RETROSPECTIVE REVIEW OF MANAGEMENT ADVICE FOR THE NORTHEAST ARCTIC COD

by

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Introduction

The history of fishery of the Northeast Arctic cod is almost a millennium (Rollefsen, 1966; Dyrvik et al., 1979), while the history of its management is much shorter. We reviewed 100 years period of managements measures development.

Currently for all commercially important fish stocks in the Barents Sea area, Norwegian and Russian management authorities receive annual advice from ICES on total allowable catches (TAC's) and other management measures. The advice is based on the stock monitoring and research carried out by PINRO and IMR.

Material and methods

All data are taken from the annual ICES reports (ACFM reports) as well as the Joint Soviet-Norwegian Fisheries Commission, later the Joint Russian-Norwegian Fisheries Commission protocols. Each year ICES produces an updated version of the assessment of all previous years, and we have compared the results from the annual assessments; i.e. the assessment that is the basis for the decision on next years TAC, with the results from the 2005 assessment for the same years.

Results

History of the management

First regulations of the cod fishery aimed at preventing the conflicts among fishers operating on the same fishing grounds are almost a century old. The development and practical application of regulatory measures began to be a more regular practice only from the mid-20th century. The need for development and subsequent implementation of regulatory measures on the cod fishery was called forth by an abrupt decline of the efficiency of this fishery in the second half of the 1950s.

Before that, a minimum mesh size established by the "Convention on regulation of the mesh size in fishing gear and minimal legal fish size" (London, 23 March 1937) was recommended for use to limit the cod fishery. However, decisions under this Convention were not binding for all nations exploiting the stock.

Under the next Convention, which was signed in London on 5 April 1946 and came into force on 5 April 1953, it was recommended that the minimum mesh size be increased to 110 mm (the USSR acceded the Convention in 1958 and ratified it in 1961). So, this technical regulatory measure was the first direct regulatory measure in the history of cod fishery.

A later history of exploitation of cod in the Barents Sea showed, that application of technical regulatory measures alone could not help avoiding sudden variations and repeated decline of the efficiency of fishery, variations in the size composition of catch and its decline.

Redused catch rates and disappearance of large cod from catches, near Lofoten including, in the second half of the 1950s gave grounds for the Russian and Norwegian researchers to conclude that the trawl fishery had a strong impact on the cod stock (Maslov, 1957a; Sætersdal and Hylen, 1964). It was formulated, that "a method to manage the biological processes in a water body lies in regulating the fishery by establishing science-based catch limits strictly complied with by the industry (Maslov, 1957b)".

A more effective measure to ensure rational exploitation is fishery regulation through establishing a science-based total catch limit (TAC) based on a stock status. Therefore, the subsequent history of the cod fishery management was based on giving the priority to establishing a TAC on the basis of scientific advice with simultaneous development of other regulatory measures for the fishery.

In 1958 the first meeting of the Arctic Fisheries Working Group (AFWG) under the International Council for the Exploration of the Sea (ICES) was held in Bergen, where for the first time assessment of the Barents Sea commercial fish stocks, cod including, was undertaken. Russian and Norwegian scientists Yu.Yu.Marti, V.I.Travin, G.Rollefsen, A.Hylen participated. After that the assessment of stocks was conducted on an annual basis. In 1964 to assess the cod stock the Virtual Population Analysis (VPA) was applied for the first time.

It should be noted, that before mid-1970s although the AFWG provided scientific advice on catch options, no binding decisions were taken to regulate the fishery by quotas. This left the total fishing effort unrestrained from increasing, as a result of which the fishing mortality of juvenile cod, not having used its potential for growth, increased in the 1970s, when even strong year classes could not support yet long-term mean, let alone high, catch rates (Ponomarenko, 1982).

Introduction of national economic zones and negative trends in the Barents Sea commercial fish stocks dynamics were major reasons for establishing the Joint Soviet-Norwegian Fisheries Commission, later the Joint Russian-Norwegian Fisheries Commission, in January 1976 with the objective to ensure a coordinated effective management of joint stocks.

Annual cod quotas have been setting up by the Joint Fisheries Commission since late 1970s. It should be noted that at some of its annual meetings the levels of commercial harvest adopted by the Commission were higher than recommended by Russian and Norwegian scientists. In addition, until mid-1980s there were no limitations for fishing of cod by net, line and jigger, which increased the harvest beyond recommended levels.

A revision of established limits in order to reduce them for critical status of the cod stock was needed only once – in 1988. The reduction of catch limits led to a reduction of fishing mortality (Jacobsen, 1992) and gradual growth of the stock. In 1992 the catch limit was revised with the aim to increase it.

Later on a higher accuracy of management advice for the cod fishery was achieved through refining the methodology for estimating a TAC, taking into account predator-prey relations and cannibalism.

The next step in optimizing the cod fishery was an agreement concerning “a 3-year harvest control rule” adopted by the 31st session of the Joint Russian-Norwegian Fisheries Commission and effective from 2004. Under this agreement, seeking to achieve a year-to-year stability of TACs and create conditions for high long-term yield from the stock the Parties decided:

- estimate the average TAC level for the coming 3 years based on Fpa. TAC for the next year will be set to this level as a starting value for the 3 years period;
- the year after, the TAC calculation for the next 3 years is repeated based on updated information about the stock development, though such that the TAC should not be changed by more than +/-10% compared with the previous year’s TAC;
- if the spawning stock falls below Bpa, the Parties should consider a lower TAC than according to the decision rule above.

Simultaneously with the scientific advice for the management of cod stock being improved technical measures to regulate this fishery were also modified. For instance, minimum mesh size was revised several times (from 80/90 mm for Norwegian/Soviet trawlers in 1946 to 135/125 mm in 1982) and minimal landing size for cod as well (from 34 cm in 1964 to 47/42 cm for Norwegian/Russian fishing vessels in 1988/1990). Furthermore, in order to reduce the by-catch of juvenile cod sorting grids were made mandatory for use on the trawl fishery from 1997. In mid-1980s a limit for allowable by-catch of juvenile *Gadidae* on the shrimp fishery was established and in mid-1990s a mandatory use of sorting grids on this fishery was introduced.

Table 1. The history of alteration of management measures applied on the Northeast Arctic cod fishery

Year	Management measures
1961	Introducing minimal mesh size in trawls of 110 мм
1963	Introducing minimal mesh size in trawls of 120/130 мм
1978	Establishing annual TAC for trawl fishery
1979	Introducing measures to improve spawning conditions
1981	Introducing minimal mesh size in trawls of 125 мм
1982	Introducing minimal mesh size in trawls of 135 мм*
1983	Establishing annual TAC for the cod fishery (for all fishing gear, including fixed engines)
1984	Limiting the by-catch of juvenile *Gadidae* on shrimp fishery
1992	Limiting the by-catch of juvenile *Gadidae* on capelin fishery
1993	Introducing sorting grids on shrimp fishery
1997	Introducing sorting grids on cod fishery

**Applies to all vessels operating in the Norwegian economic zone.*

The use of unified management measures such as TAC, mandatory use of sorting grids and others, by all nations exploiting the cod stock is certainly advantageous. At the same time, differing minimal mesh size in trawls, minimal landing size of fish applied in different economic zones complicate the development of scientific advice. Therefore, a long-term objective for Russia and Norway would be the development and implementation of unified management measures for the cod fishery overall.

The current management system

The management system for cod stock is based on three sources of information about its status (Fig.1). The first is fisheries statistics, which includes information on catch, catch per effort, mean weight at age and age composition of commercial catch provided to ICES by all nations engaged in cod fisheries.

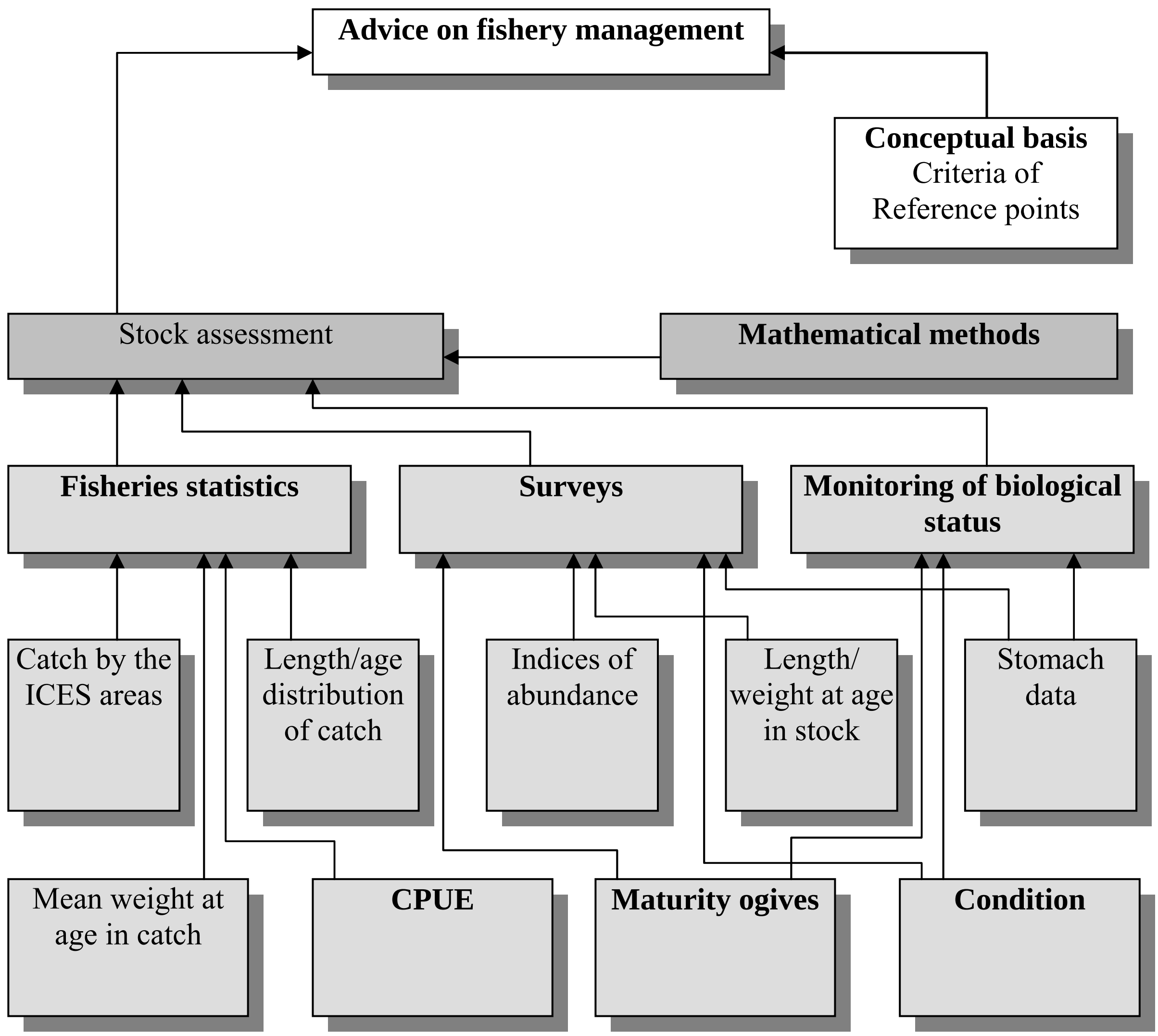

Fig 1. Diagram to show schematically how management advice for the Northeast Arctic cod is developed

The second important source of information is trawl-acoustic surveys conducted by Russia and Norway, which provides data for estimating the abundance indices, length and weight at age and maturity ogives. Survey data are supplemented by environmental data.

The third source of information is a year-round-run observer program on fishing vessels and coastal plants, which provides information on cod feeding conditions, maturation rate and abiotic conditions in its habitat.

All information compiled is used for stock assessment for which a variety of mathematical methods are applied, of them the key method is VPA. This method permits to develop a science-based advice on the level of fishing mortality (F).

In choosing the optimal fishing mortality rate various biological reference points set on the basis of the relationship between catch and F as well as recruitment and spawning stock biomass are taken into consideration. Some history of the ICES framework for advice given in Aglen et al. (2004). An optimal level of the chosen F means that a principle of maximizing the long-term yield is met (to prevent overfishing). Besides, the need to avoid excessive outtake of juvenile fish, recruits to the commercial stock, and maintain the spawning stock biomass (SSB) at the level preventing from impaired recruitment is taken into account.

Comparison of the annual and the most recent stock assessments

In a review of the exploitation and management of several stocks in the area some years ago (Nakken 1998, 2002) it was shown that agreed and actual catches frequently exeeded the advised ones. In addition, it was shown that the annual stock assessment tended to be biased, particularly for North-East Arctic cod; i.e. the annually estimated fishing mortalities were as a rule substantially lower than those arrived at in later assessments for the same year. On an average the fishing mortality rates seemed to be about 20 percent too low and consequently the stock estimate, on which the annual advice was based, was about 20 percent too high. Nakken (1998, 2002) therefore recommended that considerably more caution ought to be used by management authorities when deciding on TAC's in the future.

In the present paper we have updated the information on advised and agreed TAC's as well as actual catches, and we have also compared the annually estimated fishing mortalities, SSB and recruitment numbers (age 3) with the figures arrived at in the most recent assessment; i.e. the 2005 assessment. The results indicate that in recent years the errors in the annual assessments have been minor as compared with previous periods and than the large downward bias in fishing mortality rate (upward bias in stock estimate) has been absent since 1998.

Table 1 and Figure 1 present advised, agreed and actual catches of North-East Arctic cod in the period 1984-2004 as given by ICES. For some of the years ICES has advised on an upper limit of fishing mortality rate and we have calculated the corresponding TAC. The comparison (Fig.1) shows that since 1998 the TAC's decided on, have been much higher than the advised ones, and in most recent years the actual catches have also exceeded to a considerable extent the TAC's decided on by the authorities.

In Table 2 and Fig.2 are also showncomparisons of the main results (SSB, fishing mortality rate and recruitment) of the assessment carried out annually and those from the ICES' stock assessment in spring 2005. The figure 2 indicates that spawning stock biomass has been estimated "precisely" since 1998. It also appears that the gross underestimation of fishing mortality rate (and overestimation of SSB) in the annually estimated figures experienced in the mid 1980s and the period 1990-1997 has been absent since 1998, and there is a slight tendency to the opposite for 2000-2003. Apart for 2-3 years in the early 1990s recruitment figures seem to have been estimated with good precision (lower panel of Figure2).

Table 2. North-East Arctic cod: Adviced, agreed and actual catch (thousand tonnes), and assessment results, both from annual assessments and from the 2005 assessment. SSB is the spawning stock biomass (thousand tonnes), F is fishing mortality and R3 is recruitment at age 3 (millions spec.)

	Catch (000 tonnes)			SSB (000 tonnes)		F 5-10		R3	
Year	Adviced	Agreed	Actual	Annually	2005	Annually	2005	Annually	2005
1984	150	220	278	354	251	0.59	0.89	300	398
1985	170	220	308	407	193	0.62	0.8	677	524
1986	446	400	430	397	170	0.65	0.91	1000	1036
1987	645	560	518	275	118	0.96	1.01	443	286
1988	530	590	459	189	202	0.9	0.9	156	204
1989	335	300	351	151	194	0.67	0.72	175	173
1990	172	160	212	327	340	0.27	0.29	136	242
1991	215	215	319	680	674	0.19	0.34	227	412
1992	250	356	513	1047	869	0.39	0.44	642	721
1993	256	500	582	1024	737	0.43	0.55	808	896
1994	649	700	771	774	599	0.51	0.86	908	811
1995	681	700	740	570	499	0.58	0.79	717	655
1996	746	700	732	720	569	0.57	0.7	474	437
1997	993	850	766	694	564	0.79	1.04	763	717
1998	514	654	561	419	387	0.91	0.92	819	851
1999	360	480	485	266	256	0.96	1	585	599
2000	110	390	415	223	229	0.91	0.86	591	688
2001	263	395	427	298	334	0.84	0.71	462	542
2002	181	395	535	505	520	0.69	0.64	498	447
2003	305	395	552	643	585	0.46	0.5	502	502
2004	398	486	579	714	714	0.57	0.57	276	276

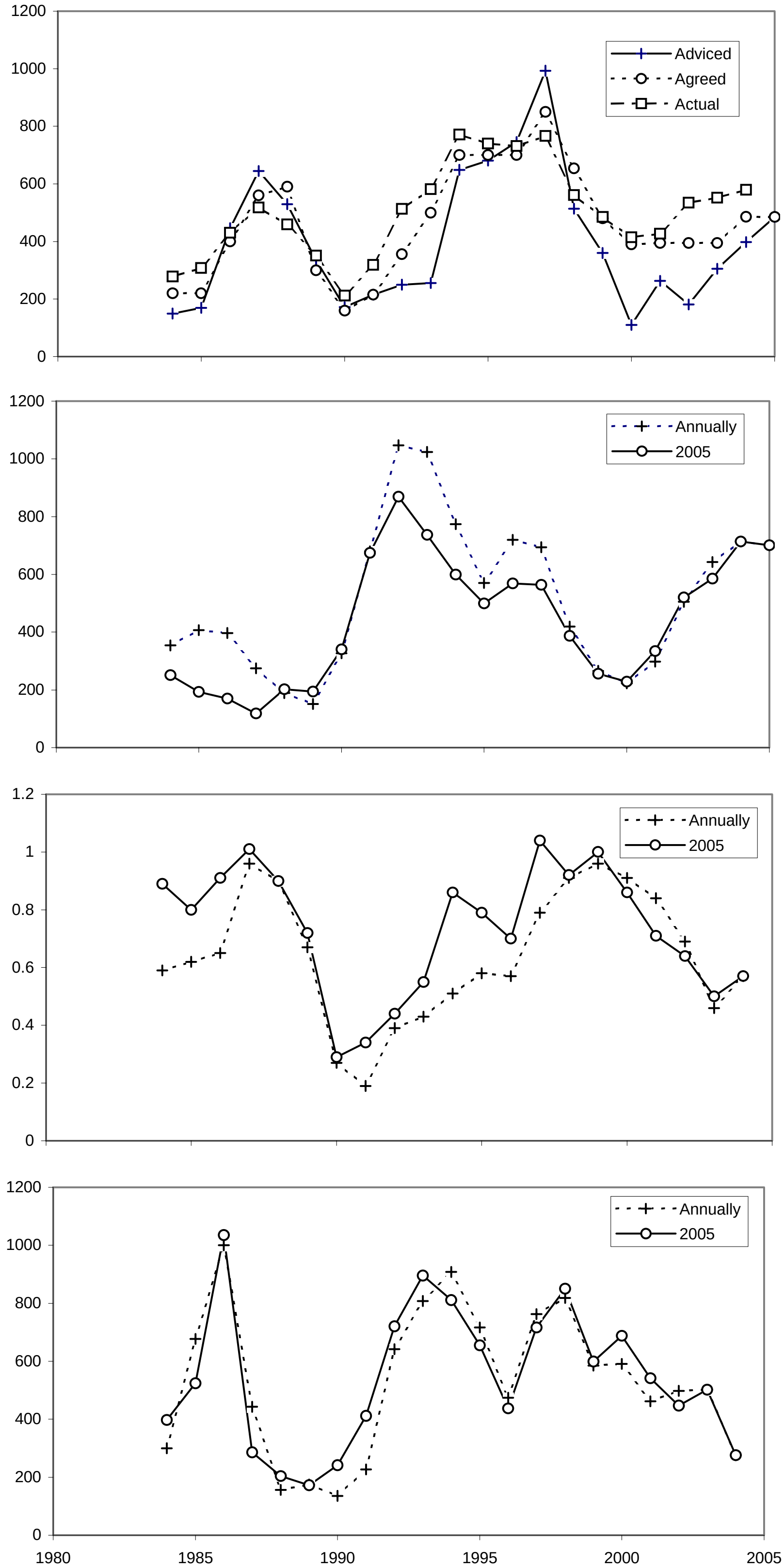

Figure 2. North-East Arctic cod. Panels from top: Catch (thousand tonnes), spawning stock biomass (thousand tonnes), fishing mortality, and recruitment at age 3 (millions spec.). Data as shown in Table 1

Statistical and political geography of the NEA cod's distribution range

There are several international and national schemes of division of the NEA cod's distribution range into areas, which directly or indirectly serve the purpose of management of biological resources, cod stock including.

For instance, the split into areas established by ICES aims at addressing a wide range of issues, such as catch statistics, assessment and distribution of stocks (Fig. 3A).

One of the reasons of establishing a system of economic, fishing and fish protection zones in the Barents Sea (Fig. 3B) in 1976 de jure and 1978 de facto was also a need for more effective management of stocks. All fishery regulations concerning fishing gears to be used, fishing seasons and areas, by-catch limits etc. are zone-specific or related to international agreements in force.

Russian trawl-acoustic and trawl surveys of stocks in the Barents Sea, cod including, use a map of fishing areas, which are in turn divided into rectangles of 10x10 n.miles^2 each (Fig. 3C). The same map is used for temporal closure of areas, when the by-catch of juveniles of commercial fishes on the trawl fishery of *Gadidae* and shrimp exceeds the established limit.

In Norwegian trawl-acoustic surveys of bottom fish a system of strata is applied (Fig.3D) and a system of statistical areas for harvest control.

This diversity of schemes, which serve to address a wide range of tasks, does not, at present, represent any impediment to accurate assessment of the cod stock. However, one of the steps towards deriving more accurate abundance indices by surveys could be establishing a unified scheme of division of the cod distribution area into strata.

Future of management

Despite a fairly long history of research on the Northeast Arctic cod and its extensive scope many aspects of the biology of this species still remain inadequately studied. To fill the gaps it is, for instance, important to undertake a more thorough analysis of the spawning stock/recruitment relationship with the focus on the phenomenon of skipped spawning, sex composition of the parent stock etc.

In our view, the stock assessment should place higher emphasis on biological aspects of cod's life history.

Moreover, some political problems has to be solved, such as

- unification ofishery management rules within the margin of cod area
- getting of reliable fishery statistics.

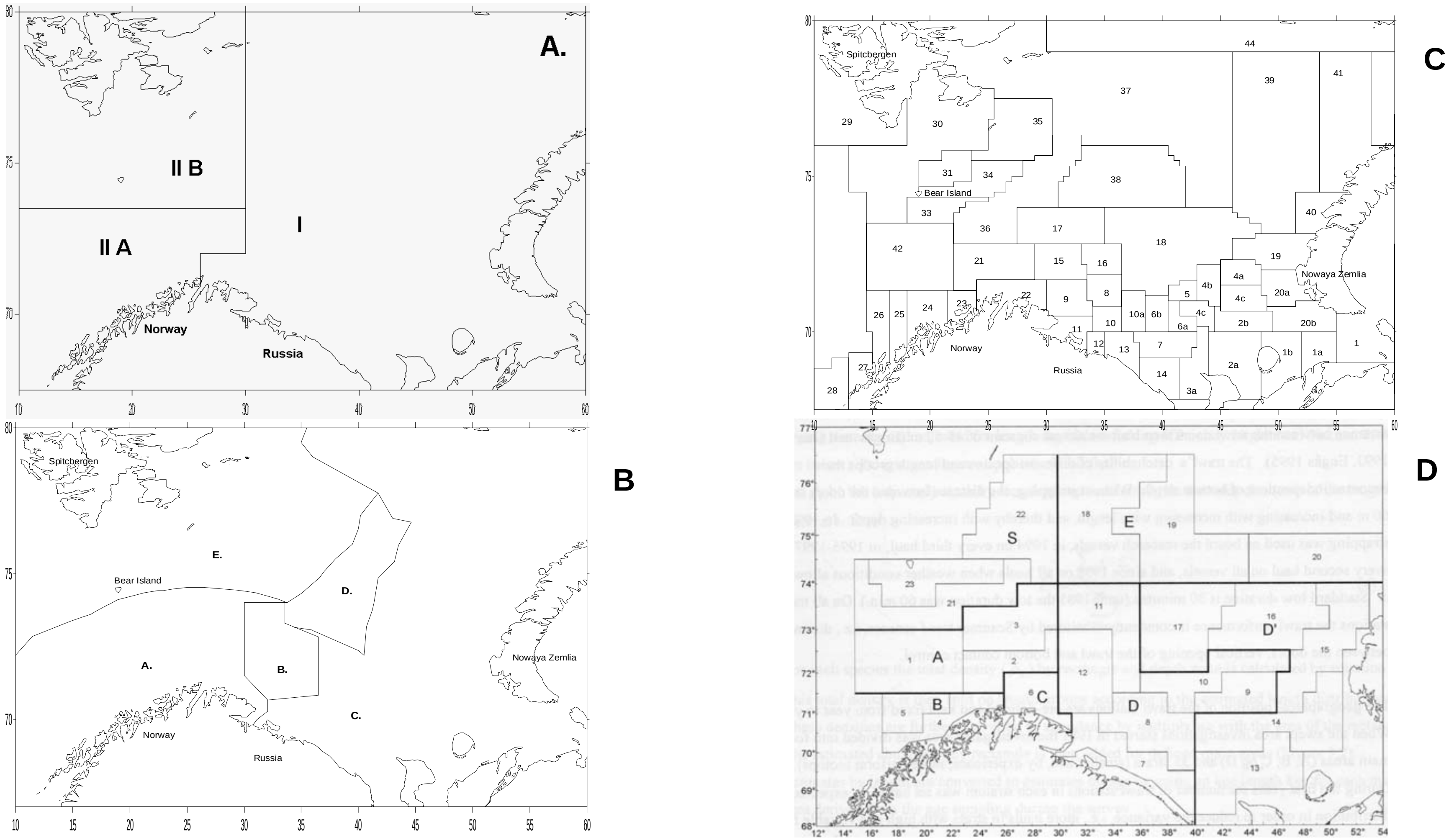

Fig.3. International and national division of the NEA cod distribution range into areas
(A – ICES areas; B – Economic and fishing zones; C – Russian fishery areas; D – Norwegian strata and main areas

Legend to fig 3:

Fig.3C. The Russian fishery areas (Trudy PINRO, vyp. 10, 1957).
Eastern areas (1; 1a; 1b; 2a; 2b; 3a; 3b; 20b).
Central areas (4a; 4b; 4c; 5; 6a; 6b; 7; 18; 19; 20a).
Coastal areas (12; 13; 14).
Western areas (8; 9; 10a; 10b; 11; 15; 16; 17; 21; 22).
Norwegian coast (23; 24; 25; 26; 27; 28).
Northwestern areas (29; 30; 31; 32; 33; 34; 35; 36; 37; 38; 42).
Northeastern areas (39; 40; 41).

Fig.3B. Economic and fishing zones in the Barents and Norwegian Seas

A. Exclusive Economic Zone of Norway;
B. Area of joint fisheries between Russia and Norway;
C. Exclusive Economic Zone of Russian Federation;
D. Area outside Economic Zones of Russia and Norway (Enclave);
E. Bear Island – Spitsbergen area.

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