Northwest Atlantic Fisheries Organization

Serial No. N2440 NAFO SCR Doc. 94/66

SCIENTIFIC COUNCIL MEETING - SEPTEMBER 1994

On Relation of Some Commercial Fish Species Year-classes Abundance and Hydrological Conditions in the Northwest Atlantic

by

Igor K. Sigaev and Vladimir A. Rikhter

Atlantic Scientific Research Institute of Marine Fisheries and Oceanography (AtlantNIRO)
5, Dm. Donskoy St., Kaliningrad, 236000, Russia

Abstract

Year-class abundance variations of silver hake, cod, pollock, haddock, herring and capelin in several NAFO subareas and interannual water temperature variability during 1977-1991 were discussed based on the hypothesis of oceanographic conditions impact on abundance of fish year-classes from different hydrological structures. The qualitative direct and inverse relation of the latter is revealed. It is assumed that the year-classes abundance of warm-water fish species is rather related to the warm water advection on the shelf, than to that of cold water. On the contrary the year-classes abundance of the cold-water fish species is related to the cold water advection.

Introduction

It is known, that commercial fishes abundance in fishing grounds of the World Ocean shows significant interannual variations. In conditions of optimal fishery, assuming no excessive removal, the above mentioned variations should be strongly related to the environmental conditions, the impact of which on the fish life cycle could be hardly overestimated.

Thus one of the most important tasks of the fishery oceanography is to reveal those conditions and particular environmental factors, directly or indirectly affecting the abundance of commercial fishes year-classes. The North-West Atlantic is the area of the most likely relation between fish year-classes abundance and environmental conditions (particularly oceanographic ones). This is stipulated by the fact, that the area is the location of interaction of the two strong boundary currents, which create hydrological fronts with extremely high temperature, salinity and other gradients, separating waters of different climatic zones. Those oceanographical peculiarities provide the extremely high biological productivity of the North-West Atlantic area, and, at the same time, may strongly affect the commercial fishes abundance and distribution, particularly near the boundery

of the area. Temperature is the most important factor of fishes life, as it determines the physical state of environment and appears to be the major ecological factor, affecting reproduction and survival at early stages (Rose, 1992; Myers and Drinkwater et al., 1992; Drinkwater and Myers, 1987), as well as qualitative and quantitative composition of food items and other elements of fish life cycle. It should be noted, that water temperature variations in the North-West Atlantic are mainly determined by advective processes, caused by the warm water northward transport by the Gulf Stream system and the cold water southward transport by the Labrador current system, which differed both in physical characteristics and biotopes. Taking into account those peculiarities, the attempt was made to compare interannual varaitions of some fish species year-classes abundance of the North-West Atlantic and interannual variations of the seasurface temperature and some indices of warm and cold waters advection in 1977-1991.

Materials and Methods

Temporal series of average annual sea surface temperatures by the squares of 2.5 x 2.5° obtained from average monthly data, presented by the Moscow Hydrometeocenter were used as materials. Indices of hydrological fronts location at the sea surface which were assumed to be the distance (in tens of miles) of hydrological frons northward of 37°N at each longitude between 59° and 65°W, were used as water advection indices. Those indices were obtained by averaging the data of 3-4 day canadian maps of hydrological fronts by a month and year over entire area from 59° to 65°W.

Data on year-classes abundance in the age of 1-3 years by several fish species and assessment methods were obtained from different sources, shown in Table 1. The mathods of year-classes abundance assessment include VPA, trawl and acoustic surveys.

The natural series of oceanographical indices and fish abundance utilized for the 15-years period from 1977 to 1991 were statistically treated by personal computer according to STATGRAPH programme.

Results and Discussion

Silver hake (4VWX). During the period of study the one-year hake abundance varied considerably. The lowest abundance amounted to 1.8×10^7 specimens was found in 1979, and the highest one of 55.2×10^7 sp. - in 1985. Comparison of young hake abundance and temperature and dynamic indices shows the direct relation to the latter (Fig. 1 A-C). The years of the most strong hake year-classes correspond to the years of the highest average annual SST and of the most northward shift of the cold shelf water boundary. The more close relation to SST is found at the Scotian shelf slope, where hake aggregarions are distributed in warm water of the slope during major part of a year. The comparison of one-year-old hake abundance to three hydrological predictors shows the most close correlation to the temperature of slope warm water (Fig. 1, B). The figure shows a beginning of SST

increase in 1991, which allows to expect an appearance of strong hake year classes in near future.

Cod (5Z). The strong inverse relation of one-year-old cod abundance of that subarea and SST in the Labrador current area (Fig. 1, D) is revealed. The highest cod abundance is found in the years of the lowest SST. The correlation coefficient value (o.48) shows the cold water advection impact on that stock reproduction. As is seen from Figure 1 D, the variability of cod abundance and sea-surface temperature has one peculiarity, i.e. before 1986 the inverse relation appeared every year, and variations of both parameters were rather sharp. Since 1986 the above mentioned "response" of cod abundance to SST variations ceased, and in 1986-1991 its values slightly differed from year to year and were close to minimum level. As Hunt and Buzeta (1992) show those years were characterized by the cod stock decrease in the area as a result of several poor year-classes appearance. The causes of those poor year-classes appearance seem to be related to some other conditions, not temperature, however as is shown in the Figure 1 D, the rise of the Labrador water temperature was found in those years. A preliminary conclusion could be made, that the decrease of the Labrador water temperature since 1990 permits to expect cod year-classes abundance increase in 5Z zone. The first year in this row is that of 1991.

Pollock (4-5). The interannual varaiations of three year-old pollock abundance also show the inverse relation to SST of Labrador water (r=-0.40), illustrated in Figure 1-E. Temporal series of abundance data is restricted by 1988 , and that of temperature - by 1991. The plots suppose that 3-year old pollock abundance was higher in 1989 than in 1988, decreased in 1990 and was considerably higher in 1991 than in 1990.

Haddock (4W). The one-year-old haddock abundance variability is correlated both to SST in the Scotian shelf area and to the advective index, i.e. to the cold shelf water bounder. Thus the years of the lowest abundance 1983-1986 and 1989-1991 correspond to the most pronounce northward shifts of the bounder (Fig. 1-F). The plots suppose that the haddock year-classes abundance will remain at relatively low level unless the cold water advection at the Scotian shelf increases after 1991.

Herring (4T). Unlike cod, pollock and haddock, the abundance of 2-year-old herring shows no marked relation to the temperature conditions, however, comparison of the abundance and the warm water advection (variations of the Gulf Stream front bounder) at the trend level during the entire period, revealed decrease of the warm water advection at shelf and slow growth of herring abundance (Fig. 1-G).

Capelin (3L). The abundance of 2-year -old capelin shows the most close relation (r=-0,65) to the temperature of Labrador water, as compared to the above mentioned cold water species (Fig. 1-H), however, it shold be noted, that the temporal series available are the most short one and the relation obtained is not considered a reliable one.

Thus, the analysis shows mainly the qualitative relation of year-classes abundance of some commercial fish species in the North-West Atlantic to temperature and advective factors considered. The relation revealed appeares a direct one for warm water species (silver hake) and an inverse one for cold water species (cod, haddock, pollock, herring and capelin). It seems that hake abundance variations is related rather to warm water temperature variations (slope water, the Gulf Stream) and its advection, than to Labrador water advection, while cod year-classes abundance is more close related to the Labrador current system variability. Templeman (1972) shows that strong year-classes of cod and haddock appear at moderately low temperatures in the area between the Georges Bank at the West and the Barents Sea at the East and the higher temperatures southwards should unfavourably affect the year-classes abundance. It is illustrated by haddock of the South Grand Bank, the abundance of which greatly depends on the climatic varaiability. As to silver hake of the Scotian shelf, it should be noted that the latter is a warm water species, as compared to cod and haddock, and distributs at the northern boundary of the area. Hence, we may suppose, that strong year-classes of the hake population concerned will appear mainly in the years of positive temperature anomalies. In any case, the results of the researches carried out are not contradicting to the above mentioned conclusions.

References

1. Annand C. and D.Beandlands. 1992. Assessment of Pollock (Pollachius virens) in Divisions 4VWX and Subdivision 5Z for 1--1. CAFSAC Research Doc. 92/44: p.

2. Claytor R.R., G.Nielsen, H.M.C.Dupuis and F.Mowbray, 1991. Assessment of Atlantic herring in NAFO Division 4T. CAFSAC Research Doc. 92/76: 88 p.

3. Drinkwater K.F. and R.A.Myers. 1987. Testing predictions of marine fish and shelffish landing from environmental variations. Journ.Fish.Aquat.Sci. 44: 1568-1573.

4. Hunt J.J. and M.I.Buzeta. 1922. Status of the Atlantic cod on Georges Bank in unit areas 5Zj and 5Zm, 1978-1991. CAFSAC Research Doc. 92/48: p.14.

5. Miller D.S. 1991. Observations and studies on SA2 + Div. 3K Capelin in 1911. CAFSAC Research Doc. 92/15: 18 p.

6. Myers R.A., K.Drinkwater, N.Barrowman. 1992. Cold water and recruitment in 2J3KL cod. CAFSAC Research Doc. 92/97: 13p.

7. Myers R.A., K.F.Drinkwater, N.J.Barrowman, J.Baird. 1992. The Influence of Salinity on Cod Recruitment in Newfoundland Region. CAFSAC Research Doc. 92/98: 22p.

8. Rose G.A. 1992. An Account of Annual Variability in 2J3KL Cod Trap Landings relative to Stock Biomass and Sea Temperature. CAFSAC Research Doc. 92/56: 10 p.

9. Templeman W. 1972. Year-class success in some North Atlantic Stocks of cod and haddock. ICNAF Spec.Publ. No. 8: 223-232.

10. Waldron D.E., M.A.Showell and M.C.Bourbonnais. 1992. Status of theScotian Shelf silver hake (whiting) population in 1991 with projections to 1993. NAFO SCR Doc. 92/50: 22 p.

11. Zwanenburg K. 1992. An assessment of eastern Scotian Shelf Haddock for 1992. CAFSAC Research Doc. 92/39: 42 p.

Table 1

Methods of fish year-classes abundance assessment (1-3 years) in NAFO zone

Species	Stock unit	Age	Method of assessment	Source
Silver hake	Scotian area	1	Trawl survey	Waldron et al., 1992
Cod	Georges Bank	1	VPA	Hunt and Buzeta, 1992
Pollock	New Scotland Georges Bank	3	Trawl survey	Annand and D.Beanland, 1992
Haddock	Scotian area	1	Trawl survey	Zwanenburg, 1992
Atlantic herring	Gulf of St.Laurence	2	VPA	Claytor et al., 1991
Capelin	Great Newfoundland Bank, 3	2	Acoustic survey	Miller, 1991

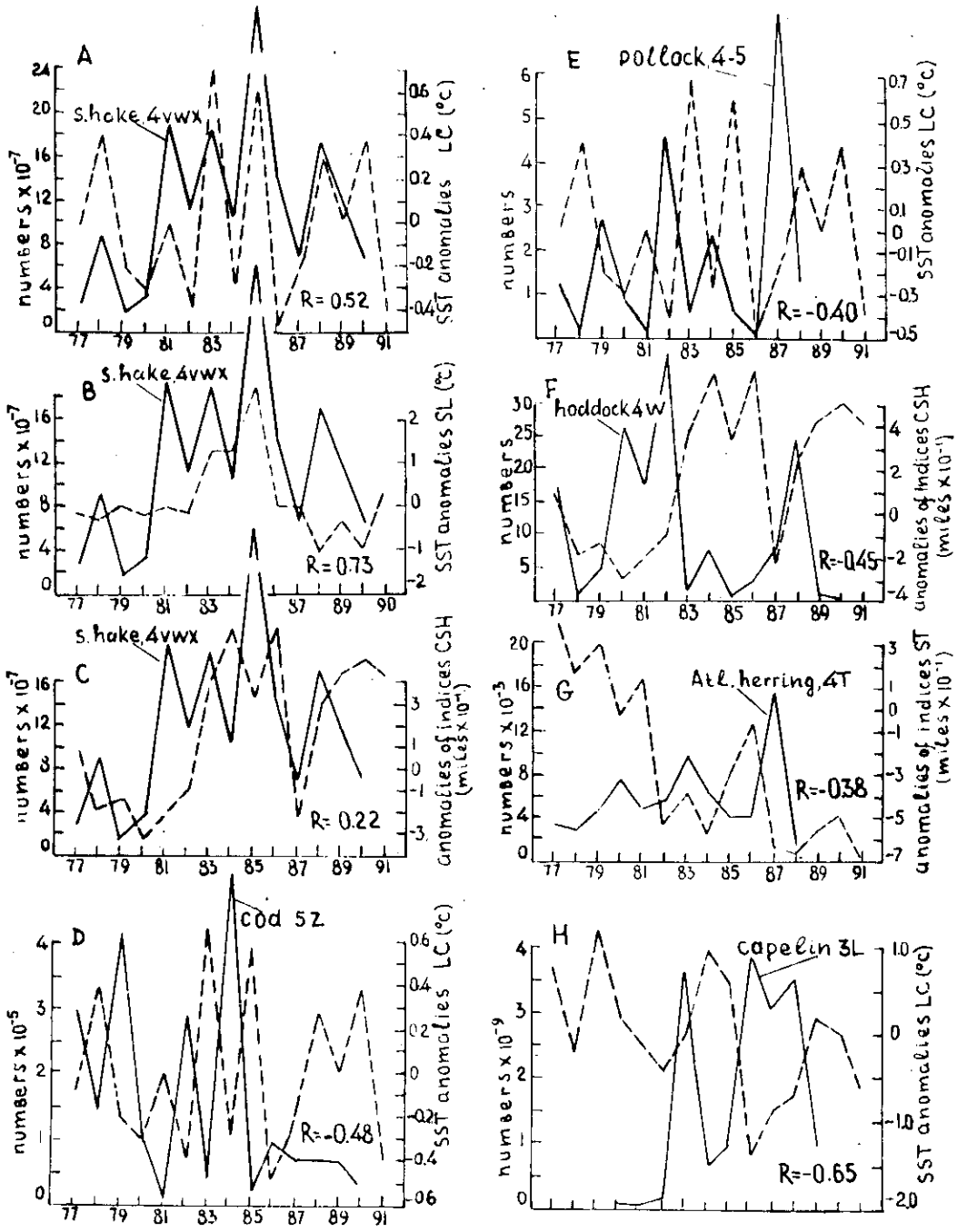

Fig. Interannual variability of some fish species year-classes abundance and hydrological conditions in the North-West Atlantic in 1976-1991.

Comments: SST - sea-surface temperature
LC - waters of the Labrador current
SL - slope waters
CSH - cold shelf waters
ST - water of the Gulf-Stream