

Fol. 4/K

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International Council for
the Exploration of the Sea

C.M. 1984/K: 19
Shellfish Committee

Fiskeridirektoratet
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THE SQUID GONATUS FABRICII (LICHTENSTEIN)
INVESTIGATIONS IN THE NORWEGIAN SEA
AND WESTERN BARENTS SEA 1982-1983

by

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ABSTRACT

Investigations on Gonatus fabricii (gonatus) in the Norwegian Sea and western Barents Sea continued during June-September 1982 and 1983. Materials were collected with pelagic trawls and from stomach contents of blue ling and Greenland halibut. Dorsal mantle lengths (DML) were mainly 20-50 mm, extremes 10 mm and 100 mm. Larger gonatus, DML 80-200 mm, were taken in deep pelagic and bottom hauls at 200-400 m. Gonatus with DML 95-255 mm were the main contents in stomachs of blue ling and Greenland halibut fished in April-June on the continental slope off western Norway. Age and growth were estimated from counts of primary growth rings in the statoliths. In the juveniles, linear relations were found between DML and number of growth

rings, but with varying slopes of the regression lines, and correlation coefficients, r , varying from 0.47 to 0.67.

In larger gonatus, the regression curve had a sigmoid shape. The assumption that larger gonatus, having left the surface layers, grow considerably faster than the juveniles, seems to be confirmed.

The relationship between total statolith length (TLS) and DML, both in mm, was calculated for various length groups with the following results:

DML 10-250 mm: $TLS = 0.131 DML^{0.47}$, $n = 201$, $r^2 = 0.93$
 DML 10- 69 mm: $TLS = 0.104 DML^{0.53}$, $n = 163$, $r^2 = 0.93$
 DML 70-250 mm: $TLS = 0.328 DML^{0.26}$, $n = 38$, $r^2 = 0.74$

There is a considerable change in the relationship for DML longer than 70 mm, indicating a slower growth of the statoliths.

The main spawning period seems to be from December to April, on, or near the bottom in 300-700 m depth or more on the continental slopes of the Norwegian Sea, from the west coast of Norway to West-Spitsbergen, and westwards to Iceland and Jan Mayen. The food of juvenile gonatus was dominated by amphipods, Parathemisto sp., but copepods, chaetognaths, euphausiids, pteropods and Pasiphaea sp. were also identified. Larger gonatus also take fry of redfish and pearlside, and smaller gonatus.

INTRODUCTION

Investigations on Gonatus fabricii (gonatus) were continued during 1982 and 1983 following the same program as before (WIBORG, GJØSÆTER and BECK 1982).

MATERIALS AND METHODS

Gonatus were taken as bycatch during surveys with pelagic trawls for postlarval and 0-group fish and for blue whiting in the Norwegian Sea and adjacent areas during July-September 1982 and 1983.

Large gonatus from stomach contents of blue ling and Greenland halibut, caught on the continental slope off western Norway in April-June 1981-1983(ENGAS 1983 and pers. comm.) were measured. Other materials were deep-frozen and worked up in the laboratory after thawing. Dorsal mantle lengths (DML) were measured to the nearest mm, stomach contents studied under a stereoscopic microscope. Statoliths were measured, and primary growth rings counted as described earlier (WIBORG, et al. 1982).

RESULTS AND DISCUSSION

Distribution

During June-September 1982 and 1983 juvenile gonatus were most abundant off the continental slope off northwestern Norway, maximum 1800 squid in a one hour haul in the upper 50 m (Fig. 1 and 2).

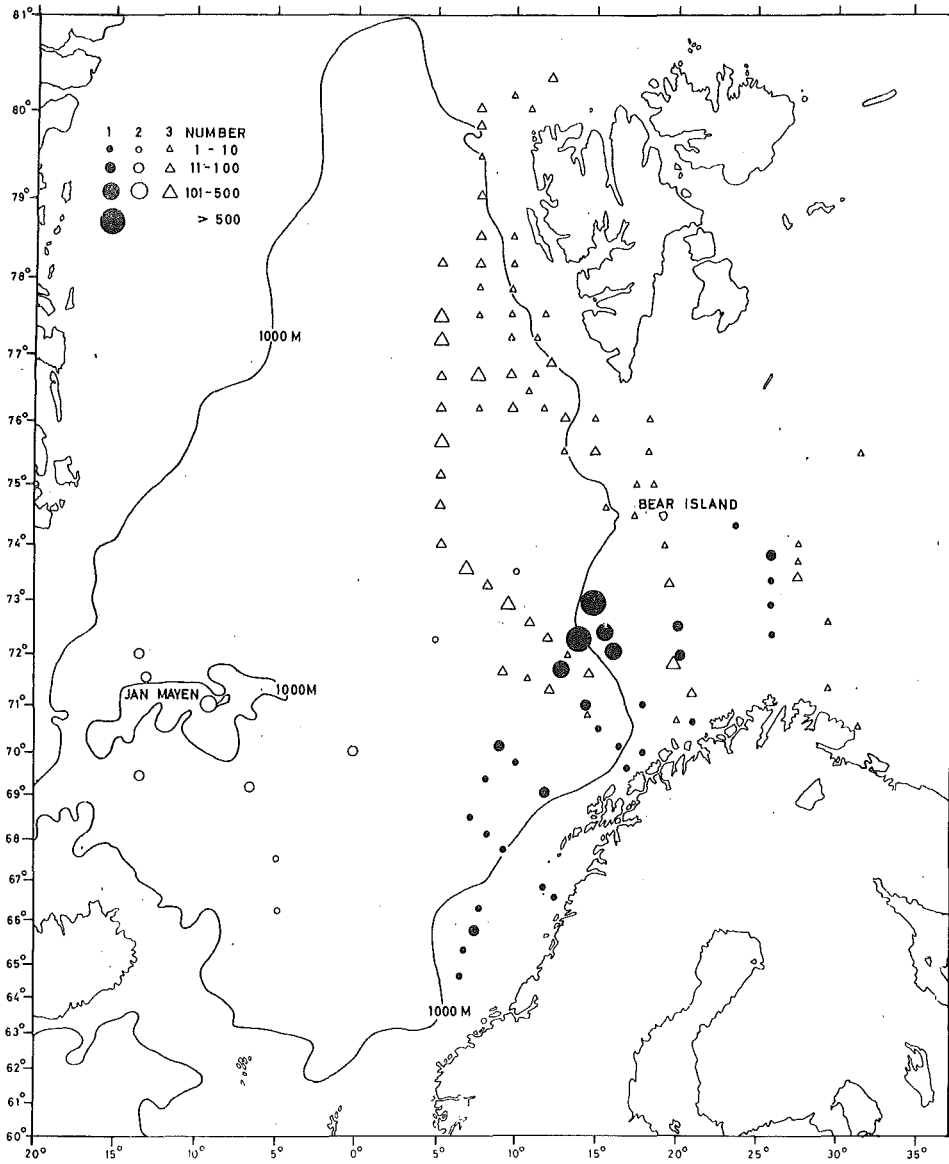


Fig. 1. Distribution of juvenile *G. fabricii* in the Norwegian and Barents Seas in July-September 1982. Number per one hour haul with Harstad trawl in the upper 40 m. 1) 4-28 July, 2) 7-17 August, 3) 18 August-4 September.

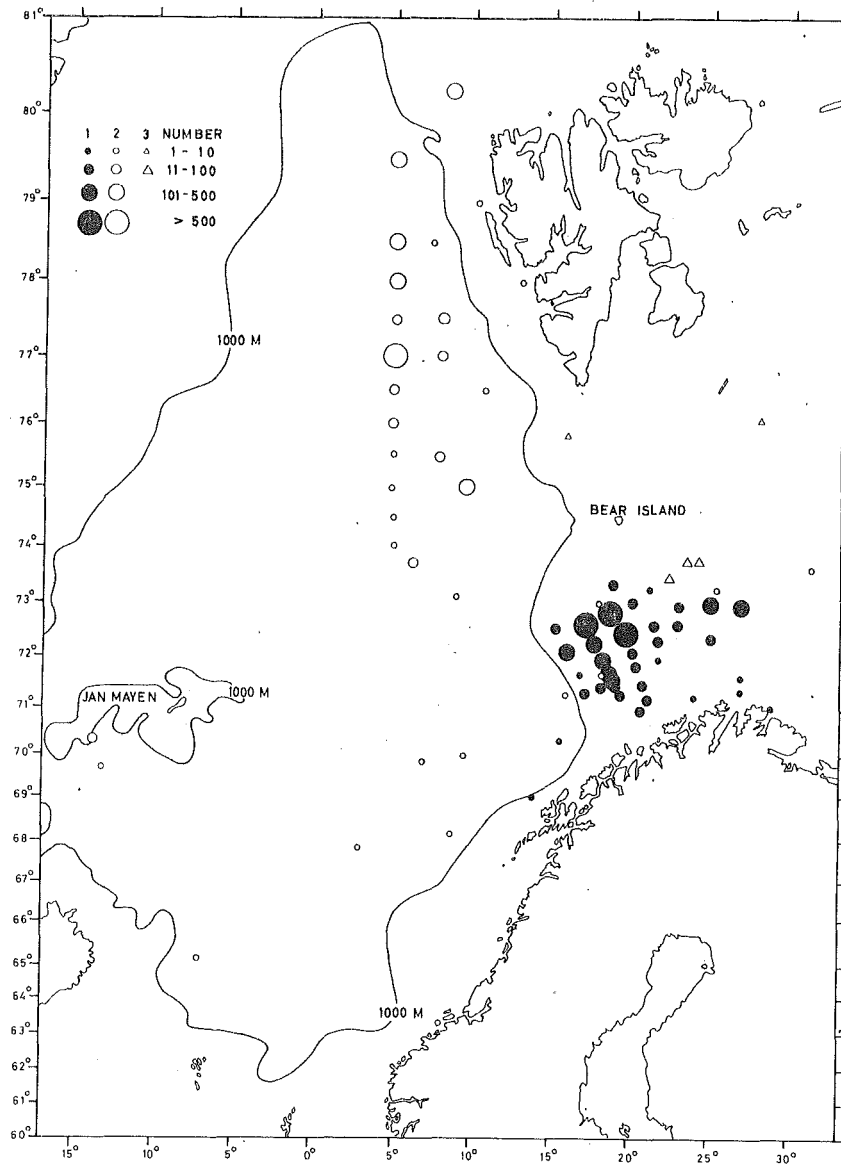


Fig. 2. Distribution of juvenile *G. fabricii* in the Norwegian and Barents Seas in July-September 1983. Number per one hour haul with Harstad trawl; mainly in the upper 40 m. 1) 26 June-14 July, 2) 5 August- 28 September, 3) 15-38 September.

Size distribution

Gonatus caught in the upper 50 m had DML 15-100 mm, the majority 20-50 mm, with peaks at 15-29 mm and 35-39 mm (Fig. 3, 5 and 7).

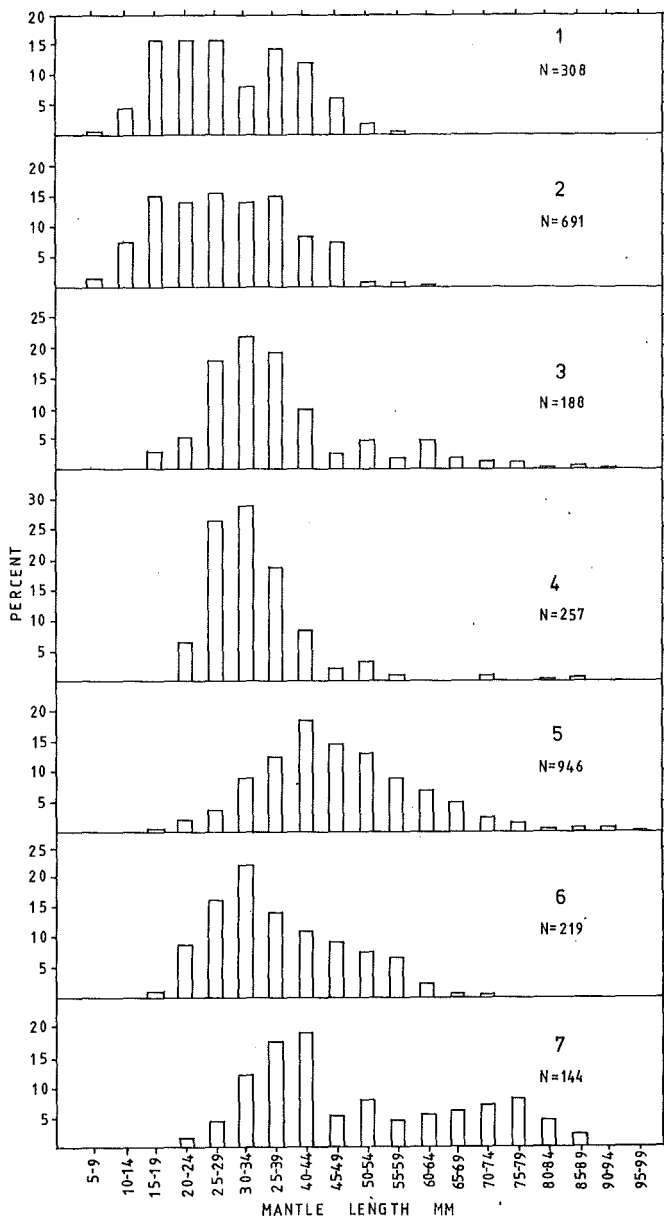


Fig. 3. Distribution of mantle

lengths of *G. fabricii* in 1982 and 1983. 1) Eastern Norwegian Sea 4-29 July 1982 (Fig. 1-1), 2) Off North Norway 26 June-14 July 1983 (Fig. 2-1), 3) At Jan Mayen 3-20 August 1982 (Fig. 1-2). 4) Northern Norwegian Sea 18-28 August 1982, $71^{\circ}30' - 73^{\circ}30'N$, $09^{\circ}00' - 14^{\circ}00'E$ (Fig. 1-3), 5) Northern Norwegian Sea 28 August-1 September 1982, $74^{\circ}00' - 80^{\circ}20'N$, $05^{\circ}00' - 12^{\circ}00'E$ (Fig. 1-3), 6) West of Bear Island, $75^{\circ}00'N$, $08^{\circ}00'E$, 2 September 1983 (Fig. 2-2, partly), 7) Western Barents Sea, $70^{\circ}30' - 76^{\circ}00'N$, $13^{\circ}00' - 31^{\circ}00'E$, 23 August-5 September 1982 (Fig. 1-3, partly).

In August 1983 a few gonatus with DML 80-200 mm were taken in deeper hauls off the continental slope between $67^{\circ}N$ and $73^{\circ}N$. A number of gonatus, DML 95-255 mm, were found in stomach contents of blue ling and Greenland halibut, fished with long lines in 460-600 m depth at the continental slope (Storegga) in April-May 1981 and May-June 1983 respectively (ENGAS 1983 and pers. comm. Fig. 4).

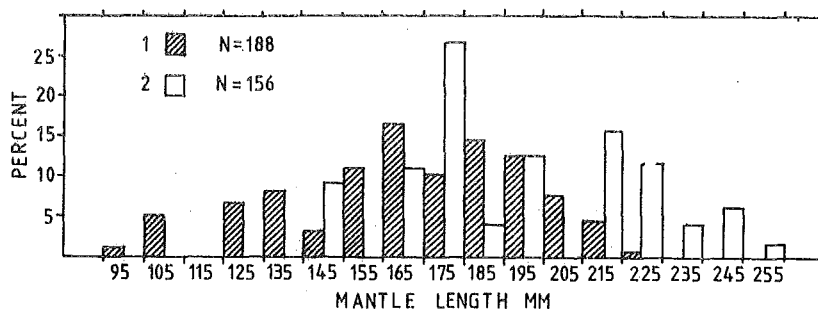


Fig. 4. Mantle lengths of *G. fabricii* from Storegga off Western Norway in 1981 and 1983. 1) from stomachs of blue ling caught 15 April-3 May 1981 at "Skallen" ($63^{\circ}12'N$, $05^{\circ}20'E$, depth 490-580 m), 2) from stomachs of Greenland halibut caught 21 May-7 June 1983 at $64^{\circ}38'N$, $05^{\circ}35'E$, depth 600 m.

Stomach contents

Samples taken at random showed the same food organisms as found earlier. Amphipods, mainly *Parathemisto* sp. dominated, followed by copepods (*Calanus* sp., *Euchaeta* sp., *Temora* sp.), chaetognaths, euphausiids and *Pasiphaea* sp. In July 1983, *Spiratella* sp. was the main food of gonatus on the Tromsøflaket bank. Those with DML 60 mm or more, had eaten fry of redfish and pearlside, and small gonatus.

Age and growth

Growth rings in the statoliths of gonatus are supposed to be formed daily (WIBORG 1982, WIBORG *et al.* 1982), but the question is open when the formation starts. The larvae may have 30-80 rings in the statoliths at hatching.

Table 1. Estimated spawning period and average age based on number of growth rings in the statoliths of *Gonatus fabricii* from various areas in 1982 and 1983. DML-dorsal mantle length, SD-standard deviation, N-number of squid.

AREA	SPAWNING PERIOD									Mean number		
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	of growth rings	SD	N
1982												
NORWEGIAN SEA												
July 14-28												
(Fig. 1,1)	1	9	16	<u>31</u>	22	8	6			177.8	38.0	93
JAN MAYEN SEA												
August 7-17												
(Fig. 1,2)			1	10	9	<u>24</u>	5			165.1	26.5	48
N. NORWEGIAN SEA												
W. BARENTS SEA												
Aug. 18-Sept.												
(Fig. 1,3)			9	26	<u>43</u>	33	21	3		184.4	35.7	135
1983												
NORWEGIAN SEA												
July 7-14												
DML 26-54 mm			4	<u>26</u>	13	1				135.3	16.3	44
DML 17-28 mm						6	3			79.4	9.2	9
N. NORWEGIAN SEA												
August 5-26												
DML 31-203 mm		2	1	1	<u>12</u>	2	2			155.4	31.7	20
DML 11-22 mm							1	2		60.7	11.6	3
(Fig. 2,3)												
N. NORWEGIAN SEA												
W. BARENTS SEA												
Sept. 2-28												
DML 15-75 mm					7	15	6	1		140.0	20.5	29
(Fig. 2,3)												

Table 1 shows the supposed spawning times and average number of growth rings in gonatus from the different samples. In 1982, the average numbers of growth rings were 165-184. Gonatus, taken in the eastern Norwegian Sea in July, may have been spawned in December 1981-February 1982, those from the Jan Mayen area in August, in January-March 1982, and those from the northern Norwegian Sea and western Barents Sea in August, in January-April 1982.

In 1983, the average numbers of growth rings were 135-155. Gonatus, taken in July, were supposed to have been spawned in February-March, those taken in August, - in March, and gonatus taken in the northern Norwegian Sea in September, -in April. Small gonatus, DML 11-28 mm in July-August, had only 60-80 growth rings, and had possibly been spawned May-June.

The main spawning seems to occur in winter-early spring, while the total spawning time may extend for 5-7 months.

Relationship: Dorsal mantle length/number of growth rings

The relationship between DML and growth rings (GR) in the statoliths was studied by WIBORG *et al.* (1982). They found that a linear regression could be used for gonatus with DML less than 7 cm. For larger individuals the growth was apparently more rapid. Calculations for the 1982 and 1983 materials gave the following results:

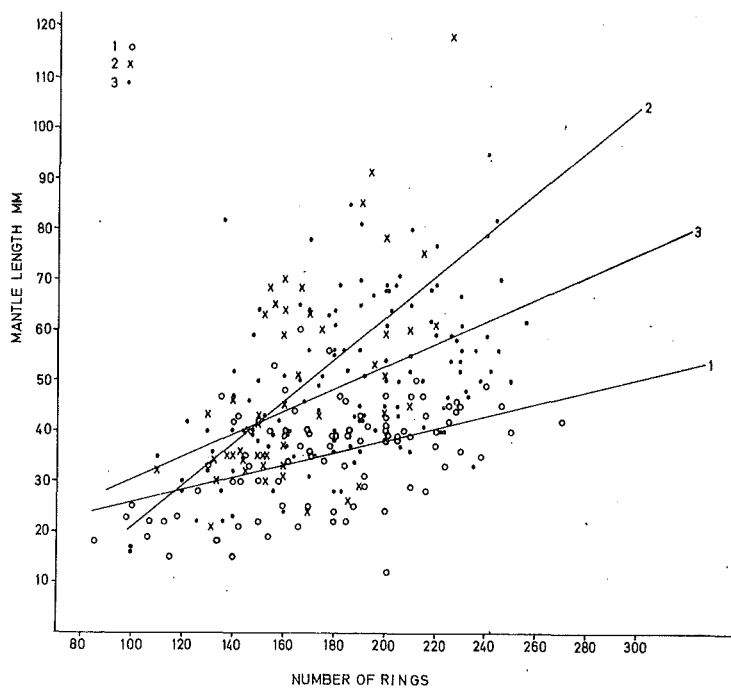


Fig. 5. Relation between DML and number of growth rings (GR) for statoliths of *G. fabricii* caught in 1982. 1) Norwegian Sea 14-28 July (Fig. 1-1): $DML(mm) = 0.12 GR + 13.28$, $n = 93$, $r = 0.47$; 2) Jan Mayen 7-17 August (Fig. 1-2): $DML(mm) = 0.39 GR - 15.10$, $n = 49$, $r = 0.49$; 3) Northern Norwegian Sea, western Barents Sea, 18 August-4 September (Fig. 1-3): $DML(mm) = 0.22 GR + 8.06$, $n = 136$, $r = 0.52$.

The Norwegian Sea, July 14-28:

$$DML = 0.12 GR + 13.28, n = 83, r = 0.47$$

Jan Mayen area, August 7-17:

$$DML = 0.39 GR - 15.10, n = 49, r = 0.49$$

Northern Norwegian Sea, August 18 - September 4:

$$DML = 0.22 GR + 8.06, n = 136, r = 0.52$$

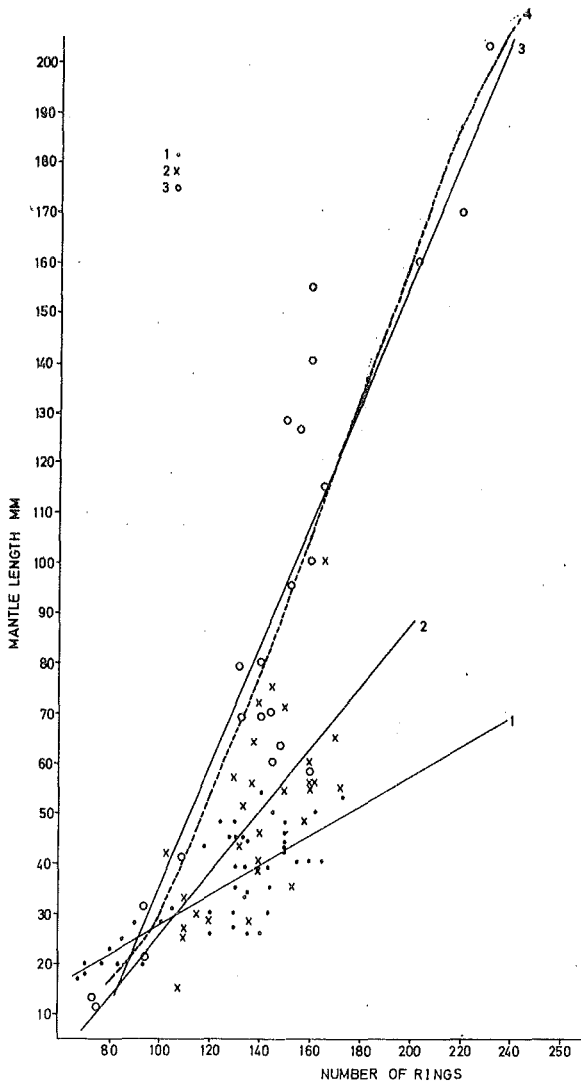


Fig. 6. Relation between DML and number o growth rings (GR) for statoliths of *G. fabricci* caught in 1983. 1) Norwegian Sea 7-14 July (Fig. 2-1): $DML(mm) = 0.30 GR - 1.65$, $n = 53$, $r = 0.77$; 2) Northern Norwegian Sea 5-26 August (Fig. 2-3): $DML(mm) = 1.21 GR - 86.25$, $n = 23$, $r = 0.91$; 3) Northern Norwegian Sea, western Barents Sea 2-28 September (Fig. 2-3): $DML (mm) = 0.61 GR - 36.21$, $n = 29$, $r = 0.67$; 4) Areas and period as 3): $lg DML = lg 292(1 - 1.4577 e^{-0.0130GR})$.

Norwegian Sea, July 7-14:

$$DML = 0.30 GR - 1.65, n = 53, r = 0.77$$

Northern Norwegian Sea, western Barents Sea, September 2-28:

$$DML = 0.61 GR - 36.21, n = 29, r = 0.67$$

Northern Norwegian Sea August 5-26 (DML < 80):

$$DML = 0.72 GR - 37.58, n = 12, r = 0.90$$

The total sample:

$$DML = 1.21 GR - 86.24, n = 23, r = 0.91$$

The results for squid with DML less than 80 mm are in reasonable accordance with earlier calculations (WIBORG *et al.* 1982), even if the growth rate is somewhat higher. The materials from the northern Norwegian Sea in August 1983 contain a few larger

squid. The curve for DML/GR (Fig. 6) is slightly s-shaped. In order to describe this curve, an adaption of a modified Gompertz curve was tried: $\lg \text{DML} = \lg \text{DML}_{\infty} (1 - K e^{-b\text{GR}})$, where DML_{∞} is the theoretical maximum length, and K and b, invariables. The adaption gave the following results:

$$\lg \text{DML} = \lg 292 (1 - 1.4577 e^{-0.0130\text{GR}})$$

The curve seems to fit the observations, but the material is too scanty to permit reliable conclusions on the growth pattern. The investigations in 1982 and 1983 indicate an increase of the growth rate at DML of 60-80 mm, probably related to a change in living habits.

Statolith length/mantle length

According to KRISTENSEN (1980) statoliths in small gonatus increased more rapidly with increasing DML than in larger squid. The change took place at a DML of about 50 mm. The relationship: total statolith length (TLS) to dorsal mantle length (DML) was investigated in gonatus from the 1982 and 1983 samples for three DML-groups: 10-250 mm, 10-69 mm and 70-250 mm.

The results were:

$$\begin{aligned} \text{DML 10-250 mm: TLS} &= 0.131 \text{ DML}^{0.47}, n = 201, r^2 = 0.93 \\ \text{DML 10-69 mm: TLS} &= 0.104 \text{ DML}^{0.53}, n = 163, r^2 = 0.93 \\ \text{DML 70-250 mm: TLS} &= 0.328 \text{ DML}^{0.26}, n = 38, r^2 = 0.74 \end{aligned}$$

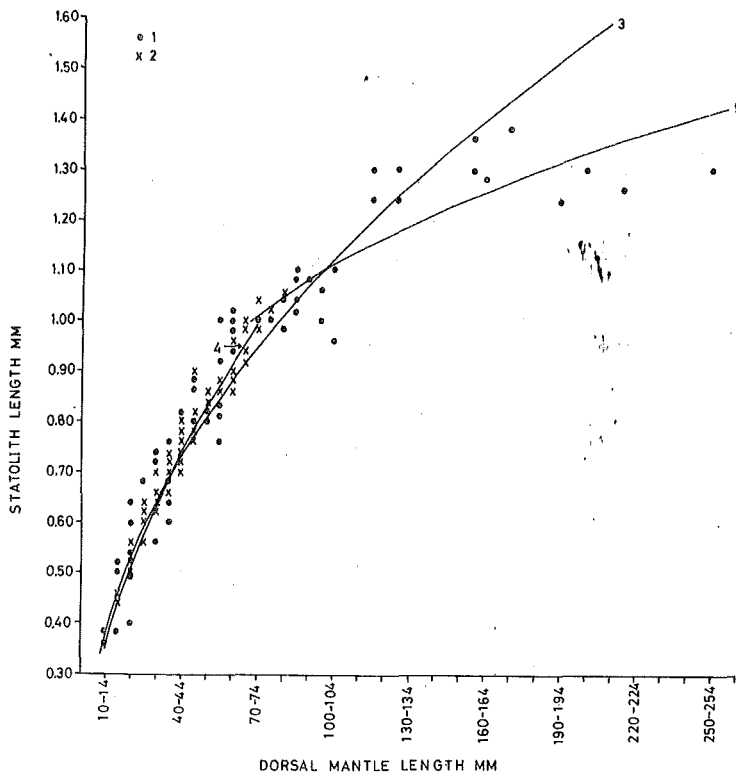


Fig. 7. Relation between total statolith lengths (TLS) and dorsal mantle length (DML) in *G. fabricii* in materials from 1982 and 1983. 1) Single individuals, 2) 2-8 individuals, 3) DML 10-250 mm: $TLS = 0.131 DML^{0.47}$, $n = 201$, $r^2 = 0.93$, 4) DML 10-69 mm: $TLS = 0.104 DML^{0.53}$, $n = 163$, $r^2 = 0.93$. 5) DML 70-250 mm: $TLS = 0.328 DML^{0.26}$, $n = 38$, $r^2 = 0.74$.

As shown in Fig. 7 the growth rate of the statoliths decreases strongly in gonatus with DML 70-250 mm. As mentioned above, the growth rate of the mantle increases at DML 60-80 mm. Both changes seem to occur at the transition from an epipelagic life to a deep pelagic or bottom life (WIBORG 1982, WIBORG *et al.* 1982).

Spawning areas

It has been assumed that gonatus spawn on the continental slopes from the Tampen-Møre area to West-Spitsbergen, and

between Iceland and Jan Mayen (WIBORG 1979, WIBORG et al. 1982). The large gonatus eaten by blue ling and Greenland halibut in April-June on the continental slope off western Norway may have been spawning or spent. According to KRISTENSEN (1981), gonatus probably spawn on the bottom. Spawning concentrations of gonatus may be of commercial interest.

Acknowledgements

We wish to thank Karsten Hansen for assistance during cruises, and Berit Endresen for working with the material and drawing of figures. Also many thanks to Anne E. Myklestad for typing the manuscript.

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