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Life Table Analysis and Sustainable Fisheries

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Abstract : In this study, the Life Table Method also known as the Cutler-Ederer life table technique, was introduced and practicability of this technique for determining life period of fish species of which natural mortalities were found by estimation using parameter of length weight relationships has also been searched. The aim of this study is to show that life table method used for human beings, can be also used to predict fish species. The data employed in the present study is that of scldfish *Arnoglossus laterna* (Walbaum, 1792) (Pisces: Bothidae) obtained from the Aegean Sea. Life span of five years and its ages were directly taken into account in the table prepared by the data concerned. Consequently, according to the data estimated, the life expectancy of the species in the Aegean Sea is approximately 11 years. Furthermore, the number of individuals estimated to live more than 5 years from the scldfish population including 1000 individuals was calculated to be some 970.

a. Introduction

Preservation of the living or the non-living natural resources and transferring them to future generations consists in sustainability. Fisheries in almost all seas have rarely been sustainable. Rather, overfishing has led to gradual depletions, long masked by improved technology, geographic expansion and exploitation of previously spurned species lower in the food web (Pauly et al. 2002).

Estimations should be performed on the number of the animals especially for endangered species even for strains in the same species to determine their population in the future, according to which new programmes should be developed and precautions taken. Methods of calculation depend on in the related techniques and number of the equations used, and whether or not they consist of seasonal influences, are classified as quantitative (time series analysis, causal models and survival analysis) and qualitative (market analysis, decision hypothesis, growth curves, simulation) ones. According to the data and the hypothesis to be tested, survival analyses performed by the three methods: Life Table Method (Cutler-Ederer Method), Kaplan-Meier Method, and Cox Regression Method (Özdamar, 1999).

The life table method is one of the oldest to measure mortality and describe the survival experience of a population. It has been used by actuaries demographers, governmental agencies and medical researchers in the studies of survival, population growth, fertility, migration, and so on. There are two kinds of population life tables namely: the **cohort life and current life tables**. The cohort life table describes the survival or mortality experience from birth to death of a specific cohort of individuals which were born at about the same time. The current life table is made by applying the **age-specific mortality rates** of a population in a given period of time to a hypothetical cohort of 100.000 or 1000.000 individuals. One of the most often reported statistics from current life tables is the life expectancy. The life expectancy of a population is a general indication of the capability of prolonging life. It is used to identify trends and compare longevity. The term 'population life table' is often used to refer to the current life table (Lee & Wang 2003).

The aim of the study is to show that the life table technique used extensively for human beings (Lee 1992; Lee & Wang 2003; Keiley & Martin 2005) can also be employed in prospective estimations of the numeral magnitude of the fish species whose natural mortality is found by the above mentioned calculations.

b. Material and Methods

The data used in the present study belongs to scald fish samples obtained from the Aegean Sea coast of Turkey from January 2002 to March 2003. The total length (TL) of each fish obtained was measured to the nearest cm. The total body weight (W) was determined to the closest 0.01 g.

The sagittal otoliths were removed from the specimens, and cleaned with distilled water. The otoliths were placed in a black dish with glycerin (30%) and alcohol (70%) to improve readings. The translucent bands observed under a stereoscope with reflected light (30 magnifications) were counted. Based on the otolith readings, the age distribution of the samples ranged from I to V years. The length-weight relationships for weight was calculated using the equation, $W=aL^b$ (Ricker 1979) where a is a coefficient related to body form and b is an exponent indicating isometric growth when equal to 3. It has been suggested that there is a correlation such as $M=W^{-1/b}$ between spontaneous mortality and mean weight of the specimen using mean weight value in which von Bertalanffy's growth constants were found in rate of spontaneous mortality (M) (Sparre et al.1989; Avşar, 1998). $M=W^{-1/b}$, where W is the mean weight and value (b) is the slope of regression constants calculated by length-weight relationships for the same material.

Current life tables usually have the following columns (Lee & Wang 2003):

6. Age interval $[x \text{ to } x + t]$. This is the time interval between two exact ages x and $x + t$; t is the length of the interval.
7. Proportion of individuals alive at beginning of age interval but dying during the interval (q_x). The information is obtained from census data. This column is usually calculated from the data of the decennial census of population and deaths occurring in the given time interval.
8. Number living at beginning of age interval (l_x). The initial value of l_x , the size of the hypothetical population, is usually 100,000 or 1,000,000. The successive values are computed using the Formula

$$l_x = l_{x-1} (1 - tq_{x-1})$$

where $1 - tq_{x-1}$ is the proportion of individuals who survived the previous age interval.

10. Number dying during the age interval (d_x)

$$d_x = l_x(q_x) = l_x - l_{x+1}$$

- Stationary population (${}_tL_x$ and T_x). Here ${}_tL_x$ is the total number of years lived in the i th age interval or the number of individual-years that l_x individuals, aged x exactly, live through the interval. For those who survive the interval, their contribution to ${}_tL_x$ is the length of the interval. For those who die during the interval, we may not know exactly the time of death and the survival time must be estimated. The conventional assumption is that they live one-half of the interval and contribute $t/2$ to the calculation of ${}_tL_x$. Thus,

$${}_tL_x = t(l_{x+1} + t/2 d_x)$$

The symbol T_x is the total number of individual-years lived beyond age t by individuals alive at that age, that is,

$$T_x = \sum_{j \geq x} {}_tL_j$$

and

$$T_x = {}_tL_x + T_{x+t}$$

- Average remaining life time or average number of years of life remaining at the beginning of age interval (e_i). This is also known as the *life expectancy* at a given age, which is defined as the number of years remaining to be lived by individuals at age x .

$$e_x^0 = \frac{T_x}{I_x}$$

The expected age at death of a person aged x is $x + e_x^0$. The e_x^0 at $x = 0$ is the life expectancy at birth. The life expectancy of a population is a general indication of the capability of prolonging life. It is used to identify trends and compare longevity ([Lee, 1992](#); [Lee & Wang, 2003](#)).

c. Results and Discussion

Sample of 1081 specimens was used to determine age. The age distribution of individuals of *A. laterna* population was found to be between I and V. The natural mortality rates calculated for each age (I-V) group of *A. laterna* inhabiting the Aegean Sea and the life table obtained are presented in the Tab. 1. Consequently, the data estimated indicates that life expectancy of the species in the Aegean Sea is approximately 11 years. Furthermore, the number of individuals likely to survive for over V years from the scald fish population of 1000 individuals was calculated to be some 970.

Age (x)	N_x	D_x	m_x	q_x	p_x	I_x	d_x	L_x	T_x	e_x
I	43	0.823	0.019	0.019	0.981	1000.000	18.958	990.521	10609.070	10.609
II	337	0.737	0.002	0.004	0.995	981.042	4.282	1957.802	9618.547	9.804
III	321	0.701	0.002	0.007	0.993	976.760	6.378	2920.713	7660.745	7.843
IV	312	0.658	0.002	0.008	0.992	976.760	8.205	3890.631	3890.631	3.983
V	68	0.642	0.009	0.046	0.954	970.382	44.751	4740.031	4740.031	4.885

Table 1: The life table for calculated natural mortalities of scaldfish.

Reliability of the estimations obtained by life table analysis requires validity of the assumptions admitted by it. The number of the individuals in the last age group considered in the table in particular of whose future we are not convinced tends to effect estimations of the other age groups. Moreover, rates of mortality by ages considered regarded in structuring the table is another factor to affect accuracy of the estimations concerned. Both factors above can be said to be drawbacks of the analysis itself.

Meanwhile number of many species decreases with their genetic diversity gradually becoming extinct. Estimations of howlong the species could further survive in the studies related to biologies of the species of economic value and to their protection of fauna to be likely to extinction and in those involving aquaculture and fisheries have been of great importance.

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