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A Method of Quantitative Evaluation of the Effect of the Scientific-Technological Progress upon the Development of the Marine Fisheries

by

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In order to forecast the development of the fisheries in the open seas and oceans it is necessary to have a possibility not only of determining the tendencies of increase in the catches by fleet, but also estimating the changes in those tendencies which are due to the scientific-technological progress.

This progress in the fisheries has many aspects and is manifested in the development of the commercial fishing technique, ship-building, fish-processing technology, in the management, in the studies of the fish stocks, in the discovery of the new fishing areas and in many fields of technology and science cooperated in the modern commercial fisheries. It is impossible at present to estimate by specific factors the effect of the progress upon the increase in yield. Therefore, in order to forecast the probable catches in the seas and oceans an attempt was made to find out a complex evaluation of the effect of the scientific-technological progress upon the changes in each particular time period. To enable us to do this the following assumptions were used:

The changes in the total catch of fish and other sea products in the open seas and oceans can be ascribed to three main factors:

1. Changes in the conditions of the stocks in some fishing areas.
2. Increase of the fishing effort in terms of number of ships and tonnage.
3. Scientific-technological progress.

The effect of the first factor - for instance, the stock conditions getting worse in some fishing areas - is at present equilibrated by the availability of the manoeuvering fleet and its ability for a quick redislocation; the improvement in the condition of the exploited stocks in the traditional fishing areas in the presence of a large number of vessels in the fisheries does not either change sharply the general tendency of the catches. In this relation, the total catches by fleet, as influenced by this factor, vary only insignificantly, and it may be balanced completely by using the method of smoothing the catch curve, i.e., by presenting the curve in the form of the following polinomial:

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$$Uc = cP_{(t)} + dP^2_{(t)} + \dots + q\,P^m_{(t)} \quad \dots\dots (1)$$

where Uc is a smoothed catch curve for t years; $P_{(t)}$, $P^2_{(t)}$, ..., $P^m(t)$ are Chebyshev's orthogonal multinomials for collection in t years; c,d,....q are coefficients.

Thus, the catch variation curve, Uc, is now influenced by the two last factors only.

However, the extent to which each of these factors exerts an influence in the various time periods is different and it is actually this fact that changes the tendencies in the Uc curve increase in each particular length of time. Let us divide the length of time t for which we observe the change in the catch into two lengths of time t_λ and $t_n = t - t_\lambda$. Let us then investigate the influence of each of these factors upon the fisheries development (the increase in catches by fleet). Let us further assume that the tendencies in the increase in fleet for t_n length of time remain the same as for t_λ, as well as, the level of the scientific-technological process.

Then the fisheries development should follow the logistic law, like any biological or technological-biological progress[x], that is

$$U = \frac{1}{a+be^{-kt}} \quad \dots\dots\dots (2)$$

where U is the size of a catch;

t is the duration of the period investigated; and

a,b,k - coefficients.

The coefficients a,b,k, are found by using the data of the statistical observations for t_λ years in the following way:

$$\frac{dU}{dt_\lambda} \doteq kbe^{-kt_\lambda}\,U^2 \quad \dots\dots\dots (3)$$

$$\frac{dU}{dt_\lambda} \cdot \frac{1}{U^2} = kbe^{-kt_\lambda} \quad \dots\dots\dots (4)$$

If we assume that $kb = A$ .... (5)

then $\frac{dU}{dt_\lambda} \cdot \frac{1}{U^2} = Ae^{-kt_\lambda}$ .... (6)

and $\ln \frac{dU}{dt_\lambda} \quad 2 \ln U = \ln A - kt_\lambda$ .... (7)

By using the method of the least squares we can then find the "A" and "K" values.

Substituting "K" and "A" values in the equation (5) we find the value of the coefficient "b".

In this case the coefficient A is found by the following equation:

$$A = \frac{\sum(\frac{1}{U} - be^{-kt_\lambda})}{t_\lambda} \quad \dots\dots\dots (8)$$

When extrapolating the catch values in a period

$$U_{tn} = \frac{1}{a+be^{-k(t_\lambda + t_n)}} \quad \dots\dots\dots (9)$$

x) Kesteven, G.L., Holt, S.I. Papers presented at the International Technical Conference on the Conservation of the Living Aquatic Resources in the Sea. Rome, 1955 FAO.

The tendency in the catch variation would have been like this provided that in tn period the level of the scientific-technological progress were invariable and that the increase in the fleet remained as in period t .

The total or calculated yield for tn period would have been:

$$\sum_{t=t_\lambda}^{tn} U_{tn}^{cal} = \int_{t_\lambda}^{tn} \frac{dt}{a+be^{-kt}} \quad \ldots\ldots\ (10)$$

However, under the influence of the scientific-technological progress and the changes in the tendencies of the fleet increase the observed volume of the catches differed from calculated yield (10) and varied in the following way:

$$\sum_{t=t_\lambda}^{tn} U^{obs}_{tn} = \int_{t_\lambda}^{tn} (cP_{(t)} + dP^2_{(t)} + \ldots + q\, P^n_{(t)})\, dt \quad \ldots\ldots\ (11)$$

The increase in the observed volume of the catches as compared with those calculated:

$$\Delta U_{obs} = \int_{t_\lambda}^{tn} (cP_{(t)} + dP^2_{(t)} + \ldots + q\, P^n_{(t)})\, dt - \int_{t_\lambda}^{tn} \frac{dt}{a+be^{-kt}} \quad \ldots\ldots\ (12)$$

was caused by the effect of the scientific-technological progress and by the changes in the fleet increase.

The rate of the increase in catch under the influence of these factors would then be:

$$T_{T+M} = \frac{\Delta U\ obs}{\sum_{t=t_\lambda}^{tn} U^{obs}_{tn}} \quad \ldots\ldots\ (13)$$

where T_{T+M} is the rate of the increase in catch under the influence of the scientific-technological progress and of changes in the increase in fleet for the period tn.

Let us study the way in which the tendencies of the fleet increase change within the period tn. As an initial premise we shall take the fact that in the fisheries any level of exploitation of the stocks is corresponded by the level of the material and technological base development. The closeness of this relation was justly noted by A. Negolevsky who came to the conclusion that "in fisheries, as well as in agriculture the intensification of the production and the industrialization are the two sides of the same process stipulating and supporting each other".[x)]

Since the fisheries development follows the logistic law, it can be supposed that the fleet development follows it too. The analysis of the observed data on the increase in fishing fleet confirms this suggestion. Consequently, the general increase in the fishing fleet can be expressed by the equation:

$$M_{cal} = \frac{1}{p + le^{-rt_\lambda}} \quad \ldots\ldots\ (14)$$

The coefficients p,l,r, of equation (14) can be calculated by the data of the statistical observations for the t_λ period. However, due to a number of

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x) A. Negolevsky. A theory of the fisheries development. Marine Publ., Gdynia, 1965.

reasons the increase in the fleet does not remain constant. It is the difference between the observed fleet power and the calculated one for the tn period which determines the rate of the changes in these tendencies:

$$\Delta M_{obs} = M_{obs} - \int_{t_\lambda}^{tn} \frac{dt}{p+1e^{-rt}} \qquad \ldots\ldots\ (15)$$

where ΔM_{obs}

is the difference between the observed and calculated fleet increases:

M_{obs}

is the observed fleet power for the tn period of years.

Correspondingly, the rate of the changes in the catches caused by the changes in the increase of the fleet T_M, is determined in the following way:

$$T_M = \frac{\Delta M_{obs}}{M_{obs}} \qquad \ldots\ldots\ (16)$$

Hence, the rate of changes in the catches caused by the scientific-technological progress would be equal to:

$$T_T = T_{T+M} - T_M \qquad \ldots\ldots\ (17)$$

while the absolute yield increase due to the scientific-technological progress in the period is:

$$\Delta U_T = T_T \sum_{t=t_\lambda}^{tn} U_{tn}^{obs} \qquad \ldots\ldots\ (18)$$

Thus, by using the suggested method we can tentatively estimate the extent to which the scientific-technological progress and the increase in fleet influence the fisheries development and we can obtain the initial data for further forecast of these tendencies.