Northwest Atlantic Fisheries Organization

Serial No. N1850

NAFO SCR Doc. 90/114

SCIENTIFIC COUNCIL MEETING - SEPTEMBER 1990

Year-class Variations of American Plaice and Yellowtail Flounder in Div. 3LNO and the Abundance of Other Commercial Fish

by

J. Paz and M. G. Larrañeta

Instituto de Investigaciones Marinas, Eduardo Cabello 6
36208 Vigo, Spain

INTRODUCTION

In a previous paper (Paz and Larrañeta, 1989) we obtained a significant positive correlation between cod year-class size in Div. 3NO and American plaice spawning biomass in Div. 3LNO, that was interpreted by supposing a strong predation of 0-group cod on 0-group American plaice. On the contrary, we have not found significant correlations between cod year-classes and spawning biomasses of other species in the area as redfish, yellowtail and mackerel.

Following the same method, in this paper we explore correlations between American plaice (*Hippoglossoides platessoides*) and yellowtail flounder (*Limanda ferruginea*) year-class sizes and biomasses of adult fishes of these species and those of cod (*Gadus morhua*), mackerel (*Scomber scombrus*) and redfishes (*Sebastes spp.*).

MATERIAL AND METHODS

Data on American plaice recruitment (N_5) and spawning biomass (B_{11+}) in Div. 3LNO (Table 1) have been taken from Brodie (1989), yellowtail flounder recruitment (N_4) and spawning biomass (B_{6+}) in Div. 3LNO (Table 2) from Brodie and Walls (1988), cod spawning biomass (B_{6+}) in Div. 3NO (Table 3) from Baird and Bishop (1989), mackerel biomass referred to Labrador North Carolina area (Table 4) from figure 19.1 in Anon. (1986), and nominal redfish catches in Div. 3LN (Table 5) from Atkinson and Power (1989). These catches were considered as abundance indices of this population.

The possibility of trophic relationships between 0-age groups and juveniles belonging to plaice, yellowtail and other species has been explored by relating the year-class sizes of these species to the adult biomass values of the other species, from one to three years before (negative lag) or after (positive lag) the year of the plaice and yellowtail year-classes. Finally the plaice and yellowtail year-classes are also related to their spawning biomasses, respectively, which gave rise to them, and to their spawning biomasses lagged from one to three years before or after. The year-class is measured at the time of recruitment, N_5 for plaice and N_4 for yellowtail.

RESULTS

Correlations between plaice recruitment and its spawning biomass are shown in table 6, and between yellowtail recruitment and its spawning biomass in table 7; the only positive and significant correlations are with -2 and -3 year lags for plaice.

The correlation coefficients between plaice recruitment and the yellowtail spawning biomass are shown in table 8; positive coefficients appear with 0, 1 and 2 year lags. There is no significant correlation between plaice recruitment and cod spawning biomass (Table 9). On the contrary, positive and highly significant correlations appear between plaice recruitment and mackerel biomass with 0, 1 and 2 year lags (Table 10).

Likewise correlation between plaice recruitment and redfish catches was positive and significant with a 1 year lag (Table 11).

No significant correlation coefficients appear between yellowtail recruitment and plaice, cod, mackerel and redfish biomasses (Tables 12-15).

Finally, table 16 shows the linear regression parameters when correlations have a random probability equal to or less than 0.01.

DISCUSSION

There were no significant correlations between plaice and yellowtail recruitment and their spawning biomasses (0-year lag in tables 6 and 7). We find no immediate explanation for correlations for plaice with -2 and -3 year lags (Table 6).

The positive correlation (Table 8) between plaice recruitment and yellowtail spawning biomass suggests that 0-group plaice prey on yellowtail eggs and larvae, because in the Grand Bank the plaice spawning peak occurs in late April (Pitt, 1966) and yellowtail one in late June (Pitt, 1970); plaice hatching time is 11-14 days at 4ºC (Bainbridge et al., 1971) and metamorphosis in *Pleronectes platessa* , a related species, takes place 120-130 days after spawning time. Yellowtail flounder hatching occurs at the age of 5 days at 10-11ºC (Scott and Scott, 1988).

It does not seem that the positive and strongly significant correlations between plaice recruitment and mackerel biomass with 0, 1 and 2-year lags (Table 10) can be justified by supposing predation of 0, 1 and 2-group plaice on 0-group mackerel. The 0-group mackerel has a fast growth rate and is a very active predator on eggs and larvae of other fish species; there is even cannibalism between its larvae. On the other hand plaice 1 and 2-groups are benthic, being separated from the pelagic zone which mackerel inhabits. But adult mackerel prey intensively on gadoid eggs and larvae, and because 0-group cod seem to prey significantly on 0-group plaice (Paz and Larrañeta, 1989), the mackerel biomass influence on plaice may be indirect, by reducing the 0-group cod abundance. On the other hand mackerel and plaice spawning areas are separated (Gulf of St. Lawrence and Div. 3N, respectively). But during the winter-spring season, adult mackerel extend to Div. 3NO, since its peak spawning period does not occur until late in June and early July. .

Previously (Paz and Larrañeta, 1989) we found a positive and strongly significant correlation between cod recruitment in Div. 3NO and plaice spawning biomass in Div. 3LNO, but now, conversely, we do not find any significant correlation between plaice recruitment and cod spawning biomass in the same divisions (Table 9).

The positive correlations between plaice recruitment and redfish biomass with 1 and 2-year lags (Table 11) have no easy explanation. Although redfish estrusion larvae occur at 200 m or more on the shelf edge (Bainbridge and Cooper,1971; Akenhead, 1987), it seems very doubtful that redfish larvae are significantly preyed upon by group-1 plaice. In general, there is no significant correlation between yellowtail recruitment and the adult biomasses of the other species studied.

We have seen that recruitment of some species (species A) is related to adult abundance of other species (species B). The hypothesis is that the 0-groups of species A prey on the 0-groups of species B. However, recruitment of species B is not related to the abundance of adults of species A. These species pairs are cod(A)-plaice(B) and plaice(A)-yellowtail(B). Let us suppose that a good recruitment is a survival of 100 eggs per female, and that a bad recruitment is 1 egg per female. The relationship between good and bad survival rates will be $S_g/S_b=100$, whilst the relationship between mortality rates will be $1-S_g/1-S_b \sim 1$. That is to say, survival causes (food) could be more important that mortality causes (predation).

Summarizing, we find positive and significant correlations between plaice recruitment and yellowtail, mackerel and redfish adult biomasses, but not between yellowtail recruitment and adult biomass of the other species studied (Table 17). This seems coherent with the idea that Div. 3LNO represent the central area of the *Hippoglossoides platessoides* population in the Northwest Atlantic, and therefore it will be a very integrated species in the Grand Bank ecosystem. In this way plaice population dynamics could depend very much on the biotic factors in this area. It is in agreement with the important contribution of plaice to the fish assemblages on the Grand Bank (Gomes et al., 1989). However, the presence of yellowtail as a fishery resource in this area is recent, only since the second half of the 1960s (ICNAF Statistical Bull., 1975). Pitt (1970) suggests that the rapid increase in abundance of yellowtail was related to an increase in bottom temperatures and a drastic reduction in the size of haddock stocks, which were apparently competitors of yellowtail. In any case the yellowtail distribution center is south of the Grand Bank, so that its integration into the dynamics of the ecosystem be less mature and its abundance will depend more on physical factors than on biotic ones.

ACKNOWLEDGEMENT

We are indepted to Dr. T. Wyatt for critically reviewing this manuscript.

REFERENCES

Anom. 1986. Status of the fishery resources off the North-eastern United States for 1986. NOAA Tech. Mem. MNFS/NEC 43. 130 p.

Akenhead, S.A. 1987. Diffusion and redfish larvae on Flemish Cap. Can. Tech. Rep. Fish. Aquat. Sci., 1556:iv+65p.

Atkinson, D.B. and D. Power. 1989. Redfish in NAFO Divisions 3LN. NAFO SCR Doc. No. 54, Ser. No. 1634: 26p.

Bainbridge V. and G.A. Cooper. 1971. Population of *Sebastes* larvae in the North Atlantic. Res. Bull. ICNAF, 8: 27-35.

Baird, J.W. and C.A. Bishop. 1989. The assessment of the cod stock in NAFO Div. 3NO. NAFO SCR Doc. No. 35, Ser. No. 1611: 61p.

Brodie, W.B. 1989. An assessment of the American plaice stock in Division 3LNO. NAFO SCR Doc. No. 37, Ser. No. 1477: 51p.

Brodie, W.B. and S.J. Walsh. 1988. An update on the status of yellowtail flounder stock in Division 3LNO. NAFO SCR Doc. No. 38, Ser. No. 1478: 42p.

Gomes, M.C., R. Haedrich and J.C. Rice. 1989. Fish assemblages on the Grand Bank of Newfoundland. NAFO SCR Doc. 89, Ser. No. 89, Ser. No. 1656: 31p.

ICNAF. 1975. Statistical Bulletin for the year 1973. Vol. 23. Dartmouth, Canada: 277p.

Paz, J. and M.G. Larrañeta. 1989. Cod in Div. 3NO: year-class variations and the abundance of other commercial fish. NAFO SCR No. 72, Ser. No. 1653: 9p.

Pitt, T.K. 1966. Sexual maturity and spawning of the American plaice, *Hippoglossoides platessoides* (Fabricius), from Newfoundland and the Grand Bank areas. J. Fish. Res. Bd. Can., 23: 651-672.

Pitt, T.K. 1970. Distribution, abundance and spawning of yellowtail flounder, *Limanda ferruginea,* in the Newfoundland area of northwest Atlantic. J. Fish. Res. Bd. Can., 27: 2261-2271.

Scott, W.B. and M.G. Scott. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci., 219: 713p.

Table 1 .- American plaice.Div. 3LNO spawning stock biomass (B11+) and recruitment (N5). From Brodie (1988).

Year class	Biomass (tons)	Recruits (000)
1960		236421
1961		211435
1962		189939
1963		149426
1964		146251
1965	138197	138500
1966	158756	177331
1967	157325	220607
1968	138837	269745
1969	120238	261976
1970	94378	274795
1971	81403	259997
1972	62129	216563
1973	52619	203490
1974	50889	187753
1975	45906	177919
1976	39864	175574
1977	45515	216181
1978	48818	206101
1979	60846	170123
1980	67125	178060
1981	53278	255644
1982	46852	
1983	42294	
1984	46090	
1985	56357	
1986	42383	

Table 2.- Yellowtail flounder Div.3LNO: recruitment (N4) and spawning stock biomass (B6+). From table 24 of Brodie and Walls (1988).

year class	Biomass (tons)	Recruits (000)
1964		156799
1965		147013
1966		119893
1967		110606
1968	25926	121785
1969	40372	113144
1970	50199	75637
1971	48747	71659
1972	33846	79483
1973	24049	83973
1974	21034	86856
1975	18159	70496
1976	19152	68298
1977	18809	121448
1978	21776	175222
1979	17415	168279
1980	26325	88426
1981	20530	55605
1982	16098	12925
1983	28755	
1984	44789	
1985	50805	
1986	31474	

Table 3.- Cod Div.3NO: spawning biomass (B6+).From Baird and Bishop (1989).

Year	Biomass (tons)
1956	-
1957	-
1958	-
1959	8840
1960	7234
1961	8974
1962	8032
1963	8787
1964	11264
1965	12051
1966	10462
1967	9344
1968	8268
1969	8026
1970	8137
1971	8819
1972	7812
1973	7618
1974	5373
1975	1929
1976	1233
1977	1655
1978	1948
1979	2628
1980	5713
1981	8830
1982	9152
1983	10004
1984	9556
1985	10305
1986	11069
1987	10990
1988	9120

Table 4.- Mackerel Labrador-North Carolina: population biomass (B1+). From figure 19.1, Anon. (1986).

Year	Biomass (000 tons)
1963	275
1964	311
1965	323
1966	371
1967	623
1968	1198
1969	1533
1970	1856
1971	1868
1972	1653
1973	1389
1974	1126
1975	970
1976	719
1977	491
1978	467
1979	503
1980	467
1981	479
1982	599
1983	695
1984	1078

Table 5.- Redfish Div. 3N: nominal catches (t) from table 1 of Atkinson and Power (1989).

Year	Catch
1959	10478
1960	16547
1961	14826
1962	18009
1963	12906
1964	4206
1965	4042
1966	10047
1967	19504
1968	15265
1969	22142
1970	13359
1971	24310
1972	25838
1973	28588
1974	10867
1975	14033
1976	4541
1977	3065
1978	5725
1979	8483
1980	11663
1981	14873
1982	13677
1983	11090
1984	12065
1985	16880
1986	14971

Table 6.- Correlation coefficients between plaice recruitment and plaice spawning biomass.

Lag	-3	-2	-1	0	1	2	3
n =	14	15	16	17	18	19	20
r =	0.763	0.784	0.555	0.132	-0.193	-0.422	-0.514
p =	0.004	<0.001	0.024	0.618	0.450	0.072	0.019

Table 7.- Correlation coefficients between yellowtail recruitment and yellowtail spawning biomass.

Lag	-3	-2	-1	0	1	2	3
n =	12	13	14	15	16	17	18
r =	-0.170	-0.268	-0.228	-0.081	-0.022	-0.072	-0.227
p =	0.606	0.385	0.442	0.779	0.936	0.788	0.370

Table 8.- Correlation coefficients between plaice recruitment and yellowtail spawning biomass.

Lag	-3	-2	-1	0	1	2	3
n =	11	12	13	14	15	16	17
r =	-0.064	0.165	0.589	0.701	0.722	0.697	0.390
p =	0.852	0.610	0.026	0.007	0.004	0.004	0.183

Table 9.- Correlation coefficients between plaice recruitment and cod spawning biomass.

Lag	-3	-2	-1	0	1	2	3
n =	20	21	22	22	22	22	22
r =	0.220	0.091	0.076	0.046	-0.008	-0.023	-0.014
p =	0.328	0.695	0.737	0.839	0.972	0.920	0.950

Table 10.- Correlation coefficients between plaice recruitment and mackerel population biomass.

Lag	-3	-2	-1	0	1	2	3
n =	16	17	18	19	20	21	22
r =	-0.364	0.095	0.429	0.692	0.809	0.731	0.475
p =	0.169	0.722	0.075	0.001	<0.001	<0.001	0.025

Table 11.- Correlation coefficients between plaice recruitment and redfish biomass (catches).

Lag	-3	-2	-1	0	1	2	3
n =	20	21	22	22	22	22	22
r =	-0.261	0.035	0.271	0.515	0.624	0.542	0.386
p =	0.270	0.880	0.225	0.015	0.003	0.010	0.056

Table 12.- Correlation coefficients between yellowtail recruitment and plaice spawning biomass.

Lag	-3	-2	-1	0	1	2	3
n =	15	16	17	18	19	19	19
r =	-0.105	-0.032	0.126	0.341	0.529	0.565	0.485
p =	0.715	0.907	0.635	0.169	0.019	0.014	0.034

Table 13.- Correlation coefficients between yellowtail recruitment and cod spawning biomass.

Lag	-3	-2	-1	0	1	2	3
n =	19	19	19	19	19	19	19
r =	0.021	-0.094	-0.124	-0.079	-0.004	0.176	0.297
p =	0.932	0.706	0.619	0.752	0.987	0.477	0.221

Table 14.- Correlation coefficients between yellowtail recruitment and mackerel population biomass

Lag	-3	-2	-1	0	1	2	3
n =	17	18	19	19	19	19	18
r =	-0.168	-0.346	-0.422	-0.374	-0.275	-0.214	-0.035
p =	0.527	0.162	0.072	0.116	0.259	0.385	0.893

Table 15.- Correlation coefficients between yellowtail recruitment and redfish biomass (catches).

Lag	-3	-2	-1	0	1	2	3
n =	19	19	19	19	19	19	19
r =	-0.198	-0.330	-0.480	-0.434	-0.207	0.075	0.227
p =	0.422	0.170	0.037	0.063	0.401	0.763	0.354

Table 16.- Regression parameters, only when P<0.01

Biomass (tons) x	Recruits (mill.) y	Lag	a	b
Plaice	Plaice	-3	160.33	0.6562
Plaice	Plaice	-2	161.13	0.6618
Yellowtail	Plaice	0	151.37	0.2423
Yellowtail	Plaice	1	153.79	0.2409
Yellowtail	Plaice	2	150.86	0.2411
Mackerel	Plaice	0	157.08	54.231
Mackerel	Plaice	1	149.38	63.216
Mackerel	Plaice	2	155.54	56.997
Redfish	Plaice	2	164.51	3.055

Table 17.- Significant correlations (P<0.01) between recruitment and population biomass. In parenthesis year-lag

Biomass of	Recruitment of		
	Plaice	Yellowtail	Cod
Plaice	(-2) (-3)	-	(-1) (0) (1) (2) (3)
Yellowtail	(0) (1) (2)	-	-
Cod	-	-	-
Mackerel	(0) (1) (2)	-	-
Redfish	(1)	-	-