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On the Relation Between Recruitment Dynamics of Some Fish Populations in the Northwestern Atlantic Ocean (NAFO Subareas 2-4)

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Abstract

The relation between recruitment dynamics of 12 fish populations in North-Western Atlantic (NAFO Subareas 2-4) is analyzed. In 19 cases of 66 significant correlations reliable at 95 and 99% probability has been revealed. The direct relation between cod 2J + 3 KL and 3NO and other gadoid populations of Nova Scotian area (Pollock 4VWX + 5Zc, cod 4VsW, haddock 4TVW) as well as the negative correlation between Greenland halibut 2+2KLMNO and cod 3NO, 4VsW and pollock seems to be of the most interest. On the basis of obtained results the possibility has been considered to reveal the current trends of recruitment dynamics in several stocks simultaneously in the cases when no reliable data is available on the year-classes appeared during the latest years of observations. Besides the opinion has been expressed that availability of stable relations mentioned above provides the basis of predicting the trends of respective populations biomass for several years in advance.

Introduction

In North-Western Atlantic (NWA) several commercial fish populations (stock units) are observed with strong ad even dramatic variability of abundance. As long-term observations show some stock units reveal almost synchronous fluctuations while the other have opposite ones. It is hardly an accidental event. Rather we may speak about the researched populations response to environment factors sufficiently affecting their year-classes abundance. Evidently, the above considerations are of speculative nature. However, the reliable data on the pattern of relation between various population abundance dynamics will undoubtfully promote the better understanding of some processes in NW Atlantic ecosystem (e.g. populations response to interannual variability of hydrometeorologic conditions, interspecies relations, etc.). In turn, the data obtained seem to be useful in developing recommendations for fish resources management in the area considered. In this work the attempt is made to assess statistically the degree of relation between 12 unit stocks abundance dynamics and to discuss the preliminary results in view of their potential utilization in prediction of the considered stocks dynamics during the first decade of XXI century.

Materials and Methods

Correlation coefficients were estimated in 12 stock units. The required information (year-classes abundance at respective age) was obtained from NAFO and Canadian Stock Assessment Secretariat scientific documents (Alpoim and Avila de Melo, 2000; Avila de Melo *et al*., 2000; Bowering *et al*., 2000; Cervino and Vazquez, 2000; Frank *et al*., 1997; Lilly *et a1*., 1999; Mohn *et a1*., 1998; Morgan *et al*., 1999; Nei1son *et al*., 1999; Showe11, 1997; Stansbury *et a1*., 1999; Wa1sh *et a1*., 1999).

Year-classes range of each population and age-groups abundance data of which were used in calculations are shown in the table below.

Stock Unit	Year-classes Range, Years	Recruitment Age, Year	Method of Year-class Assessment
Cod 2J+3KL	1981-95	2	Trawling surveys
Cod 3NO	1978-95	2	VPA
Cod 3M	1987-95	1	VPA
American plaice 3LNO	1978-92	5	VPA
American place 3M	1986-95	2	Trawling surveys
Yellowtail flounder 3LNO	1981-95	3	Trawling surveys
Greenland halibut 2+3KLMNO	1978-95	2	VPA
Redfish 3M	1985-95	4	VPA
Silver hake 4VWX	1978-95	1	VPA
Cod 4VsW	1978-95	1	VPA
Haddock 4TVW	1978-93	1	VPA
Pollock 4VWX + 5Zc	1980-95	2	VPA

Only abundance data of the same year-classes were compared in each pair of observations sets.

Results

Correlation coefficients are shown in Table 1. The relation reliable with probability 95 or 99% was observed in 19 cases out of 66. Besides, in 15 cases correlation was considerable ($0.5 < r > 0.7$) and in 4 cases it was strong ($r > 0.7$). Recruitment dynamics of the populations with significant relation revealed is shown in Fig. 1-19, which provide more evident idea of the relation and processes relevant to respective stock units dynamics during the years considered. The most interesting seems to be the positive relation between recruitment dynamics of cod 2J+3KL and 3NO and other gadoid populations in Nova Scotian area, i.e. much more southwards. The positive correlation between recruitment of American plaice 3LNO and gadoid stocks excluding silver hake 4VWX and cod 3M also should be noted. As regards the latter stock the lack of reliable relation to all stock units considered is likely explained primarily with too short observation series of its abundance (only 9 years). Silver hake is standing apart since its abundance dynamics seems to be determined by specific conditions of living on Scotian Shelf. A positive correlation is observed between pollock, cod 4VsW and haddock 4 TVW. The direct relation is traced in recruitment dynamics of Greenland halibut and yellowtail flounder, while the inverse relation is found between Greenland halibut and cod 3NO, 4VsW and pollock.

TABLE 1. Matrix of correlation coefficients between recruitment of 12 fish populations in NW Atlantic – (+) or (++) below a coefficient value means that this relation is reliable at 95 and 99% probability, respectively).

Unit Stock	Cod 2J+3KL	Cod 3NO	Cod 3M	American plaice 3LNO	American plaice 3M	Yellowtail flounder 3LNO	Greenland halibut 2+3KLMNO	Redfish 3M	Silver hake 4VWX	Pollock 4VWX +5Zc	Cod 4VsW	Haddock 4TVW
Cod 2J+3KL	1.000	0.679++	-0.072	0.440	0.266	-0.255	-0.433	-0.130	0.025	0.558+	0.704++	0.641++
Cod 3NO	0.679++	1.000	0.228	0.703++	0.552	-0.273	-0.499+	-0.135	0.052	0.683++	0.629++	0.762++
Cod 3M	-0.072	0.228	1.000	-0.147	0.539	-0.455	-0.598	0.124	-0.579	-0.168	-0.041	-0.615
American plaice 3LNO	0.440	0.703++	-0.147	1.000	0.869	0.095	-0.417	0.023	0.199	0.580+	0.562+	0.599+
American plaice 3M	0.266	0.552	0.539	0.869+	1.000	-0.016	-0.383	-0.108	-0.231	0.148	0.810++	-0.294
Yellowtail flounder 3LNO	-0.255	-0.273	-0.455	0.095	-0.016	1.000	0.652++	-0.180	-0.220	-0.360	-0.191	-0.084
Greenland halibut 2+3KLMNO	-0.433	-0.499+	-0.598	-0.417	-0.383	0.652++	1.000	-0.299	0.364	-0.580+	-0.495+	-0.232
Redfish 3M	-0.130	-0.135	0.124	0.023	-0.108	-0.180	-0.299	1.000	-0.385	0.301	-0.117	-0.448
Silver hake 4VWX	0.025	0.052	-0.579	0.199	-0.231	-0.220	0.364	-0.385	1.000	-0.151	-0.166	0.257
Pollock 4VWX+5Zc	0.558	0.683++	-0.168	0.580+	0.148	-0.360	-0.580+	0.301	-0.151	1.000	0.618+	0.656+
Cod 4VsW	0.704++	0.629++	-0.041	0.562+	0.810++	-0.191	-0.495+	-0.117	-0.166	0.618+	1.000	0.437
Haddock 4TVW	0.641++	0.762++	-0.615	0.599+	-0.294	-0.084	-0.232	-0.448	0.257	0.656+	0.437	1.000

Discussion

Availability of reliable correlation between recruitment dynamics of fish populations even of different species evidences apparently similar or opposite response to environment changes.

Let us see how can we interpret the results obtained in view of the better understanding of trends in dynamics of the stocks considered. Thus, having reliable data on recruitment dynamics trends of anyone population during the latest observation years we probably have the right to expect similar trends in other populations (during the same years) if significant correlation is found between recruitment of the first and other populations. Let us consider some stock units with such relation observed. At present we have no reliable data on year-classes recruitment of cod 2J+3KL, 3NO, 4VsW and pollock, appeared after 1996. At the same time we have sufficiently reliable data on appearance of average haddock year-classes in 1995-1997 and a strong-year-class in 1999 (DFO, 2000). On this basis it may be assumed that in the late 1990s the trend towards relatively strong year-classes formation has appeared also in other stock units. Certain indications of this are already available, e.g. on pollock (Neilson *et al*., 1999) and cod 3NO (NAFO, 2000). It should be noted that the late-1990s are marked with the warming process commencement covered NAFO Subareas 2, 3 and 4 (Drinkwater *et al*., 2000). We think that this event may to certain extent explain the above considerations. In this case several gadoid populations are likely to respond similarly to environment variations (water temperature increase). Another example: reliable direct relation is observed between Greenland halibut and yellowtail flounder. Abundance of Greenland halibut year-classes appeared after 1995 trends to reduction (Dowering *et al*., 2000). Thus it may be assumed that in the late 1990s yellowtail flounder recruitment dynamics was of similar pattern. At the same time the negative relation between Greenland halibut and cod 3NO, 4VsW and pollock suggest the idea that the warming process covering NW Atlantic now may negatively affect Greenland halibut year-classes abundance.

Conclusions

The researches carried out allows to reveal in some cases a reliable correlation (both positive and negative) between recruitment dynamics of fish populations even belonging to different species and distributed far from each other. Availability of statistically significant relation is likely to evidence a similar (or opposite) response to environment variability .The results obtained provide a possibility to reveal current trends of recruitment dynamics in several stock units simultaneously in the cases when reliable data on year-classes abundance appeared during the latest observation years are absent. Thus, based on the data on haddock 4TVW year-classes appeared during the late-1990s it may be assumed that the similar trend is observed during the same period in cod 2J+3KL, 3NO, 4VsW and pollock. The reliable negative correlation between recruitment of Greenland halibut and cod 3NO, 4VsW and pollock is the additional evidence of the fact that by the end of XX century the trend towards recruitment increase is likely to appear in the latter 3 stock units. If the relations revealed are sustainable, the possibility appears to predict trends in biomass dynamics of several populations simultaneously for several years ahead taking into consideration their maturation and full entering fishery age.

The results of researches carried out certainly need confirmation. As regards the approach used in this work it seems to be useful in study of some processes occurring in NW Atlantic ecosystem and in NAFO fishing resources management at multispecies level.

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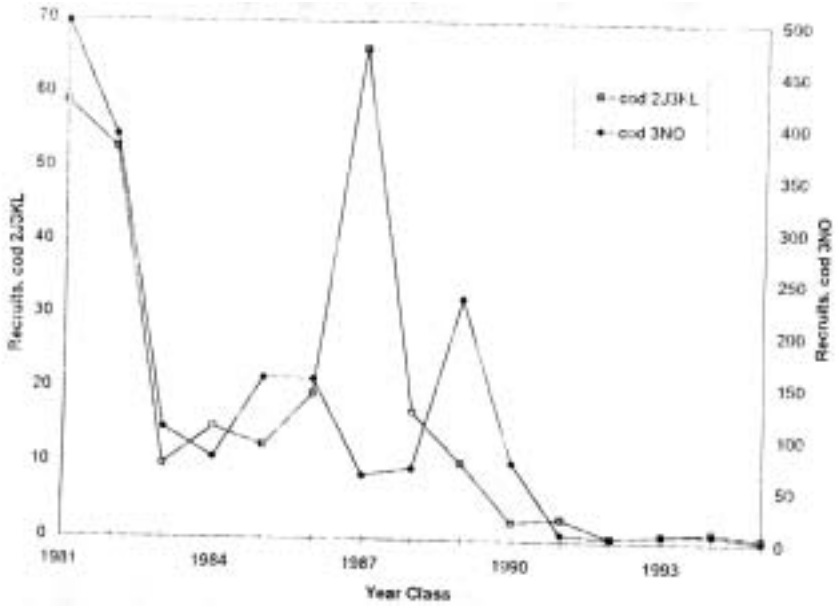

Fig. 1. Recruitment dynamics of cod 2J3KL and 3NO (1981-95 year-classes, r = 0.679).

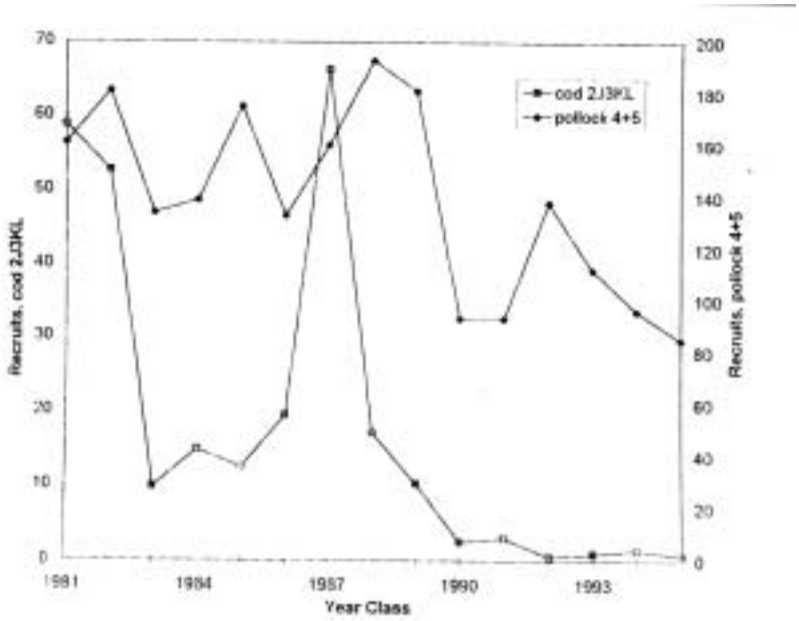

Fig. 2. Recruitment dynamics of cod 2J3KL and pollock 4VWX+5Xc (1981-95 year- classes, r = 0.558).

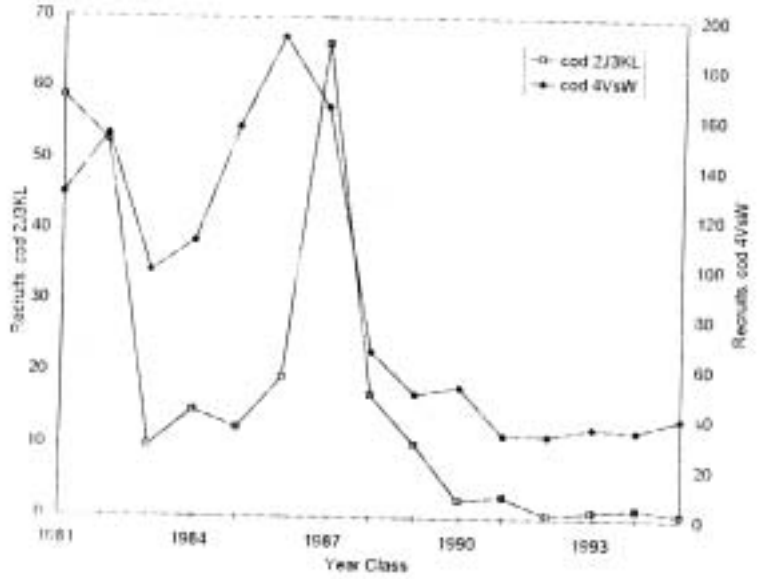

Fig. 3. Recruitment dynamics of cod 2J3KL and 4VsW (1980-95 year-classes, r = 0.704).

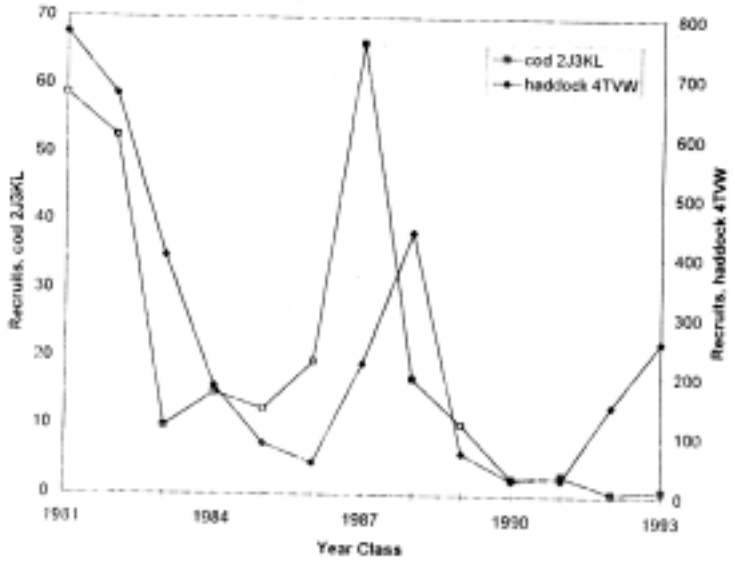

Fig. 4. Recruitment dynamics of cod 2J3KL and haddock 4TVW (1981-93 year- classes, r = 0.641).

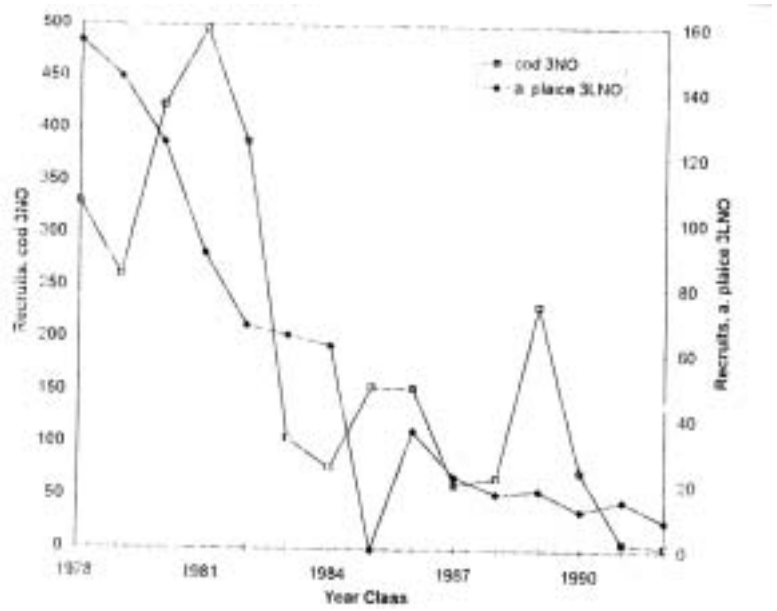

Fig. 5. Recruitment dynamics of cod 3NO and American plaice 3LNO (1978-92 year- classes, r = 0.703).

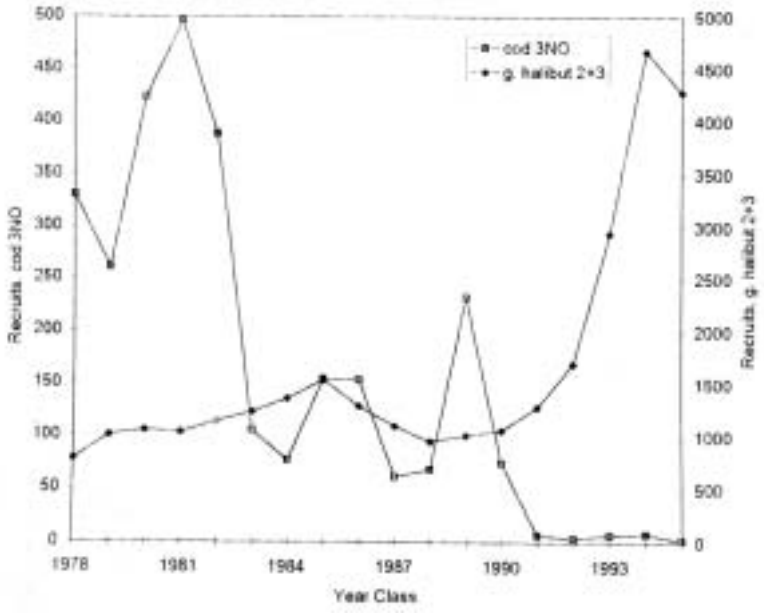

Fig. 6. Recruitment dynamics of cod 3NO and Greenland halibut 2+3KLMNO (1978- 95 year-classes, r = -0.499).

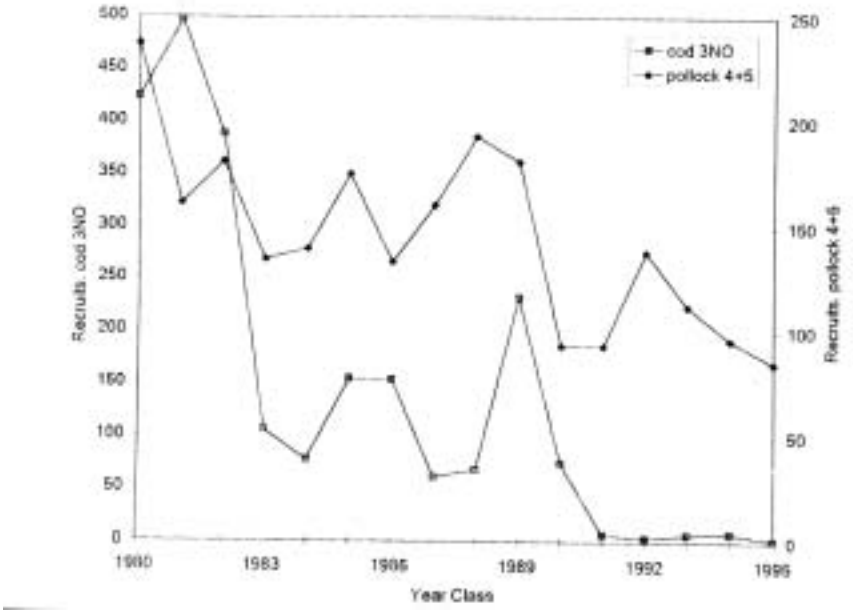

Fig. 7. Recruitment dynamics of cod 3NO and pollock 4VWX +5ZC (1980-95 year- classes, r = 0.683).

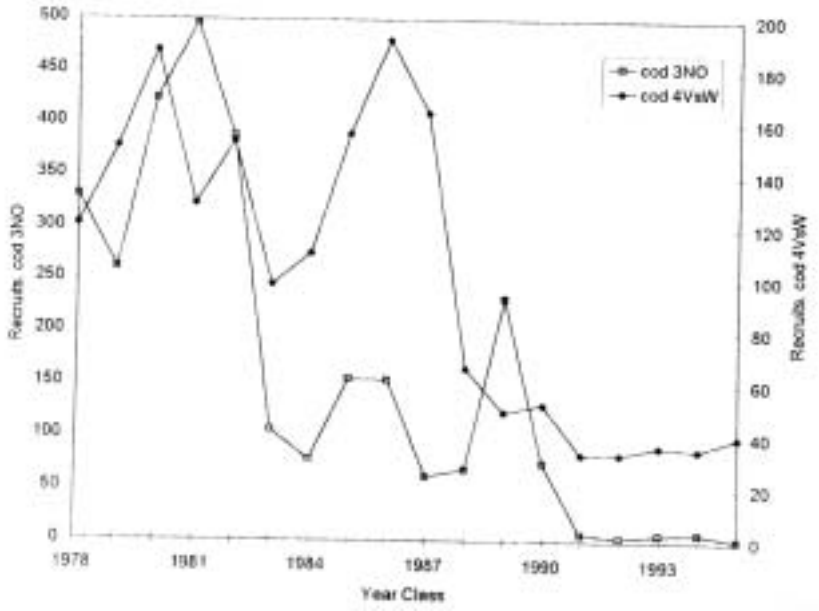

Fig. 8. Recruitment dynamics of cod 3NO and cod 4VsW (1978-95 year-classes, r = 0.629).

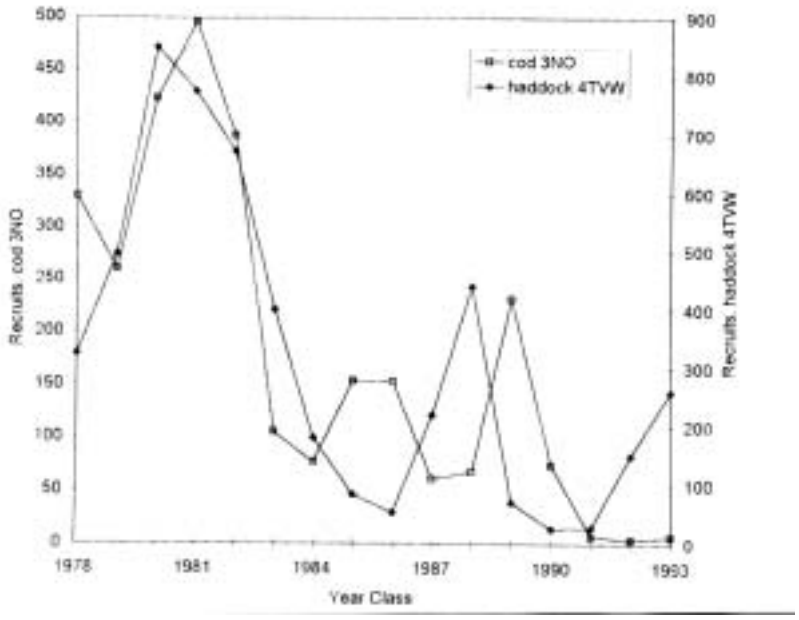

Fig. 9. Recruitment dynamics of cod 3NO and haddock 4TVW (1978-93 year-classes, r = 0.762).

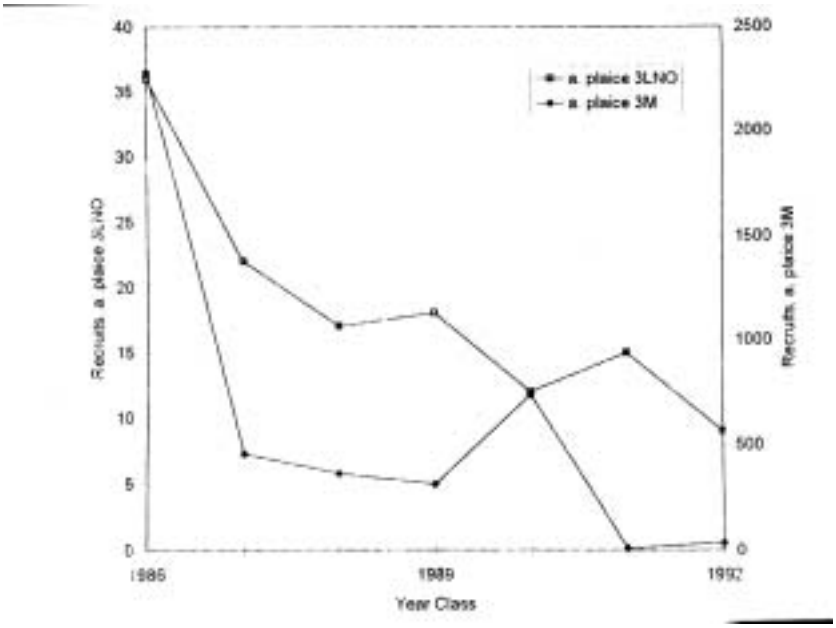

Fig. 10. Recruitment dynamics of American plaice 3LNO and American plaice 3M (1986-92 year-classes, r = 0.869).

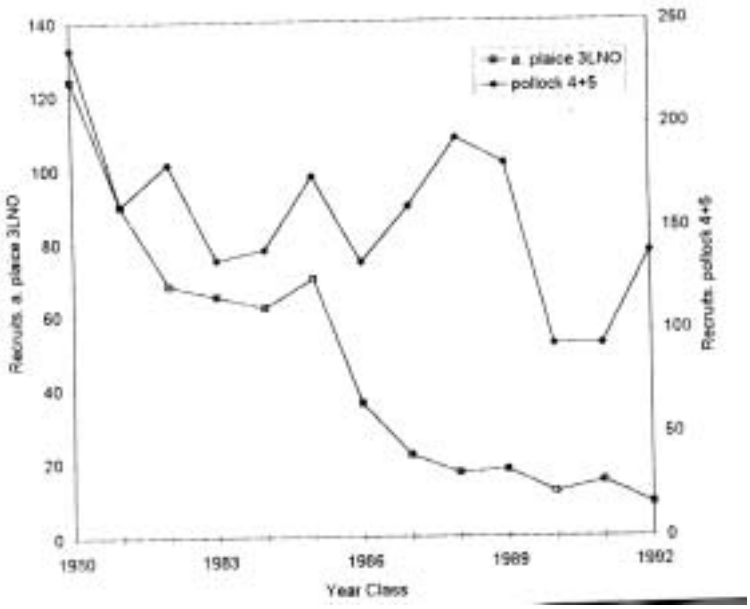

Fig. 11. Recruitment dynamics of American plaice 3LNO and pollock 4VWX +5Zc (1980-92 year-classes, r = .580).

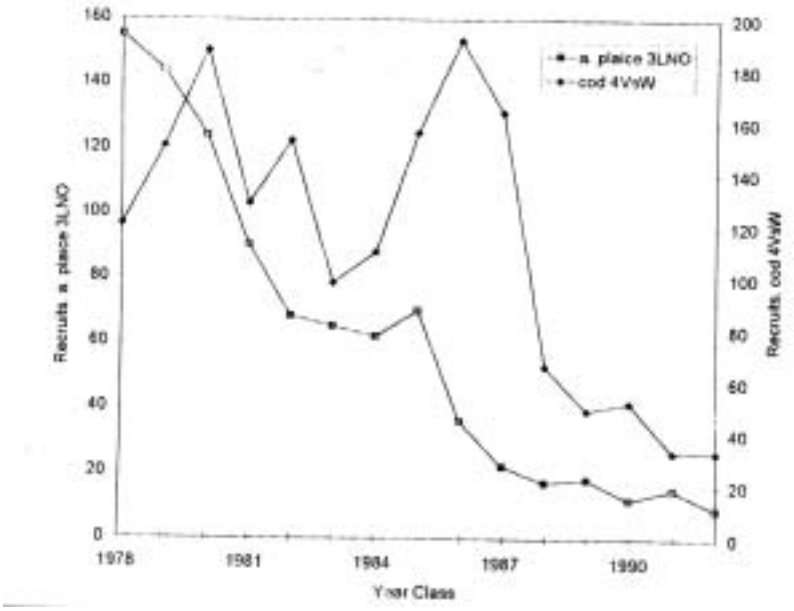

Fig. 12. Recruitment dynamics of American plaice 3LNO and cod 4VsW (1978-92 year-classes, r = 0.562).

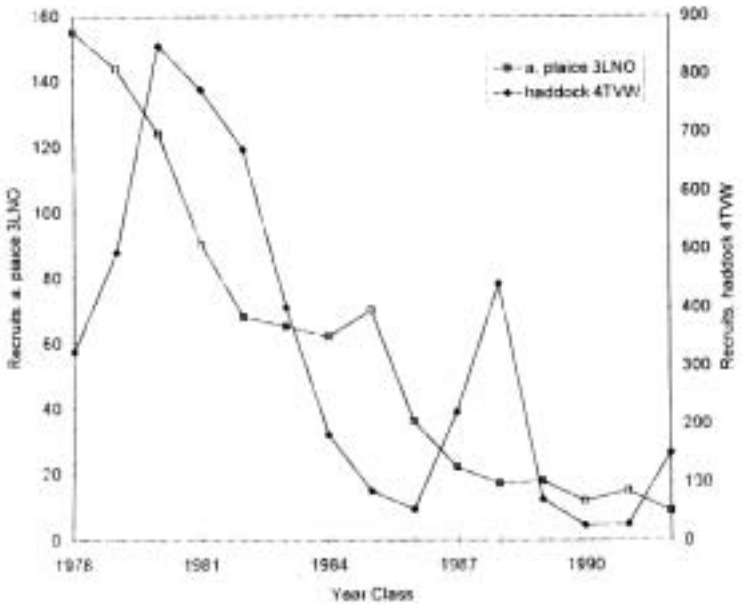

Fig. 13. Recruitment dynamics of American plaice 3LNO and haddock 4TVW (1978- 92 year-classes, r = 0.599).

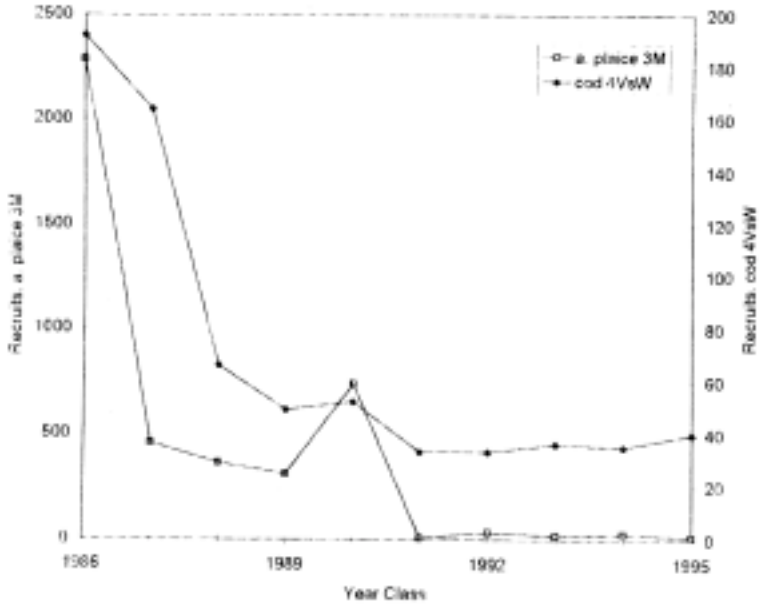

Fig. 14. Recruitment dynamics of American plaice 3M and cod 4VsW (1986-95 year- classes, r = 0.810).

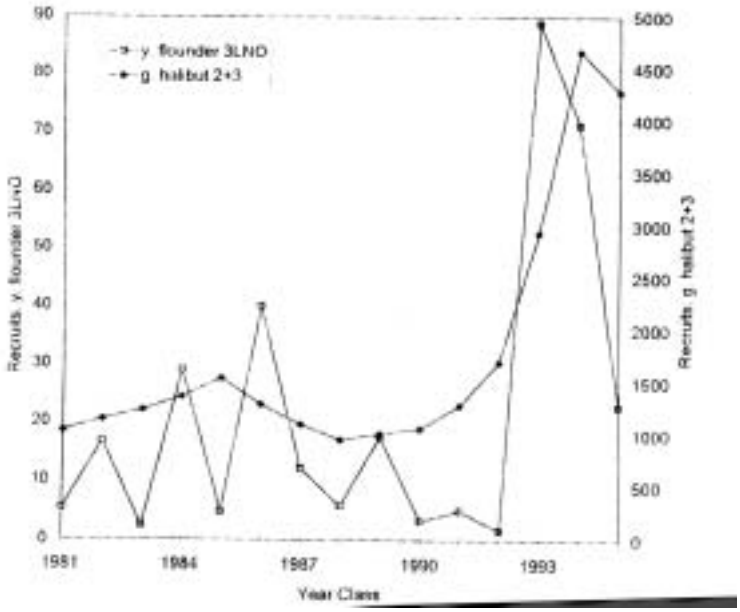

Fig. 15. Recruitment dynamics of yellowtail flounder 3LNO and Greenland halibut 2KLMNO (1981-95 year-classes, r = 0.652).

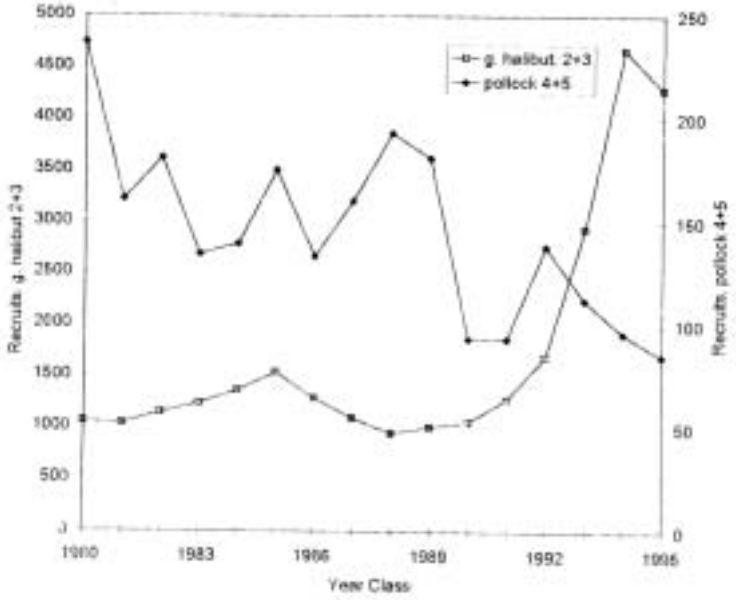

Fig. 16. Recruitment dynamics of Greenland halibut 2+2KLMNO and pollock 4VWX+5Zc (1980-95 year-classes, r =- 0.580).

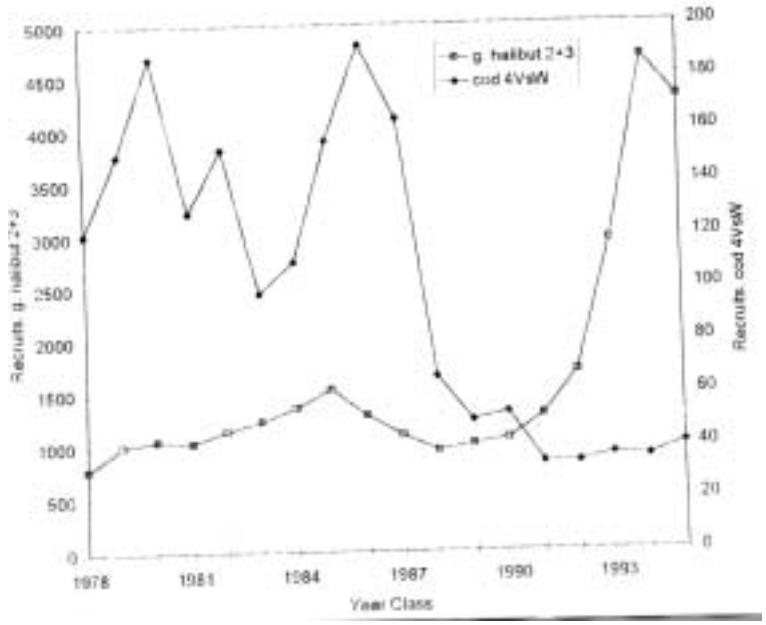

Fig. 17. Recruitment dynamics of Greenland halibut 2+3KLMNO and cod 4VsW (1978-95 year-classes, r = -0.495).

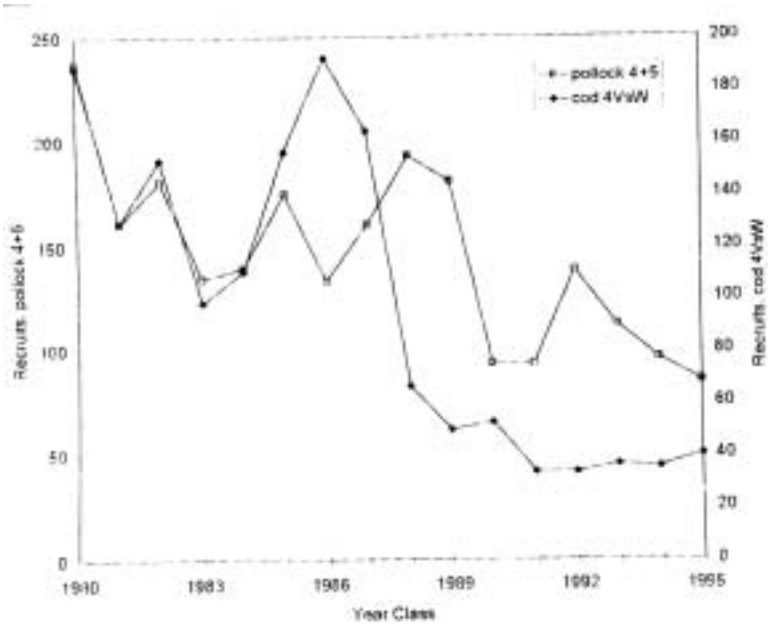

Fig. 18. Recruitment dynamics of pollock 4VWX+5Zc and cod 4VsW (1980-95 year- classes, r = 0.618).

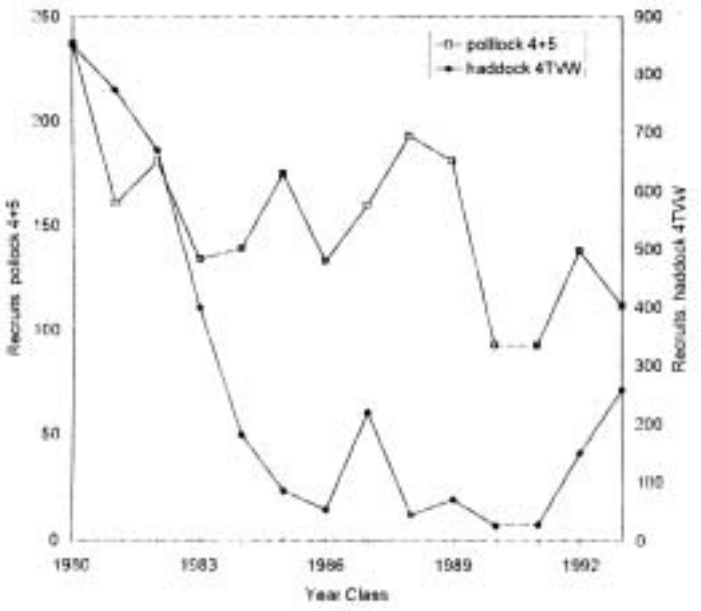

Fig. 19. Recruitment dynamics of pollock 4VWX+5Zc and haddock 4TVW (1980-93 year-classes, r = 0.656).