Multispecies considerations

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Cod consumption

The consumption by cod of various prey species is shown in Table 1. The consumption is calculated using the same method as in Bogstad and Mehl (1997), using stomach content data from the joint PINRO-IMR stomach content data base, a model for the gastric evacuation rate of cod and data on sea temperature and the abundance and geographical distribution of cod. The consumption is calculated for three main areas in the Barents Sea and for the first and second half of the year, for age groups 1-11+ separately. On the average 6000 stomachs have been sampled annually since 1984. The consumption estimates in Table 1 do not include consumption by mature cod in the period when it is outside the Barents Sea (assumed to be 3 months during the first half of the year). During this period it may consume significant amounts of adult herring (Bogstad and Mehl, 1997).

The consumption of capelin decreased from approximately 3 million tonnes in 1991-1993 to about 650 thousand tonnes in 1996. This decrease corresponds well to the observed development of the capelin stock. Amphipods and krill combined accounts for about 35% of the diet in 1995-1996, with krill as the most important of those two in 1996. After a drop in 1993-1994, the consumption of redfish is now back at the normal level of 200-300 thousand tonnes. The consumption of cod by cod (cannibalism) has increased strongly since 1992, and cod now makes up more than 10 % of the diet. The consumption of haddock by cod has varied around 100 thousand tonnes since 1992. The consumption of cod and haddock by prey age group is given in Tables 2 and 3. The consumption of herring and polar cod decreased strongly from 1994 to 1996, and those two species combined made up only 3 % of the diet in 1996. The consumption of shrimp has been stable around 500 thousand tonnes in the last years.

Table 1. The Northeast Arctic cod stock's consumption in 1000 tonnes of main prey species in 1984 - 1996.

	Prey species											
Year	Amphip.	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	Gr. hal.	Others	Total
1984	27	112	439	735	77	15	23	51	370	0	511	2359
1985	168	57	154	1617	180	3	33	47	225	0	1153	3637
1986	1216	107	140	828	132	140	82	109	312	+	660	3727
1987	1061	65	187	225	32	199	24	4	313	+	666	2778
1988	1246	313	130	336	8	91	9	3	225	0	411	2772
1989	835	247	132	593	3	33	8	11	233	0	744	2838
1990	143	94	202	1679	7	6	20	17	250	0	1620	4037
1991	81	94	209	3093	8	12	27	21	326	8	1202	5083
1992	117	190	444	2849	348	111	57	114	209	28	1160	5627
1993	314	820	388	3644	196	327	328	87	114	2	958	7177
1994	725	924	654	1391	196	822	276	63	99	+	869	6019
1995	1349	719	484	813	165	335	541	159	272	2	1170	6010
1996	658	1503	525	652	79	85	663	98	200	0	1210	5672
Mean	610	403	314	1420	110	168	161	60	242	3	949	4441
%	14	9	7	32	3	4	4	1	6	0	21	100

Table 2. The Northeast Arctic cod stock's consumption of cod in 1984-1996, by prey age group.

Year	Age 0 cons.	Age 1 cons.	Age 2 cons.	Age 3 cons.	Age 4 cons.	Age 5 cons.	Age 6 cons.
1984	0	440	23	+	0	0	0
1985	1479	380	70	+	0	0	0
1986	53	418	392	99	0	0	0
1987	654	176	274	14	0	0	0
1988	29	422	23	2	0	0	0
1989	967	142	+	0	0	0	0
1990	0	64	29	0	0	0	0
1991	141	156	221	2	0	0	0
1992	4262	1117	162	4	0	0	0
1993	4895	23375	602	61	2	+	0
1994	10347	9355	820	147	57	8	+
1995	11038	19789	1095	357	120	4	+
1996	53	26011	2245	241	94	29	2

Table 3. The Northeast Arctic cod stock's consumption of haddock in 1984-1996, by prey age group.

Year	Age 0 cons.	Age 1 cons.	Age 2 cons.	Age 3 cons.	Age 4 cons.	Age 5 cons.	Age 6 cons.
1984	1906	1011	16	+	0	0	0
1985	1678	1197	5	0	0	0	0
1986	91	558	242	165	0	0	0
1987	0	759	0	0	0	0	0
1988	0	16	1	9	0	0	0
1989	22	238	0	0	0	0	0
1990	0	149	42	4	0	0	0
1991	52	470	15	0	0	0	0
1992	0	2254	155	1	0	0	0
1993	171	1844	184	40	4	3	0
1994	1082	2009	93	28	9	1	+
1995	1797	3818	236	18	41	42	+
1996	0	1716	290	93	12	6	8

Consumption by minke whales and harp seals

Nilssen *et al*. (1997) and Folkow *et al*. (1997) calculated the consumption by harp seals and minke whales in the Barents Sea using data on energy intake, diet composition, energy density of prey and stock size. The food consumption by the 700 000 harp seals (including 100 000 pups) was calculated both for periods with a high and low capelin stock. In the calculations of the consumption by 85 000 minke whales in the Barents Sea and in Norwegian coastal waters , data from 1992-1995 were used, but data from 1992 in areas with much capelin were excluded in order to get an estimate for a period with a low capelin stock. Table 4 compares the consumption by minke whale, harp seal and cod in the Barents Sea for a situation with a low capelin stock and high herring stock. The consumption by harp seals in a situation with a high capelin stock is given in brackets.

Table 4. Annual consumption by minke whale, harp seal and cod in the Barents Sea when the capelin stock is low and the herring stock is high. 1000 tonnes (wet weight)

Prey	Minke whale consumption	Harp seal consumption (period with high capelin stock in brackets)	Cod consumption (1993-1995 average)
Capelin	142	7(258)	1949
Herring	633	131(70)	186
Cod	256	93(32)	382
Haddock	128	14(*)	103
Krill	602	215(215)	821
Amphipods	0	115(109)	796
Shrimp	0	*(*)	509
Polar cod	*	326(213)	495
Other fish	55	224(142)	163[1]
Other crustaceans	0	127(104)	999[2]
Total	1816	1253(1143)	6402

* indicates that the prey species is included in the 'other' groups for this predator

[1] redfish and Greenland halibut only

[2] including fish other than redfish, Greenland halibut and the fish species mentioned in the table.

Haug *et al*. (1997) studied variations in the diet of minke whales, and found that in the ES (Svalbard) area (west of 30° E and north of 73°N), minke whales switched from a capelin-dominated diet to a diet almost completely comprised of krill *Thysanoessa* sp. In the EB area (the rest of the Barents Sea including the coastal areas of Finnmark and Kola), the diet was dominated by herring in 1992-1994. Herring was replaced by krill and capelin in the diet in 1995-1996, when the abundance of herring was greatly reduced.

Prognosis for development of the capelin stock

The Barents Sea capelin stock is at present at a low level, but is probably going to recover within a relatively short time. Consequently, it is nearly impossible to give any prognosis for its development. The recovery could take two years (as it did in 1988-90) or it could take five, depending on the conditions. The two main factors regulating the process of recovery are the presence of young herring in the Barents Sea (which will hamper the recruitment) and the amount of zooplankton (which will regulate the growth of the capelin cohorts already in the stock). The stock will in 1998 consist of the year classes 1997, 1996, 1995, and 1994.

The 1994 year class

This year class was estimated in autumn 1996 at 11.5 billion individuals and 215 000 tonnes, out of which almost 200 000 tonnes probably spawned in winter 1997. This unusually high proportion of spawners among the 2 (3 at time of spawning) years old fish was caused by the highest growth rate on record. Consequently, only some 2 billion individuals will probably survive the spawning season, and the majority of those surviving until winter 1997-98 will spawn and die in winter 1998. Not much will be left till spring-summer 1998.

The 1995 year class

This year class was estimated in autumn 1996 at 82 billion individuals which is considerably stronger than the preceding year class, but still a weak one in a longer perspective. With the same mortality as the 1994 year class at the same age, it will be reduced to 54 billion by August 1997, which is a little less than 5 times the strength of the 1994 year class at corresponding age. With the same growth as the proceeding year class (which may seem too optimistic) its biomass in autumn 1997 will be about 900 000 tonnes, out of which about 800 000 tonnes will be maturing and will spawn in winter 1998. Less than 100 000 tonnes (when reduced by natural mortality) will survive till spring-summer 1998.

The 1996 year class

This year class has yet to be estimated by acoustic methods. At the international 0-group survey in August 1996 an index of 291 was calculated, high compared to the three preceding year classes at the same stage, but still a weak year class in a longer perspective. Gundersen & Gjøsæter (in press) established a linear regression between the 0-group indices and the number of 1-group one year later. According to this regression, the prognosis for its abundance in autumn 1997 is about 150 billions or about twice that of the 1995 year class at the same stage. Following the logic discussed above, (which may be even more optimistic for this year class) it will constitute about 1.7 million tonnes in autumn 1998, out of which 1.5 million tonnes will mature and spawn in winter 1999.

The 1997 year class

Not much is known about this year class yet. Its larval abundance in June 1997 was estimated at 6.9 thousand billion individuals, which is probably an underestimate since the surveying vessel was not granted permission to work in Russian EEZ. This means that the 1997 year class may be of "normal" strength at the larval stage. Its fate is, however, totally determined by the predation from herring in the period June-September 1997. During the same survey as that where the capelin larval abundance was estimated, low numbers of young herring was found. However, herring of the 1996 year class, which, on the basis of the 0-group survey in autumn 1996 was thought to be numerous, may stay in the Russian EEZ, which was not surveyed. It is therefore impossible to give any prognosis for the 1997 year class of capelin at the present stage. A first estimate of its size will be obtained during the 0-group survey in August.

Conclusions

The first signs of a recovery of the Barents Sea capelin stock is evident. The year classes 1995 and 1996 are seemingly stronger than the preceding ones, and the 1997 year class may be of a "pre-collapse" strength. If the predation rate on the larvae continues to be low, and if the growth rate of all age groups continues to be high, the stock may recover within 1-2 years from now. If either the growth slows down or the natural mortality increases, it may take longer. The stock biomass and M-output biomass for the period 1984-1996 is shown in Table 5, together with predictions for 1997 and 1998.

Table 5. Capelin stock biomass and M-output biomass 1984-1998. All quantities in thousand tonnes.

Year	Total stock biomass (Oct. 1)	M output biomass during year
1984	2964	3197
1985	860	1987
1986	120	657
1987	101	200
1988	428	80
1989	864	549
1990	5831	357
1991	7287	3326
1992	5150	7751
1993	796	4590
1994	199	981
1995	193	163
1996	503	261
1997 *	1300	600
1998 **	2000	1000

* Estimate, includes the 1996 year class which size is estimated from a regression on an 0-group index
** Guestimate, includes the 1997 year class which size is unknown, in addition to the 1996 year class

Relationship between cod growth and capelin abundance

References

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