Northwest Atlantic Fisheries Organization

Serial No. N2073

NAFO SCR Doc. 92/26

SCIENTIFIC COUNCIL MEETING - JUNE 1992

The Fecundity of American Plaice (*Hippoglossoides platessoides*) from the South of the Grand Bank and Flemish Cap

by

Javier Zamarro

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

ABSTRACT

In this paper the variability of the fecundity of American plaice in the south of the Grand Bank of Newfoundland between 1987-1991 is analyzed, and we compare the results obtained with previous estimates (1957-1962) of Pitt (1964), and with current estimates of the fecundity in Flemish Cap (1989 y 1991). The results obtained show low interannual variability in the south of the Grand Bank (2.7% with historic data), and moderate variability between Flemish Cap and south of the Grand Banks (21.4% for a female 45 cm length).

The observed variability is discussed in relation to the means by which of fecundity can regulate population.

INTRODUCTION

Fecundity is the number of eggs that a female produces during a spawning season. Control of this number, may be one the mechanism by which a population tends to reach a optimum size in the environment where it develops. Changes in fecundity might be the response to the presence of different environmental or populational conditions.

The mechanism by which fecundity can regulate population size has been little studied, and the spatial and temporal variability of fecundity are known in only a few species.

In this paper, the temporal variability of fecundity is analyzed in the south of the Grand Bank (3N division), and the fecundity estimate in Flemish Cap (3M Division) and to the South of the Grand Bank are compared. The results are discussed in ralation to the means by which can regulate population size.

MATERIAL AND METHODS

From 1987 to 1991 a total of 208 ovaries of American plaice from the south of the Grand Bank and Flemish Cap were collected. Numbers of ovaries and their size ranges each year are given in table 1.

The ovaries were collected in January and February on board commercial trawlers. For each individual sampled the size and weight were recorded, and the ovaries preserved in 10% formalin solution; in the laboratory they were weighed with a precision of 0'01 gr.

Fecundity was obtained with a gravimetric method, using three samples of between 100 and 125 mg of each ovary, the mean number of oocytes per gramme of ovary, in the three samples, was multiplied by the ovarys weight to obtain fecundity.

From 1987 to 1989, samples were obtained from a small size range. In these years the mean relative fecundity (fecundity /weight) was considered representative of each year, and differences between years were tested with ANOVA.

From 1990 to 1991 the samples were obtained from all sizes presents in the catches, and regression analyses between size (L) and weight (W) with fecundity were performed. Differences between regressions for years and divisions were tested with Chou's test (Gujarati, 1970), this is a general test that indicates when are differences in slope (b) or in the intersection (a) between two regressions.

RESULTS

A) Relation fecundity/size ($F = a*L^b$).

The analysis of the relation between size and fecundity for 1990 and 1991 in the south of the Grand Bank were the following:

DIVISION 3N					
YEAR	N	R.	P	a	b
1990	49	0.89	<0.001	0.0249	4.3555
1991	45	0.82	<0.001	0.0280	4.3139

There are no significant differences between these regressions.

The independent regression of the 3N and 3M data from 1987 to 1991 provided the following results:

DIVISION	YEARS	N	R	P	a	b
3N	87-91	174	0.79	<0.001	0.1718	3.8388
3M	89 y 91	36	0.73	<0.001	1.1013	3.4017

Chou's test shows significant differences between these regressions (P< 0.005). A female of 45 cm from Flemish Cap is 21.4 % more fecund than a female of the same size from the south of the Grand Bank.

B) Relation fecundity/weigth (F = a+bW).

The results of the regression analysis between fecundity (thousands of eggs) and the weight (Kg) in Division 3N for 1990 and 1991, were the following:

DIVISION 3N					
YEAR	N	R	P	a	b
1990	49	0.94	< 0.001	-213.4	670.5
1991	45	0.90	<0.001	-230.9	633.9

There are no signifficant differences between these regressions.

With the independent analysis of the 3N and 3M data, we obtained these results:

DIVISION	YEARS	N	R	P	a	b
3N	1987-1991	174	0.82	<0.001	-129.3	534.9
3M	1989 y 1991	36	0.84	<0.001	-34.8	526.3

Chou's test shows significant differences between these regressions (P<0.05). A female of 1000 gr is 21.2% more fecund in Flemish Cap than in the south of the Grand Bank.

C) Relative fecundity (fecundity/weigth).

From 1987 to 1989, fish sampled were between 50 and 55 cm in length in Division 3N. Relative fecundity in this size range does not show a significant correlation, and the mean relative fecundity values for each year were considered representative of the annual fecundity in the size range analyzed. The results obtained were:

DIVISION 3N			
YEAR	N	Rel.fec	SD
1987	23	384	80
1988	30	419	78
1989	25	421	82

The ANOVA of these mean relative fecundities do not show significant differences.

The correlations between the size and the relative fecundity in divisions 3N and 3M were:

DIVISION	YEARS	N	R	P
3N	87-91	174	0.18	0.018
3M	89 and 91	36	0.04	0.983

In Flemish Cap the correlation was not significant, and in the south of the Grand Bank, the correlation coefficient (R) is so low that the mean relative fecundity for each division was considered representative of each area. The results were:

DIVISION	N	RELFEC	SD
3N	170	439	98
3M	36	491	73

The ANOVA show significant differences between relative fecundities in these areas (P = 0.0028).

D) Relation size/ weight ($L = a+P^{b}$)

The relation size/weigth do not show significant differences between 1990 and 1991 in division 3N. The comparison between divisions 3N and 3M does not show significant differences:

DIVISION	N	R	P	a	b
3N	174	0.93	<0.001	0.0025	3.376
3M	36	0.92	<0.001	0.0021	3.417

E) Relation Number of oocytes per gram of ovary/ size

The correlation analysis between the number of oocytes per gram of ovary (NOGO) and the female size for January and February in division 3M give these results:

DIVISION 3N		N	R	P
JANUARY	1991	45	-0.326	0.03
FEBRUARY	1990	49	-0.467	<0.001

These correlations are significant and negative; the females of larger size have lower numbers of oocytes per gram of ovary. An increase in the correlation coefficient with the proximity of the spawning season is also observed.

DISCUSSION

Interannual fecundity variability in the south of the Grand bank.

Interannual variations in fecundity have been reported in some North Atlantic species, in *Pleuronectes platessa,* Horwood (1986) found differences of 44% between consecutive years, and maximum differences of 60%. Other species where this kind of changes has been described are *Hippoglossoides platessoides limandoides* (Bagenal, 1956), *Glyptocephalus cynoglossus* (Bowering, 1978), *Melanogrammus aeglefinus* (Hodder, 1963) y *Gadus morhua* (Pinhorn, 1984).

The fecundity of American plaice for a determined size or weight showed slight variation between 1987 and 1991. If we compare the results obtained by Pitt (1964) from 1957 to 1962 with our results (1987-1991), the differences are slight. A female of 45 cm was 2.7% more fecund from 1957 to 1962 than from 1987 to 1991. The differences in relative fecundity are about 5%.

The slight variability of fecundity contrasts with the plasticity that has been shown in other biological parameters of this species. Pitt (1975) in the Grand Bank described important changes in the growth rate and age of 50% of maturation, and Beacham (1984) found changes in the age and size of 50% maturation on the Scotian Shelf.

The abundance of American plaice in the south of the Grand Bank is presently *lower than* at any time since 1955. The standardized catch rates of the Canadian commercial fishery (Brodie, 1991) (fig.1) between 1987 and 1991 were nearly three times lower than between 1957 and 1962, when Pitt (1964) estimated its fecundity. Important changes in abundance did not produce noticable changes in the relations of length or weight with fecundity.

Fecundity of American plaice in the south of the Grand Bank and Flemish Cap

The results obtained here show that females from Flemish Cap are more fecund than females from the south of the Grand Bank. For a individual of 45 cm this difference is about 21% .

In American plaice of the Grand Bank, geographical changes in fecundity were analyzed previously by Pitt (1964). His results showed no significant differences in fecundity between females from St. Mary's Bay, north and south of the Grand Bank.

Few papers analyze geographical changes in fecundity of North Atlantic species. In *Gadus morhua* in the Grand Bank these changes are in relation to environmental condition (Pinhorn, 1984). In *Pleuronectes platessa* the maximum values are in the Baltic Sea and minimum in the North Sea (Bagenal, 1966; Horwood, 1986; Rinjsdorp, 1991). In *Reinhardtius hippoglossoides* there are significant differences between southern Labrador and southeastern Gulf of St Lawrence (Bowering, 1980), and in *Glyptocephalus cynoglossus* between St.Pierre and the Grand Bank of Newfoundland (Bowering, 1978).

Geographical variations of fecundity can be produced by different oceanographic conditions (Bagenal, 1966). Areas with more stability could favour the selection of less fecund females, while in areas where the oceanographic conditions produce dispersa of eggs, natural selection would favour the development of more fecund females. Conditions in the areas considered in this paper could explain the differences found in fecundity. In Flemish Cap during the spawning season of American plaice, the superficial water circulation forms an anticyclone gyre, the intensity of which is directly correlated with the recruitment of cod (Akenhead, 1982). Cod also has pelagic eggs, and spawns one month before American plaice. Years with a more intense gyre produce less dispersion of eggs and larvae and better survival conditions. In contrast to Flemish Cap, in the South of the Grand Bank no direct relation was found between oceanographic conditions and recruitment. The situation in this area seems to be more complex with predation by other species, such as cod, on eggs and larvae of American plaice determining recruitment (Paz y Larrañeta, 1989 and 1990).

If oceanographic conditions are the cause of higher fecundity in Flemish Cap, other species with spawning seasons close in time to that the American plaice, should show the same kind of differences compared with the south of the Grand Bank. To explore this possibility, the cod fecundity in Flemish Cap (Wells, 1986) and the South of Grand Bank (May, 1967 and Pinhorn, 1984) were compared. A female cod 60 cm length is 59.6% more fecund in Flemish Cap than the South of the Grand Bank, reinforcing the idea that in Flemish Cap conditions favorable to the development of more fecund females are found.

Geographical variations in growth rate show a direct relation with fecundity in some species (Smyly, 1957; Bagenal, 1966 and Pinhorn, 1984), and could explain the differences found. On Flemish Cap, the American plaice grows faster (Pitt, 1967) and has lower size and age at 50% maturity (Bowering and Brodie, 1991) than in the south Grand Bank. Nevertheless the slight interannual variation of fecundity in the south of the Grand Bank, where there are important changes in growth rate, may indicate that there are racial differences between Grand Bank and Flemish Cap American plaice populations, confirming the reproductive isolation between these populations proposed by Pitt (1967 and 1975).

Relative fecundity

The number of eggs per gram female (relative fecundity) was a 11.8% larger in Flemish Cap than in the south of the Grand Bank. If the eggs at spawning are the same size in both areas, the reproductive effort of a female in Flemish Cap is a 11.8% larger than south Grand Bank.

There is little geographical variation in egg size (Bagenal, 1971), however the comparison between egg size in different population is not easy due to differences in the spawning season and the diminution of egg size during the spawning period (Kjorsvik; et al, 1990).

A comparison of february gonadosomatic indices in Flemish Cap and south of the Grand bank did not reveal significant differences so it is not known if the reproductive effort is greater in Flemish Cap fish.

Oocyte developing in relation to size

Two explanations are possible for the direct relation observed in the south of the Grand Bank between size and the number of oocyte per gram ovary:

a) Larger females reach the stage necessary to start spawning earlier.

b) Larger females produce larger eggs

In American plaice, Pitt (1966) has comfirmed the earlier spawning season of larger females, and in some species the eggs size is positively correlated with female length (Moar, 1950; Kjesbu, 1989; McEvoy, 1991). Our data do not permit us to discern between these two options, but is possible that both occur.

Fecundity as a population regulator in the south of the Grand Bank.

The response of American plaice to changes in abundance with changes in growth rate, size and age of 50% maturaty (Pitt, 1975 and Beacham, 1984); and the slight variation in the relations of fecundity to weight and length in the south of the Grand Bank, indicate that the means by which fecundity regulates population size is not direct but associated with changes in growth and maturation. Changes in population abundance produce changes in growth rate and in the size and age of 50% maturaty, which in turn produce changes in fecundity for a determined age. By this mechamism fecundity regulates population in a way similar to that proposed by Rinjsdorp (1991) for *Pleuronectes platessa* populations.

BIBLIOGRAPHY

AKENHEAD,S.A., 1982
Flemish Cap cod year-class strength and environmental variables. NAFO SCR Doc. 82/VI/41.

BAGENAL,T.B., 1965
The fecundity of Long Rough Dabs in the Clyde Sea area. J.mar.biol.Asso.U.K. 45:599-606.

BAGENAL,T.B., 1966
The ecological and geographical aspects of the fecundity of the Plaice. J.mar.biol.ass.U.K. 46:161-186

BAGENAL,T.B., 1971
The interrelation of the size of fish eggs, the date of spawning and the production cycle. J.Fish.Biol. 3:207-219

BEACHAM,T.D., 1983
Variability in size and age at sexual maturity of American plaice and Yellowtail flounder in the Canadian maritime regions of the Northwest Atlantic ocean. Can.tech.Rep.Fish.Aquat.Sci. 1196:75p.

BOWERING, W.R., 1978
Fecundity of Witch Flounder (*Glyptocephalus cynoglossus*) from St. Pierre Bank and the Grand Bank of Newfoundland. J.Fish.Res.Board Can. 35: 119-1206

BOWERING, W.R., 1980
Fecundity of Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum), from southern Labrador and southeastern Gulf of St. Lawrence. J.Northw.Atl.Fish.Sci., 1: 39-43

BOWERING,W.R. and W.B. BRODIE, 1991
Distribution of commercial flatfishes in the Newfoundland-Labrador region of the canadian northwest Atlantic and changes in certain biological parameters since exploitation. Neth.J.Sea.Res. 27:407-422

BRODIE,W.B. and J.W.BAIRD, 1991
An assessment update for the American plaice stock in Divisions 3LNO. NAFO SCR Doc. 91/93, 41p

GUJARATI,D., 1970
Use of dummy variables in testing for equality between sets of coefficients in two linear regressions: a note. The American Statistician, 1970: 50-53.

HODDER,V.M. 1963
Fecundity of Grand Bank Haddock. J.Fish.Res.Board Can.; 20: 1465-1487.

HORWOOD, J.W., R.C.A.BANISTER and G.J.HOWLETT, 1986
Comparative fecundity of North Sea plaice (*Pleuronectes platessa*). Proc.R.Soc.Lon.B. 228: 401-431

KJESBU,O.S., 1989
The spawning activity of Cod, *Gadus morhua* L. J.Fish.Biol. 34:195-206

KJORSVIK,E., A.MANGOR-JENSEN and I.HOLMEFJORD, 1990
Egg quality in fishes. Advances in Marine Biology, 26: 71-113

MacEVOY,L. and J. MacEVOY, 1991
Size fluctuation in the eggs and newly hatched larvae of captive turbot (*Scophtalmus maximus*). J. mar.biol.Ass.U.K. 71:679-690

MAY,A.W., 1967
Fecundity of Atlantic Cod. J.Fish.Res.Board Can 24:1531-1551

MOAR, A., 1950
A supplement to the fertility of Char *Salmo alpinus* L. in Faxalven water system, Sweden. Report of the Institute of Freswater Research of Drottingholm, 31:127-136

PAZ,J. and M.G.LARRAÑETA, 1989
Cod in Division 3NO: year-class variations and the abundance of other commercial fish. NAFO SCR Doc. 89/72, 9p

PAZ,J. and M.G. LARRAÑETA, 1990
Year-class variations of American plaice and yellowtail flounder in Division 3LNO and the abundance of other commercial fish. NAFO SCR Doc. 90/114, 10p

PINHORN, A.T., 1984
Temporal and spatial variation in fecundity of Atlantic Cod. (*Gadus morhua*) in the Newfoundland waters. J.Northw.Atl.Fish.Sci.,5:161-170.

PITT,T.K., 1964
Fecundity of American plaice, *Hippoglossoides platessoides*, from Grand Bank and Newfoundland areas. J.Fish.Res.Board Can., 21:594-612

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

PITT,T.K., 1967
Age and growth of American plaice (*Hippoglossoides platessoides*) in the Newfoundland area of the Northwest Atlantic. J.Fish.Res.Board Can. 24:1077-1099

PITT,T.K., 1975
Changes in abundance and certain biological characteristics of Grand Bank American plaice, *Hippoglossoides platessoides*. J.Fish. Res. Board Can., 32: 1383-1398.

RINJNSDORP, A.D., 1991
Changes in fecundity of female North Sea plaice (*Pleuronectes platessa* L.) between three periods since 1900. ICES J.mar.Sci., 48:253-280

SMYLY,W.J.P., 1957
The life-history of the bullhead or Miller's Thumb (*Cottus gobio* L.). Proc.zool.Soc.Lon., 128:431-453

WELLS, R., 1986
Fecundity of Cod on the Flemish Cap, NAFO SCR Doc. 86/112.

Table 1. Ovarys samples from 1987 to 1991 by divisions and size range

YEAR	NUMBER	SIZE RANGE	DIVISION
1987	23	50-55	3N
1988	30	50-55	3N
1988	10	45-50	3M
1989	25	50-55	3N
1990	49	39-63	3N
1991	45	40-64	3N
1991	26	40-51	3M

Figure 1. American plaice in Div. 3LNO: standardized catch rates (Brodie and Baird, 1991)