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Fish stock protection

ON OPTIMUM SIZE LIMIT FOR THE GULF OF GDANSK FLOUNDER STOCK
O OPTYMALNYM WYMIARZE OCHRONNYM DLA STADA STORNI ZATOKI GDAŃSKIEJ

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The protective size limit of flounder *Platichthys flesus* L. at the present exploitation level (F = 0.40) was estimated by means of two methods: the Beverton and Holt on the one hand and the Goh on the other. Regardless of the procedure used, it was found advisable to increase the present protective size limit (21.0 cm). In the author's opinion, the Goh method assuming a limited fishing season yields more reliable results. The author proposes to increase the flounder protective size limit from 21.0 to 24.0 cm.

INTRODUCTION

The concept of fishery regulation, commonly in use nowadays, covers a variety of means undertaken to steer man's fishing activities so that the total annual catch does not exceed a level warranting a sustained maximum yield from the exploited stock under defined environmental conditions.

The productivity of a non-exploited stock depends on three „intrinsic" factors: reproductive potential, man-independent mortality, and growth rate. The actual values of indices reflecting the influence of each of these factors on the stock production are related to environmental conditions. In the sea, man's influence on fish stocks via purposeful manipulation of abiotic environmental factors is virtually impossible at the present technological level. Worse, our knowledge on relationships between processes taking place in ecosystems and fish stock responses to them is in most cases so negligible that we are unable to quantify with desirable precision the changes likely to occur in the stock as a consequence of the previously recorded environmental alterations.

Under these circumstances, when considering man's impact on fish stocks we have to assume that environmental conditions tend to fluctuate within a certain range, and any possible deviation from an average exerts no significant influence on the stock size compared to the impact of fishing exploitation.

This impact is manifest by the removal of a certain part of the stock's biomass. When no interaction from other stocks exist, a part of the ecological niche (in a spatial sense) become empty: the remaining individuals gain access to more food, larger shelter from natural enemies, and better spawning conditions. As a consequence, the stock tends to fill the resultant empty living space, which is expressed in weight units as an increased production recorded over the year compared to the non-exploited stock.

The impact of fisheries on any stock is evaluated by means of the following indices: percentage of biomass removed, size (age) of the fish subject to fishing mortality, decrease in the stock's reproductive potential resulting from the elimination of spawners, and an index expressing a reduction of the area available to fishes resulting from the destructive action of fishing gear.

Among the currently used fishing gear, bottom trawl is the most hazardous device in terms of destroying the superficial bottom sediment layer. The fishing gear impact on stock survival can be considered irrelevant in the case of those species which neither build nests on the bottom nor lay their eggs there.

Control on other factors can be exercised by introducing the so-called protective measures, the commonest of which are:

1. minimum fish size permitted for a fisherman to retain,
2. minimum permitted mesh (hook) size correctly adjusted to fish species,
3. maximum permitted annual catch from the stock,
4. maximum annual fishing effort permitted to be applied to the stock,
5. a ban on fishing at certain areas and/or in certain seasons,
6. a ban on certain fishing gear.

These measures affect two indices of those listed above as decisive for the stock state. The measures listed under 1–2 determine fish size (age) limit past which the individuals become liable to fishing mortality, while those under 3–6 limit the catch size, thus reducing fishing mortality.

The exploitation effect, i.e., the annual catch, depends on an equilibrium between these two factors. It should be added that an efficient introduction of those measures belonging to the second group is particularly difficult in international multi-species fisheries as a consequence of a variety of fishing effort units used, a situation resulting in a limited accuracy of estimates of the total fishing effort expressed in standard units. To supervise the implementation of the second-group protective measures a complex international control system is called for.

On the other hand, it is much easier to supervise the implementation of the measures classified in the first group. The knowledge on fishing gear selectivity makes it possible to set minimum mesh sizes warranting the removal of those individuals only that have reached a size securing the rational exploitation of the stock. The fishing gear control is a simple procedure that can be effected at a fishing ground or in the harbour.

The present paper deals with the problem of the most appropriate selection of the most appropriate minimum size limit of flounder. The objective was to poinpoint those protective measures that would make it possible to optimally utilise the stock's productivity, with a due consideration to natural properties of the species and to the present fishery pressure. In other words, the author considers calls to limit the catches and reduce the amount of fishing gear to be of a little effect and expresses a view that the problem of adjusting the exploitation level to the current stock productivity should be solved by introducing a protective size limit and a limited fishing season not extending on periods when the fish are of the lowest consumptive value and lay eggs, their amount securing the future stock density.

In 1963, the Minister of Shipping decreed that for the eastern area, hereafter termed the Gulf of Gdańsk, a minimum flounder size limit (21.0 cm) be set; only those individuals exceeding this size might be retained by fishermen. Thet was the so-called protective size limit. A question then arises as to the nature of a causal relationship between increased catches and this protective measure. Additionally, the present protective regulations limit the flounder fishing season to May – January, which means that the individuals past the minimum size are exposed to fishing mortality over three quaters of the year only. Market requirements with regard to fish quality (flesh texture, fat content) lead to a situation when, due to fish dealers' internal regulations, the Baltic flatfish are not purchased in May, whereby the fishing season is practically limited to 0.67 year.

In the present paper, the author – assuming a wide range of fishing effort (F = 0.05–4.00) – analyses the purposefulness both of various protective size limits and of varying duration of the protective season in terms of the most appropriate utilisation of the stock's natural productivity. In the author's opinion, this can be achieved by adopting proper indices of exploitation rate, age at first capture, and a limited fishing season.

While raising the problem, the author is aware that he is not the first to do so. It was Cięglewicz (1978) who first dealt with the problem in his paper summarising results of many years' work, who initiated this form of flounder fishery control, and who for the first time estimated effects of introducing the minimum fish size permitted in fishery and gathered biostatistical data for 1938–1977. Those materials enabled a comprehensive analysis of the stock's response to fisheries to be performed.

In this paper, the author wishes to present his results obtained when using a different methodological approach which serves the purpose of verifying the previous results and increasing the basis for scientific discussions on the applicability of mathematical procedures to the assessment of phenomena occurring in a stock. The author attempts to show the applicability of his studies to an optimal decision-making in management of the industry based on the exploitation of renewable resources within the Polish fishing zone. Survey of previous studies on impact of fisheries on Gulf of Gdańsk flounder stock.

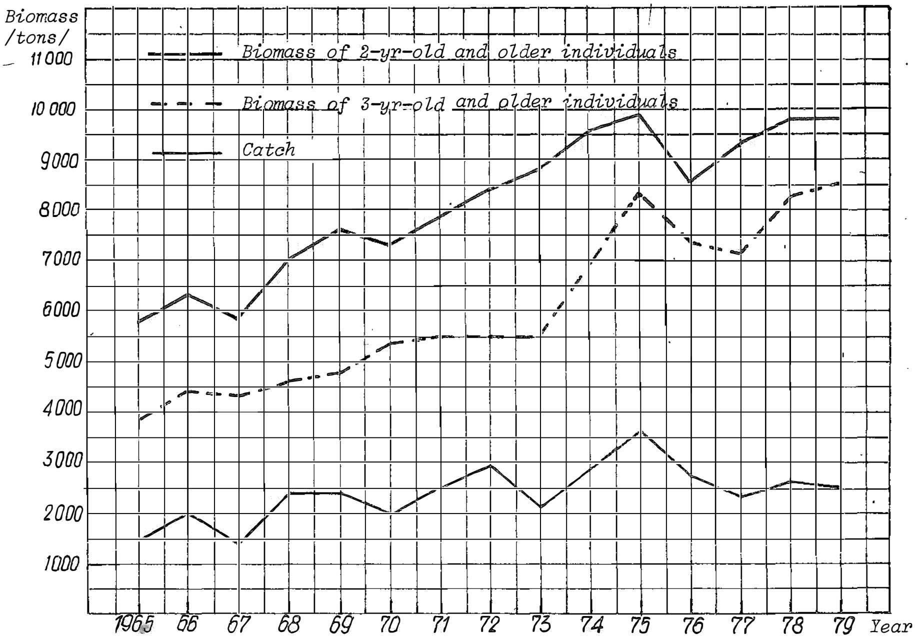


Fig. 1. Catches and biomass of the Gulf of Gdańsk flounder over 1965–1979

Within the recent 15 years, the flounder catches off the Polish eastern coast (the eastern region covers the inshore waters from 18°E to the Polish eastern border; according to the ICES grid, it is Area 26 bordered by the 56°30 N' parallel, 18°E meridian, and the shore line) were showing a clearly growing trend. About 90% of the annual catch of the species is effected by the Polish fishery, the remainder being ascribed to the USSR fishermen.

The stock state analysed for 1965–1979 by the stock biomass recurrent groups method (Draganik 1980) shows a biomass increase within the period analysed, certain fluctuations resulting from a poorer recruitment in some years (Fig. 1).

It should be emphasised that an increase in the resources supporting the Baltic fisheries is observed not only in the flounder but in other species as well (Thurow, 1978). The phenomenon is explained as caused by two factors:

1° the increase in nutrient contents in the Baltic waters, nutrients being supplied by land runoff from intensively fertilised arable areas in the Baltic countries with advanced agriculture, and

2° intensive exploitation creating conditions favouring the maximum production but not exceeding the level past which any increase in fishing effort would result in a drop in catches rather than in increased biomass removed.

A question then arises: to what degree do the present lawenforced regulation of the fisheries off the eastern coast contribute to the maintenance of the stock at its maximum

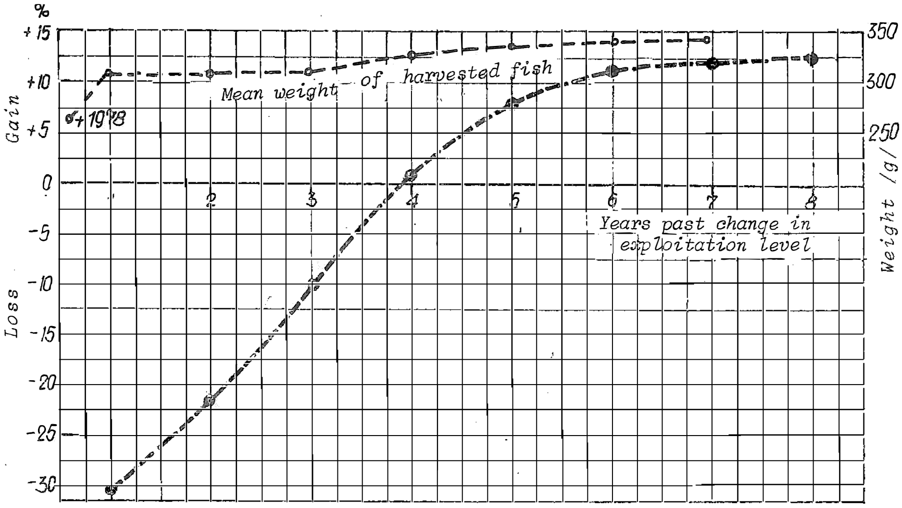


Fig. 2. Effect of changes in age group ratio in harvested fishes on annual catch (in % of 1978 catch amouting to 2649 tons)

production level? and, are the currently used measures optimal in terms of the stock's biological potential under the present exploitation regime?

The problem of an optimal utilisation of the Gulf of Gdańsk flounder stock under the present exploitation conditions was discussed by the author in one of his previous papers (Draganik, 1979). The analysis was based on the stock size estimation showing that, over 1970–1978, the biomass of 3-yr-old and older individuals ranged within 6600–8900 ton (Fig. 1).

When the 2-yr-old individuals are included, the mean increases to 9000 ton. The annual recruitment with the 2-yr-old individuals was 10–24 x 10^6 individuals over that period.

The estimates quoted above were arrived at, assuming the exponential coefficient of natural mortality to be 0.20 over a year.

Draganik (1979) assessed effects of changes in exploitation intensity and protective size limit on annual catches. He found the measures that would result in the elimination of the 2-yr-old individuals and 20, 18, and 10% reductions of the age groups 3, 4, and 5, respectively, to yield a 30% catch decrease in the first year of the new measures being in force. In the subsequent years the losses will be diminished (Fig. 2) to reach 0% in the fourth year of the new exploitation mode (the catch size equal to that in the last year befor the change in exploitation system). In the sixth year there will be a 10% gain reaching 11% in the following years. The calculations were based on an assumed stable recruitment and a constant fishing mortality coefficient.

The model presented in that paper allows to assess changes likely to result from a reduced fisheries pressure on the younger part of the stock and is very convincing in its correctness and "elegance" of the results obtained. However, a question may be asked as to how, under the flatfish fishery conditions in the Polish fishing zone, to practically arrive at a partitioning of the fishing effort among various age groups. The only solution is to adjust properly the fishing gear selectivity. The implementation of the results referred to requires changes in the fishing gear construction; in view of high costs involved we must be positive that an estimation error is minimised before the decision is made.

The available results of experimental studies on gear selectivity in the flatfish fishery are insufficient for an accurate plotting of selectivity curves for the flounder. It is thus logical to propose that the efficiency of the suggested fisheries control method be related directly to the fish, and only at a later stage to consider the feasibility of changes in the fishing system.

The other methodological approach discussed in the paper referred to (Draganik, 1979) involves, too, the assumption of recruitment being constant over 1979–1981 (20.7×10^6 individuals of the age group 2 per year) and constant ratios between age groups in catches, while the fishing intensity expressed numerically as the fishing mortality coefficient is the variable. The assumption is that only 30% of fishes reaching 2 years of life and 80% of those reaching 3 years become liable to the gear. In the author's opinion, it is a result of an uneven distribution of younger fishes over the fishing ground rather then of the gear selectivity.

If the above assumption is accepted and the fact that the 1978 catch amounted to 1649 ton considered, the weighted mean fishing mortality coefficient (F) would equal 0.44 and not 0.33, the latter value emerging from the assumption that all the 2- and 3-yr-old individuals in the stock are exposed to the gear equally to the older ones.

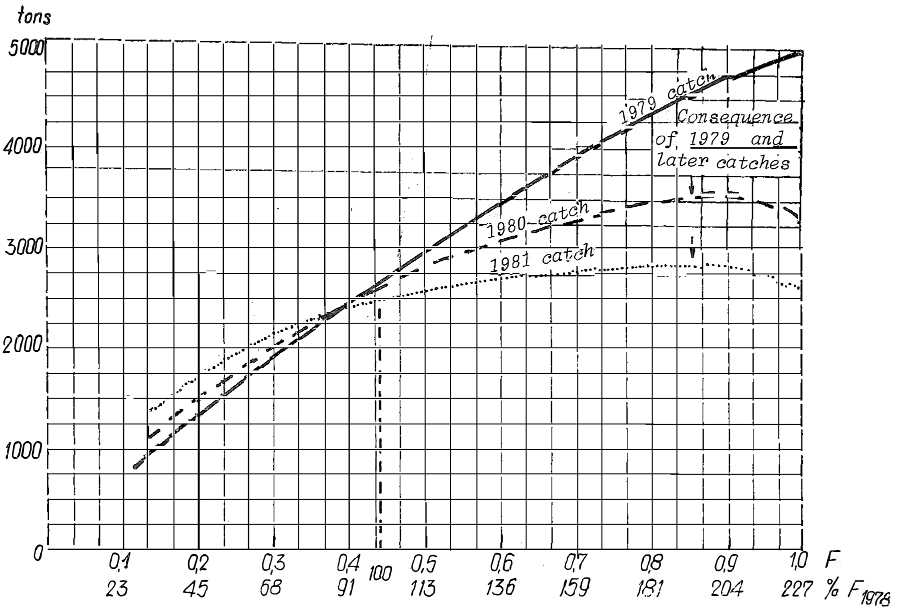
In the author's opinion, the exploitation intensity in 1979 will be crucial for the stock state and catches in the subsequent years.

The simulation of effects of the 1979 exploitation on catches in nexr years is presented in Fig. 3. The results obtained are interpreted as follows: if the 1979 exploitation is maintained at a level such as that in the previous year, no marked change in next years will occur (to be more precise, a 100 ton decrease will be recorded in 1981). On the other hand, the 1979 catch increased by 1350 ton (to a total of 4000 ton) would call for a 65% increase in the exploitation intensity. A higher exploitation pressure in the subsequent years would result in catches decreasing by 3500 ton in 1980 and down to 2900 ton in 1981, given the recruitment not larger than assumed.

Owing to the fact, however, that the statistics available point to the 1979 catches remaining at the 1978 level, there is no ground for fear as to the 1980 and 1981 catches.

The concept of "exploitation intensity" used here cannot be practically determined in unit fishing effort due to a variety of gear and vessels employed in flounder fishing.

In spite of this insufficient information restricting the conclusions, the author found that, with the stock size such as that in 1979, a 50% increase in catches compared to 1978 would bear no catastrophic consequences in the subsequent years. It is more appropriate to consider the problem in terms of exploitation affecting a part of the stock



Rys. 3. Predicted catch of the Gulf of Gdańsk flounder at different exploitation levels (1978 results adopted as reference)

only rather than to accept the increase in catches regardless of other possibilities of increasing the exploitation efficiency.

MATERIALS AND METHODS

In the present paper, two different methods of fish protective size limit assessment are used. The first is based on the Beverton and Holt (1957) model; its mathematical form, the so-called general equation of catchability enables one – via consecutive substitutionsto calculate a minimum age at which the fish should be subject to fishing mortality, given a defined fishing intensity expressed as the exponential coefficient of fishing mortality (F).

$$Y/R = F\,W_\infty e^{-M(t_c-t_r)} \sum_{n'=0}^{n'=3} \frac{Qn' e^{-n'K(t_c-t_o)}}{F+M\,n'K} \left(1-e^{(F+M+nk)(t_\lambda-t_r)}\right)$$

where: $Q_0 = 1,\ Q_1 = -3,\ Q_2 = 3,\ Q_3 = -1$

The equation can be simplified by rejecting its last term, provided $t_\lambda - t_t$ is sufficiently high (more than 8). In other words, the equation was used to plot isopleths, i.e., lines connecting points of equal yield, with respect to two variables: the fishing mortality coefficient, and the age of first capture (t_c). By connecting the points of the minimum first capture age there results a curve the interpretation of which provides a basis to select a minimum fish size so that the maximum yield at the present exploitation level (F) is guaranteed. The Beverton and Holt model assumes the fish growth to proceed according to the von Bertalanffy equation, the losses being described by an exponential equation. The model is adjusted to a situation, whereby the fishing proceeds continuously over the year. On the other hand, for those species that can be harvested on a seasonal basis only, the model appears to be less adequate since its assumptions are not fulfilled. The flounder fishing season can be shortened or extended depending on the stock conservation and market requirements, and/or meteorologic conditions restricting fishing operations.

To determine the flounder protective size limit with a particular reference to the Gulf of Gdańsk stock exploitation conditions a method described by Goh (1977) was used. The method stems from the fact that the stock is affected by the fishery over a part of the year only. Its application involves finding the fish age as an independent variable in equations describing growth rate and individual productivity index over the time interval from (t+1) to t_λ such that a value equivalent for the two functions is obtained.

The von Bertalanffy growth rate equation, when expressed in unit weight of fishes at the age t enlarged by the length of the fishing season (Δt) takes the form of

$$W_{(t+\theta\Delta t)} = W_\infty (1-e^{-K(t+\theta\Delta t-t_o)})^n$$

The value of individual productivity index at the age (t+Δt) was estimated by the recurrent groups method from the equation:

$$G(t-1+\theta\Delta t) = G(t+\theta\Delta t)\,\psi((u)t)) + (1-m)^{S-1}\,W(t+\theta\Delta t(u)t)$$

$$\phi(u(t)) = (1-m)^{S-1}\,[1-(m+u)t)]$$

$$m = 1-e^{\Delta t M}$$

$$u(t) = e^{\Delta tM} - e^{-(M+F)\Delta t} \quad \text{for} \quad t = t_{min}, t_{min}+1 \ldots t_\lambda-1$$

$$S = \frac{1}{\Delta t}$$

where F = instantaneous fishing mortality coefficient,
K = katabolism coefficient in the Brody-Bertalanffy growth equation,
M = instaneous natural mortality coeffiçient,
b = constant in length/weight equation,
n′ = addition constant (i.e., $Q_0 = 1$; $Q_1 = -3$; $Q_2 = 3$; $Q_3 = -1$),
t_c = age at which fishes are first retained by the gear in use,
t_r = age of recruitment to the fishery (average age at which fish become vulnerable to the gear under consideration),

t_0 = theoretical age at which both length and weight equal 0 in the von Bertalanffy equation,
t_λ = maximum age obtained (the end of the lifespan),
t_{min} = age of the year-class at the beginning of the first fishing season,
T = age of the oldest fishes when (t–1) does not coincide with the onset of fishing season,
$G(T-1+\theta\Delta t) = 0$
W = value of W at which weight increments equal 0,
θ = constant taking values within 0.4–0.5,
Δt = duration of the limited season.

The equations given above were derived by the authors referred to. It should be borne in mind that the function $G(t+\theta\Delta t)$ is defined only at a discrete number of points.

By connecting these points with a line there results a curve; its intersection with the growth rate curve determines t_{min} and a corresponding value of W_{min}. The minimum fish length (protective size limit) corresponding to t_{min} can be determined from a length/weight equation.

To assess the growth parameters used in subsequent calculations, a modified von Bertalanffy equation (Szypuła, 1979) was used. Mean weights for age groups obtained from direct measurements as well as a mean exponential coefficient (b) determining the length/weight relationship were used to estimate W_∞, K, and t_0.

RESULTS AND DISCUSSION

The Beverton and Holt model as well as that of Goh are both analytical models, i.e., they allow to consider separately effects of variability of a number of factors (mortality, growth rate, age limits at which fishes become susceptible to gear or insensitive to it) on catch. Consequently, the adequateness of the final estimate depends on the level of approximation of calculated natural mortality values and growth rate parameters to the actual ones.

Cięglewicz et al. (1969) presented a linear characteristics of the Gulf of Gdańsk flounder growth rate based on otolith readings. The growth rate parameters for the Gulf of Gdańsk flounder were reviewed in one of the ICES reports (Anon., 1974).

The authors mentioned above ignored sex-dependent differences in the flounder growth rate. The materials collected for the present study in 1978 and 1979 point to males having a shorter exploitation life stage as compared to females (6 and 10 years, respectively). The flounder stock under study exhibits an "even" growth manifested by a low K and a high W_∞. The flounder growth rate curves plotted from the coefficients estimated in this paper indicate to differential growth rates of males and females, particularly in older individuals (Fig. 4).

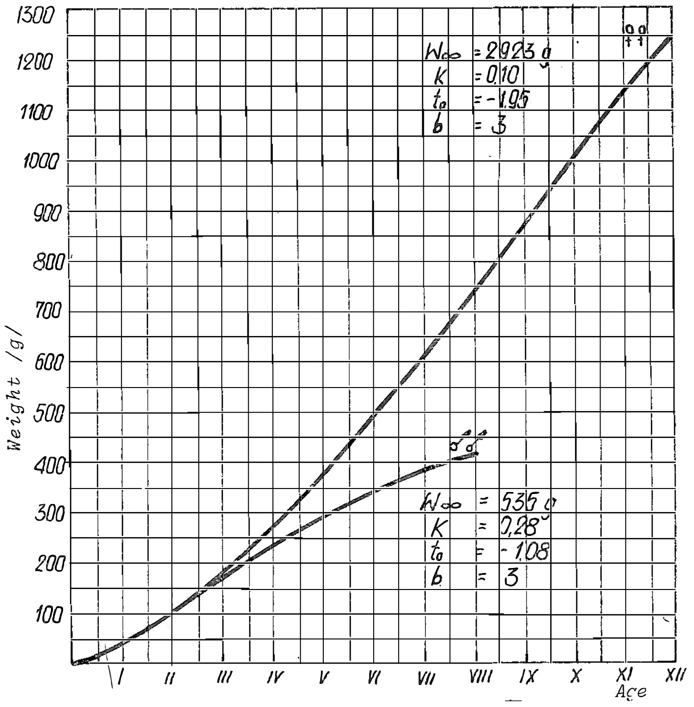


Fig. 4. Curves illustrating the Gulf of Gdańsk flounder growth rate for males and females

Owing to the fact that the present paper was aimed at determining a size limit serving to establish a protective size rather than the yield from the stock, it was deemed appropriate to enter only the female growth parameters into the calculations. Actually, the male protective size limit may be somewhat lower than of females; its overestimation (in the author's opinion, a minor one) will nevertheless bear no adverse effects while diminishing a chance of an inappropriate utilisation of the stock productivity. It should be explained that the growth differences between females and males are small over their first years of life (37 g at the age of 5), which justifies treating the stock as if it consisted of females only.

The exponential coefficient of natural mortality for fishes at the exploited stage of life (M = 0.20) was used in the analysis.

To counteract criticisms as to his assuming a constant natural mortality in all age groups, the author estimated the stock biomass variance at varying M (Draganik, 1978). The results obtained are, in the author's opinion, sufficient to adopt a simplifying assumption of M = const. = 0.20.

The changes in yield/recruitment are determined for the flounder at the age interval of 2–9 years (t_c), while the age of recruitment to the exploited stock (t_r) is given as 2 years.

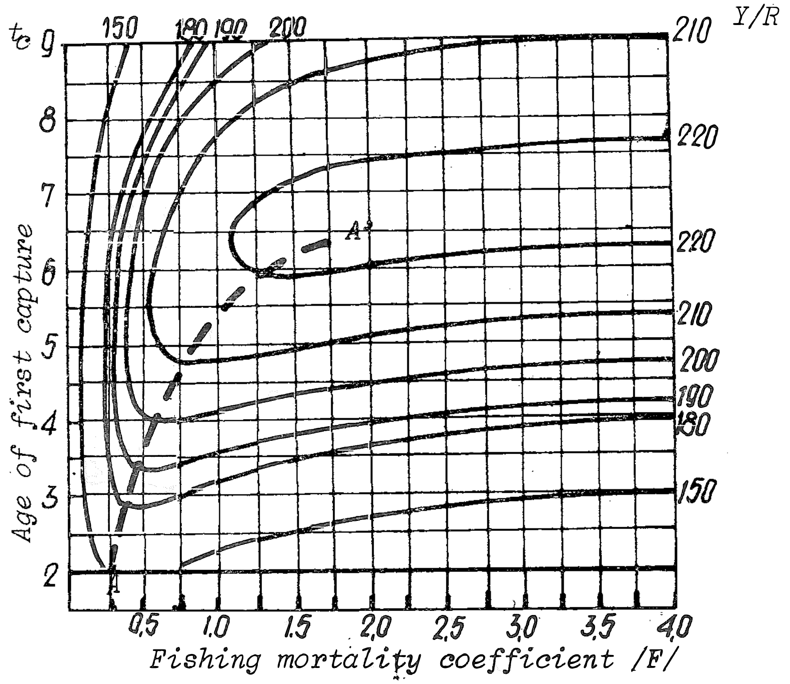


Fig. 5. The Gulf of Gdańsk flounder isopleths

The fishing mortality coefficient (F) is assumed to change within 0.05–4.00.

Cięglewicz (1978) has found out that an increase in the protective size up to 26 cm would, at the present exploitation rate (fishing mortality coefficient ranging within 0.80–1.00), result in a 22% increase in yield. The author mentioned assumes the following values of growth parameters in his calculations: $L_\infty = 45.6$ cm; $K = 0.21$. He estimated fishing mortality rate from a reduction in each generation's abundance in consecutive years of exploitation. A high reduction rate in older fishes contributing to a negligible extent to the stock biomass and catches was found to bear a significant effect on increasing the mean value of F.

In the present author's opinion, a reduction rate over the past decade as calculated with a due consideration to each age group in the stock did not exceed 0.40. The stock yield calculated assuming various F's and t_c is presented in Fig. 5. At the present exploitation rate, the flounder should be subject to fishing mortality at the age of 2.7 years, which corresponds to the total body length of 24.6 cm.

A more dateiled analysis of the Y/R estimates in terms of a rational utilisation of productivity of the stock shows the latter to be very sensitive to changes in exploitation rate (the A-A'curve is steep). To increase slightly (by 0.10) the fishing mortality coefficient, a corresponding increase in the protective size up to 27 cm is called for, if we insist on observing the principles of the rational utilisation adopted when constructing the model.

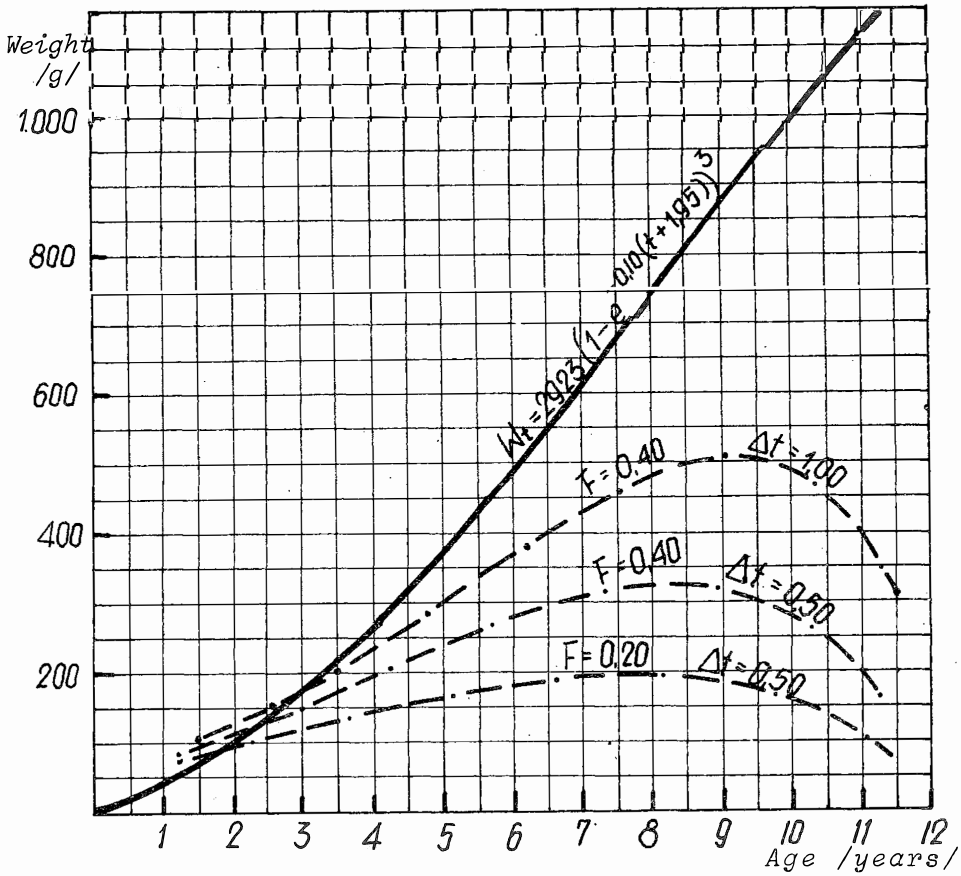


Fig. 6. Graphic method of optimum size limit determination

The regulation measures mentioned in the introduction, currently in use, allow the flounder to be harvested only from June (or May) through January, so $\Delta t = 0.75–0.67$. The above reasons have prompted the present author to use the Goh method to estimate t_{min}. Several curves plotted by connecting points corresponding to values of the function $G(t+\theta\Delta t)$ at different Δt and F are presented in Fig. 6.

Results of a more detailed analysis revealed that under conditions of a uniform growth rate and low natural mortality the duration of the flounder fishing season bore no significant effect on the protective size limit. An explanation is necessary as to what the author means by a "significant effect". This will be best illustrated by an example. The calculations show that if $F = 0.40$ and t ranges from 0.15 to 1.00, the t_{min} range is 1.20–2.80.

Values of t_{min} were estimated for a number of F's and Δt's. Including the t_{min} values in the F and Δt coordinates system, the lines connecting points corresponding to equal t_{min} values were plotted (Fig. 7). A graph thus obtained can serve to find a value to which t_{min} should be increased (a linear protective size limit in practice) to maximise the catch likely to be obtained from the stock, given a defined F and fishing season (Δt).

At the present fishing intensity ($F = 0.40$), the minimum age permitted for landings should equal 2.55 years, which corresponds to the total body length of 24.0 cm. An effect of decreasing, from 0.2 to 0.1, the exponential coefficient of natural mortality M on the protective size limit was studied as well. If such were the case, the size limit should be increased to 30 cm. The sensitivity of the method to the accuracy of estimates of the parameters is thus evidenced. All this indicates to a necessity of an experimental tagging of the Southern Baltic flounder. Results of the experiment may permit a more accurate estimation of M.

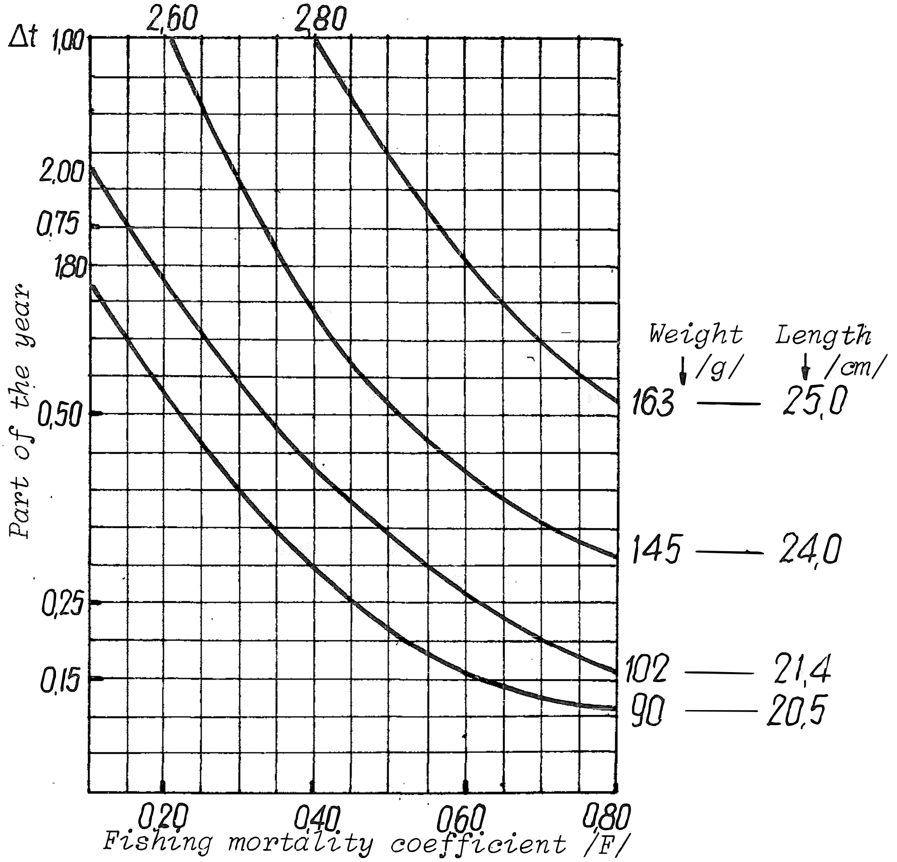


Fig. 7. Isolines determining flounder protective size vs. exploitation intensity and length of fishing season

CONCLUSIONS

At the present exploitation rate of the Gulf of Gdańsk flounder Stock, the fish protective size limit as determined using the Beverton and Holt model should be equal to 24.6 cm. This parameter's value was found to be 24.0 when determined by the Goh method, given the fishing season shorter than a full calendar year (0.65 year).

The results presented in the paper show unequivocally that the present protective size limit of the flounder should be increased by 3 cm.

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DOBÓR OPTYMALNEGO WYMIARU OCHRONNEGO DLA STADA STORNI *PLATICHTHYS FLESUS* (L.) ZATOKI GDAŃSKIEJ

STRESZCZENIE

Praca przedstawia przegląd wyników dotychczasowych badań nad reakcją stada storni Zatoki Gdańskiej na eksploatację. Zostały zestawione i przedyskutowane wartości parametrów tempa wzrostu i śmiertelności zarówno naturalnej jak i połowowej. Tempo wzrostu zostało określone na podstawie średnich ciężarów ryb w grupach wieku, wskazuje ono istotne różnice w zależności od płci. Samce rosną wolniej i charakteryzują się większą śmiertelnością. Wyraża się to brakiem w eksploatowanym stadzie samców w wieku 9 lat i starszych.

Analiza dotychczasowego stanu stada przy użyciu metody rekurencyjnej tzw. wirtualnej populacji wykazała stały wzrost biomasy stada na przestrzeni lat 1967–1979. Średni wskaźnik śmiertelności połowowej w ostatnim pięcioleciu był bliski 0,40.

Różnorodność stosowanych narzędzi połowu uniemożliwia oszacowanie nakładu pracy połowowej, któremu można byłoby odnieść wartość oszacowanego wskaźnika śmiertelności połowowej. Ogranicza to możliwość stosowania środków regulujących eksploatację stada storni do wymiaru ochronnego ryb oraz okresu zakazu połowów. W kalkulacjach wymiaru ochronnego uwzględniono tylko wartości parametrów wzrostu równania von Bertalanffy'ego określonych dla samic (W = 2923, K = 0,10, t_0 = –1,95). Równanie wyłowu Bevertona i Holta posłużyło do określenia wymiaru ochronnego storni, który przy obecnym poziomie eksploatacji powinien wynosić 24,6 cm. Ograniczenie połowów storni przepisami ochronnymi do 0,75 roku sprawia, że w rzeczywistości śmiertelność połowowa oddziaływuje na ryby tylko przez część roku. Fakt ten skłonił autora do zastosowania metody opisanej przez Goh'a uwzględniającej sezonowość połowów. Oszacowany tą metodą wymiar ochronny przy użyciu analogicznych danych wyjściowych jak w przypadku uprzednio zastosowanej metody wynosi 24,0 cm.

Б. Драганик

ПОДБОР ОПТИМАЛЬНОГО ПРОМЫСЛОВОГО РАЗМЕРА ДЛЯ СТАДА БАЛТИЙСКОЙ КАМБАЛЫ (PLACHTHYS FLESUS(L.)) ИЗ ГДАНСКОГО ЗАЛИВА

Резюме

Работа представляет собой обзор результатов, опубликованных до настоящего времени, касающихся реакции стада балтийской камбалы Гданского залива на эксплуатацию. Составлено и обсуждено значения параметров темпа роста и смертности – естественной и промысловой. Темп роста был определен на основании средних весов рыб в возрастных группах. Он проявляет существенные различия в зависимости от пола. Самцы растут медленнее и характеризуются большей смертностью. Проявляется это отсутствием в эксплуатированном стаде 9 летних и старших самцов. Анализ состояния стада при помощи метода „рекуренции", так называемой „виртуальной" популяции, показал постоянный рост биомассы стада на протяжении лет 1967–1979. Средний коэффициент промысловой смертности за последние 5-летие был близок 0,40. Разнообразность при-

меняемых орудий лова не дает возможности произвести оценку промыслового усилия к которому должно быть отнесено значение оцениваемого коэффициента промысловой смертности.

Это ограничивает возможность применения средств регулирующих эксплуатацию стада балтийской камбалы до промыслового размера рыб а также запрета вылова. В расчете промыслового размера принимали во внимание только значения параметров роста уравнения Берталанфи определенных для самок($W = 2923$; $K = 0,10$; $t_0 = -1,95$).

Уравнение вылова Бивертона и Хольта послужило для определения промыслового размера балтийской камбалы, который при настоящем уровне эксплуатации должен составлять 24,6 см. Ограничение вылова балтийской камбалы правилами охраны рыболовства до 0,75 года приводит к тому, что в действительности промысловая смертность действует на рыб только в течение части года. Этот факт позволил автору применить метод описанный Гох, учитывающий сезонный характер уловов. Оцениваемый этим методом промысловый размер при использовании аналогичных выходных данных, как в случае предыдущего метода, составляет 24,0 см.

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