International Commission for the Northwest Atlantic Fisheries

Serial No. 5003
(D.c.2)

ICNAF Res.Doc. 77/VI/3

ANNUAL MEETING, 1977

On the Age Contingent of Catches of Beaked Redfish (*Sebastes mentella* Travin)

by

V.A. Chekhova, K.G. Konstantinov and I.S. Shafran
Polar Research Institute of Marine Fisheries and Oceanography (PINRO)
Murmansk, USSR

The size of the optimum yield from any population regularly fished off is in a close relationship with the age at which fish becomes the object of the fishery and on the rate of exploitation. By the rate of exploitation is meant "the ratio (expressed in percents) between the number of fish caught during a given period (for example a year) and its stock at the beginning of the period" (Konstantinov, 1969). This wording is also recommended by Ricker on page 42 of his excellent Russian-English Dictionary for Students of Fisheries and Aquatic Biology (Ricker, 1973). Besides, the term "rate of exploitation" has synonyms "fishing mortality for a season" and "degree of stock exploitation" (Zasosov, 1970).

However, when constructing different mathematical models, the term "instantaneous rate of fishing mortality", usually designated on the diagrams or in formulas by "F" index, is mostly used. Both terms - "instantaneous rate of fishing mortality" and "rate of exploitation" - are virtually equivalent and interchangeable; they are easily converted from one to another with the help of simple equations or tables.

By now the theoretical relationship between fishing mortality and catch by weight per one recruit is calculated by ichthyologists on the example of many regularly exploited populations (stocks) of commercial fishes. Let us mention at least one of the recent papers dealing with the cod of the southern slopes of the Great Newfoundland Bank (Pinhorn and Wells, 1975). The curve expressing relationship between fishing mortality and yield per recruit is shown on fig.2 of the above paper. The run of the curve is typical of many similar cases : the yield per recruit first raises and then drops again as the fishing mortality increases. Consequently, there exists an optimum fishing mortality which provides maximum sustainable yield from the exploited stock[x/].

The pattern of the curve considered will not be similar under different levels of natural mortality and under different age composition of catches. An ichthyologist has usually to do with a whole family of curves. For example, in the paper which is concerned with the redfish of the Nova Scotia area (Mayo and Miller, 1976) there presented curves constructed for different age at which redfish is involved in the regular fishery: 6, 7, 8 and 9 years. Instantaneous rate of natural mortality (M) is taken as 0.1 in all the cases.

Similar curves based on the methods by Beverton and Holt (Beverton and Holt, 1957) are obtained by the authors of the paper for the beaked redfish (Sebastes mentella Travin) from the East Greenland area. In Fig.1 are shown curves for three different cases in which redfish is used by the fishery : beginning since 5, 8 and 10 year olds; natural mortality is taken as 0.11.

It is seen from the figure that if fish not younger than 10 years is subjected to the fishery, the yield per recruit reaches maximum when instantaneous rate of fishing mortality is about 0.4, and it practically does not change with its further increase. The appropriate curve has no descending branch within limits of the instantaneous rate of fishing mortality considered by us.

The pattern of another curve constructed for the fishery of specimens not younger than 8 years closely agrees with the first one. And only if redfish becomes vulnerable at age 5, the yield per recruit markedly decreases as soon as fishing mortality exceeds 0.2.

However, the assumption that natural mortality of redfish is equal to 0.1 is highly improbable. Because that means that

---

x/ When constructing similar curves the influence of natural factors (for example, fluctuations in the abundance) are conditionally taken as invariable. Actually fluctuations can fully overlap the influence of fishing mortality (Konstantinov, 1976)

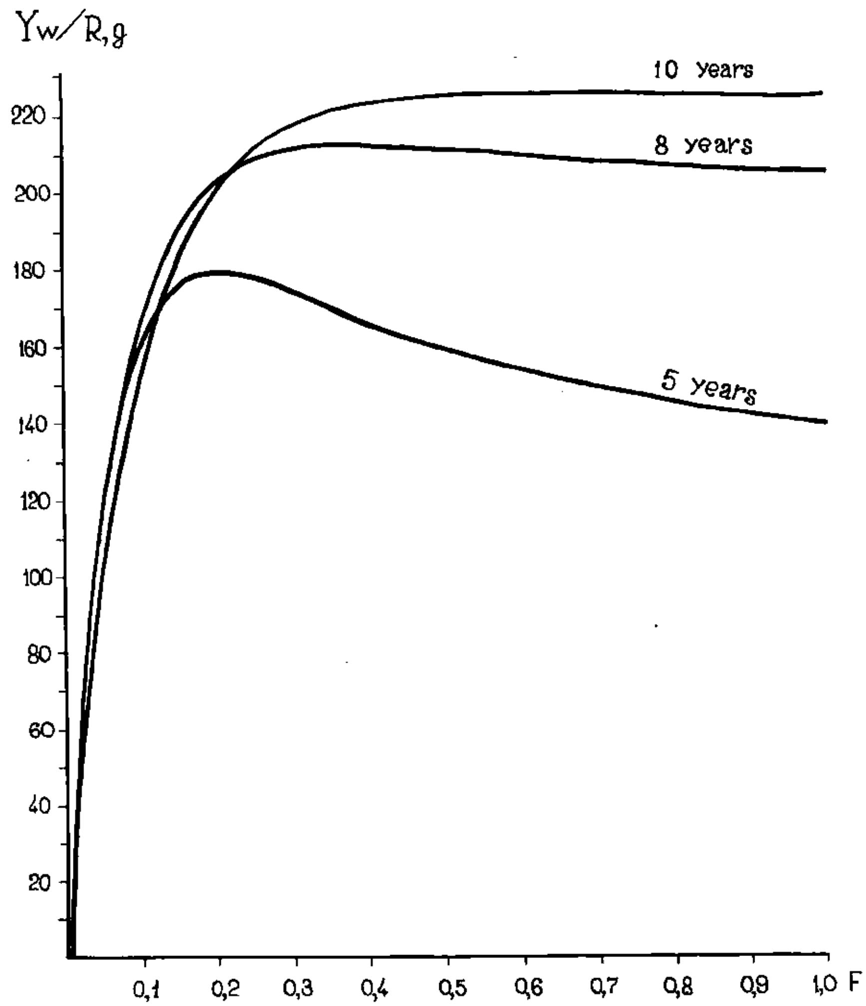

Fig. 1. Yield per recruit (g) for beaked redfish of the East Greenland area in relation to the instantaneous rate of fishing mortality when fishes become vulnerable at age 5, 8 and 10 years. Instantaneous natural mortality is taken as 0.11.

only less than 9.5% of specimens die annually from all natural causes. Needless to say, the virtual death from predators,parasites and deseases should be considerably higher especially of young redfish (at age 5 to 10 years). As a rule,beaked redfish keep together with active,abundant and mobile predator -Greenland halibut (Paschen,1968). Redfish serves as one of the most important food objects for Greenland halibut (Konstantinov and Podrazhanskaya, 1972). An extremely low rate of growth and comparatively small velocity of swimming make redfish an easy pray for a number of predatory fishes. Finally, mass deaths of beaked redfish were observed in the East Greenland area, which were apparently caused by sharp changes in oceanological conditions (Konstantinov, 1959). It will be recalled that natural mortality for adult cod is usually taken by ichthyologists as 0.20 (Pinhorn and Wells, 1975) or 0.18 (Pinhorn, 1975).

Thus, natural mortality of the order of 0.25 is most probable for beaked redfish, that corresponds to the annual loss of about 22% of specimens. In this case the relationship between fishing mortality and yield per recruit takes radically new form (Fig.2). Maximum sustainable yield is achieved when specimens reaching 5 years become vulnerable, yield per recruit not decreasing under any increase of fishing mortality.

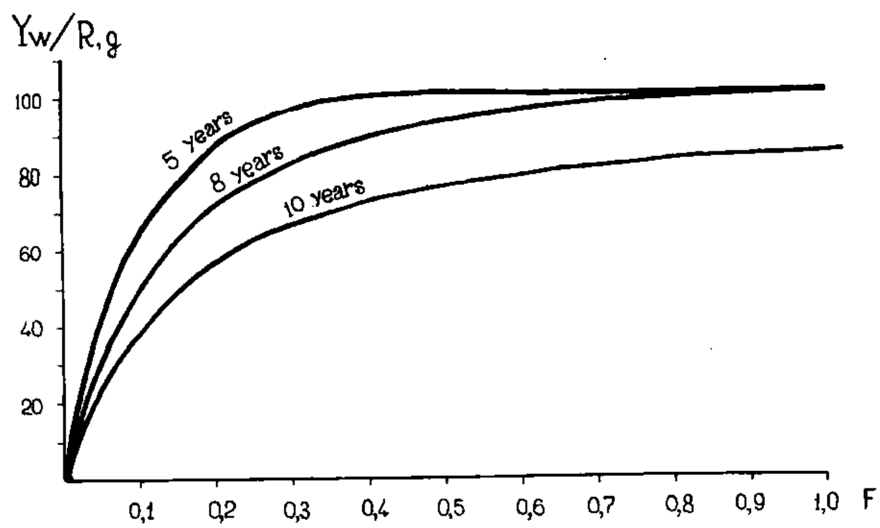

Fig. 2. Yield per recruit (g) for beaked redfish of the East Greenland area in relation to the instantaneous rate of fishing mortality when fishes become vulnerable at age 5, 8 and 10 years. Instantaneous natural mortality is taken as 0.25.

This very important conclusion holds true not only for beaked redfish of East Greenland but also for other areas. The main biological parameters are similar for all northern populations of beaked redfish. Let us compare, for example, data obtained by Chekhova (1971) and Kosswig (1973); comparison shows that linear rate of growth is practically the same for beaked redfish of the Flemish Cap Bank and of the southwestern Iceland.

Thus it would be quite rational to base fishery mainly on young beaked redfish. This is also true for some other sea fishes, such as the West Atlantic scup (Finkelstein, 1971), sand eel of the English Channel (Reay, 1973) and others.

In the meantime, specimens 31 to 33 cm long always dominate in the fishing stock of beaked redfish off East Greenland, that particularly showed regular investigations by Icelandic ichthyologists (Magnusson, 1975). Approximately the same peak of length frequency was revealed in the cruise of the Soviet scouting vessel "Zarnitsa", who made a series of trawlings in the first half of April 1976, mainly at depths from 350 to 400 m between 62-65°N and 35-40°W (Table 1). Specimens 31 to 33 cm long were at age 12 to 14 years. Apparently it is expedient to base fishery on younger redfish - viz., as show the above data and considerations, when it reaches the age of 5 or 6 years.

Table 1. Length composition (per mille) of beaked redfish in catches taken by bottom trawl in the East Greenland area in April 1976.

Total length (cm)	Males	Females	Males and females
21-22	1	1	2
23-24	5	5	10
25-26	23	15	38
27-28	49	39	88
29-30	58	52	110
31-32	70	64	134
33-34	67	65	132
35-36	57	60	117
37-38	58	53	111
39-40	36	46	82
41-42	26	26	52
43-44	21	18	39
45-46	21	16	37
47-48	13	11	24
49-50	9	5	14
51-52	4	2	6
53-54	3	1	4
Sex ratio (°/oo)	521	479	1000
Number of specimens measured	2266	2096	4362
Mean length (cm)	34.99	35.03	35.01

In late June 1976 an age sample of beaked redfish was taken by Soviet ichthyologists in the East Greenland area. Age determination made it possible to improve at what length beaked redfish reaches the age of 5 and 6 years (Table 2).

Table 2. Length of beaked redfish at age 5 and 6 in the East Greenland area in June 1976

Age (Years)	Number of specimens examined	Average length (cm)
5	101	20.89
6	109	22.88

Thus, **maximum** sustainable yield of beaked redfish can be achieved under involving it in the regular fishery when it is 21 to 23 cm long.

The use of young specimens provides the basis for pond fisheries and for the cattle-breeding. In this case it is considered necessary to meet one rather important condition - maintenance of the brood stock which is rather abundant for a normal replacement.

However, from a number of interesting papers (Messtorff, 1959; Hempel, 1964; Gulland, 1965; Templeman, 1965, 1972; Cushing, 1968; Sonina,1969; Tveit, 1971; Grauman, 1973; Hylen and Dragesund, 1973; Jones, 1973; Mikhman and Mikhailov, 1973; Ponomarenko, 1973) it follows that in the populations existing in reality the strength of a year class does not practically depend on the number of producers : environmental conditions determining the survival of developing eggs, larvae and fry are of decisive importance.

The above point is convincingly confirmed on the example of beaked redfish of the Bear Island - Spitsbergen Shallows. By 60's an intensive fishery has markedly affected the abundance and sex ratio of redfish of the population (Sorokin, 1963; 1964). However, determining the abundance of young redfish showed that exceptionally strong year classes appeared in 1964, 1965 and 1966 (Berger and Cheremisina, 1974).

REFERENCES

BERGER, T.S. and CHEREMISINA, R.A. 1974. Distribution and age of young redfish, S. mentella Travin and S. marinus L., in the Barents Sea in the autumn-winter period 1972-1973. ICES C.M. 1974/F:26.

BEVERTON, R.J.H. and HOLT, S.J. 1957. On the dynamics of exploited fish populations. Fish. Invest., Ser.2, vol.19.

CHEKHOVA, V.A. 1971. On methods for the determination of age and growth rate in redfish. Annu. Meet. Int. Comm. Northw. Atlant. Fish., Res. Doc. 71/90

CUSHING, D.H. 1968. Fisheries biology. A study in population dynamics. Madison, Milwaukee, and London.

FINKELSTEIN,S.L. 1971. Migration, rate of exploatation and mortality of scup from the inshore waters of eastern Long Island. N.Y. Fish and Game J., vol.18, No.1.

GRAUMAN, G.B. 1973. Investigations of factors influencing fluctuations in abundance of Baltic cod. Rapp. et proc.-verb. réun. Cons. perman. inter. explorat. mer, vol.164.

GULLAND, J.A. 1965. Survival of the youngest stages of fish, and its relation to year-class strength. ICNAF Spec. Publ., No.6.

HEMPEL, G. 1964. Über die Dynamik genutzter Seefischbestände. Forsch. und Fortscr., Bd. 38, Nr.2 und 3.

HYLEN A., DRAGESUND O. 1973. Recruitment of young Arcto-Norwegian cod and haddock in relation to parent stock size. Rapp. et proc.-verb. réun. Cons. perman. inter. explorat. mer, vol.164.

JONES, R. 1973. Density dependent regulation of the numbers of cod and haddock. Rapp. et proc.-verb. réun. Cons. perman. inter. explorat. mer, vol.164.

KONSTANTINOV, K.G. 1959. Mass death of redfish in the Danish Strait. Priroda, No.10.

KONSTANTINOV, K.G. 1969. On the terminology of fishery biology, in particular the concept of "stock available for exploitation". Voprosy Ikhtiologii, tom.9,vyp.2(55).

KONSTANTINOV, K.G. 1976. On fluctuations of the annual cod yield on the southern Grand Bank. Annu. Meet. Int. Comm. Northw. Atlant. Fish., Res. Doc. 76/VI/108.

KONSTANTINOV, K.G., PODRAZHANSKAYA, S.G. 1972. Feeding and food interrelations of grenadier (Macrurus rupestris) and other deep-water fishes of North-West Atlantic. Trudy PINRO, vyp.28.

KOSSWIG, K. 1973. Alter und Wachstum des Rotbarsches. Informationen für die Fischwirtschaft, Nr.3.

MAGNUSSON, J. 1975. Icelandic investigations on redfish in 1973. Ann. biol. Cons. perman. inter. explorat. mer, vol.30.

MAYO, R.K. and MILLER, D.S. 1976. A preliminary assessment of the redfish, Sebastes marinus (L.), in ICNAF Divisions 4 VWX. ICNAF Selected Papers, No.1.

MESSTORFF, J. 1959. Untersuchungen über die Biologie des Wittlings Merlangus merlangus (L.) in der Nordsee. Ber. Dtsch. Wiss. Kommiss. Meeresforschung, Bd. 15, Nr.4.

MIKHMAN, A.S., MIKHAILOV, N.V. 1973. The use of the analysis of variance to establish factors causing fluctuations in the strength of recruitment to the Azov tiulka stock Clupeonella delicatula delicatula (Nord.), Voprosy Ikhtiologii, tom 13, vyp.4(81).

PASCHEN, U. 1968. Ergebnisse einiger Untersuchungen am Schwarzen Heilbutt (Reinhardtius hippoglossoides) im Jahre 1967 bei Island. Fischerei-Forschung, Bd.6, H.1.

PINHORN, A.T. 1975. Estimates of natural mortality for the cod stock complex in ICNAF divisions 2J, 3K and 3L. Res. Bull. Int. Commis. Northw. Atlant. Fish., No.11.

PINHORN, A.T., and WELLS, R. 1975. Virtual population assessment of the Southern Grand Bank cod stock (ICNAF Divisions 3N and 3O). Res. Bull. Int. Commis. Northw. Atlant. Fish., No.11.

PONOMARENKO, I.Ya. 1973. The effects of food and temperature conditions on the survival of young bottom-dwelling cod in the Barents Sea. Rapp. et proc.-verb. réun. Cons. perman. inter. explorat. mer, vol. 164.

REAY, P.J. 1973. Some aspects of the biology of the sandeel, Ammodytes tobianus L., in Langstone Harbor, Hampshire. J. Mar. Biol. Assoc. U.K., vol.53, No.2.

RICKER, W.E. 1973. Russian-English dictionary for students of fisheries and aquatic biology. Bull. Fish. Res. Board Canada, 183.

SONINA, M.A. 1969. Migrations of the Barents Sea haddock and factors determining them. Trudy PINRO, vyp.26.

SOROKIN, V.P. 1963. On the influence of fishery on the structure of golden redfish and beaked redfish populations. Materialy rybokhozyaistvennych issledovanii Severnogo basseina, sbornik 1.

SOROKIN, V.P. 1964. On a possible method of calculating the absolute abundance of the commercial population of Sebastes mentella Travin in the Barents Sea. Rapp. proc.-verb. réun. Cons. perman. internat. explorat. mer, vol.155.

TEMPLEMAN, W. 1965. Relation of periods of successful year-classes of haddock on the Grand Bank to periods of success of year-classes for cod, haddock and herring in areas to the north and east. ICNAF Spec. Publ., No.6.

TEMPLEMAN, W. 1972. Year-class success in some North Atlantic stocks of cod and haddock. ICNAF Spec. Publ., No.8.

TVEIT, S. 1971. Fluctuations in year-class strength of cod and pollack in south-eastern Norwegian coastal waters during 1920-1969. Fiskeridir. Skr., Ser. Havundersøkelser, vol.16, No.2.

ZASOSOV, A.V. 1970. Theoretical foundations of the fishery. Moscow.