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THE SQUID TODARODES SAGITTATUS (LAMARCK)
INVESTIGATIONS IN NORWEGIAN COASTAL AND BANK WATERS,
JULY 1983-JANUARY 1984, AND WEST OF THE BRITISH ISLES,
MARCH-APRIL 1984

by

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ABSTRACT

During the second half of 1983 Todarodes sagittatus invaded the coast of Norway to the same extent as in 1982. Materials for investigation were obtained from research cruises near Shetland in July, on the Viking Bank in August, in coastal and bank waters of western and northern Norway from August 1983 to January 1984, and west of the British Isles in March-April 1984.

In August two size groups, dorsal mantle length (DML) 20-31 cm and 34-47 cm, were present on the Viking Bank and off the coast of Norway. In July-October the squid in fjords in western Norway measured 20-28 cm; in November the mean length was 35 cm; in January 36.6 cm. In March-April two size groups, 20-29 cm and 31-44 cm were present west of the British Isles.

The stomach contents were mainly fish; pearlside, blue whiting, saithe, redfish and a few others. Euphausiids, copepods and Pasiphaea sp. were sometimes important as food, while squid seldom surpassed 20% in frequency.

Liver weights were low near Bergen, on an average 4-8% of total weight, in other areas 10-11%.

Males were scarce or absent in jig samples from coastal areas, in trawl samples from oceanic areas, 31-63%.

In August, males 34-40 cm were all mature or maturing, females 37-47 cm in maturing stages 2-3.

Age determinations based on counts of primary growth rings in the statoliths indicated average ages of 8-10 months.

The main spawning season seems to be November-January. Squid caught in January had probably been hatched in March-April, those taken in March-April, - in May-August.

The relationship statolith length/dorsal mantle length (TLS/DML) was calculated for males and females. At the same DML, males had larger TLS than the females, the difference decreasing with increasing DML. Tagging of 452 squid resulted in two recaptures near the tagging place one month after tagging.

Attempts to keep T. sagittatus in aquarium were unsuccessful.

The commercial fishery yielded 19 000 m tons.

INTRODUCTION

During the second half of 1983 the invasion of T. sagittatus to the coastal areas of Norway was of nearly the same extent as in the previous year. Single squid appeared near Shetland in July. In fjords in western Norway the squid were very abundant from the beginning of August to the end of November. The

Table 1. Dorsal mantle length (DML) of *T. sagittatus*, July 1983-April 1984. n-number, SD-standard deviation. For location, see Figs 1,2.

Area	SHETLAND-FAIR ISLE		VIKING BANK		COASTAL BANK		LJULANDET		BLOMVÅG		ÅLESUND		BERGEN		COASTAL BANKS		BERGEN		BERGEN		HERØY-HOLMEN		SYLTE-FJORD		WEST OF BRITISH ISLES				
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♀	♂	♀	♀	♀	♀	♀	♀	♂	♀	♂	♀	
Date	July 23		Aug. 2,4,18		Aug. 4,18		Aug. 3		Aug. 24		Sep. 5-8		Sep. 15		Oct. 4-11		Oct. 6		Oct. 12		Nov. 8		Jan. 25		Mar. 6-Apr. 6				
	n	n	n	n	n	n	n	%	n	%	n	n	n	%	n	n	n	n	n	%	%	n	n	n	n	n	n		
DML																													
cm																													
20		2	1									1																1	
21							1.9					1		1.0														1	2
22	3	2		2		1	3.9	1	5.6	4			1	2.6			1											-	4
23	2	3	1	3			8.5	1	7.0	5	2		2	8.2			1				1.0						3	4	
24		2	1				4	13.7	1	8.4		3		21.4	1		7		2		3.0						5	9	
25		2		3			1	20.9		14.1		2	4	23.5	2		7		1		4.5						2	4	
26			1	4		2		14.4		7.1		6		15.8		1	4				18.0						3	5	
27				1			1	21.6		21.1		1	1	13.3							22.0	1.2						2	
28				2				10.5	1	15.5		1		6.1			2				19.5							-	
29				1				3.3		12.7		2		4.1	1	1					11.5	3.7						1	
30								1.3		7.1		3		1.5							10.5	4.9						-	
31				1								1		2.0		1					4.5	3.7						1	
32														0.5							0.5	6.2					1	1	
33																1					1.5	16.0							
34			1						1.4							1					3.5	9.9							
35				8												1					0.5	8.6		1					
36			2			1										1						7.4		2				1	
37			4	1			1															12.3		4					
38				3																		14.8							
39				1	2																	6.2							
40				3																		4.9							
41					2																								
42																													
43					1																								1
44					3																								1
45																													
46					3																								
47					1																								
n	5	11	4	17	2	3	6	153	4	71	11	21	8	196	4	7	22	3	200	81	7	15	31						
DML cm	22.7	23.1	23.4	25.8			24.9	25.9	24.8	26.7	22.4	26.8	24.5	25.7	25.9	32.3	25.1	24.7	28.0	34.9	36.6	24.1	24.5						
SD	0.8	1.8	2.3	2.6			1.1	1.9	2.6	2.4	1.0	2.4	1.6	2.0	2.1	3.6	1.5	0.2	2.2	4.5	0.7	1.7	1.8						
n			22	13																					1	5			
DML cm			36.9	43.0																					32.0	37.4			
SD			1.9	3.1																					-	6.1			

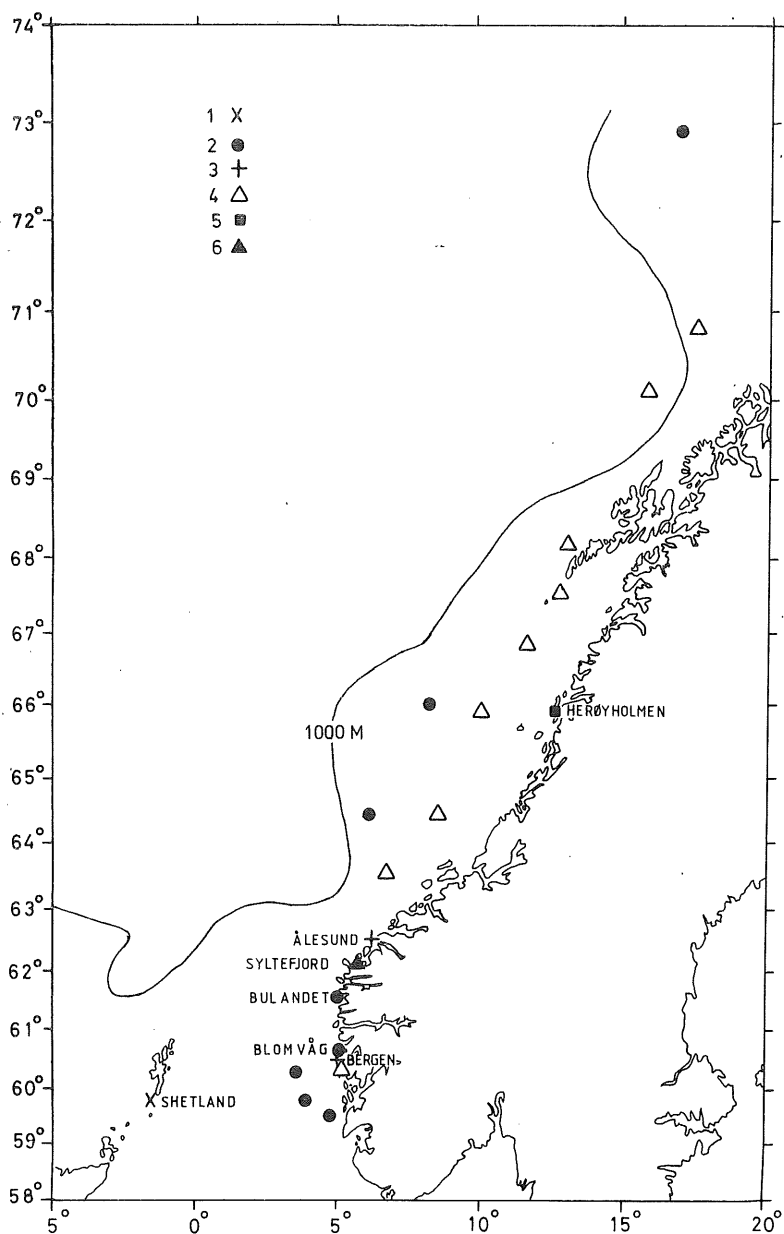


Fig. 1. Localities for sampling of *T. sagittatus*, July 1983-January 1984. 1) July, 2) August, 3) September, 4) November, 5) January.

materials from 1983 have been dealt with (WIBORG and BECK 1984).

MATERIALS AND METHODS

Squid were caught during cruises in July-October 1983 and March-April 1984, and bought from commercial catches in August-January (Table 1, Fig. 1,2). In open waters the squid were

of the statoliths were measured under microscope to the nearest 1/100 mm. The statoliths were prepared, and primary growth rings counted as described by ROSENBERG, WIBORG and BECK (1980). Maturity stages were determined after WIBORG et al. (1982). In two localities, 452 squid were tagged with anchor tags and released.

RESULTS AND DISCUSSION

Dorsal mantle length

In July the squid near Shetland measured 20-25 cm (Table 1). In August two size groups, 20-31 cm, and 34-47 cm, were observed on the Viking bank. The same groups appeared off the Norwegian Shelf (Egga) between 66°N and 73°N. At the coast of western Norway only small squid were taken, mean DML of females, 25-27 cm. In the fjords the squid remained small throughout October; near the continental slope larger squid, DML 32-36 cm, were taken. At the beginning of November the mean length of squid at the west coast was 35 cm, in January 36.6 cm. In March-April two size groups, 20-29 cm and 31-44 cm, were observed west of the British Isles.

Stomach contents

The frequency of various food organisms in the stomachs of T. sagittatus in samples taken during July 1983-March 1984 is shown in Table 2. Empty stomachs are excluded.

Fish were nearly always dominating. Euphausiids, pelagic shrimps and copepods were sometimes very common, while squid varied between 7 and 33%.

The species of fish identified at various localities are listed below, frequency in the order mentioned:

Shetland, July:	Blue whiting
Viking Bank, August:	Blue whiting, pearlside, silver smelt, silver pout
Bulandet, August:	Pearlside, blue whiting, saithe, sand eel, redfish
Blomvåg, August:	Pearlside, blue whiting, saithe
Ålesund, September:	Pearlside, saithe, blue whiting, herring
Bergen, September:	Pearlside, blue whiting, herring, redfish
Coastal banks, October:	Blue whiting, redfish, pearlside
Herøyholmen, November:	Pearlside, lantern fish, blue whiting, Norway pout
Syltefjord, January:	Herring, pearlside
West of the British Isles, March:	Blue whiting, <u>Argyrolepecus</u> sp., silvery pout, pearlside.

Blue whiting dominated in squid from trawl samples, while pearlside was most important in those caught with igs.

Table 2. Frequency (%) of food organisms in stomach contents of T. sagittatus, July 1983 - March 1984. n-number.

Locality	Month	n	Fish	Squid	Euphausiids	Shrimps	Amphipods	Copepods	Nereis	Chaetognaths
Shetland	July	16	100.0	12.5	37.5					
Viking Bank	August	45	80.0	11.1	75.5	2.2				
Bulandet	August	29	89.7	13.8	13.8	2.2	17.2	58.6		
Blomvåg	August	30	73.3	6.7	30.0	36.7	3.3	3.3		
Ålesund	Sept.	21	71.4	19.1	23.8	28.6	14.3	23.8		
Bergen	Sept.	21	75.3	33.3				95.3	9.5	9.5
Bergen	Sept.	12	75.0	16.7						
Coastal banks	October	15	46.7		40.0		6.7			
Herøyholmen	November	31	87.1	12.9	83.9	38.7	12.9		6.5	
Syltefjord	January	7	71.0		43.0	14.0				
West of Brit. Isles	March	38	92.1	5.3	29.0	5.3				

Liver percentage

Variations and mean percentage of weight of liver in relation to total weight are shown in Table 3. The range of variation is very great, 1.9-17.0%. The mean values were below 4% near Bergen in October, probably reflecting poor feeding conditions. In other areas the mean figures varied from 7 to 11%. On the Viking Bank, larger squid had somewhat higher percentage than the smaller ones, but the difference is not significant.

Table 3. Weight of liver in % of total weight of T. sagittatus, July 1983-March 1984. n-number, SD-standard deviation.

Locality	Month	n	Variation	Mean	SD
Shetland	July	16	5.6-13.0	9.6	1.8
Viking Bank	August				
DML 35-48 cm		33	6.6-17.0	11.3	2.8
DML 22-35 cm		16	5.6-12.2	10.4	2.8
Blomvåg	August	30	3.3-14.4	8.1	2.4
Bergen	September	23	1.9- 8.4	4.8	1.7
Bergen	October	21	2.8- 6.8	3.9	0.9
Coastal banks	October	9	4.3-10.4	7.3	3.2
Herøyholmen	November	31	4.5-14.6	10.1	3.2
Syltefjord	January	7	7.8-12.7	10.3	1.9
West of British Isles	March	46	2.7- 9.5	5.8	1.4

Sex ratio

As shown in Table 1, males were most often scarce or absent in the samples, especially in those taken with jigs. During a fishing experiment near Ålesund it was observed that the males kept near the surface, under the bottom of the vessel, while the females stayed at deeper levels. In trawl samples taken on the Viking Bank and Porcupine Bank, males constituted 31-63%.

Maturation

Maturity stages were determined after WIBORG et al. (1982). In August, males with DML below 28 cm and females with DML below 31 cm, were immature (Stage 1). Males, DML 36-40 cm, were maturing or mature, 8 in Stage 2 and 14 in Stage 3, the latter

with spermatophores well developed. Females, DML 37-47 cm, were partly immature (3), partly in Stage 2(6) and Stage 3(3). The presence of mature males does not indicate a forthcoming spawning. In Todarodes pacificus, a squid nearly related to T. sagittatus, mature males are relatively common, and mating may take place long time before spawning, while mature females are rare (SASAKI 1921).

Age, and time of hatching

Primary growth rings in the statoliths have been counted, following the method of ROSENBERG, WIBORG and BECK (1980). The results from the present material are shown in Table 4. Assuming the growth rings to represent daily growth, the squid had average ages of 225-295 days ($7\frac{1}{2}$ -10 months). In August, large squid on the Viking Bank (DML 34-48 cm) were 34 days older than those with DML 23-31 cm. As shown in Table 1, the large males had an average DML about 6 cm less than the females (36.9 cm and 43.0 cm). When the age distribution was split up the difference in mean age was not significant (19 males: 286.16 ± 28.00 rings, 13 females: 280.08 ± 23.32 rings).

Squid, caught in August, seems to have been hatched in the period October-January, with maximum in November-December, those from September-November were hatched in December-February, and those from January, - in March-April. T. sagittatus, caught west of the British Isles in March-April, had been hatched during May-September, most of them in June. The results agree relatively well with those obtained for the same areas and periods during the preceding year (WIBORG, GJØSÆTER and BECK 1983).

Most of the squid fished commercially in Norway is taken during the period August-November. These squid have mainly been hatched during December-January, 8-11 months earlier.

Table 4. Months of hatching of T. sagittatus caught at the Norwegian coast and west of the British Isles July 1983-April 1984. n - number of statoliths read. MV - mean number of growth rings. SD - standard deviation.

Locality	Date	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	n	MV	SD
Shetland	July 23			5	7	1									13	230.88	18.54
Coast of Norway	Aug. 4,18		2	1	1										4	267.00	31.92
Viking bank	Aug. 2,18																
	34-48 cm	9	10	11	2										32	283.68	25.97
	23-31 cm		3	4	9										16	249.06	19.72
Bulandet	Aug. 3			2	22	4									28	224.61	14.77
Blomvåg	Aug. 24			1	18	9									28	245.11	13.38
Ålesund	Sep. 6,7				9	18	2								29	238.69	14.92
Bergen	Sep. 15				6	9	4								19	243.84	16.70
Bergen	Oct. 6					10	10	1							21	245.52	14.45
Coastal banks	Oct. 4-11				6	4									10	274.00	17.70
Herøyholmen	Nov. 8				3	20	8								31	295.29	14.45
Syltefjord	Jan. 25							2	4						6	290.00	14.10
W. of Br. Isles	Mar.9-Apr.6									10	21	10	3	1	45	276.22	27.92

Relationship: statolith length/dorsal mantle length

The relationship between greatest length of the statoliths (TLS) in mm, and dorsal mantle length (DML) in cm was studied for males and females of T. sagittatus (Fig. 3). The following equations were found:

Males: $TLS = 0.4938 DML^{0.41}$, $r^2 = 0.75$, $n = 79$

Females: $TLS = 0.4259 DML^{0.45}$, $r^2 = 0.76$, $n = 303$

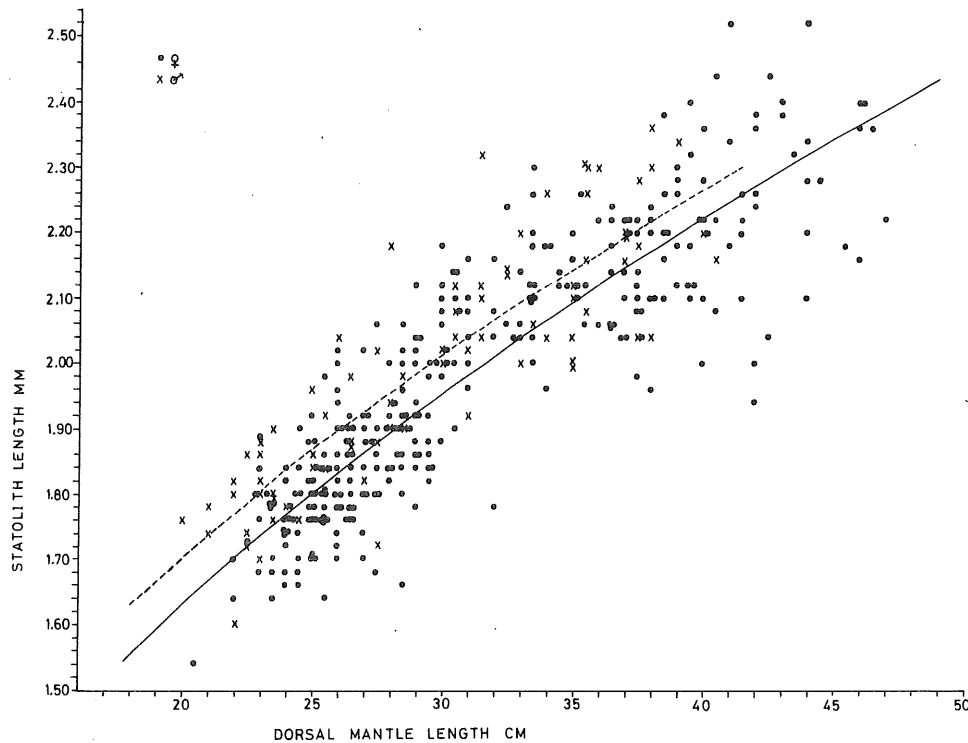


Fig. 3. Relationship: Total statolith length(TLS)/dorsal mantle length(DML) in T. sagittatus in materials from 1983. Crosses and hatched curve: males, dots and drawn curve, females. Equations: see text.

At the same DML males have longer statoliths than the females, but the relationships are not significantly different. The curves approach each other at increasing DML. LIPINSKI (1981) did not find any difference in the relationship for males and females of Illex illecebrosus.

Tagging

In 1983, 452 squid were tagged with anchor tags, 69 near Ålesund in September, and the remainder near Bergen in September and October. Two squid were recaptured near the tagging place at Ålesund, respectively 24 and 34 days after tagging.

Survival of squid in aquarium

Experiments with maintaining squid in aquarium have been made by several scientists, especially with T. pacificus. FLORES, IGARASHI and MIKAMI (1977) succeeded in keeping T. pacificus alive for 50 days.

During the autumn of 1983 we tried three times to maintain T. sagittatus in aquarium, but the attempts were all unsuccessful. The squid were fished near Bergen with hand line, placed singly in tubs with 20 l of seawater and transported to the Institute. The seawater was renewed once during the transport which lasted for ½ hour. The squid were placed 15-30 together in a rectangular aquarium of concrete of 40 m³ capacity. They swam frantically around, bumping against the walls of the aquarium, and also attacking each other. During the two first experiments all were dead after 6-7 hours. In the third experiment, the walls of the aquarium had been covered with sheets of black plastic, but the squid panicked, bumped against the bottom, and also succeeded in swimming beneath the cover. Only 2 squid survived for 24 hours. The dark cover may have contributed to the panic, because the squid did not see the walls.

In future experiments the squid should be kept singly in small tanks, or perhaps in large circular tanks or "raceway systems" (O'DOR, DURWARD and BALCH 1977, MATSUMOTO and SHIMADA 1980, HANLON, HIXON and HULET 1983).

Fishery for *T. sagittatus*

In 1983 the Norwegian fishery yielded 19 000 tons of squid, mainly in August-November, with maximum quantities in September and October.

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