# ANALOG COMPUTATION AND FISH POPULATION STUDIES[1]

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The analog computer can give valuable assistance in the study of the dynamics of fish populations and has been used in yield analysis (Silliman, 1967), age and growth studies (Richards, 1968) and in studies of predator-prey relationships (Doi, 1962). In the near future, hybrid systems involving both the analog and digital computer will be used in the study of complete biological systems rather than isolated components. Mortality, fecundity, growth, intraspecific and interspecific relationships as they become known could be put together for system models. The purpose of this paper is to demonstrate some of the capability of the analog computer.

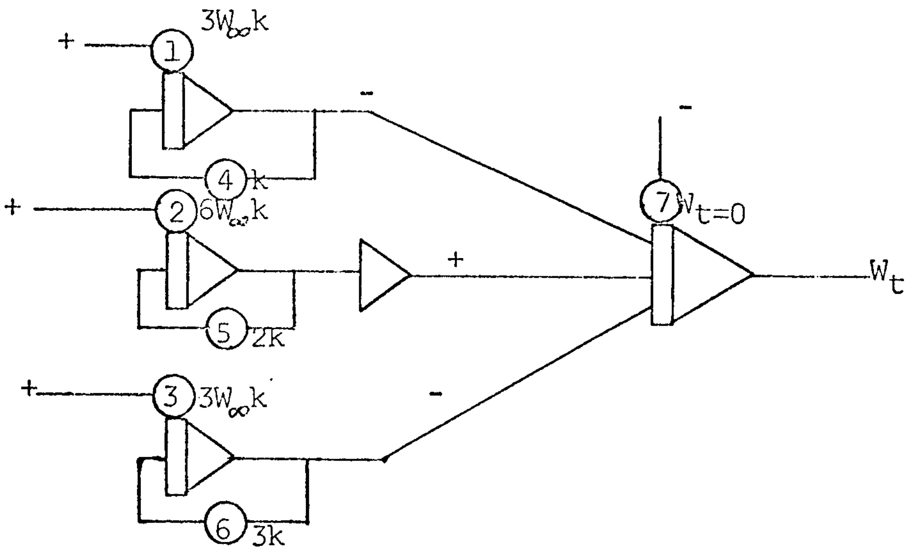
Segments or data blocks of a population study are growth in weight, mortality rates, and fecundity. These can be simulated by the analog computer. The expanded von Bertalanffy equation, where:

$$W_t = W_\infty - 3W_\infty e^{-kt} + 3W_\infty e^{-2kt} - W_\infty e^{-3kt} \qquad (1)$$

is written as the differential equation:

$$W_t = 3kW_\infty e^{-kt} - 6kW_\infty e^{-2kt} + 3W_\infty e^{-3kt} \qquad (2)$$

This equation is integrated and solved by the analog circuit:




Values of K and maximum weight are obtained through the technique described by Richards, (1968). Growth curves (Figs. 1-2) of female and male striped bass, (*Roccus saxatilis*), based on data from Mansueti (1961), are typically sigmoid.

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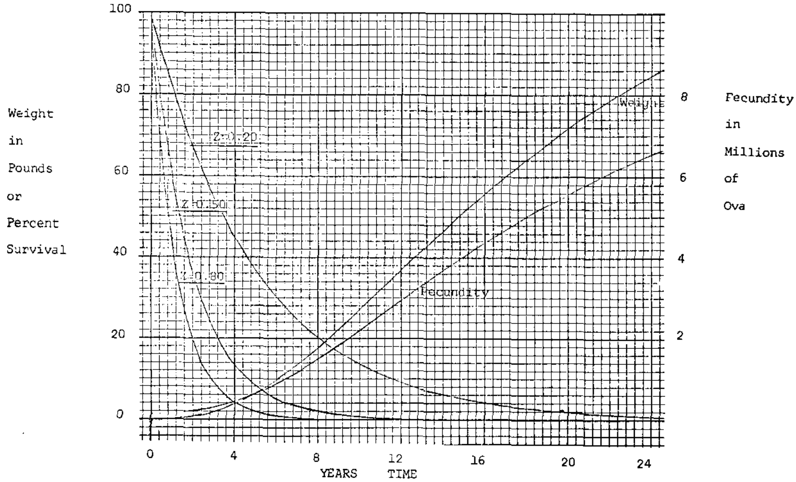



Figure 1. Growth, fecundity and survival curves for female striped bass.

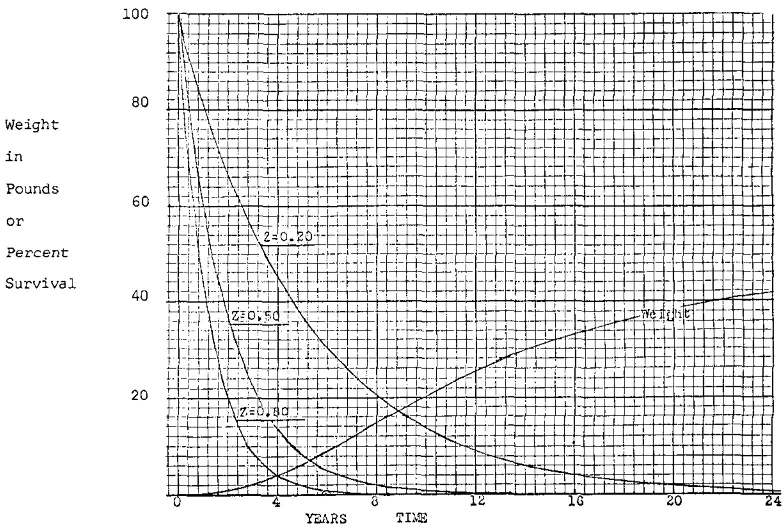



Figure 2. Growth and survival curves for male striped bass.

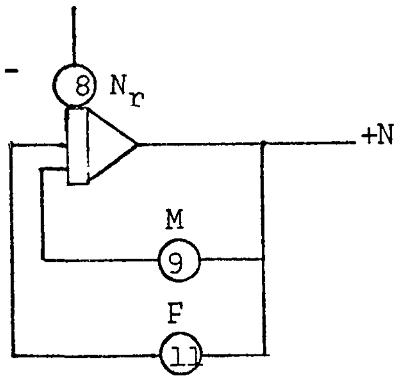
The mortality-survival equation:

$$N_t = N_r e^{-(F+M)t} \quad (3)$$

or

$$N_t = N_r e^{-Zt} \quad (4)$$

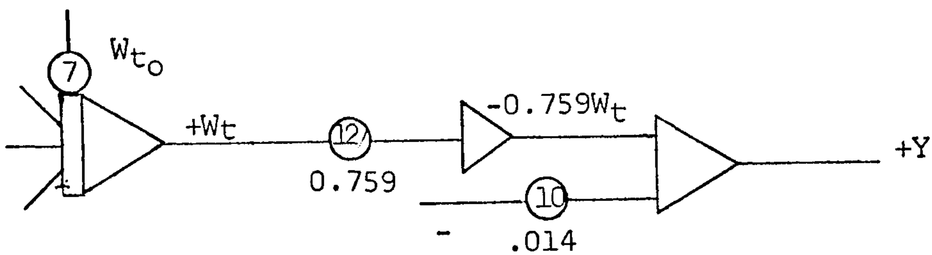
representing decreasing numbers of fish of a given year class is simulated by the circuit:




The resultant survival curves for total mortality rates (i or Z) of 0.20, 0.50, 0.80 are shown (Figs. 1 & 2) on the same time scale as the weight curve. The point of intersection of these curves indicates the time of maximum yield in weight. The maximum weight yield for female striped bass with a mortality rate of 0.20 would occur approximately at t = 8.25 years. Similarly, for Z = 0.50 and 0.80 the maximum yield would occur at t = 5.2, and t = 4.0 years.

Changes in the mortality rate can also be programmed. An electronic comparator switch is set to operate automatically under desired conditions of time. A change in total mortality rate from 0.80 to 0.20 at four years is shown (Fig. 3).

Fecundity is usually related to weight of a species. Lewis and Bonner (1966) derived a linear relationship for striped bass, Y in thousands of eggs = 555,182 + 75,858 (X - 7.3). This equation reduces to Y = 75.9 $W_t$ + 1.4 and is generated by the analog computer by attenuation of the voltage representing weight by a factor of .759, and adding .014 as shown in the circuit below. The resultant curve is shown in Fig. 1.




The relationship as established by Lewis and Bonner (ibid) is limited to fish weighing between 2 and 16 lbs. Fecundity estimates of larger females probably should not be made from these data although the estimates seem reasonable.

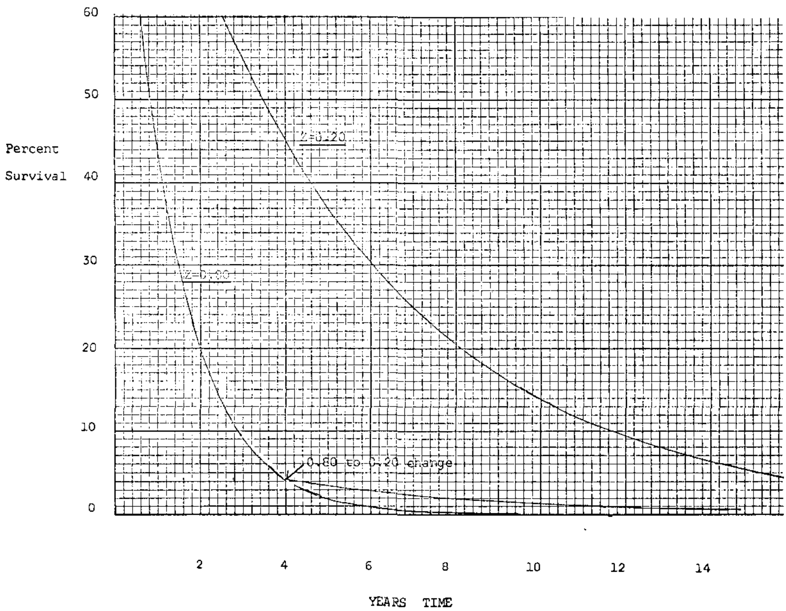



**Figure 3. Survival curves with mortality rates of Z=0.80, Z=0.20 and with a change at t=4 years from Z=0.80 to Z=0.20.**

Extension of the curve indicates a potential fecundity of approximately 6.6 million ova at age 24. The effect of different mortality rates on maximum yield of ova is shown in Fig. 1. This maximum is obtained at the time where the curves representing fecundity and mortality intersect.

## LITERATURE CITED

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