spawning area some time during their second year of life. In some years T. sagittatus invade the northeast coast of Scotland (Firth of Forth) in February-March (RITCHIE 1920, GILLESPIE 1953). Sometimes the squids also appear farther south, at the coast of Yorkshire; in March-April there are two size groups, one of a total length 18-20 inches, (about 20-25 cm mantle length), another 34 inches-3 ft 11 inches, (40-50 cm mantle length) (STEVENSON 1935). Whether these squids are on migration towards a spawning area can not be determined.

OCCURRENCE AND FISHERY FOR T. SAGITTATUS IN NORWEGIAN WATERS

T. sagittatus has been used for bait in the Norwegian fisheries for a long time. Since 1958, the surplus catches have been reduced to meal and oil.

The catches were not included in the Norwegian fishery statistics until 1957, but information exists on the occurrence of T. sagittatus before that year. According to ZUEV & NESIS (1971), mass invasions were observed in the Norwegian and Barents seas in the years 1885, 1891, 1930, 1931, 1937 and 1938.

Occurrence and catches of squid in Norwegian waters during 1949-1971 are shown in Fig. 7 (ANON. 1959-1970, 1970, 1971, 1972). In 1949, mass invasions were observed along the Norwegian coast, e.g. near Bergen in June (RUSTAD 1952). Some squids were also observed in 1950. The years 1951 and 1952 were evidently negative, but in 1953 some were fished. In 1954 the squids were very abundant, and large shoals were reported in December off North Cape. In September 1955 shoals were recorded on the echo sounder on board the R/V "G.O.Sars" northeast of the Faroes, and a number of specimens caught in drift nets (DEVOLD 1955). Few squids were fished at the Norwegian coast in 1955-1957. During 1958, 1962 and 1965 the catches were 6000-11000 tons, in 1959, 1966 and 1967, about 2000 tons.

The great variations in the catches with apparent periods of 3-5 years may be related to stock size. Similar variations with periods of 4 or 11 years have been observed in T.pacificus (ZUEV & NESIS 1971). T.sagittatus is also fished along the coast of Spain, but the catches are more stable, 1500-3000 tons a year, (Industrias pesqueras 1949-1972).

T.sagittatus is characterized as an Atlantic temperate species (CLARKE 1966), and variations in the influx of Atlantic water into the Norwegian Sea and adjacent areas might influence the migrations. Variations in this influx cannot always be shown directly, however, the occurrence of certain planktonic organisms, e.g. salps, may be taken as an indication of greater influx of Atlantic water.

In 1949 salps were found north and east of Shetland, after a possible absence since 1939 (FRASER 1950), but none appeared at the coast of Norway (WIBORG 1954). Since 1950, salps were observed at the coast of Norway in most years, except 1956, 1957, 1960, 1961 and 1963, especially abundant in 1954, 1955, 1958 and 1965 (BRATTSTRÖM 1972). The largest catches of T.sagittatus were taken in 1954, 1958 and 1965. In 1955, T.sagittatus was evidently abundant in the Norwegian Sea northeast of the Faroes (DEVOLD 1955). In 1962 the catches of squids were large; no salps were observed at the Norwegian coast, but many in the northwestern North Sea, (GLOVER, COLEBROOK & ROBINSON 1964).

The small, or zero catches of squid in 1956, 1960, 1961 and 1963 coincide with absence of salps, while the small catches in 1964 came in a year rich in salps.

Thus there seems to be a reasonable good, if not complete, correlation between large catches of T.sagittatus and the abundance of salps. Vice versa, small or no catches are taken in years poor in salps.

T.sagittatus has hitherto only been used to a small extent for human consumption, although a moderate demand exists in Spain and Portugal. The species seems to obtain a lower prize than other decapod squids, and is claimed to be tough and inferior in taste.

Norwegian experiments indicate that T.sagittatus, deep-frozen shortly after catching, when thawed, has a very tender meat, and when properly cooked, remains tender and is of a very good taste. One might therefore assume that this species could compete profitably with other decapod squids for human consumption.

SUMMARY

1. Todarodes sagittatus occurs in the coastal waters of western and northern Norway during August-December, exceptionally from June to April next year. The squids are all immature, mantle length 23-35 cm, weight 200-900 g. Single specimens, 36-41 cm, are caught in spring and summer. In the Faroe-Shetland area specimens measured 23-29 cm in September, 19-37 cm in October-November. Single females, 46 cm, with gonads and nidamental glands somewhat developed, were caught in November-December. West of Ireland, specimens, 23-27 cm mantle length, were taken in March.
2. Females usually outnumber males in proportions varying between 23 to 1, and 9 to 1.
3. The supposed normal life length is two years.
4. The spawning area is supposed to be in the ocean from west of Ireland and southwards to the Azores and Canary Islands, and the spawning time, December-February.
5. The most important food items were fish, squids, krill, polychaetes, amphipods and copepods, usually in the order mentioned. Of fish, Maurolicus muelleri, Trisopterus esmarki and Sebastes sp. were most common. Of squids, T.sagittatus and Gonatus fabricii were identified. Other food species were Meganyctiphanes norvegica, Nereis pelagica, Themisto sp. and Pareuchaeta norvegica.

Usually only 10 per cent of the stomachs were full or distended. The amount of food in these stomachs varied from 1% to 12% of the total weight, in the others, much less than 1%.

6. Northward migrations to the Iceland-Faroe area and the Norwegian coast follow the branches of the North Atlantic current. Major invasions of T.sagittatus seem to be correlated with major influxes of Atlantic water, characterized by large numbers of salps, but may also depend on stock size. Southward migrations have not been observed.

7. At present, T.sagittatus at the Norwegian coast is mainly used for meal and oil and bait. Experiments indicate that the species, especially after deep freezing, both in taste and tenderness can compete with other squids commonly used for human consumption.

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Table 1. Data on T. sagittatus used in the investigation, by the month.

Year	Month	Date	Ship	Area	Position	Gear	Number		% ♂	Mantle length, cm		Preservation
							♂	♀		Range	Mean	
1972	January	30	Feiebas	N. of Shetland	61° 20' N 01° 10' W	Bottom trawl	0	2	-	33, 36		deep-frozen
"	February	1	G.O. Sars	Off Vesterålen N. Norway	68° 35.7' N 11° 57' E	Pelagic trawl	1	0	-	32		deep-frozen
"	March	13	G.O. Sars	W. of Ireland	54° 13.4' N 11° 44' E	Pelagic trawl	7	7	(50)	23-29	25.2	deep-frozen
1950	April	14	G.O. Sars	Røstegga, N. Norway	68° 05' N 10° 29' E	Bottom trawl	0	1	-	37		alcohol 70%
1938	June	15	-	Korsfjorden. Bergen W. Norway	60° 11' N 05° 09.5' E	Hand line	0	1	-	41		alcohol 70%
1898	August	-	-	Heggholmen, W. Norway	60° 35.2' N 04° 48' E	?	0	2	-	19, 35		alcohol 70%
1955	September	4	G.O. Sars	NE of the Faroes	63° 17' N 03° 52' E	Drift net	8	67	10.7	21-29	25.2	alcohol 70%
1971	September	29	Havdrøn	W. of the Faroes	60° 28' N 03° 09' W	Squid jig	1	15	(7)	24-29	27.1	measured fresh, later in formalin
1971	October	10-14	-	Sandnessjøen, N. Norway	66° 11.5' N 12° 38' E	Squid jig	13	132	9.0	25-34	29.6	deep-frozen
1971	October	-?	-	Senja, N. Norway	69° 29' N 17° 29.5' E	Squid jig	22	184	10.7	23-32	27.8	deep-frozen
1971	November	1	-	Senja, N. Norway		Squid jig	8	148	5.1	26-35	30.8	deep-frozen
1971	October- November	26-4	G.O. Sars	Faroes-Shetland	56° 15.4' N 08° 13.9' W 60° 24' N 08° 29' W	Pelagic trawl Bottom trawl	6	18	(25)	19-37, 46	-	deep-frozen
1970	December	11	G.O. Sars	W. of the Faroes	61° 58' N 08° 52' W	Pelagic trawl	0	1	-	46	-	deep-frozen

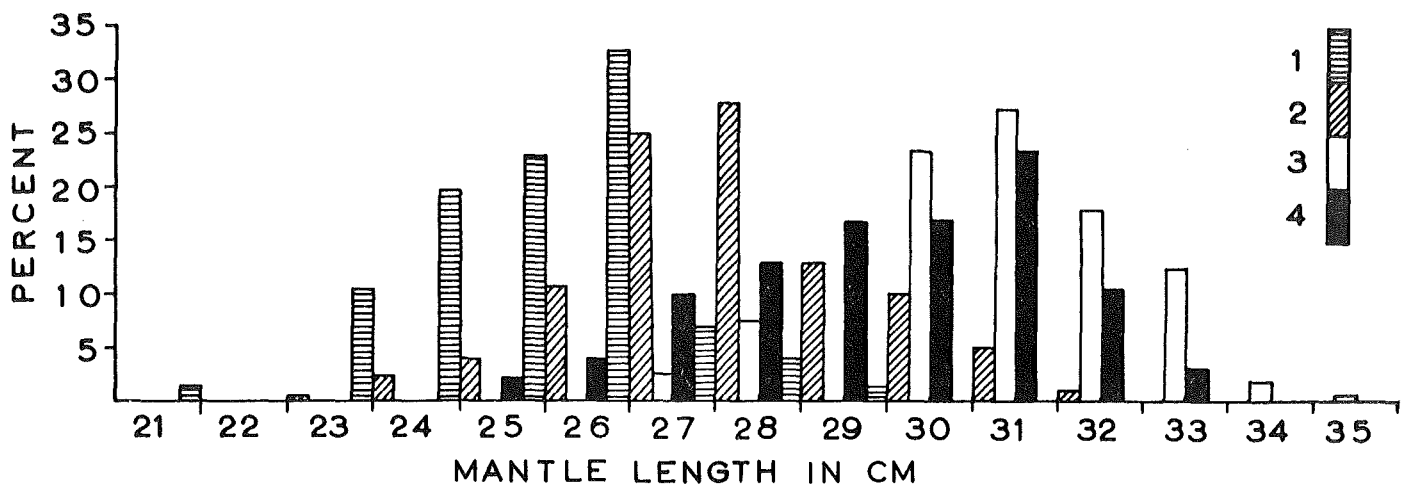


Fig.1. Mantle length distribution of *T.sagittatus*. 1) NE of the Faroes September 1955. 2) Senja, North Norway October 1971. 3) Senja November 1971. 4) Sandnessjøen, North Norway October 1971.

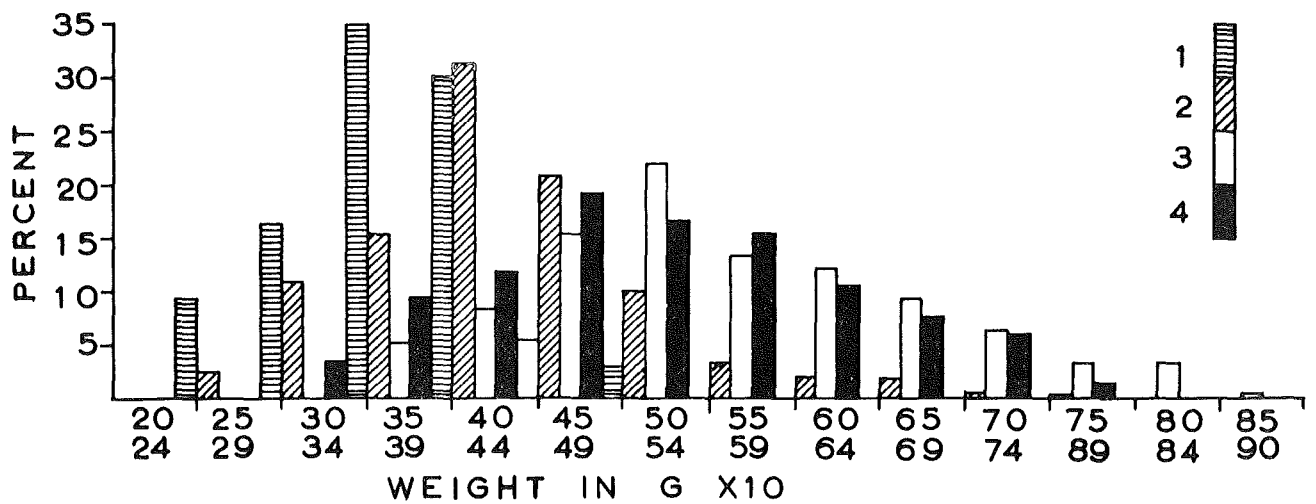


Fig.2. Weight distribution of *T.sagittatus*. Legend as in Fig.1.

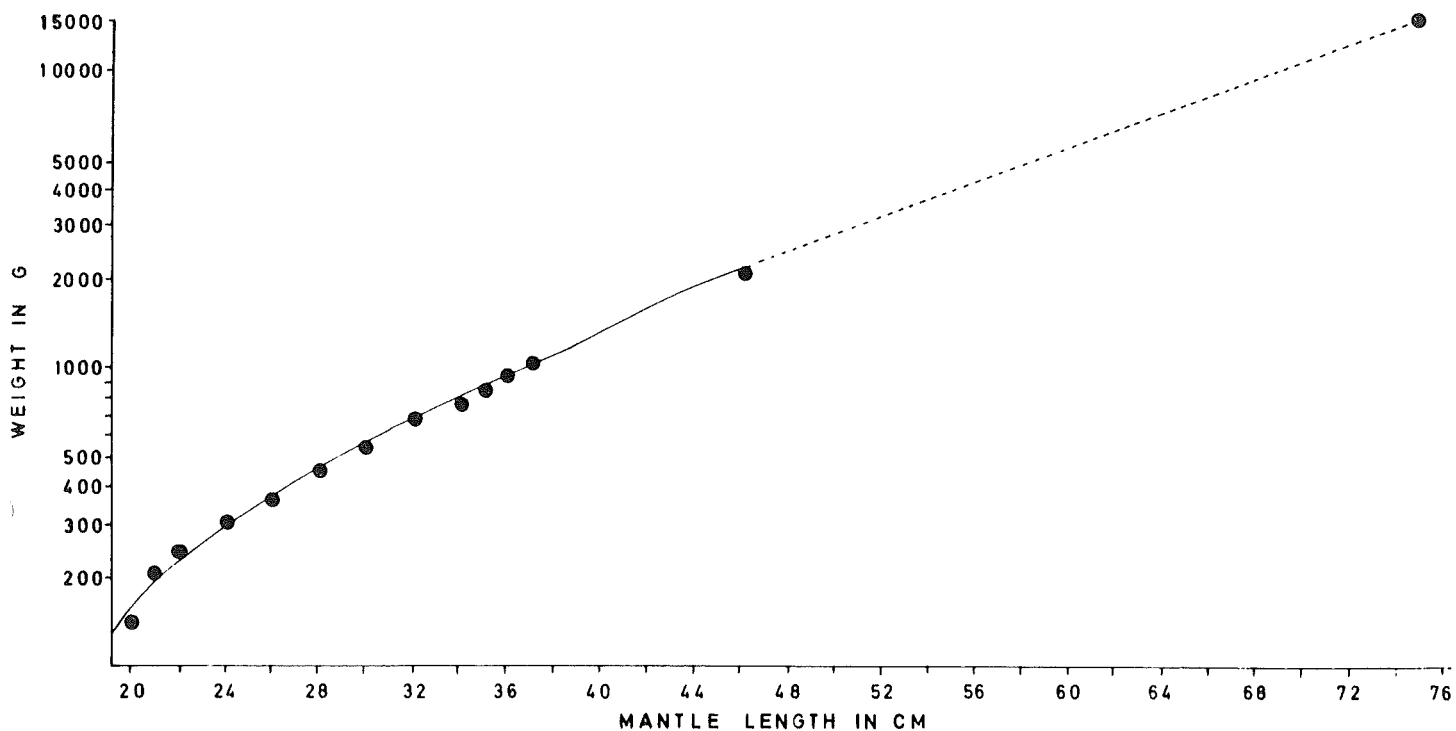


Fig. 3. Relation mantle length - weight in *T. sagittatus* in North Atlantic and Norwegian waters. Maximum length and weight from JAECKEL (1958).

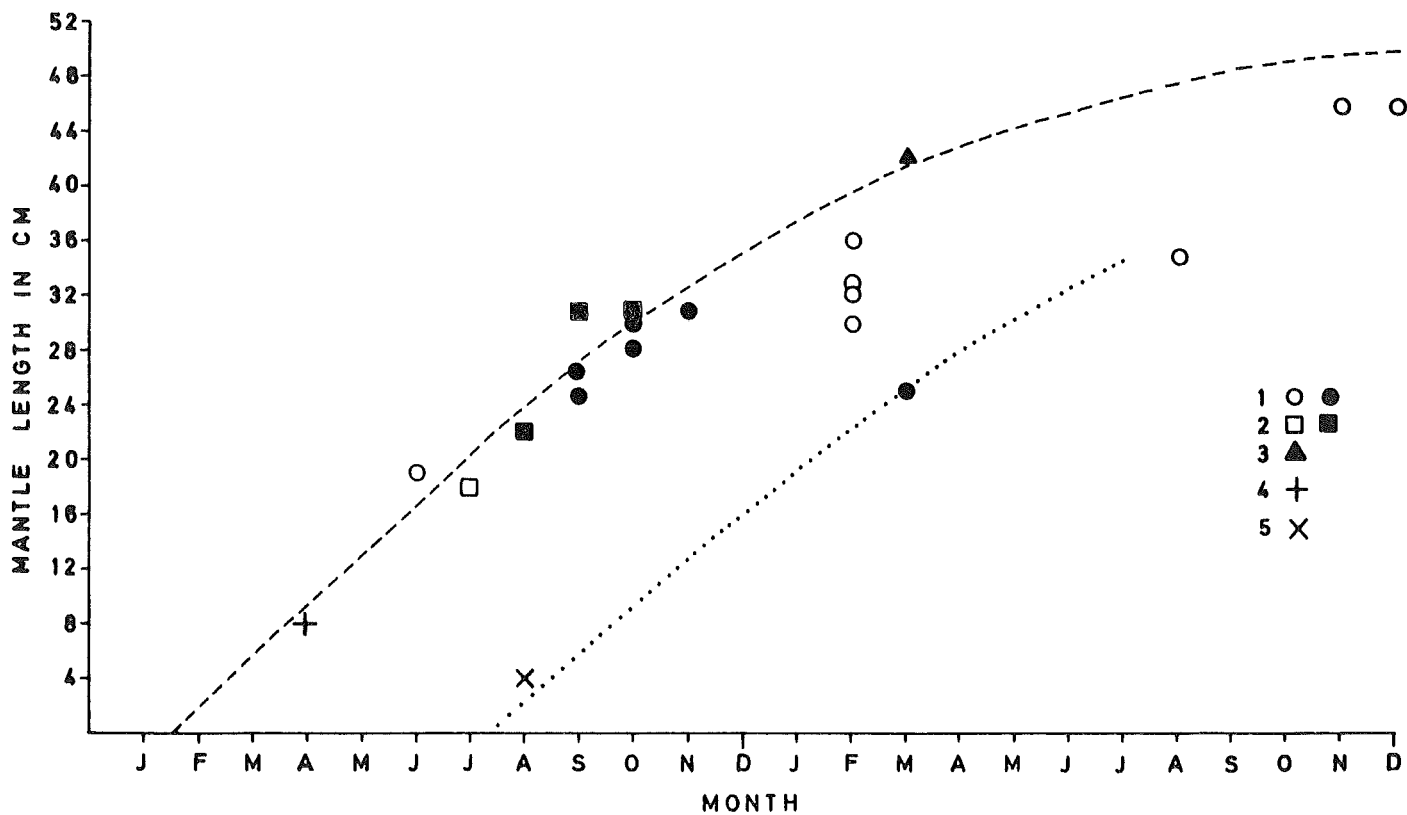


Fig. 5. Tentative growth curves of *T. sagittatus*. Filled symbols, average figures, open symbols and crosses, single figures. 1) Norwegian coast, except the March figure, which is from west of Ireland. 2) Iceland (FRIDRIKSSON 1943). 3) northern North Sea ? (CLARKE 1966, Fig. 18). 4) Madeira (REES and MAUL 1956). 5) the Azores (JOUBIN 1924).

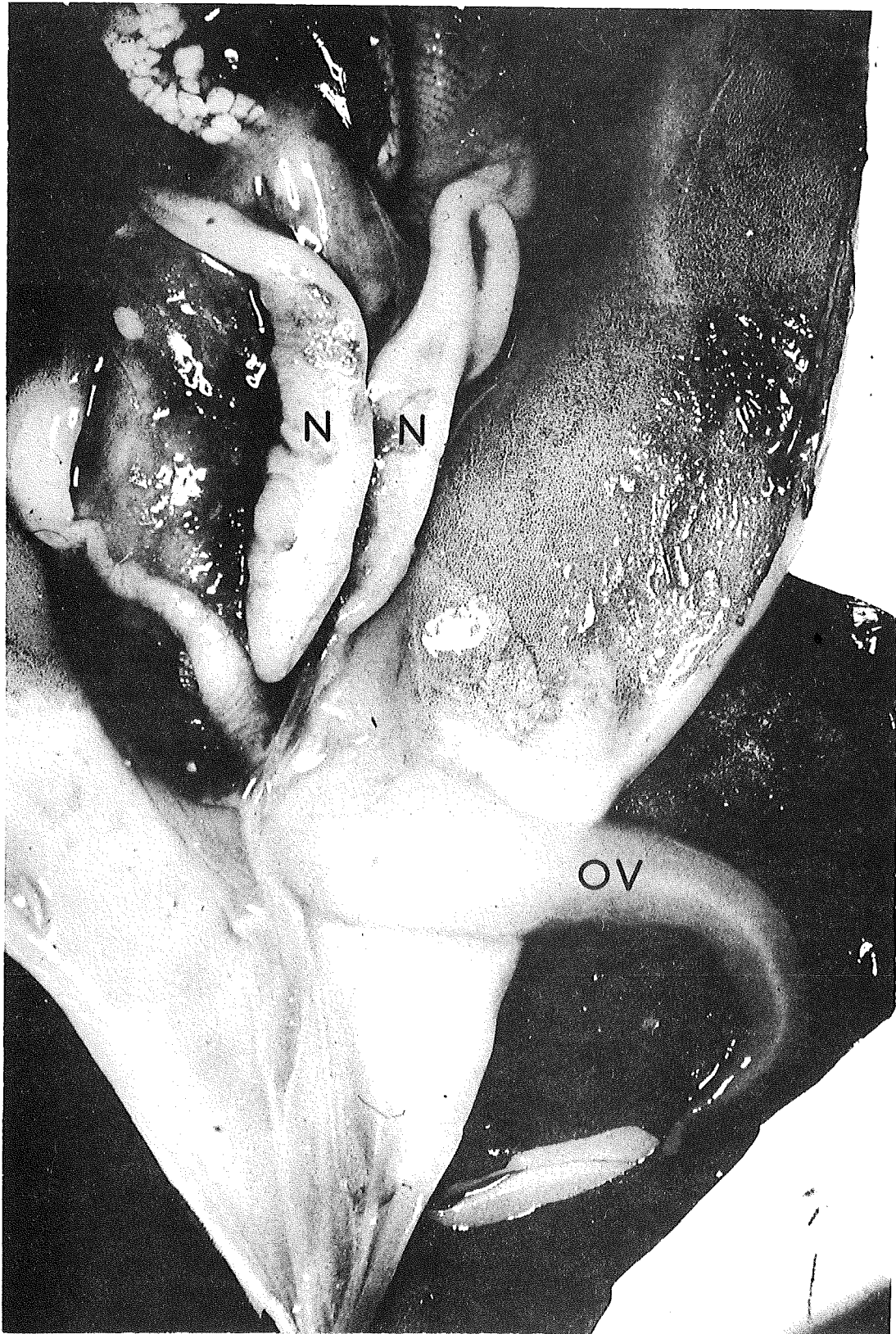


Fig. 4. Nidamental glands (N) and ovary (distal part loosened and bent to the right (OV), from T.sagittatus caught near the Faroes in November 1971.

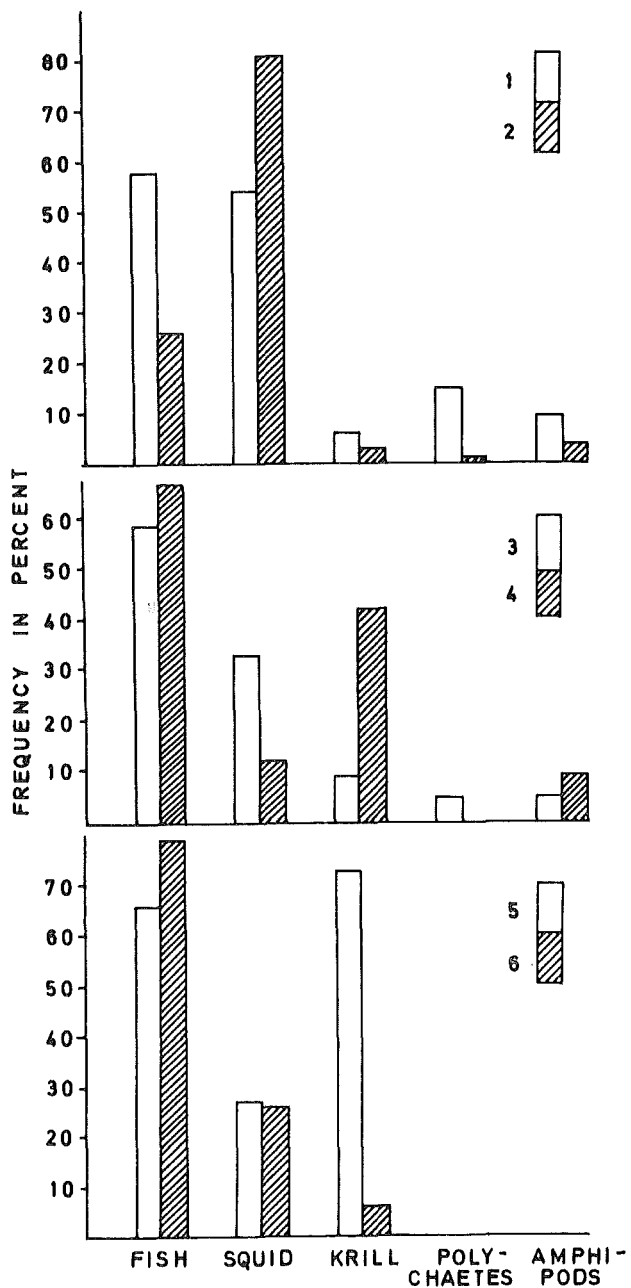


Fig. 6. Food organisms in stomach contents of *T. sagittatus*. 1) Senja, North Norway October 1971. 2) Senja November 1971. 3) Sandnessjøen, North Norway October 1971, sample No. 1. 4) Sandnessjøen October 1971, sample No. 2. 5) West of the Faroes September 1971. 6) Faroe-Shetland area November 1971.

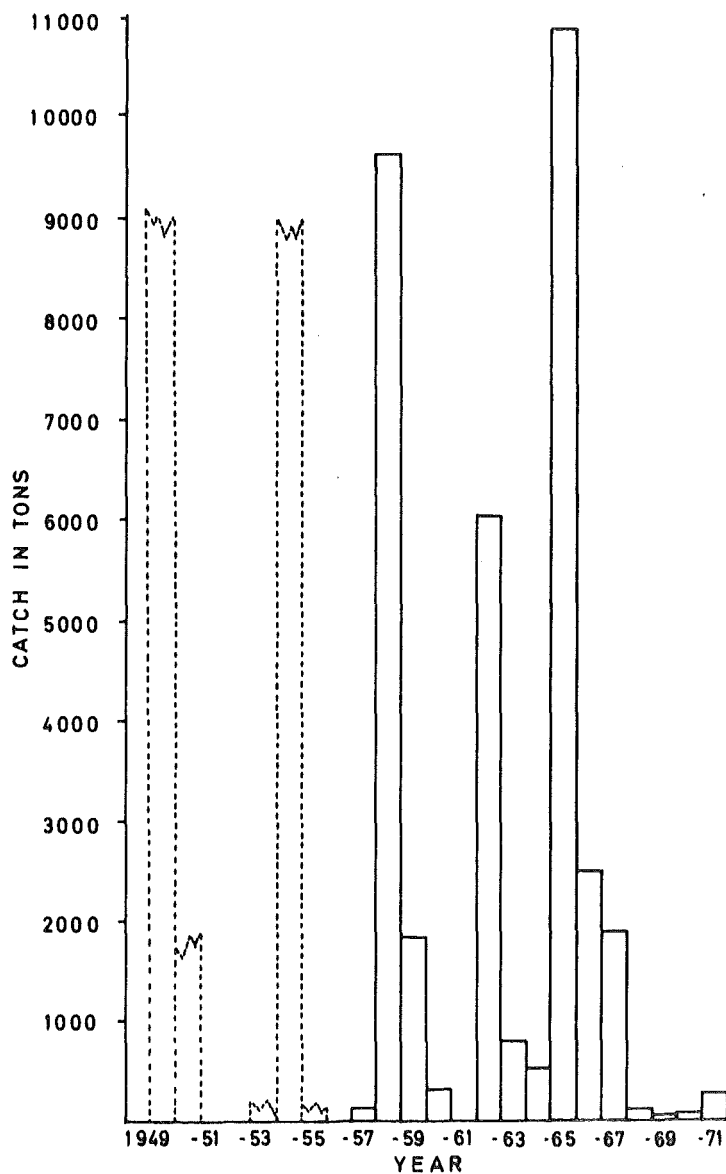


Fig. 7. Occurrence and catch of *T. sagittatus* in Norwegian waters 1949-1971. Hatched columns - tentative figures.