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Who eats the larger *Gonatus fabricii* (Lichtenstein) in the Norwegian Sea?

By

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Abstract

In the Norwegian Sea in June 1994, young *Gonatus fabricii* with dorsal mantle length from 10 to 70 mm constituted at least 1.5 m mill. tonnes of biomass in the upper 30 m. At a length of 50 to 70 mm the species disappears from the surface layers, and are found from 400 m and downwards to at least 1100 m. When the individuals die at an age of two years one cohort of *Gonatus fabricii* has produsedd a biomass of 20 mill. tonnes. The most important predators of *Gonatus fabricii* are the bottlenose whale and the sperm whale. They are estimated to eat 480 000 and 364 500 tonnes respectively. Hooded seals also eat a considerable amount of *Gonatus fabricii* . The present authors think that a surplus production of *Gonatus fabricii* takes place.

Keywords: squid, sperm whale, bottlenose whale, pilot whale, hooded seal, biomass.

Introduction.

Gonatus fabricii (Lichtenstein, 1818) is the most abundant squid of the arctic and subarctic waters of the North Atlantic. This squid was studied intensively in the eighties and is the best known oceanic cold water squid (Kristensen 1983). In his work about the biology of *Gonatus fabricii* Kristensen (1983) concludes: "*Gonatus fabricii* hatch at a size of 0.3 cm PL (Pen Length. Present authors note). As juveniles of 0.3-4.0 cm the species lives in the uppermost 80 m of the water column. At increasing size they live deeper, and as sub-adults and adults they live above the bottom from 200 m downwards, but migrate upwards at night. Growth is about 8 mm per month and they reach a size of about 10 cm PL the first year."

Until 1995 only 7 mature specimens of *Gonatus fabricii* were recorded and only one specimen closer described (Kristensen 1981, 1984 and Sennikov *et al.* 1989). These specimens were recorded at depths varying from 2700 m to 160 m. In 1995 three mature males and two mature females were caught with a pelagic trawl in depths varying stepvise from 270 m to 820 m over depths of 1350 m off Andenes (Fig. 1) (Bjørke and Hansen 1996).

In the Norwegian Sea, larger *Gonatus* is one of the main items in the diet of sperm whales, bottlenose whales, *Berardius*, and narwhales, and is also consumed by pilot whales, white whales, Sowerby´s whale and other cetaceans, Greenland seals, hooded seals, sea birds including the albatross, cod, saithe sea perch, the Greenland shark, grenadiers (*Macrurus* spp.) blue ling and greenland halibut (Nesis 1956, Kristensen 1983, Wiborg *et al.* 1984).

Increased knowledge about the biology and abundance of *Gonatus fabricii* and abundance estimates of some of its predators make it possible to evaluate its ecological importance as food in the Norwegian Sea.

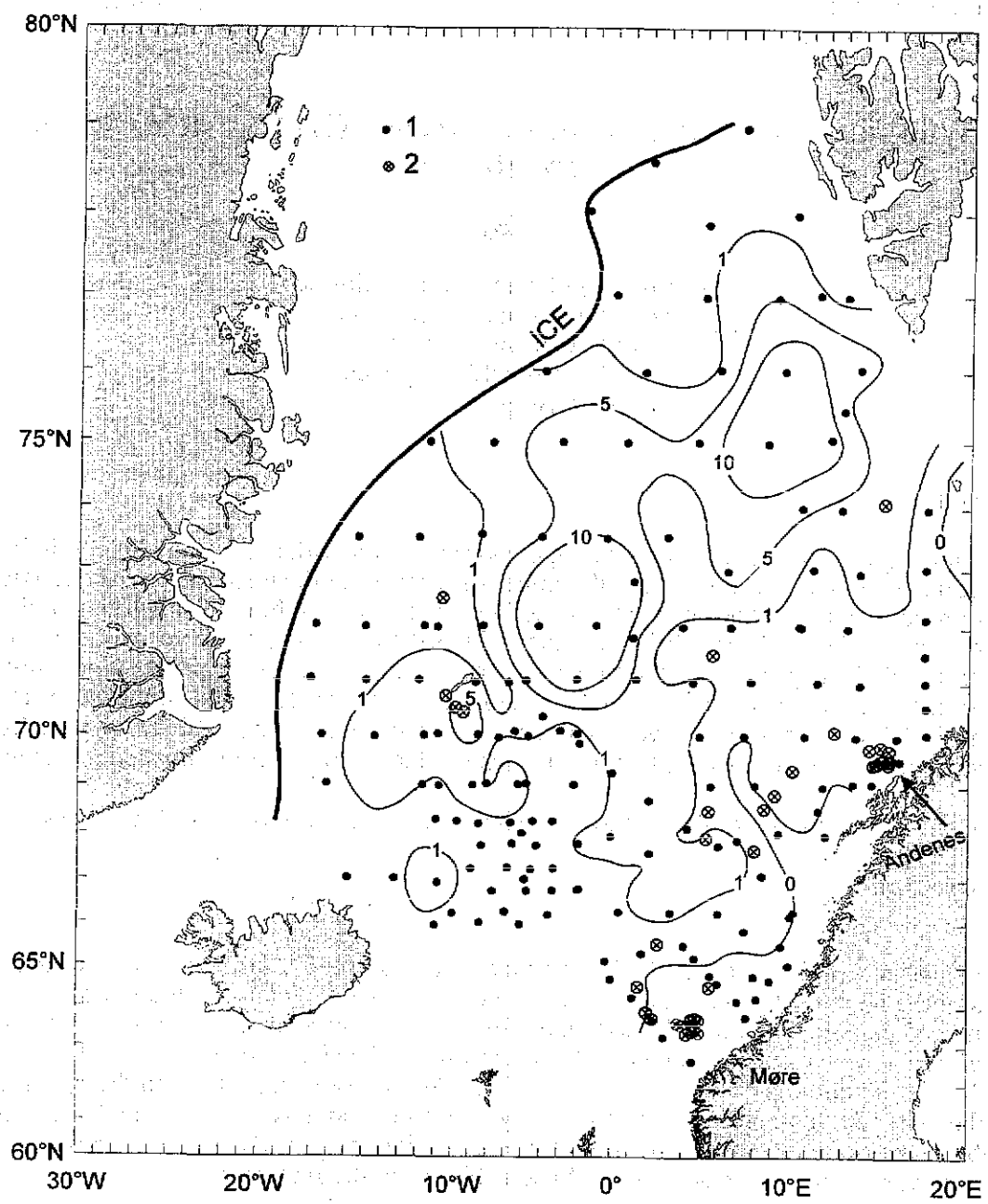

Fig. 1. Abundance of young *Gonatus fabricii* during summer 1994. Catch of *Gonatus* in kilogrammes per 30 min trawl haul in the surface layers. 1=Trawl stations. 2=Catch of *Gonatus* larger than 200 mm ML and of recordings of mature specimens.

Materials and methods

Sampling

Materials were mainly collected during four cruises; one in the period 30 May-15 August 1994 covering most of the Norwegian Sea (Dalpadado *et al.* 1998), one in the period 17-21 July 1996 off Andenes, Norway (Fig 1), one in the period 20 July-15 Aug. 1996 covering the Norwegian Economical Zone and one in the period 8-18 April 1998 off Møre, Norway (Fig

1). In addition, deep pelagic trawl hauls have been made occasionally during summer cruises in the Norwegian Sea.
The materials were sampled with a pelagic Åkra trawl with an opening of 30m*30m (Valdemarsen and Misund 1995, Dalpadado *et al.* 1998).

Biomass of smaller *Gonatus*

The pelagic trawl used during the 1994 summer coverage was fishing at the surface with a speed of 2.5 to 3 knots, and the duration of the haul was 30 min. Nothing is known about the herding effect on *Gonatus*. Godø *et al.* (1994) found insignificant herding effect of the large meshes in front of the trawl on cod larvae smaller than 65 mm and W. Valdemarsen (Institute of Marine Research, Norway, *pers. commn.)* estimated an effective catching opening of 30 $m^2 \pm 10m^2$ of the trawl in sampling young cod. Using the same reasoning for *Gonatus*, the integrated amount of young *Gonatus* in Fig. 1 constituted 3.0, 2.0 and 1.5 mill. tonnes with an effective catching opening of $20m^2$, $30m^2$ and $40m^2$ respectively. Assuming an effective catching opening of $40m^2$ the biomass of *Gonatus* shown on Fig 1 constitute 1.5 mill. tonnes. The biomass estimates are based on trawl catches in the upper 30 m. This is a very low estimate since theoretically only 6.32 (40^{-2}) m of the water column is sampled effectively. Usually a continous layer of plankton and juvenile fish is observed in the upper 50-60 m during summer and autumn surveys made in these waters (Sundby *et al.* 1989). Dalpadado *et al.* (1998) refers to the computer program doing the integrating. The program integrates a variable over an area to estimate the total amount present.

Length-weight relationship

Based on data on length and weight from the field in 1996, a length-weight relationship for *Gonatus* was established. The data comprised 34 length and weight measurement of *Gonatus* in the length range 100 to 360 mm ML for the two sexes combined. The length-weight relationship was described by the equation $W=aL^b$, where W is weight in grams and L is dorsal mantle length in mm. A linear regression of log-transformed data gave $a=1.912 \cdot 10^{-5}$ and $b=2.99$. The observations and the estimated relationship are shovn on Fig. 2.

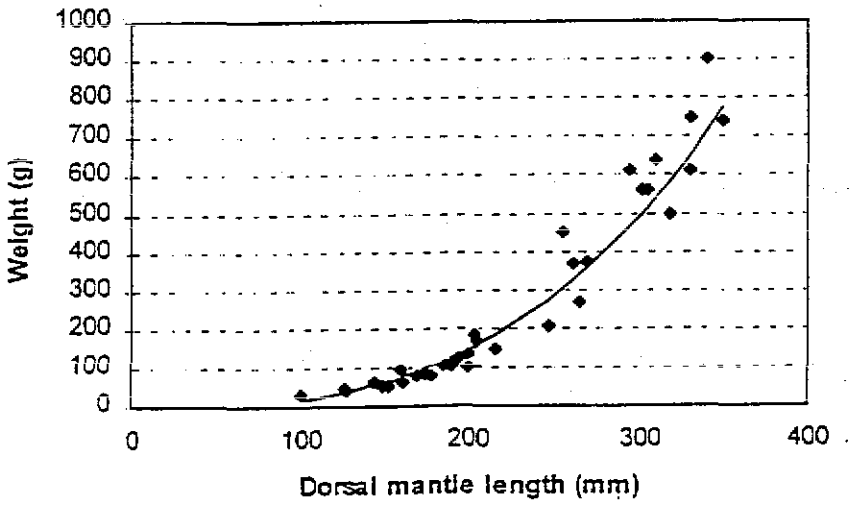

Fig. 2. Length-weight relationship for *Gonatus* (sexes combined) based on a field study including 34 specimens in 1996. The observations are shown together with the modelled relationship according to the equation $W=1.912 \cdot 10^{-5} \cdot L^{2.99}$.)

Biomass estimates of larger *Gonatus*

In order to estimate the biomass production of *Gonatus* in the Norwegian Sea a simple model was made. The model have the following assumtions: *Gonatus* live for two years (Arkhipkin and Bjørke *in prep.*) and the instantaneous mortality rate is constant over the first 23 months (equalling 0.06 $month^{-1}$), when 95% of the individuals have died. The remaining 5% of the cohort spawn and die in the 24^{th} month. Growth in length is constant and equals 14 mm $month^{-1}$ Weight is related to length according to the equation $Weight=1.912\ 10^{-5} \cdot Length^{2,99}$, when weight is measured in grams and lenght in mm. All individuals are assumed to be hatched in January. The calculations are further based on a measured biomass in July of 1.5 million tonnes, corresponding to 140 billion individuals, and number hatched in January is then 275 billion individuals. The production is calculated by multiplying the number of individuals dying each month by their mean weight.
The production (Fig. 3) is seen to increase slowly from almost nil during the first month to about 1 million tonnes near the end of the two-year life cycle. When the spawning stock, constituting about 7.5 million tonnes die in connection with spawning the output production reaches 8 million tonnes in month no. 24. During this period the cumulative production, however, amounts to more than 20 million tonnes, of which 85% are output during the second year of life. In a steady situation, the production of one cohort during its lifetime is equal to the total production of one cohort during one year. This means that about 20 million tonnes of *Gonatus* dies of natural causes each year.

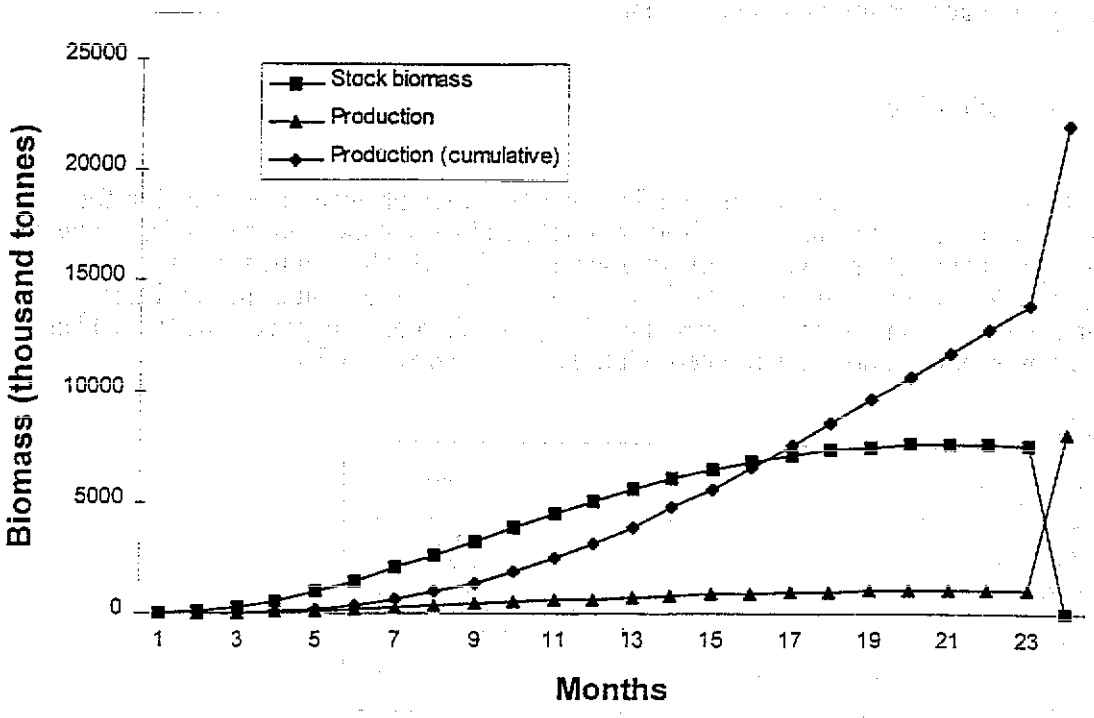

Fig. 3. Output from the production of *Gonatus fabricii* described in the text.

Biology of *Gonatus fabricii*

Distribution

Gonatus fabricii is found in offshore arctic and subartic waters of the northern North Atlantic from the Newfoundland Basin, around Greenland and eastwards to the Barents Sea (Roper *et al.* 1984).

Hatching and spawning area

Nesis (1965) assumed that *Gonatus* did not make any significant spawning migration. Bjørke and Hansen (1996) suggested that *Gonatus fabricii* females matured at lengths between 190 and 250 mm while males did so at smaller lengths.
Fig. 1 shows recordings of mature *Gonatus fabricii* by other authors (Kristensen 1981, Sennikov *et al.* 1989) and of specimens larger than 200 mm sampled in the period 1995-1997. Larger *Gonatus* seems to be distributed all over the Norwegian Sea (Fig. 1), and are caught whenever the a trawl haul is made at depths of 1000 m or deeper. This distribution and the distribution of younger specimens (Fig. 1) indicate that spawning and hatching takes place over large areas. Wiborg (1979) suggested that areas with high abundance of bottlenose whale could be spawning ground for *Gonatus fabricii* since *Gonatus* is the main food item for bottlenose whale (Fig. 5). Bjørke *et al.* (1997) found eggs of *Gonatus* off Andenes (Fig. 1) in July.

Hatching period

By backcalculating length distribution Bjørke (1995) suggested that hatching took place during most of the year with a maximum in January-February. Specimens of *Gonatus fabricii* smaller than 10 mm; i. e. less than one month old have been recorded in plankton sampled off the Norwegian shelf in January, April and July.

Vertical distribution of larger *Gonatus*

During the preliminary sampling in 1997 off Andenes three hauls of three hrs. duration were taken in 1000-900 m, 800-700 m and 600-500 m to locate the vertical distribution of *Gonatus fabricii* . Individuals larger than 200 mm were only found in the deepest haul. Most of the hauls were later taken at depths of 1100 m, which was the maximum depth of the gear. The sampling was done with 24 hrs. daylight. *Gonatus fabricii* larger than 200 mm have, however, been sampled in shallower depths (Sennikov *et al.* 1989, Wiborg 1984), and during a cruise in April 1998 *Gonatus fabricii* larger than 200 mm were found at depths as shallow as 400 m both day and night. This was at the bottom of a scattering layer extanding from 250 to 400 m (Skjoldal *et al* . 1993). However, *Gonatus fabricii* larger than 200 mm were recorded at all depths down to 1200 m which was the maximum depth fished.

Shoaling

Nesis (1965) and Kristensen (1983) reports that *Gonatus* is a shoaling squid. When trawling at random in the Norwegian Sea at depths larger than 1000 m (Fig. 1) one or more *Gonatus* larger than 200 mm were always caught. From this it can be concluded that *Gonatus* does does not seem to be shoaling when it becomes larger.

Predators

Of the mammals mentioned above which prey upon larger *Gonatus* the abundance of sperm whale, bottlenose whale and hooded seal in the Norwegian Sea can be estimated. The cephalopod consumption by sperm whale, bottlenose whale and hooded seal is further investigated. Hence it is possible to make a rough estimation of the consumption of *Gonatus fabricii* by some of these predators.

Sperm whale as predator

Fig. 4 shows the distribution of sperm whales (*Physeter macrocephalus*) in the Norwegian Sea during summer 1995. They are distributed all over the Norwegian Sea, but there is a tendency

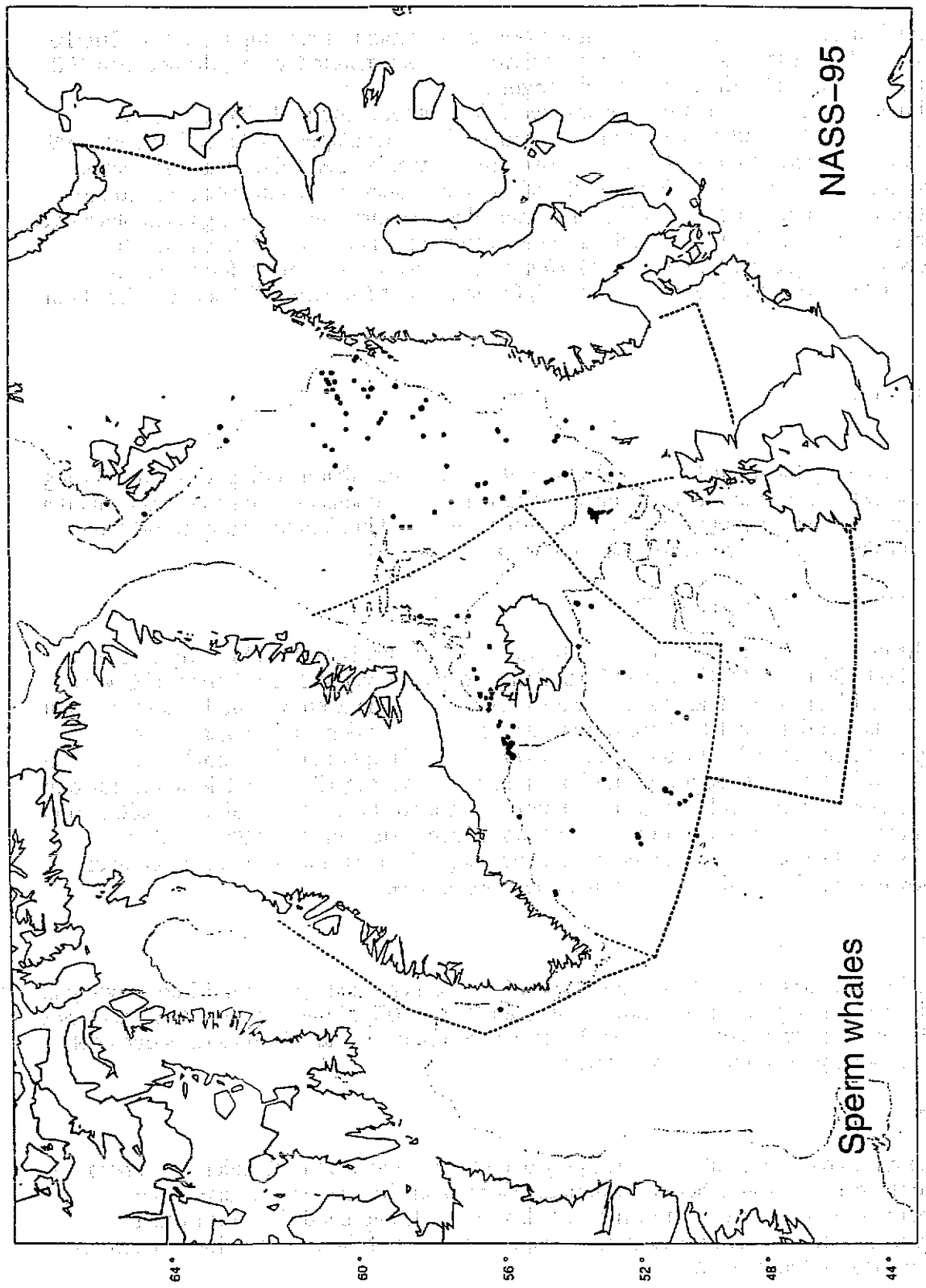

Fig. 4. Distribution of sperm whale sightings during NASS-95. From Namco (1997)

to concentrate in the eastern part of the ocean. Usually cephalopods are the main diet of sperm whales (Kawakami 1980), but Roe (1969) found that fish was the dominant food of the sperm whales caught off Iceland. This was later confirmed by Martin and Clarke (1986), and they found that squids belonging to the families cranchidae and histioteutidae contributed 25% and 38% to the weight of cephalopods eaten and gonatidae 9%.
The food of sperm whale from the Norwegian Sea is not investigated, but Hjort and Ruud (1929) classified it as large fish and squids. Benjaminsen (IMR, Bergen *pers. comm.*) investigated briefly the stomach contents of 12 sperm whales caught off Andenes during the summer 1971. Two of the stomachs were empty, four contained beaks of squids only, and six both beaks and fish remains. Santos *et al.* (1996) found that *Gonatus* sp. constituted more than 90 % of the stomach content in weight of six sperm whales stranded near Aberdeen, and they suggested that concentrations of spawning *Gonatus fabricii* probably represent an important recource for sperm whales in the North Atlantic.This is also suggested by Clarke (1996) and the present authors believe that *Gonatus fabricii* is the main food item for the sperm whales in the Norwegian Sea. During the sampling of the larger *Gonatus fabricii* shown in Fig. 1, 189 kg of cephalopods were sampled and 72% of this represented the octopod *Cirroteuthis mülleri* (Eschricht). This is, however, a slow swimming species and is oversampled compared to the much quicker *Gonatus fabricii*, but it might be eaten by the sperm whale. Of other cephalopod species was only found one specimen of *Teuthowenia megalops*.
Christensen *et al.* (1992) estimated the abundance of sperm whales in the northern part of the Norwegian Sea to be 2500 individuals. Øien (IMR Bergen, Norway, *pers. comm*) estimated roughly the average weight of the sperm wales to be 30 tonnes with a daily consumption of 3 % of bodyweight. Øien supposed that the sperm whale was to be found in the Norwegian Sea for about six months, allthough there were indications that some were to be found for a longer period. Using these and Santos *et al* . (1996) numbers (90 %), the total consumption of *Gonatus fabrcii* by sperm whale is calculated to be 364500 tonnes per year.

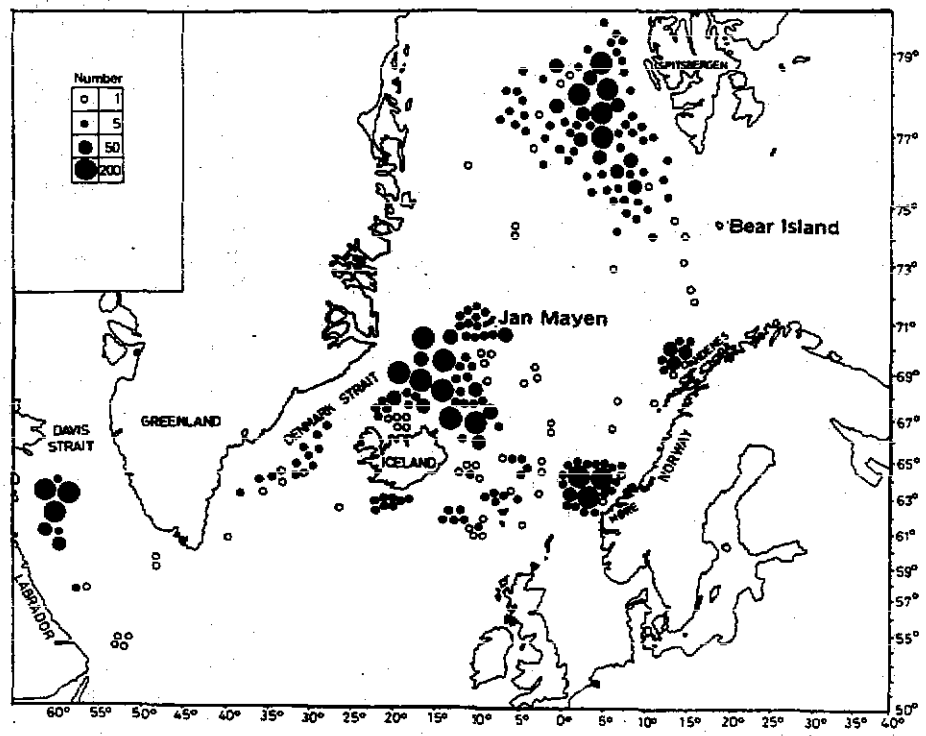

Fig. 5. Locations of bottlenose whale (*Hyperoodon ampullatus*) caught by Norwegian whalers in the period 1938-1972. From Benjaminsen and Christensen 1979.

Northern bottlenose whale as predator

Nammco (1995) made a sighting estimate of 8827 bottlenose whales (*Hyperoodon ampullatus*) in the North Atlantic. Use of correction factors due to the long dive time of this species led to an estimate of around 40,000 animals. Benjaminsen and Christensen (1979) investigated the stomach content of 46 bottlenose whales caught northeast off Iceland in 1976. Of these 40 had eaten only *Gonatus fabricii* while four had eaten fish and *Gonatus fabricii* . The bottlenose sighting map for the 1995 surveys shows that bottlenose whales also was observed outside the Norwegian Sea i. e. in the Irminger Sea and south of Iceland (Nammco 1995). In this area the distribution of *G. steenstrupi* overlaps that of *G. fabricii* so theoretically some of the 40,000 whales could have eaten *G. steenstrupi.* Sigurdjónsson and Vikingsson (1992) assumed that 95 percent of the prey groups of the bottlenose whale consisted of cephalopods. In the 1987 surveys the area northeast of Iceland towards Jan Mayen had far the greatest abundance of bottlenose whales (75%) (Sigurdjónsson and Vikingsson 1992). Assuming the same distribution in the 1995 surveys this means that at least 75 % of the 40,000 whales were recorded in the North Atlantic where only *Gonatus fabricii* is to be found. Assuming the number of bottlenose whales around Iceland and adjacent waters to be 41625 whales, Sigurdjónsson and Vikingsson (1992) estimated the consum of cephalopods to be 650,851 tons. This means that at least 480,000 (75%) tonnes of *Gonatus* sp. eaten by the bottlenose whale is *Gonatus fabricii.*

Hooded seal as predator

The West Ice stock of hooded seal (*Cystophora cristata*), which spend most of their life in the Norwegian Sea may count in the order of 250 000 animals, with an average weight of 170 kg (Folkow and Blix 1995).
Potelov *et al .*(1997) investigated stomach content of hooded seal during moulting off the east coast of Greenland and found that *Gonatus fabricii* constituted 79.2 % of the prey biomass in the few stomach with contents. Polar cod (*Boreogadus saida*) and the amphipod *Themisto* sp. constituted 15.7 % and 5.1 %, respectively. During moult the seals eats very little. Folkow and Blix (1995) examined the distribution and diving behaviour of hooded seals and found that they may dive repeatedly to >1,000 m, but usually dive to 100-600 m depth. After moult the satellite tagged seals performed excursions which lasted for approximately 3-7 weeks to such distant areas as the waters off the Faroe Islands, the Irminger Sea, north/northeast of Iceland, areas in the Norwegian Sea and along the continental edge from Norway to Bear Island. Investigations of the seals diet in this areas have not been made, but the the authors suggested that the spatial and temporal distribution of the seals off the Faroe Islands and west of Ireland correlated well with the known distribution of the blue whiting (*Micromesistus poutassou*). The tagged seals spent 16 % of the seal days in these areas. They were calculated to consume 105 000 tonnes of blue whiting during this period. In the Irminger Sea the seals spent 3.8 % seal days and the authors suggested that the seals most likely fed on redfish. The consumtion of redfish was estimated to be 18 000 tonnes. In the ice covered area off east Greenland the tagged seals spent 38 % seal days. This is much more than what is needed for breeding and moulting when the seal is fasting. It is thus reasonable to believe that at least 100 000 tonnes of *Gonatus* is consumed by the hooded seal in this area.

Pilot whale as predator.

The Pilot whale (*Globicephala melas*) is known to be a squid eater (Desportes and Mouritsen 1988, Nesis 1965). Desportes and Mouritsen (1988) investigated the diet of pilot whales caught at the Faroe Islands. In years when *Todarodes saggitatus* was present beaks of this species was found in all the stomachs, and represented 96 % of the beaks. *Gonatus* sp. appeared in 40 % of the stomachs but contributed only 4 % of the beaks. In years when no *Todarodes* were landed, *Gonatus* sp. was recorded in 80 % of the stomachs and represented 80 % of the beaks, The *Gonatus* species eaten was most probably *Gonatus fabricii* since the whales were reported to feed north of the Faroe Islands. However, the pilot whale is not very common in the Norwegian Sea (Christensen, IMR, Bergen, Norway *pers. commn.*). Although

in most probably feed on *Gonatus fabricii* in the Norwegian Sea occationally, the biomass consumed is probably small compared to that of the sperm vhale.

Discussion

A yearly production of 20 mill tonnes of *Gonatus* is rather high, knowing that the spawning stock of herring in the Norwegian Sea is about 9 mill. tonnes. Nesis (1997), however, investigated the yearly production of gonatid squids in the subartic North Pacific and estimated the yearly production to be in the order of 50-80 mill. tonnes. Hence a yearly production of 20 mill. tonnes in the Norwegian Sea seems to be in the right order of magnitude. Before the spavning takes place and the individuals die the production is about 15 mill. tonnes. Most probably it is this production that is preyed upon. Summing up the amount of *Gonatus* eaten by the assumed most important predators the amount eaten is around 1 mill. tonnes. If the calculations above is correct, this means that 14 mill. tonnes of *Gonatus* could be eaten by the other predators mentioned above. This amount is rather high and the present authors think that some of the *Gonatus* is not eaten by the predators mentioned above and that a surplus production of *Gonatus* occur.
This is supported by the fact that in 1890, before the hunting on the bottlenose whale started, the stock of bottlenose whale was estimated to be in the order of 120 000 specimens (Christensen I. IMR *pers. commn.*).
Although both the model and the assumptions underlying may be questioned, these results indicate that *Gonatus* in these areas provide a substantial food supply to its predators.

Conclusions

The yearly production of *Gonatus fabricii* in the Norwegian Sea is estimated to be 20 mill. tonnes. The most important predators of *Gonatus fabricii* are the bottlenose whale and the sperm whale. They are estimated to eat 480 000 and 364 500 tonnes respectively. Hooded seals also eat a considerable amount of *Gonatus fabricii* . The present authors think that a surplus production of *Gonatus fabricii* takes place.

References

Benjaminsen, T and Christensen, I. (1979). The natural history of the bottlenose whale, *Hyperoodon ampullatus* (Foster). in: Winn, Howard E.; Olla, B. L., eds. Behavior of marine animals. : Plenum Publishing Corporation, 3: 143-164.

Bjørke, H. (1995). Norwegian investigations on *Gonatus fabricii* (Lichtenstein) (1995). ICES C. M./. 1995; K:12.: 13 pp.

Bjørke, H. and Hansen, K. (1996). Recordings of mature *Gonatus fabricii* (Lichtenstein) off the Norwegian coast. ICES CM 1996/K:17 : 11 pp.

Bjørke, H., Hansen, K. and Sundt, R. C. (1997). Egg masses of the squid *Gonatus fabricii* (Cephalopoda, Gonatidae) caught with pelagic trawl off northern Norway. Sarsia. 82(2): 149-152.

Christensen, I., Haug, T. and Øien, N. (1992). Seasonal distribution, exploitation and present abundance of stocks of large baleen whales (Mysticeti) and sperm whales (*Physeter macrocephalus*) in Norwegian and adjacent waters. ICES J. mar. Sci.; 49: 341-355.

Clarke, M. R. (1996). Cephalopods as prey . 3. Cetaceans. Philosophical Transactions of the Royal Society of London Series B - Biological Sciences. 351(1343): 1053-1065

Dalpadado, P Ellertsen, B., Melle, W. and Skjoldal, H. R. (1998). Summer distribution patterns and biomass estimates of macrozooplankton and micronecton in the Nordic Seas. Sarsia.; 83: 103-116.

Desportes, G. and Mouritsen, R. (1988). Diet of the pilot whale, *Globicephalus melas* , around the Faroe Islands. ICES C. M. 1988. N:12: 15 pp.

Folkow, L. P. and Blix, A. S. (1995). Distribution and diving behaviour of hooded seals. in: Blix, A. S.; Walløe, L.; Ulltang, Ø., eds. Whales, seals and man. : Elsevier Science B. V.; 1995: 193-202.

Godø, O. R., Valdemarsen, J. W. and Engås, A. (1994). Comparison of efficiency of standard and experimental juvenile gadoid sampling trawls. ICES mar. Sci. Symp. 196: 196-201.

Hjort, J. and Ruud, J. T. (1929). Whaling and fishing in the North Atlantic. Rapp. P.-v. Reun. Cons. int. Explor. Mer. 56: 1-123.

Kawakami, T. (1980). A review of sperm whale food. Scientific Reports of Whales Research Institute.32: 199-218.

Kristensen, T. K. (1981). First record of a mature female of the squid *Gonatus fabricii* (Lichtenstein 1818) (Cephalopoda: Teuthoidea). Steenstrupia. 7(5): 101-108.

Kristensen, T. K. (1983). *Gonatus fabricii*. in: Boyle, P. R., ed. Cephalopod life cycles. Volume I. Species accounts. London: Academic Press; 159-173. 475 pp.

Kristensen, T. K. (1984). Biology of *Gonatus fabricii* (Lichtenstein, 1818) from West Greenland waters. Meddr Grønland, Biosci. 13: 3-17.

Martin, A. R. and Clarke, M. R. (1986). The diet of sperm whales (*Physeter macrocephalus*) captured between Iceland and Greenland. J. Mar. Biol. Ass. U. K. 66(779-790). food/feeding.

Nammco (1995). Annual Report 1995. Annex 1. North Atlantic Marine Mammal Commision, Tromsø.

Nammco (1997). Annual Report 1997. Annex 3. North Atlantic Marine Mammal Commision, Tromsø.

Nesis, K. N. (1965). Distribution and feeding of young squids *Gonatus fabricii* (Licht.) in the Labrador Sea and the Norwegian Sea. Oceanologi(Translation of the Russian Okeanologiya by Scripta Technia Inc. for The American Geographical Union).; 5: 102-108.

Nesis, K. N. (1997). Gonatid squids in the subarctic North Pasific: ecology, biogeography, niche diversity, and role in the ecosystem. Program and Abstract. 63rd Annual Meeting American Malacological Union and the 30th Annual Meeting Western Society of Malacologists 21-27 June 1997. Santa Barbara California.

Potelov, V., Nilssen, K. T., Svetochev, V. and Haug, T. (1997). Feeding habits of harp *Phoca groenlandica* and hooded seals *Cystophora cristata* during moult (April-June) in the Greenland Sea. NAMMCO. 1997; SC/5/ME/8: 12pp.10-15 March 1997. Tromsø, Norway

Roe, H. S. J. (1969). The food and feeding habits of the sperm whale (*Physeter catodon* L.) taken off the west coast of Iceland. J. Cons. int. Explor. Mer 33:93-102.

Roper, C. F. E.; Sweeney, M. J.; Nauen, C. E. (1984). FAO species catalogue, vol. 3. Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. FAO Fish. Synop. 1984; 125 Vol. 3: 277 p.

Santos, M. B., Pierce, G. J., Carter, T. J.,Hoskins, S.,Ross, H. M., Reid, R. J. and McKenzie, C. (1996). Stomac content of sperm whales stranded in the North Sea. ICES C. M. 1996; N:10.

Sennikov, A. M., Muchin, S. G. and Bliznichenko, T. E. Distribution and trophic importance of juvenile squid (*Gonatus fabricii* Lichtenstein) in the Norwegian and Barents Seas in 1986-1988.ICES. C. M. 1989; K:15: 18 pp.

Sigurjonsson, J. and Vikingsson, G. A. Investigations on the ecological role of cetaceans in Icelandic and adjacent waters. ICES c. M. 1992/. 1992; N:24. 23 pp.

Skjoldal, H. R.; Noji, T..Giske, J., Fosså, J. H., Blindheim, J., and Sundby, S. (1993). Mare Cognocum. Science plan for research on Marine Ecology of the Nordic Seas (Greenland, Norwegian, Iceland Seas. Report. Institute of Marine <Research, Bergen Norway, 162 pp.

Sundby, S., Bjørke, H., Soldal, V. A.; and Olsen, S. (1989). Mortality rates during the early life stages and year-class strength of the northeast Arctic cod (*Gadus morhua* L.). Rapp. P.-v. Reun. Cons. int. Explor. Mer. 191: 351-358.

Valdemarsen, J. W. and Misund, O. (1995). Trawl design and techniques used by Norwegian research vessels to sample fish in the pelagic zone. 135-144 in: Hylen, Arvid, ed. Presision and relevance of pre-recruit studies for fishery managemant related to fish stocks in the Barents Sea and adjasent waters; 1994 jun 14-17;. Bergen: Institute of Marine Research; 323 pp.

Wiborg, K. F. (1979). *Gonatus fabricii* (Lichtenstein), en mulig fiskeriressurs i Norskehavet. (*Gonatus fabricii* (Lichtenstein), a possible fishery resource in the Norwegian Sea). Fisken Hav. 1: 33-46.

Wiborg, K. F., Beck, I. M. and Gjøsæter, J. (1984). The squid *Gonatus fabricii* (Lichtenstein) investigations in the Norwegian Sea and western Barents Sea 1982-1983. Coun. Meet. int. Coun. Explor. Sea. 1984; K:19: 14 pp.