Northwest Atlantic Fisheries Organization

Serial No. N187 NAFO SCR Doc. 80/IX/118

ANNUAL MEETING OF SCIENTIFIC COUNCIL - SEPTEMBER 1980

Drift of Eggs and Larvae of Yellowtail Flounder (*Limanda ferruginea* (Storer)) in the Northwest Atlantic

by

S. A. Evseenko and M. M. Nevinsky
All-Union Research Institute of Marine Fisheries and Oceanography (VNIRO)
Moscow, USSR

The Yellowtail Flounder - Limanda ferruginea inhabits the Northwest Atlantic in the area from Labrador (the Bell Isle Straits) to Chesapeake Bay and can be found within the boundaries of the shelf at depths no more than 250 m.

The Yellowtail Flounder has been atraditional object of fishing in the Northwest Atlantic for a long time. The biology of this species has been studied as long as that. However, the knowledge of the life cycle of L.ferruginea is far from being complete. The gap in knowledge especially relates to the early periods of its life.

At present there are many publications on the pattern of distribution of eggs and larvae of the Yellowtail Flounder in different areas of the Northwest Atlantic (Marak, Colton, I96I; Serebryakov, I962; Nevinsky, I973; Smith et al. I975; etc.). However, most of these papers do not touch upon questions related to clearing up the pattern of the drift of eggs and larvae, i.e. the influence of oceanographical factors on the distribution of the early stages, though it is during passive migrations in early ontogenesis that the future destiny of the progeny of populations is determined.

This paper cites the results of a study of the drift pattern of eggs and larvae of the Yellowtail Flounder in different areas of the Northwest Atlantic which was based on the data on the distribution of eggs, larvae and fry of this species published by one of the authors earlier (Nevinsky, I973).

The pattern of the drift of eggs and larvae

The pattern of the drift of eggs and larvae of the Yellowtail Flounder in the Northwest Atlantic is determined by circulation of water masses of different origin. The spawning grounds of the Yellowtail Flounder off Newfoundland are in the sone of the Labrador current, while off Nova Scotia and the Georges Bank they are in the zone of the Nova Scotia current (Cabot's current). Besides, in the Grand Newfoundland Bank and Georges Bank the yellowtail flounder spawning grounds are in immediate proximity to the Gulf Stream.

By comparing the charts of the distribution of eggs, larvae and fry of the Yellowtail Flounder and the charts of the location of spawning grounds of this species published by the authors earlier (Nevinsky, I973) on one hand and the charts of the currents (Klimenkov, Pakhorukov, I962, I964; Bumpus, Lauzier, I965) on the other hand, one can get an idea of the main paths of drift of eggs and larvae of the Yellowtail Flounder in the Northwest Atlantic (Fig. 1).

Eggs spawned off the northern slope of the Grand Newfoundland Bank drift with the waters of the coastal branch of the Labrador current along Avalon south-westward at the rate of 0.3-0.4 knot and southward at the rate of 0.1 knot into the inner areas of the Grand Newfoundland Bank.

In the inner areas of the Grand Newfoundland Bank the currents have different directions as there are cyclonic and anticyclonic circulations here (Kudlo, Burmakin, I972) but the general transfer of water masses remains southward. Consequently, the bulk of the eggs and larvae of the Yellowtail Flounder are kept in the Newfoundland Bank drifting as a rule southward with currents of very low speed, about 2.5-5 miles in 24 hours. Apparently off the Grand Newfoundland Bank eggs and larvae are not carried out far away from the spawning grounds and young fish come over to the bottom mode of life in the spawning areas, as larval fish and fry were found in the same places where eggs were. However, some eggs

and larvae are carried out beyond the Grand Newfoundland Bank to areas of oceanic depths with the eddies of the Labrador current.

Eggs spawned in the Saint Pierre Bank and Green Bank can be carried out beyond these shoal currents which have the pattern of a cyclonic circulation. Eggs and larvae of the Yellowtail Flounder in the waters of this circulation drift south-eastward and can penetrate into adjacent areas of the Grand Newfoundland Bank. From the northern slope of the St. Pierre Bank eggs and larvae may drift northwestward to the coast of Newfoundland. However, it is difficult to expect that a considerable amount of eggs and larvae should be carried out beyond the Saint Pierre Bank and Green Bank as the local conditions, i.e. the low rate of the current (0.I-0.2 knot), high temperature of surface water in the summer period (I5-I9^{o}C) facilitating the rapid development of eggs and larvae impede this process.

The waters of the Nova Scotia shelf are dominated by the current coming out of Cabot's Straits and following along Nova Scotia south-westward. In these waters there are drifting eggs spawned in the north-easter part of the Nova Scotia shelf. The amount of eggs and larvae carried out beyond the shelf is evidently not great due to permanent cyclonic circulations occuring here in the spring-summer period (Bumpus, Lauzier, I965) and keeping eggs and larvae in shallow waters.

From spawning grounds off the Browns Bank (the south-western extremity of Nova Scotia) the main direction of the drift of eggs and larvae of the Yellowtail Flounder is north-westward, towards the Gulf of Maine.

Eggs and larvae of Yellowtail Flounder off the Georges Bank drift in different directions. Some of them drift south-westward with the current which is traced up to Cape Hatteras (Bumpus, Lauzier, I965). Smith et al. (I975) who studied passive migrations of Yellowtail Flounder larvae in shelf waters in the area from Cape Cod to Cape Hatteras also

indicate the same direction of the drift of eggs and larvae, i.e. towards Long Island and New Jersey.

Some eggs and larvae can be carried out beyond the southern slope of the Georges Bank into Gulf Stream which is proved by the occurence of eggs of this species (Fig. 1).

However, the main drift of eggs and larvae of the Yellowtail Flounder has a closed circular pattern which is accounted for by the anticyclonic circulation with the centre in the northern part of the Georges Bank (Klimenkov, Pakhorukov, 1964; Bumpus, Lauzier, 1965).

Thus, the spawning and drift of eggs and larvae of the Yellowtail Flounder in the Northwest Atlantic occur mostly in areas with sufficiently closed circular water masses or eddies of currents with low speed impeding the carrying-out of eggs and larvae into areas with conditions unfavourable for their development.

In the Northwest Atlantic such areas can be the Grand Newfoundland Bank, Saint Pierre Bank, Green Bank, Banks of Nova Scotia and the Georges Bank which are the habitat of the local populations of the Yellowtail Flounder.

Dependence of these populations from each other is determined by degree of water exchange between the areas they inhabit. Judging from data on circulation in Northwest Atlantic (Klimenkov, Pakhorukov, 1962, 1964; Bumpus, Lauzier, 1965; Bumpus, 1973; etc.) this area is characterized by considerable transfer of water masses from Nova Scotia Banks-Mizein and Bankero to the Emerald Bank and Browns Bank, from the Georges Bank to areas south of Cape Cod.

Proceeding from this it should be expected that the progeny of yellowtail flounder populations inhabiting the Mizein Bank and Bankero Bank evidently serves as additional source of recruitment for the populations of this species that live southwesterly, in the Emerald Bank and Browns Bank. A similar interrelation evidently exists between yellowtail flounder populations inhabiting the Georges Bank and areas south of Cape Cod. In other words, it is possible that the above groups of populations are depen-

dent to a certain extent, i.e. the recruitment of one of them partly occur at the expense of the transfer of eggs and larvae from another.

These considerations of groups of dependent populations, in case they are right, should be taken into account when introducing rational fisheries and distributing fishing effort in areas inhabited by Yellowtail Flounder.

As has been stated populations of the Yellowtail Flounder in the south of the Grand Newfoundland Bank and the Georges Bank are in immediate proximity to the Gulf Stream which is the zone of the carrying out of eggs and larvae of this typical neritic species whose whole life cycle is connected with shelf waters.

It is known that in the Georges Bank there often occurs a flush of relatively warm water of the continental slope which leads to mass death of eggs and larvae of the boreal species inhabiting the Bank including the Yellowtail Flounder as a result of an abrupt rise in the temperature of water (Colton, 1959).

Besides, there is evidence that from time to time a considerable amount of water from the Georges Bank is carried out southward and southwestward to areas with the water warmer and more saline waters of the continental slope (Bigelow, 1929, Walford, 1938). Yellowtail Flounder eggs and larvae that are carried out here cannot return to the shelf of complete the life cycle and are doomed to extintion.

According to Colton and Temple (1961), most of eggs and larvae of fishes spawning in the Georges Bank are carried out to the areas of slope waters and it is under exceptional hydrological conditions that appreciable numbers of eggs and larvae are retained on the Bank. i.e. mortality in these species mostly occurs in early periods of development due to changes in the direction of passive migrations.

Thus, the intensive exchange between the waters of the Georges Bank and the slope water and the Gulf Stream brings about changes in the conditions and the direction of drift which are unfavourable for eggs and larvae of the Yellowtail Flounder and lead to increasing mortality of this species in the early periods of development.

The intensity of water exchange between these areas is determined by different factors, i.e. by meandering of the Gulf Stream, wind regime, etc.

The modern data of sattelite observations show that with the intensification of meandering of the Gulf Stream, eddies in areas adjacent to the Georges Bank become more frequent which leads to increasing exchange between bank water and slope waters that surround the Bank. It is most markedly seen from the chart of the position of the core of the Gulf Stream and anticyclonic eddy-making processes published by Gunn (1979).

The opinion has been that the high rate of eddy production in the spring-summer period is evidently linked with preceding cold weather. The possibility of the existance of such connection is supposed by Celone and Chamberlin (1979) who marked a high rate of eddy production in 1978 that followed a record cold winter. Data on the anticyclones of the Gulf Stream in 1974-1977 obtained by Mizenko and Chamberlin (1979) point to the same effect.

If such interrelation between cold weather in winter and eddy production in the subsequent spring-summer period really exists, it should be expected that after severe winters processes of interexchange of shelf water and slope water and the Gulf Stream will be markedly intensified which will lead to deteriorating conditions and changes in the direction of the drift of yellowtail flounder eggs and larvae, i.e. to their higher mortality and the mortality of other boreal species with pelagic larval phase of development spawning in spring and summer in the southern and western areas of the Georges Bank.

The hydrological situation in the south of the Grand Newfoundland Bank determining the pattern of passive migrations of eggs and larvae is in many respects different from the situation in the Georges Bank. Though here the influence of the Gulf Stream on circulation is also great.

Off the southern extremity of the Grand Newfoundland Bank

there permanently exists a most prominent cyclonic eddy which forms at the joint of the warm water of the Gulf Stream and the cold Labrador current.This is a very stable peculiarity of the circulation south of Newfoundland.

However,in different years and seasons this eddy can change its location and size (Shtokman,I949).

Such changes in the location and size of the eddy depending on the fluctuating intensity of the Gulf Stream off the Grand Newfoundland Bank will certainly tell on the destiny of yellowtail flounder eggs and larvae drifting in its water and affect the strength of generations of this species.

R E F E R E N C E

Bigelow H.G.,I929.Plankton of the offshore waters of the Gulf of Maine. - Bull. U.S.Bur.Fish.,40(2):I-509.

Bumpus D.F.,I973. A description of the circulation on the continental shelf of the east coast of the United States.-Prog.Oceanogr.,6(4):III-I57.

Bumpus D.F.,Lauzier L.M.,I965. Surface circulation on the continental shelf of eastern North America between Newfoundland and Florida. - Am.Geogr.Soc., Serial Atlas of marine environment,Folio 7 : 4 pp.8 pl.Appendix.

Celone P.J.,Chamberlin J.L.,I979. Anticyclonic warm core Gulf Stream eddies of the Northeastern United States during I979. -ICNAF RES.Doc.79/VI/97,serial No.5459,I7 pp.

Colton J.B.,I959. A field observation of mortality of marine fish larvae due to warming. - Limnol.and Oceanogr., 4(2); 2I9-222.

Colton J.B.,Temple R.F.,I96I. The enigma of Georges Bank spawning.- Limnol.and Oceanogr. 6(3): 280-29I.

Gunn J.T.,I979. Variations in the position of the Shelf Water front off the American coast between Georges Bank and Cape Romain in I976. -NOAA Tech.NMFS, Circ.427, p.30I-3I4.

Klimenkov A.I.,Pakhorukov V.I.,I962. Hydrological observations in the North-West Atlantic in the spring-summer period of I962. - Sovetskie rybokhozajstvenye issledovanija Severozapadnoy chasti Atlanticheskogo okeana, VNIRO-PINRO,pp.I89-200 (Russian).

Klimenkov A.I.,Pakhorukov V.I.I964. Hydrological observations in the West Atlantic. -PINRO Transactions issue I6, pp.I5-23 (Russian).

Kudlo B.P.,Burmakin V.V.,I972 Water circulation in the South Labrador and Newfoundland areas in I970-I97I.- - Redbook ICNAF,p.III.P.27-33.

Marak R.R.,Colton J.B.,I96I. Distribution of fish eggs and larvae, temperature and salinity in the Georges Bank - Gulf of Maine area I953.-U.S.Fish Wildlife Serv. Spec.Sci.Rep.Fish.,393,_6I pp.

Mizenko D.,Chamberlin J.L.,I979. Gulf Stream anticyclonic eddies (warm core rings) off the northeastern United States in I977. - Ann.Biologiq.,34,p.39-44.

Nevinsky M.M.,I973. Reproduction of Limanda in the North-West Atlantic. - VNIRO Transactions,v.93,pp.262-284 (Russian).

Serebryakov V.P.,I962. On studies of ichthyoplankton of Labrador and Newfoundland.-Sovetskie rybokhozajstvenye issledovanija v severozapadnoy chasty Atlanticheskogo okeana,VNIRO-PINRO, pp.227-235 (Russian).

Shtokman V.B.,I949. On the cause of the Gulf Stream deviation south of Newfoundland. - Meterrology and hydrology, No 6.,p.65-7I (Russian).

Smith W.G.,Sibunka J.D.,Wells A.,I975. Seasonal distributions of larvae flatfishes (Pleuronectiformes) on the continental shelf between Cape Cod,Massachusetts, and Cape Lookout,North Carolina,I965-66. - NOAA Techn. Rep.,NMFS SSRF-69I, 68 pp.

Walford L.A., I938. Effects of currents on the distribution and survival of eggs and larvae of haddock (Melanogrammus aeglefinus) on Georges Bank. - Bull.U.S.Bur.Fish.,49(29) : I-73.

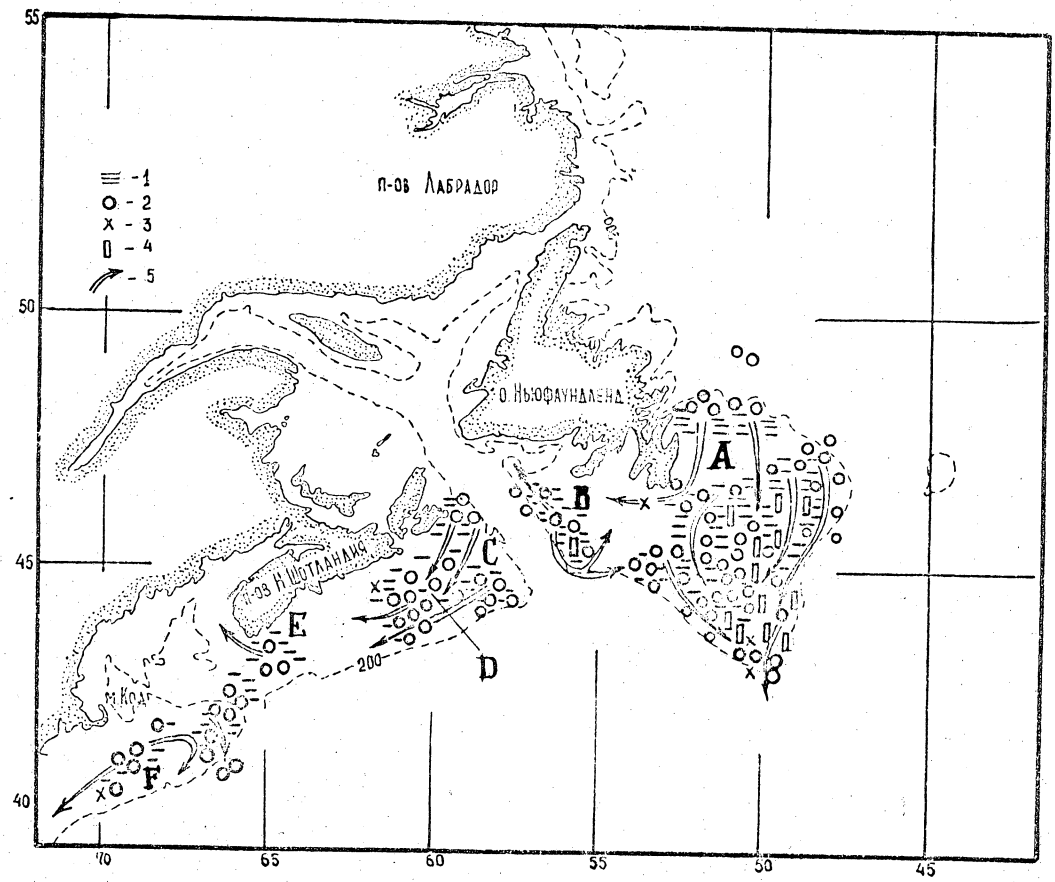

Fig. 1. Chart of passive migrations of yellowtail flounder eggs and larvae in the Northwest Atlantic.

I. - spawning grounds

2. - eggs

3. - larvae

4. - fry

5. - direction of drift of eggs and larvae

A - Grand Newfoundland Bank

B - Saint Pierre Bank and Green Bank

C - Mizein Bank and Bankero Bank

D - Middle Bank and Emerald Bank

E - Browns Bank

F - Georges Bank