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Comparative analysis of year-classes strength of some commercial fishes in the Atlantic and Pacific Oceans and adjacent seas

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ABSTRACT

The comparative analysis of year-classes strength of 72 fish populations in the Atlantic and Pacific Oceans was carried out using the abundance criteria proposed in this study. The results obtained, at least concerning NAFO and ICES areas, evidence in favor of non-randomness of simultaneous occurrence of abundant and poor year-classes in fish populations, including populations of different species quite often separated by large distances. The years, when strong and weak year-classes appeared, were considered as the years with favorable and unfavorable environment conditions for year-classes abundance formation. The opinion has been advanced that similarity found sometimes in the abundance dynamics of several populations, was determined by common reasons and may be explained with the theory by G.K. Izhevskiy (1961, 1964), which relates fish reproduction and interdependency of hydro- and atmospheric processes. The attempt has been made to interpret the relationship between the number of cases of especially favorable and unfavorable conditions occurrence and the number of respective populations in the certain areas of the World Ocean as the indicator of fish stocks productivity increase and reduction.

Introduction

In our opinion, at present no appropriate attention is given to the subject indicated in the title of this paper, though it is directly related to the processes occurred in various areas of the World Ocean. Similar researches were carried out in restricted limits by some scientists in the middle of the last century (Cushing, 1975; Tåning, 1953; Templeman, 1965, 1972). These researches were focused at populations of cod, haddock and herring in the North Atlantic Ocean. The obtained results, which were actually based on the analysis of 10 populations only, indicated that in some years strong year-classes appeared in 9 populations simultaneously. Since then much water has flowed under the bridges, however, researches of this subject are still very important. The purpose of this study was to reveal populations with simultaneous (in the same year) appearance of strong (or weak) year-classes and on this basis to attempt distinguishing the years, when the environment conditions seems to be especially favorable (or unfavorable) for year-classes abundance formation in some fish populations.

Material and Methods

Retrospective estimates of year-classes abundance (the year-classes entering fishery for the first time) obtained from NAFO scientific documents, ICES Working Groups Reports and the data base created by the Canadian scientist R.A. Myers, Department of Biology, Dalhousie University, Halifax, Canada, http://fish.dal.ca/welcome.htlm) were used as the source material. The authors had got in all the data for 72 fish populations including 44 species. The list of species and populations and the respective sources of information are presented below. The Roman figures and letters after the species names denote ICES and NAFO statistical areas.

Populations (unit stocks)	Sources
North-Western Atlantic Ocean (NAFO area)	**NAFO scientific document**
Cod (*Gadus morhua*), 2J+3KL	Baird and Bishop, 1986
Cod, 3NO	Morgan et al., 2007
Greenland halibut (*Reinhardtius hippoglossoides*), 2+3	Healy and Mahe, 2005
American plaice (*Hippoglossoides platessoides*), 3LNO	Dwyer et al., 2007
North-Eastern Atlantic Ocean, Arctic, North and Baltic Seas (ICES area)	**ICES Reports**
Cod, I and II	ICES, 2006a
Haddock (*Melanogrammus aeglephfinus*), I and II	
Pollock (*Pollachius virens*), I and II	
Greenland halibut, I and II	
Cod, 347d	ICES, 2006b
Haddock, IV and IIIa	
Pollock, IV, VI and IIIa	
European plaice (Pleuronectes platessa), North Sea	
Cod, 25-32	ICES, 2006c
Norwegian spring-spawning herring (Clupea harengus)	ICES, 2007a
North Sea herring	ICES, 2007b
Atlantic herring, VIa (S) and VIIbc	
Western Baltic herring, IIIa and 22-24	
European pilchard (*Sardina pilchardus*), VIII and IXa	ICES, 2007c
Atlantic mackerel (*Scomber scombrus*), NEA	

Below the list of populations is presented, the respective information for which is available in the Mayers' data base freely assessable at the address indicated above.

Cod, NAFO 3M
Cod, NAFO 3Ps
Cod NAFO 4RS
Cod, NAFO 4VsW
Cod, NAFO 4X
Cod, NAFO 5Z
Haddock, NAFO 4TVW
Haddock, 5Ze
Silver hake *(Merluccius bilinearis*), NAFO 4VWX
Silver hake, NAFO 5Ze
Silver hake, NAFO 5Zw+6
White hake (*Urophycis tenuis*), NAFO 4T
Yellowtail flounder (*Limanda ferruginea*), NAFO 5Zw+6
Atlantic mackerel, NAFO 2-6
Beaked redfish (Sebastes mentella), NAFO 3M
Striped bass (*Morone saxathilis*), the USA eastern cost
Red porgy (*Pagrus pagrus*), the USA eastern cost
Dogfish (*Squalus acanthias*), NAFO 4-6
Lane snapper (*Lutjanus synagris*), Cuba area
Bluefish (*Pomatomus saltatrix*), the USA eastern coast
Weakfish (*Cynoscion regalis*), the USA eastern cost
Cod, (Iceland area)
Whiting (*Merlangus merlangus*), ICES IV and VIId
Common dab (*Limanda limanda*), ICES (the Belt Sea)
Norwey pout (*Trisopterus esmarkii*), ICES (the North Sea)
Capelin (*Mallotus villosus*), ICES (the Barents Sea)

Capelin, ICES (Iceland area)
Blue whiting (*Micromesistius poutassou*), ICES (the northern part)
Atlantic herring, ICES VIa (the northern part)
Cape hake (*Merluccius capensis*), South Africa area
Pacific hake (*Merluccius productus*), the western coast of Canada and USA
Walleye pollock (*Theragra chalcogramma*), the eastern Barents Sea
Pacific code (*Gadus macrocephalus*), the western coast of Canada
Longhead dab (*Limanda proboscidea*), the shelf of western Kamchatka
Sakhalin sole (*Limanda sakhalinensis*), the shelf of western Kamchatka
Yellowfin sole (*Limanda aspera*), the shelf of western Kamchatka
Alaska plaice (*Pleuronectes quadrituberculatus*), the shelf of western Kamchatka
Flathead flounder (*Hippoglossoides elassodon*), the shelf of western Kamchatka
Rock sole (*Lepidopsetta bilineata*), the western coast of Canada
Greenland halibut, (Reinhardtius hippoglossoides) the eastern Bering Sea
Pacific halibut (Hippoglossus stenolepis)
Black Sea turbot (*Psetta maeotica*), the Black Sea
Pacific ocean perch (*Sebastes alutus*), the USA western cost
Pacific ocean perch, the Aleutian Islands area
Thornhead (Sebastolobus alascanus), Alaska Gulf
Chillpepper rockfish (*Sebastes goodei*), the USA western cost
Sablefish (*Anaplopoma fimbria*), the USA western cost
Atka mackerel (*Pleurogrammus monopterygius*), the eastern Bering Sea
Pacific herring (*Clupea pallasii*), the eastern Bering Sea
Chub mackerel (*Scomber japonicus*), Japan area
Peruvian anchovy (*Engraulis ringens*), Peru area
Southern blue whiting (*Micromesistius australis*), New Zealand area
Cape horse mackerel (*Trachurus capensis*), South Africa area
Marbled notothenia (Notothenia rossi), South Georgia area

The deviations from the long-term mean abundance were used as the criteria, which allow to judge the year-classes strength. Depending on the value of deviation to any side, the year-class strength was denoted by 0 (zero), + (plus) or – (minus). For the more accurate assessment of year-classes strength several categories were introduced, and each category corresponded to a certain range of percent deviations. The brief characteristic of the above said criteria are presented in Table 1 below.

Table 1. Criteria of year-classes abundance

Category of year-classes abundance (strength)	Deviations from the long-term mean , %	Symbols
Medium	±20	0
Moderately high	21-50	+
Moderately low	21-50	-
High	51-80	++
Low	51-80	--
Very high	>80	+++
Very low	>80	---

The ranges were selected not quite random but in such manner that each range includes sufficient number of fish year-classes of different populations and species. This condition is necessary to improve reliability of the results obtained at least at the qualitative level. As far as is known, this kind of classification has not been used in the comparative analysis of year-classes strength before. Besides, only the cases of strong year-classes appearance were considered, while research of weak year-classes formation is not less important objective.

Results and Discussion

Year-classes strength of considered fish populations by years

The above said criteria applied to the source data allowed to present the year-classes abundance in the form of Table 2, which is rather cumbersome, however, contains all required information for subsequent analysis.

In the information presented some populations (and they are not few) with alternate series of abundant and poor year-classes are attracting attention. At the same time, the duration of continuous occurrence of the latter attains sometimes 20 years. It is interesting, that periods, when strong year-classes appeared, were much shorter. It is unlikely that the number of years with environment conditions unfavorable for young fish survival considerably exceeded the number of years with favorable conditions. Therefore, the reasons of the disproportion observed should be searched somewhere else. Probably, in the cases, when the spawning biomass decreases too much, the relationship stock-recruitment begins to act preventing the recovery process even during relatively favorable (medium) environment conditions for young fish survival (Rikhter, 2009). Recall the recent event of several cod stocks collapse in the North-West Atlantic Ocean during the early 1990s in NAFO subdivisions 2 and 3 (Southern Labrador and Grand Newfoundland Bank). During that period a sharp cooling occurred in the indicated areas, which caused the above said collapse. However, starting from 1995 the trend towards warming appeared (Drinkwater et al., 1996). Nevertheless, cod populations continued to be recruited with extremely weak year-classes at least during another 8-10 years. As regards the largest stock of this species (2J+3KL), even at present no clear evidences of its abundance recovery are observed (DFO, 2009). Rikhter (2009) informed about several populations mainly from the North-West and North-East Atlantic Ocean, in which the pattern of stock-recruitment relationship assumed the high probability of the long-term period of abundance depression after the sharp reduction of the stock spawning component.

Now let us consider the number of cases of simultaneous appearance of strong and very strong year-classes (++, +++) and weak and very weak year-classes (--, ---) by years without allocation by areas (Table 3, 4).

The data presented indicate that the highest number of strong year-classes occurred in 1962-1963, 1974-1978, 1981 and 1983-1985. Most of weak year-classes appeared in 1966-1967, 1971 – 1997, 1974-1989 and 1991-1995. The record long interval was between 1974 and 1989 (16 years), which could be hardly explained by a simple coincidence.

Now let us see, in which populations and species and in what years the highest number of strong and weak year-classes appeared simultaneously. We consider the cases when these strong and weak year-classes constituted not less than 30% of the total population number (Tables 5 and 6).

The large difference between the number of years (3 and 10, respectively) satisfying the above condition in Tables 5 and 6 is surprising. Again the impression appears that the environment factors unfavorable to young fish survival occurred much more frequently than the favorable factors. However, this impression may be wrong. Earlier the assumption has been made that the pattern of the stock-recruitment relationship played an important role in such distribution of years with strong and weak year-classes. As regards the simultaneous appearance of very strong or very weak year-classes, the coincidence level of 30% and more seems sufficiently significant to assume the impact of a certain climatic factor (factors) common to several populations. Strangely enough that until recently the research of these aspects has not been generally recognized, in spite of its importance especially in terms of the rational exploitation of fish resources. If we take into consideration the regional representation of populations in Tables 5 and 6, the apparent predominance of the populations from the North Atlantic Ocean and Arctic is evident (ICES and NAFO areas). Most probably, that at least in the indicated areas the abundance dynamics of sufficiently large number of fish populations was determined basically by the same factors.

Here it is reasonable to mention the study by G.K. Izhevskiy (1961, 1964), who for the first time applied the systems approach to the analysis of events connecting fish reproduction and interrelation of hydro- and atmospheric processes. His researches were devoted to the processes occurred in the North Atlantic Ocean and the inland seas of the USSR. G.K. Izhevskiy (1961) made the following conclusion: "The fact of primary importance is that all the northern European seas (Barents, Norwegian Seas) and continental seas (Baltic, White, Black, Azov, Caspian and Aral seas) are connected with each other by the uniform system of hydro- and atmospheric interrelations realized through the atmospheric circulation, therefore, the pattern of their regime elements fluctuations in time are the same for all seas indicated". As regards fluctuations of fish year-classes abundance, T.F. Dementyeva (1976) agreed with G.K. Izhevskiy in principle, noting that the rhythm of the above mentioned fluctuations is determined by the reproduction conditions, which in many cases are related to the common sources. At the same time, the lack of coincidence of cycles with climatic variations of interrelated systems observed sometimes in no way disproves the above made conclusion, which most likely may be extended to the entire North Atlantic Ocean (including NWA) and probably to other areas of the World Ocean.

Environment conditions and year-class abundance

It is hardly doubtful that year-class abundance fluctuations by years are primarily determined by the variations of young fish survival conditions at early development stages, i.e. mainly at the first year of life, while the factor of density dependence is a secondary one (Rikhter, 2009). Combining respective abiotic and biotic factors in the term "environment conditions", we again address the data in Table 2 to distinguish the years with especially favorable and unfavorable conditions for formation of very strong and very weak year-classes (Tables 7, 8).

At first, it should be specify, what is understood under the term "special conditions". Sometimes, in order to avoid iterations, these conditions will be indicated as anomalous. In the first case the problem is solved simply. These include the conditions forming the year-classes with three pluses. It might seem that in the latter case it is reasonable to do the same. However, here the risk appeared to include in this category the years, when the environment conditions were not so bad, perhaps average for young fish survival, but extremely low abundance of the spawning stock prevented the formation of strong year-classes. Now consider the data of Table 2, where year-classes with three minuses in some populations appeared one after another during the periods of 10 years and more. Naturally, that in this situation it is simply impossible to avoid mistakes (overestimation) in determining the years with especially bad conditions. To reduce the number of mistakes, it was decided to refer to the very unfavorable category only the years in the first half of the indicated periods.

As could be expected, the number of years with special conditions appeared not very significant. However, in the data presented several peaks may be seen. In Table 7 the following years may be referred to such peaks: 1962-1963, 1973, 1976-1977 and 1983, while in Table 8 these are 1967, 1976, 1986-1987 and 1992-1994.

Now let us consider the relationship between the number of the cases indicated and populations by areas of the World Ocean for the entire observation period (Tables 9, 10). In this respect, the relationship between the first and the second indices, which could be interpreted as the coefficients of increase and reduction of fish stocks productivity (Cip and Crp) in the indicated areas. The higher these coefficients, the higher seems to be the potential recovery (increase) and reduction of the considered populations abundance.

Now let us try to compare Cip and Crp for ICES and NAFO areas. It is hardly reasonable to do the same for other areas in view of scarce data available. As may be seen, the first coefficient values are higher than these of the second. However, taking into account the above mentioned uncertainties, the latter values may appear underestimated. Most probably, that in the long-term aspect the indicated potentials approximately balance each other. Certainly, the anthropogenic impact may introduce certain corrections to the worse.

In conclusion, let us see, in which populations the year-classes marked with three pluses and three minuses appeared in the years with conditions especially favorable and especially unfavorable for their abundance formation (Tables 11, 12).

As is evident from the data presented, anomalous environment conditions were frequently observed not as individual isolated cases, but as the periods of two and more years in duration. This feature was most pronounced in populations, for which sufficient long data series are available. Certainly, there is nothing unusual in the fact that favorable or unfavorable environment factors are acting for sufficiently long time periods. However, inclusion of the shorter periods with anomalous conditions into these long time intervals seems to deserve attention in the terms of investigation of environment impact on the dynamics of fish population abundance. Here again the question appears whether the above mentioned conditions could occur in different areas of the World Ocean during the same year and facilitate the simultaneous formation of very strong or very weak year-classes in several populations, which not always belongs to the same species.

Let us make a small sample from the latter two tables, selecting years with especially favorable (+++) and especially unfavorable (---) conditions for year-classes abundance formation in most populations (Table 13).

As can be seen, in some years the number of populations, in which very strong and very weak year-classes appeared simultaneously, increased sharply. At the same time, in 1977 the populations prevailed (7 out of 11), which inhabit the areas of the World Ocean other than the North Atlantic. Probably, though infrequently, the environment conditions may synchronously affect the formation of some fish population abundance on the global scale. As regards the years, when very weak year-classes were observed, it is difficult to make any definite conclusions in view of insufficient data available. However, it is possible to assume that the above made conclusions are true in this case also.

Conclusion

The study results fully agree with the data by Tåning (1953) and Templeman (1965, 1972) being the evidence of non-random simultaneous appearance of very strong and very weak year-classes in several fish populations, including various species from NAFO and ICES areas (NWA, NEA and Arctic). As regards the similar coincidences on the global scale, it may be assumed on the basis of the results obtained, that the formation of very strong and very weak year-classes, though in rare instances, occurred due to climatic changes affecting similarly the dynamics of some populations abundance. Here the case in point is the systems approach to the analysis of events, connecting fish reproduction and interrelation of hydro- and atmospheric processes (Izhevskiy, 1961, 1964). Though the subject of study by G.K. Izhevskiy included only the North-Eastern Atlantic Ocean and inland seas of the USSR, the ideas laid in his works seem to be extended to other areas of the World Ocean.

As a matter of fact, the data indicating the year, when strong and weak year-classes appeared, are the data on the years with favorable and unfavorable environment conditions for formation of the year-class abundance in fish populations. At the same time, according to the results obtained, the years with especially favorable and especially unfavorable conditions occurred not very seldom. Therefore, they may be indicated as anomalous only conditionally.

In our opinion, the coefficients representing the relationship between number of cases of "anomalous" conditions occurrence and the total number of populations considered in respective areas of the World Ocean deserves some attention. In some cases the above mentioned coefficients probably may characterize the potentials of fish stocks productivity. Thus, according to the data obtained, the potentials of fish population increase in the North-West and North-East Atlantic Ocean seem approximately similar, while the potentials of populations reduction were somewhat higher in the first area. The strongest depression of some populations abundance in the North-West Atlantic Ocean during the early 1990s confirms the above conclusion.

In general, it should be admitted that the data presented in this study concerning simultaneous appearance of "anomalous" environment conditions for year-classes abundance formation in fish populations in different areas of the World Ocean are, to considerable extent, the information for consideration. We think that the next step should include the development and implementation of the program of profound complex researches (oceanographic and biological) in the indicated direction.

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Table 2. Abundance of year-classes (recruitment) of commercial fish populations according to criteria selected

Year-classes	Cod 2J3KL NWA	Cod 3M NWA	Cod 3NO NWA	Cod 3Ps NWA	Cod 4X NWA	Cod 4VsW NWA	Cod 5Z NWA	Cod 347d North Sea	Cod 25-32 Baltic Sea	Cod NEA and Arctic
1962	++		+++	++	++	++		--		+
1963	+++		+++	++	+++	++		-		+++
1964	++		+++	+++	0	+		0	+	+++
1965	+		+++	+	0	++		0	+	--
1966	+		+++	0	0	+		0	+	---
1967	+		+++	-	-	0		--	0	--
1968	0		+++	0	+	0		--	0	-
1969	--		++	-	0	0		+	0	++
1970	--		0	-	-	0		+++	0	+++
1971	--		0	-	0	-		--	+	0
1972	--	+++	-	0	+	-		-	++	0
1973	0	+++	-	0	0	-		-	0	0
1974	-	0	+	+	+	0		+	0	-
1975	-	--	0	--	+	-		0	++	0
1976	--	---	-	---	0	-		+++	+++	--
1977	--	0	-	0	++	0	++	0	+++	--
1978	0	-	-	+	+		+	+++	+	--
1979	-	--	-	--	0	0	0	+++	+++	--
1980	0	0	0	+	+	0	+++	0	+++	--
1981	0	0	0	+	-	0	0	+	++	-
1982		-	0	0	-	-	-	-	0	0
1983		-	--	--	0	-	++	+++	0	++
1984		+++	---	-	-	--	--	--	0	--
1985		+++	--	0	+	--	+++	+++	+	--
1986		+++	--	0	0	--	0	-	-	--
1987		-	---	0	+	-	+	--	--	--
1988		0	---	--	--	--	0	0	--	-
1989		0	-	0	-	--	-	--	--	+
1990		+++	---		0	-	0	--	--	+
1991		+++	---		0		--	0	-	+
1992		---	---		0		-	--	--	0
1993		--	---				--	++	--	-
1994		---	---				--	-	--	0
1995		---	---				--	--	--	+
1996		---	---				-	+	-	0
1997		---	---				+	---	-	0
1998		---	---					--	-	0
1999			---					-	--	-
2000			---					---	--	0
2001			---					--	--	-
2002			---					---	--	0

Table 2. Continued

Year-classes	Cod 4Rs NWA	Cod Iceland Area	Cod Pacific Ocean	S. hake 4VWX NWA	S. hake 5Ze NWA	S. hake 5Zw+6 NWA	Cape hake Area off South Africa	Pacific hake
1962		+	+++	-	+++	+++		
1963		+	+	--	+++	+++		
1964		++	0	--	0	+++	0	
1965		0	++	--	-	+	-	
1966		+	--	-	-	0	-	
1967		0	-	0	-	-	-	
1968		0	0	+++	-	-	0	
1969		-	0	+	-	-	+	
1970		+	+	+	-	0	++	-
1971	0	0	0	+++	0	+	+++	--
1972	+	+	0	+	-	+	0	--
1973	+	+++	0	+	0	+	-	0
1974	++	-	0	++	-	0	-	--
1975	+++	0	0	0	---	--	-	--
1976	+	0	-	-	---	--	0	---
1977	+++	-	+	--	---	--	+	+++
1978	+	-	-	0	---	---	0	--
1979	0	-	-	-	---	---	0	--
1980	+	0	--	0	---	---	0	+++
1981	0	-	-	++	---	---	+	--
1982	0	-	-	0	--	--	0	---
1983	-	++	-	+	---	---	-	---
1984	--	++	+	-	--	---		+++
1985	--	0	+++	+++	-	--		---
1986	--	--	-	0	---	--		--
1987	-	-	-	-	---	---		+
1988	--	-		0				-
1989	--	0		-				---
1990	--	0		-				0
1991		--		-				---
1992		-		0				---
1993		0		-				+
1994		--		+				+
1995		-		+++				
1996								
1997								
1998								
1999								
2000								
2001								
2002								

Table 2. Continued

Year-classes	Pollock 4+5 NWA	Pollock NEA and Arctic	Pollock IV, VI, IIIa North Sea	Haddock 5Ze NWA	Haddocк NEA	Haddock IV, IIIa North Sea	White hake 4T, NWA	Blue whiting North Atlantic
1962		++		+++	-			
1963		-		++	+	---		
1964		0	-	0	++	--		
1965		-	-	---	---	-		
1966		++	+++	--	---	++		
1967		+	+++	---	---	+++	-	
1968		++	+++	---	0	--	-	
1969		0	0	---	-	--	-	
1970		0	0	---	+++	+++	-	+
1971		--	0	--	+	+++	-	+
1972		-	0	-	--	-	0	0
1973		+	+++	--	--	+++	+	0
1974		0	-	--	--	+++	+++	0
1975		-	-	+++	-	--	+++	-
1976		0	--	--	0	--	+	-
1977		-	--	---	-	-	0	-
1978		+	0	+++	---	-	0	0
1979		-	-	--	---	--	-	--
1980	+++	-	-	--	---	--	-	--
1981	+	--	+	---	---	0	-	--
1982	++	-	+++	---	+	-	-	+
1983	0	0	++	-	+++	++	0	+
1984	0	0	-	---	-	--		0
1985	+	--	-	--	--	-		-
1986	0	--	--	---	---	+		-
1987	++	--	-	-	---	---		-
1988	+++	+	0	---	-	--		-
1989	+	+++	-	---	0	--		+++
1990	-	++	0	---	+++	-		
1991	-	0	-	---	=	-		
1992	0	+++	+	--	--	0		
1993	-	0	-	--	--	--		
1994	-	0	0	--	-	+		
1995	--	-	--	--	--	--		
1996	--	++	0	--	+	-		
1997	-	-	-	--	--	--		
1998	0	0	+	--	+++	--		
1999	+	++	0		++	+++-		
2000	-	-	0		0	---		
2001	+	0	-		0	---		
2002	-	0	0		+	---		

Table 2. Continued

Year-classes	Southern blue whiting New Zealand	Walleye Pollock Pacific Ocean	Greenland halibut Arctic	Pacific halibut	Greenland halibut 2+3 NWA	Greenland halibut Bering Sea	Yellowtail flounder 5Zw+6 NWA	American plaice 3LNO NWA
1962			+++	-				+
1963			+++	-				0
1964		-	+++	-				0
1965		++	++	-				0
1966		0	+	-				+
1967		0	+	-				+
1968		+	+	-				++
1969		0	0	-		0		++
1970		-	0	-		-		+++
1971		-	0	-		0		++
1972		+	0	-		+++	+	+
1973		0	0	0		+++	--	+
1974		0	-	0	0	+	0	+
1975		-	-	0	0	+++	--	0
1976		-	-	0	0	+++	++	0
1977		0	-	0	-	+++	+++	0
1978	---	+++	-	0	0	+++	0	0
1979	++	-	-	0	0	0	+	0
1980	++	-	-	0	0	-	+++	0
1981	0	-	-	0	0	--	+++	0
1982	-	++	-		+	---	--	0
1983	-	--	0		+	--	-	0
1984	--	++	0		+	--	-	0
1985	--	-	-		++	0	--	0
1986	0	--	--		+	--	--	-
1987	--	-	--		0	--	+++	--
1988	+		-		0	--	-	--
1989	---		-		0	--	--	--
1990	-		-		0	-	---	--
1991	+++		-		-	--	---	--
1992	0		0		-	---	---	---
1993	--		-		+	---	--	---
1994			-		++	---	---	---
1995			-		+		--	---
1996			-		0			---
1997			-		0			---
1998			-		0			--
1999			-		0			--
2000			0		0			--
2001					0			---
2002					-			--

Table 2. Continued

Year-classes	European plaice North Sea	Yellowfin sole Western Kamchatka	Common dab Belt Sea	Black Sea turbot	Alaska plaice Western Kamchatka	Rock sole Western Kamchatka	Flathead flounder Western Kamchatka
1962	-		-			-	
1963	+++	--	+		0	-	++
1964	-	--	0		0	-	+
1965	-	--	-		0	-	0
1966	--	--	-		-	--	0
1967	--	-	-		-	---	0
1968	-	-	-	+++	+	---	-
1969	-	-	0	0	+	-	0
1970	--	-	0	+	0		0
1971	--	-	0	+	0		0
1972	+	-	0	++	0		0
1973	0	+	++	+++	-		0
1974	0	++	0	+++	0		--
1975	-	+++	-	++	+		0
1976	0	+++	0	++	++		0
1977	0	+++	0	+	0		0
1978	0	++	0	++	0		0
1979	0	+	++		0		+
1980	0	0	++		-		-
1981	+++	0			0		-
1982	+	+					-
1983	0						+
1984	++						
1985	++						
1986	+++						
1987	++						
1988	0						
1989	0						
1990	0						
1991	-						
1992	--						
1993	--						
1994	0						
1995	0						
1996	+++						
1997	--						
1998	-						
1999	+						
2000	-						
2001	+++						
2002	--						

Table 2. Continued

Year-classes	Longhead dab Western Kamchatka	Sakhalin sole Western Kamchatka	Atlantic herring North Sea VIa(N)	Atl. herring North Sea VIa(S), VIIbc	Baltic herring. 22-24	Atlantic herring southwards of 62ºN	Norwegian spring-spawning herring	Pacific herring Eastern Bering Sea
1962						+	---	-
1963	+++					++	++	--
1964	+					0	0	--
1965	0					-	---	--
1966	-					0	--	+++
1967	-					0	---	--
1968	-					-	---	--
1969	-	+		--		0	---	--
1970	-	+	0	0		0	---	---
1971	0	0	-	0		-	---	+
1972	+	-	-	-		--	---	0
1973	+	-	0	-		-	---	+
1974	--	0	+	--		---	---	--
1975	0	+	++	0		---	---	-
1976	0	++	-	-		---	---	+++
1977	0	-	0	+		---	---	+++
1978	0	-	-	+		--	---	+++
1979	+	-	0	-		--	---	--
1980	++	--	-	0		0	---	0
1981	0	---	+++	0		++	---	--
1982	---	0	0	+++		++	---	--
1983	0	+++	0	0		+	+++	--
1984			0			+++	---	---
1985			+++			+++	--	
1986			0			+++	---	
1987			+			0	---	
1988						0	--	
1989						0	-	
1990						0	0	
1991					+	++	+++	
1992					0	+	+++	
1993					-	0	+	
1994					++	0	--	
1995					0	+	---	
1996					0	-	-	
1997					0	-	--	
1998					+	+++	+++	
1999					++	0	+++	
2000					0	+++	-	
2001					0	0	--	
2002					-	--	+++	

Table 2. Continued

Year-classes	Beaked redfish 3M NWA	Pacific ocean perch Aleutian Islands	Pacific ocean perch Western USA	Chillpepper rockfish Western USA	Thornhead Alaska Gulf	Striped bass Eastern USA	Red porgy Eastern USA	Weakfish Eastern USA
1962		+++	+++		0			
1963		0	+++		0			
1964		-	++		0			
1965		--	0		0			
1966		--	0		++			
1967		0	--		++			
1968		++	0		0			
1969		--	---		0			
1970		--	+++	++	0			
1971		--	---	+++	0			
1972		-	-	-	-		++	
1973		--	--	+++	-		++	
1974		--	--	0	-		++	
1975		-	-	+++	-		+	
1976		+++	---	--	-		+	
1977		+	---	0	-		+	
1978		+++	--	--	-		0	
1979		--	-	++	-		0	
1980		0	--	-	+		0	
1981		+++	++	--	+	--	0	0
1982		--	--	---	+	--	0	0
1983		+++	--	--	+	--	0	0
1984		-	-	+++	0	-	0	+
1985	-	-	++	-	+	--	0	+
1986	-	+	---	+	0	-	0	0
1987	--	-	0	0	+++	-	0	-
1988	--	-	--	+	0	0	-	--
1989	+++	--		+	0	+	-	-
1990	+++			-	0	0	--	-
1991	--			0	-	0	---	0
1992	---			--	-	0		0
1993	---			++		+++		++
1994	---			--		0		0
1995	--			-		+++		+
1996	--			--				0
1997	--			-				0
1998	-							
1999	0							
2000	+							
2001	+++							
2002	+++							

Table 2. Continued

Year-classes	Bluefish Eastern USA	Atlantic mackerel 2-6 NWA	Atlantic mackerel NEA	Chub mackerel Japan Area	Cape horse mackerel South Atlantic	Capelin Barents Sea	Capelin Iceland Area
1962		--					
1963		---					
1964		---					
1965		---					
1966		--			---		
1967		0			---		
1968		+++			--		
1969		+			-		
1970		-			0		
1971		-		+++	0		
1972		-	-	+	0	+++	
1973		0	0	0	0	+++	
1974		0	0	---	-	+	
1975		--	+	-	0	+	
1976		---	+	---	+++	+++	
1977		---	--	-	+++	+++	+
1978		---	-	--	+++	++	--
1979		---	+	--	+++	++	--
1980		---	+	---	+	+	--
1981	+++	--	++	--	-	++	0
1982	++	--	--	--	--	++	0
1983	+++	+++	--	+++		-	+++
1984	+	--	++	+++		---	-
1985	0	--	-	0		---	0
1986	-	---	-	-		---	0
1987	0	---	+			---	-
1988	++	-	0			-	--
1989	-	++	0			+++	0
1990	-	+	-			0	0
1991	--	++	0			0	0
1992	--	+++	0			---	0
1993	-	--	+			---	++
1994	--	++	0			---	++
1995		+++	0			--	0
1996		+++	0				
1997		+++	-				
1998			-				
1999			-				
200			--				
2001			0				
2002			+++				

Table 2. Continued

Year-class	Lane snapper Cuba Area	Norway prout North Sea	Dogfish NWA	Peruvian anchovy	Atka mackerel Bering Sea	Sable fish Western USA	Marbled notothenia South Georgia
1962	-			0			
1963	-			++			
1964	0			0			
1965	0			+			
1966	0		--	+			
1967	+		-	++			
1968	0		---	++			
1969	+++		---	+++			0
1970	++		--	+			+
1971	++		-	--			++
1972	++		0	0			++
1973	0		0	--		0	++
1974	0	+	+	--		0	++
1975	-	++	--	--		-	0
1976	--	+	-	---		-	-
1977	--	-	--	---	+++	+++	--
1978		+	-	---	-	-	-
1979		++	0		--	+++	-
1980		-	0		--	-	-
1981		+++	++		--	+++	--
1982		++	---		-	-	
1983		0	++		0	-	
1984		-	++		++	-	
1985		-	+		+	++	
1986		0	+++		++	-	
1987		--	++		-	0	
1988		-	+++		+++	-	
1989		-			-	++	
1990		-			--	0	
1991		0			----	---	
1992		-			0	--	
1993		-			---	--	
1994						-	
1995						+	
1996						0	
1997							
1998							
1999							
2000							
2001							
2002							

Table 3. Number of cases of simultaneous appearance of strong and very strong year-classes (++, +++) in researched fish populations

Years	Number of cases	Number of populations	%%
1962	13	27	48,1
1963	17	34	50,0
1964	9	38	23,7
1965	5	39	12,8
1966	6	41	14,6
1967	5	43	11,6
1968	9	43	20,9
1969	5	47	10,6
1970	9	50	18,0
1971	8	52	15,4
1972	8	57	14,0
1973	10	58	17,2
1974	10	60	16,7
1975	10	58	17,2
1976	12	60	20,0
1977	13	63	20,6
1978	10	62	16,1
1979	9	59	15,2
1980	8	62	12.9
1981	14	63	22,2
1982	8	48	16,7
1983	15	46	32,6
1984	11	52	21,2
1985	11	54	20,4
1986	5	52	9,6
1987	5	51	9,8
1988	4	46	8,7
1989	6	44	13,6
1990	4	41	9,8
1991	5	40	12,5
1992	3	39	7,7
1993	5	37	13,5
1994	4	34	11,7
1995	3	31	9,7
1996	6	25	12,0
1997	1	24	4,2
1998	3	20	15,0
1999	5	18	27,8
2000	1	18	5,6
2001	2	18	11,1
2002	3	17	17,6

Table 4. Number of cases of simultaneous appearance of weak and very weak year-classes (--, ---) in researched fish populations

Years	Number of cases	Number of populations	%%
1962	3	27	11,1
19863	5	34	14,7
1964	5	38	13,2
1965	9	39	23,1
1966	11	41	26,8
1967	10	43	23,2
1968	8	43	18,6
1969	8	47	17,0
1970	8	50	16,0
1971	10	52	19,2
1972	5	57	8,8
1973	7	58	12,1
1974	11	60	18,3
1975	12	8	20,7
1976	17	60	28,3
1977	15	63	23,8
1978	14	62	22,6
1979	16	59	27,1
1980	13	62	21,0
1981	16	63	25,4
1982	18	48	37,5
1983	11	46	23,9
1984	14	52	,26,9
1985	14	54	25,9
1986	20	52	38,5
1987	17	51	33,3
1988	15	46	32,6
1989	12	44	27,3
1990	9	41	22,0
1991	13	40	32,5
1992	16	39	41,0
1993	17	37	45,9
1994	14	34	41,2
1995	15	31	48,4
1996	7	25	28,0
1997	10	24	41,7
1998	5	20	25,0
1999	3	18	16,7
2000	6	18	33,3
2001	6	18	33,3
2002	7	17	41,2

Table 5. Populations and years when the highest simultaneous occurrence (above 30%) of strong and very strong year-classes was observed

1962	1963	1983
Cod 2J3KL NWA	Cod 2J3KL NWA	Cod 5Z NWA
Cod 3NO NWA	Cod 3NO NWA	Cod 347d North Sea
Cod 3Ps NWA	Cod 3Ps NWA	Cod NEA and Arctic
Cod 4X NWA	Cod 4X NWA	Cod Island
Cod 4VsW NWA	Cod 4VsW NWA	Pollock IV, VI, IIIa North Sea
Cod Pacific Ocean	Cod NEA and Arctic	Haddock NEA
Silver hake 5Ze NWA	Silver hake 5Ze NWA	Haddock IV, IIIa North Sea
Silver hake 5Zw+6 NWA	Silver hake 5Zw+6 NWA	Sakhalin sole Western Kamchatka
Pollock NEA and Arctic	Haddock 5Ze NWA	Norwegian spring-spawning herring
Haddock 5Ze NWA	Greenland halibut Arctic	Pacific ocean perch Aleutian Islands
Greenland halibut Arctic	European plaice	Bluefish Eastern USA
Pacific ocean perch Aleutian Islands	Flathead flounder Western Kamchatka	Atlantic mackerel 2-6 C3A
Pacific ocean perch Western USA	Longhead dab Western Kamchatka	Chub mackerel Japan area
	Atlantic herring southwards of 62°N North Sea	Capelin Iceland area
	Norwegian spring-spawning herring	Dogfish NWA
	Pacific ocean perch Western USA	
	Peruvian anchovy	

Table 6. Populations and years when the highest simultaneous occurrence (above 30%) of poor and very poor year-classes was observed

1982	1986	1987	1988	1991	1992	1993	1994	1995	1997
Silver hake 5Ze NWA	Cod 3NO NWA	Cod 3NO NWA	Cod 3NO NWA	Cod 3NO NWA	Cod 3M NWA	Cod 3M NWA	Cod 3M NWA	Cod 3M NWA	Cod 3M NWA
S. hake 5Zw+6 NWA	Cod 4VsW NWA	Cod 347d North Sea	Cod 3Ps NWA	Cod 5Z NWA	Cod 3NO NWA	Cod 3NO NWA	Cod 3NO NWA	Cod 3NO NWA	Cod 3NO NWA
Pacific hake	Cod NEA and Arctic	Cod 25-32 Baltic Sea	Cod 4X NWA	Cod 3NO NWA	Cod 347d North Sea	Cod 5Z NWA	Cod 5Z NWA	Cod 3M NWA	Cod 347d North Sea
Haddock 5Ze NWA	Cod 4Rs NWA	Cod NEA and Arctic	Cod 4VsW NWA	Cod 5Z NWA	Cod 25-32 Baltic Sea	Cod 25-32 Baltic Sea	Cod 25-32 Baltic Sea	Cod 3NO NWA	Haddock 5Ze NWA
Greenland halibut Bering Sea	Cod Iceland	Silver hake 5Ze NWA	Cod 25-32 Baltic Sea	Cod Iceland	Pacific hake	Haddock 5Ze NWA	Cod Iceland	Haddock 5Ze NWA	Haddock NEA
Yellowtail flounder 5Zw+6 NWA	Silver hake 5Ze NWA	Silver hake 5Zw+6 NWA	Cod 4Rs NWA	Pacific hake	Haddock 5Ze NWA	Haddock CBA	Haddock 5Ze NWA	Cod 347d North Sea	Haddock IV, III North Sea
Longhead dab Western Kamchatka	S. hake 5Zw+6 NWA	Pollock NEA and Arctic	Haddock 5Ze NWA	Haddock 5Ze NWA	Haddock NEA	Haddock IV, IIIa North Sea	Greenland halibut Bering Sea	Cod 25-32 Baltic Sea	American plaice 3LNO NWA
Norwegian. spring-spawning herring	Pacific hake	Pollock NEA	Haddock IV, IIIa North Sea	G. halibut Bering Sea	Greenland halibut Bering Sea	Southern blue whiting New Zealand	Yellowtail. flounder 5Zw+6 NWA	Pollock 4+5 NWA	European plaice
Pacific herring Bering Sea	Pollock NEA and Arctic	Haddock IV, IIIa North Sea	Greenland. halibut Bering Sea	Yellowtail flounder 5Zw+6 NWA	Yellowtail flounder 5Zw+6 NWA.	Greenland halibut Bering Sea	American Plaice 3LNO NWA	Pollock IV, VI, IIIa North Sea	Norw. spring-spawning herring

Pacific ocean perch Aleutian Islands	Pollock IV, VI, IIIa North Sea	Southern blue whiting New Zealand	American plaice 3LNO NWA	American plaice 3LNO NWA	American plaice 3LNO NWA	Yellowtail flounder 5Zw+6 NWA	Norwegian spring-spawning herring	Haddock 5Ze NWA	Beaked redfish 3M NWA
Pacific ocean perch Western USA	Haddock 5Ze NWA	Greenland halibut Arctic	Norwegian spring-spawning herring	Beaked redfish 3M NWA	European plaice North Sea	American plaice 3LNO NWA	Beaked redfish 3M NWA	Haddock NEA	
Chillpepper rockfish Western USA	Haddock NEA	American plaice 3LNO NWA	Beaked redfish 3M NWA	Red porgy Eastern USA	Beaked redfish 3M NWA	European plaice North Sea	Chillpepper rockfish Western USA	Haddock IV, IIIa North Sea	
Striped bass Eastern USA	Walleye Pollock Pacific	Amer. Plaice 3LNO NWA	Pacific ocean perch Western USA	Sablefish Western USA	Chillpepper rockfish 3. USA	Beaked redfish 3M NWA	Bluefish Eastern USA	Norwegian spring-spawning herring	
Atlantic mackerel 2-6 NWA	Greenland. halibut Arctic	N. spring-spawning herring	Weakfish Eastern USA		Bluefish Eastern USA	Atlantic mackerel 2-6 NWA	Capelin Barents Sea	Beaked redfish 3M NWA	
Atlantic mackerel NEA	Greenland halibut Bering Sea	Beaked redfish 3M NWA	Capelin Iceland area		Capelin Barents Sea	Capelin Barents Sea		Capelin Barents Sea	

Chub mackerel Japan area	Y. T. flounder 5Zw+6 NWA	Atlantic mackerel 2-6 NWA			Sablefish Western USA	Atka mackerel Bering Sea			
Cape horse mackerel	Norwegian spring-spawning herring	Capelin Barents Sea				Sablefish Western USA			
Dogfish C3A	P. ocean perch Western USA	Norway pout North Sea							
	Atlantic mackerel 2-6 NWA								
	Capelin Barents Sea								

Table 7. Total number of cases, when especially favorable environment conditions for abundance formation of considered species year-classes occurred by years

Years	Number of cases	Years	Number of cases	Years	Number of cases
1962	**8**	1976	**8**	1990	3
1963	**11**	1977	**11**	1991	3
1964	5	1978	6	1992	3
1965	1	1979	2	1993	1
1966	3	1980	4	1994	1
1967	4	1981	6	1995	2
1968	6	1982	2	1996	2
1969	1	1983	**9**	1997	1
1970	6	1984	4	1998	3
1971	4	1985	6	1999	2
1972	3	1986	4	2000	1
1973	**8**	1987	2	2001	2
1974	3	1988	3	2002	3
1975	6	1989	4		

Table 8. Total number of cases, when especially unfavorable environment conditions for abundance formation of considered species year-classes occurred by years

Years	Number of cases	Years	Number of cases	Years	Number of cases
1962	1	1976	**8**	1990	2
1963	2	1977	1	1991	4
1964	1	1978	4	1992	**5**
1965	3	1979	2	1993	**5**
1966	3	1980	2	1994	**5**
1967	**5**	1981	3	1995	3
1968	3	1982	4	1996	2
1969	4	1983	1	1997	1
1970	3	1984	4	1998	-
1971	2	1985	2	1999	-
1972	1	1986	**5**	2000	2
1973	-	1987	**6**	2001	1
1974	2	1988	2	2002	2
1975	2	1989	3		

Table 9. Number of cases, when especially favorable environment conditions for abundance formation of some considered species year-classes occurred by the World Ocean areas

Area	Number of cases	Number of populations	Cip
NWA (NAFO)	54	20	2.70
NEA and Arctic (ICES)	60	21	2.86
Coastal area to the west of USA	10	3	3.33
Coastal area to the east of USA	4	4	1.00
Western Kamchatka	5	6	0.83
Bering Sea	12	3	4.00
Pacific Ocean	13	8	1.62

Table 10. Number of cases, when especially unfavorable environment conditions for abundance formation of some considered species year-classes occurred by the World Ocean areas

Area	Number of cases	Number of populations	Crp
NWA (NAFO)	43	20	2.15
NEA and Arctic (ICES)	33	21	1.57
Coastal area to the west of USA	7	3	2.33
Coastal area to the east of USA	1	4	0.25
Western Kamchatka	4	6	0.67
Bering Sea	8	3	2.67
Pacific Ocean	14	9	2.12

Table 11. Populations and years with especially favorable environment conditions for the year-classes abundance formation

Populations	Years							
Cod 2J+3KL NWA	1963							
Cod 3M NWA	1972	1973	1984	1985	1986	1990	1991	
Cod 3NO NWA	1962	1963	1964	1965	1966	1967	1968	
Cod 3Ps NWA	1964							
Cod 4X NWA	1963							
Cod 5Z NWA	1985							
Cod NEA and Arctic	1963	1964	1970					
Cod 347d North Sea	1970	1976	1978	1979	1983	1985		
Cod 25-32 Baltic Sea	1976	1977	1979	1980				
Cod 4Rs NWA	1975	1977						
Cod Iceland Area	1973							
Pacific cod	1962	1985						
S. hake 4VWX NWA	1968	1971	1985					
S. hake 5Ze NWA	1962	1963						
S. hake 5Zw+6 NWA	1962	1963	1964					
Cape hake SA	1971							
Pacific hake	1977	1980						
Pollock 4+5 NWA	1980	1988						
Pollock NEA and Arctic	1989	1992						
Pollock IV, IIIa North Sea	1966	1967	1968	1973	1982			
Haddock 5Ze NWA	1962	1975	1978					
Haddock IV, IIIa North Sea	1967	1970	1973	1974	1999			

Table 11. Continuation

White hake 4T NWA	1974	1975						
Blue whiting Northern Atlantic	1989							
S. blue whiting New Zealand	1991							
Walleye pollock Pacific Ocean	1978							
Greenland halibut Arctic	1962	1963	1964					
Greenland halibut Bering Sea	1972	1973	1975	1976	1977			
Yellowtail flounder 5Zw+6 NWA	1977	1980	1981	1987				
American plaice 3LNO NWA	1970							
European plaice North Sea	1963	1981	1986	1996	2001			
Yellowfin sole Western Kamchatka	1975	1976	1977					
Black Sea turbot	1968	1973	1974					
Longhead dab Western Kamchatka	1963							
Sakhalin sole Western Kamchatka	1983							
Atl. herring VIa(N) North Sea	1981	1985						
Atl. herring Via(S), VIIbc North Sea	1982							
Atlantic herring southwards of 62º N	1984	1985	1986	1998	2000			
Norw. spring-spawning herring	1983	1991	1992	1998	1999	2002		
Pacific herring Bering Sea	1966	1976	1977	1978				

Table 11. Continuation

Baked redfish 3M NWA	1989	1990	2001	2002				
Pacific ocean perch Aleutian Islands	1962	1976	1978	1981	1983			
Pacific ocean perch Western USA	1962	1963	1970					
Chillpepper rockfish Western USA	1971	1973	1975					
Thornhead Alaska Gulf	1987							
Striped bass Eastern USA	1993	1995						
Bluefish Eastern USA	1981	1983						
Atl. mackerel 2-6 NWA	1968	1983	1992	1995	1996	1997		
Atl. mackerel NEA	2002							
Chub mackerel Japan	1971	1983	1984					
Cape horse mackerel South Africa	1976	1977	1978					
Capelin Barents Sea	1972	1973	1976	1977	1989			
Capelin Iceland	1983							
Lane snapper Cuba	1969							
Norway pout North Sea	1981							
Dogfish NWA	1986	1988						
Peruvian anchovy	1963	1967	1968					
Atka mackerel Bering Sea	1977	1988						
Sablefish Western USA		1977	1979	1981				

Table12. Populations and years with especially unfavorable environment conditions for the year-classes abundance formation

Cod 3M NWA	1976	1992	1994	1995	1996		
Cod 3NO NWA	1984	1987	1988	1990	1991		
Cod 3Ps NWA	1976						
Cod 347d North Sea	1997	2000	2002				
Cod NEA and Arctic	1966						
S. hake 5Ze NWA	1975	1976	1977	1978	1979		
S. hake 5Zw+6 NWA	1978	1979	1980				
Pacific hake	1976	1982	1983	1985	1989		
Haddock 5Ze NWA	1965	1967	1968	1978	1979	1986	1987
Haddock NEA	1965	1966	1967	1978	1979	1986	1987
Haddock IV, IIIa North Sea	1963	1987	2000	2001	2001	2002	
Yellowtail flounder 5Zw+6 NWA	1990	1991	1992	1994	2001		
American plaice 3LNO NWA	1992	1993	1994				
European plaice North Sea	1967	1968					
G. halibut Bering Sea	1982	1992	1993	1994			
Rock sole Western Kamchatka	1967	1968					
Longhead dab Western Kamchatka	1982						
Sakhalin sole Western Kamchatka	1981						
Norw. spring-spawning herring	1962	1965	1984	1995			
Atl. herring southwards of 62N North Sea	1974	1975					

Table 12. Continuation

Pacific herring Eastern Bering Sea	1970	1984					
Beaked redfish 3M NWA	1992	1993	1994				
Pacific ocean perch Western USA	1969	1971	1976	1982	1986		
Chillpepper rockfish Western USA	1982						
Atl. mackerel 2-6 NWA	1963	1976	1986	1987			
Cape horse mackerel South Atlantic Ocean	1966	1967					
Sablefish Western USA	1991						
Capelin Barents Sea	1984	1985	1992	1993			
Dogfish NWA	1968	1969	1982				
Atka mackerel Bering Sea	1991	1993					
Chub mackerel Area off Japan	1974	1976	1980				
S. blue whiting Area off New Zealand	1978	1989					

Table 13. Years and populations with simultaneous appearance of several year-classes of anomalous abundance

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1963	1977	1983	1976
Cod 2J3KL NWA	Cod 25-32 Baltic Sea	Cod 347d North Sea	Cod 3M NWA
Cod 3NO NWA	Cod 4Rs NWA	Haddock NEA	Cod 3Ps NWA
Cod 4X NWA	Pacific hake	Sakhalin sole Western Kamchatka	Pacific hake
Cod NEA and Arctic	Greenland halibut Bering Sea	Norwegian spring-spawning herring	Pacific ocean perch Western USA
Silver hake 5Ze NWA	Yellowtail flounder 5Zw+6 NWA	Pacific ocean perch Aleutian Islands	Atlantic mackerel 2-6 NWA
Silver hake 5Zw+6 NWA	Yellowfin sole Western Kamchatka	Blue fish Eastern USA	Chub mackerel Area off Japan
Greenland halibut Arctic	Pacific herring Eastern Bering Sea	Atlantic mackerel 2-6 NWA	
European plaice North Sea	Cape horse mackerel South Atlantic Ocean	Chub mackerel Area off Japan	
Longhead dab Western Kamchatka	Capelin Barents Sea	Capelin Area off Island	
Pacific ocean perch Western USA	Atka mackerel Bering Sea		
Peruvian anchovy Area off Peru	Sablefish Western USA		