INTRODUCTION

A population is a group of individuals of one particular species. There are two major disciplines in studying population biology. Population genetics deals with characteristics changes in a population and factors determining the change, such as genetic variation, selection, gene flow, genetic drift and mutation. Population ecology is the study of population size and its distribution, and factors that determine the size and distribution, such as physical environment, competition, predation, parasitism, distribution and recruitment. In this paper I will discuss general approaches to the study on population dynamics of gastropods and production.

Little is known of population dynamics of tropical marine gastropods. Most information and models employed in population studies have emerged from temperate marine species, especially fishes. Certain attributes, i.e. growth, mortality, reproduction and recruitment, of a population are needed in order to determine potential yields and production. Figure 1 demonstrates major parameters investigated in studying population dynamics.

Figure 1. Main factors investigated in fish population dynamics: recruitment, growth (positive factors), capture and natural mortality (negative) and stock size. N, Numbers; W, weight. (From Longhurst & Pauly 1987)

Population dynamics

Populations have certain group characteristics: size and density, rates of birth, death, immigration and emigration, age distribution and spatial dispersal.

Simple models will be used to help us understand how populations change over time: the exponential and logistic models (see Figure 2).

\[ \frac{dN}{dt} = (b-d)N \]

where

\[ \frac{dN}{dt} \quad \text{rate of change of number of individuals in the population} \]

\[ b = \text{birth rate} \]

\[ d = \text{death rate} \]

Let \( r = b-d \), where \( r \) is intrinsic rate of increase, then
\[
\frac{dN}{dt} = rN
\]

This equation describes the exponential growth model or unlimited growth model. By solving the above differential equation through integration, the second growth equation is obtained:

\[
N_t = N_0 e^{rt}
\]

where \(N_0\) is the number of individuals at time = 0 and \(N_t\) is the number at time = \(t\).

No single population in the real world can grow indefinitely. Populations are always limited by resources. The population size (\(N\)) fluctuates some average value. The logistic growth model in which an exponentially growing population approaches a limit was thus developed. This limit (\(K\)), the number of individuals at which \(dN/dt\) is zero, is called the carrying capacity of the environment.

\[
\frac{dN}{dt} = rn \left(1 - \frac{N}{K}\right)
\]

**Maximum sustainable yield**

From the logistic equation above, one can ask at what population size the growth rate of population is maximum. We can calculate the value by taking the derivative of \(dN/dt\) with respect to \(N\), setting it equal zero, and solving for \(N\):

\[
\frac{dN}{dt} = rN \left(1 - \frac{N}{K}\right) = rN - r \frac{N^2}{K}
\]

Take derivative of \(\frac{dN}{dt}\)

\[
\frac{d}{dN} \left(\frac{dN}{dt}\right) = \frac{d}{dN} \left(rN - r \frac{N^2}{K}\right)
\]

Set the derivative equal to zero,

\[
0 = r - \frac{2rN}{K}
\]

Therefore the maximum population growth rate occurs when \(N = K/2\). If we know the carrying capacity for a population of interest, you can take out or harvest the organisms until the size reaches half of the carrying capacity, and the population could grow at the maximum rate.

**Population regulation**

There are two schools of thoughts on the relative importance of the biological and physical environment in regulating the population size. The first group views the density independent factors such as physical factors (salinity, waves and currents, climatic factors, as well as pollution) as the influential factors preventing population from increasing without limit. The other sees the biological environment (i.e. the interaction between members of the same species and of different species as well as food supply and diseases as being most important. The latter is hence called density dependent effects because they show an increasing proportion of mortality with increasing density. Which of the factors is more influential in regulating the population may depend on the nature and environment of the population. Low density population probably are affected more by the physical environment, while there is more intense interaction in high density populations.

**Growth**

Growth rate is defined as the change in body mass or weight over time. We can measure growth rates of either individuals or a population. Direct measurement of changes in length or weight of known individuals can be done in captivity. Tagging or marking organisms with numbers, releasing back in nature and recapturing enable us to follow individual growth rates. Organisms with growth marks or growth rings allow us to estimate the growth rates as well.
One of the popular methods for obtaining growth rate is by analysis of size-frequency histograms. This can be done by measuring length or weight of a large number of samples representing the population in question and plotting the number of individuals against size. A series of class peaks or modes of length-frequency histograms can be distinguished. Several length-frequency distributions over a certain period of time are arranged in sequence so that the growth can be inferred from the shift in modes with time. This particular method has been called "Modal Progression Analysis" (Longhurst and Pauly, 1987). The modes shifting as time progresses supposedly belong to the same cohort. Growth parameters can be estimated from the growth curve using a Ford-Walford plot or computation methods (Crisp, 1984). A computer program called "Completed ELEFAN" for length frequency analysis developed by researchers at International Center for Living Aquatic Resources Management (Pauly and David, 1981; Pauly, 1982) has been used successfully with many organisms other than fishes (for examples: Pauly et al., 1984, with penaeid shrimps; Nugranad, 1991, with moon scallops Anamusium pleuronectes).

Keesing and Wells (1989) found that growth of Haliotis roei from Western Australia was well described by the von Bertalanffy model.

**Mortality**

Mortality can be defined as rate at which the number of individuals in a population decreases by death of all causes. Mortality rate comprises of two components: fishing mortality (death caused by fishing) and natural mortality.

\[ Z = F + M \]

where \( Z \) - total mortality
\( F \) - fishing mortality
\( M \) - natural mortality

If a survivorship-time curve of a particular population is known, we can estimate mortality rate by plotting \( \log N \) (where \( N \) is the number of individuals of a stock or the specified age class surviving per unit area) against time. Mortality rate can be estimated by multiplying \( 1/N \) and the value of the slope, \( d(\log N)/dt \).

\[ Z = \frac{1}{N} \frac{d(\log N)}{dt} = \frac{d(\ln N)}{dt} \]

For populations that are well suited for length frequency analysis, total mortality (\( Z \)) can be computed with the ELEFAN II in the Completed ELEFAN computer program.

**Reproduction and recruitment**

When individuals in a population grow to a size of sexual maturity, the surplus of energy intake will be allocated to reproduction. The size or length at which organisms first become sexually mature (\( L_{mr} \)) should be determined. This information is essential in studying the population dynamics. Size regulation or harvesting is also based on the maturation size. In general, organisms should be allowed to reproduce at least once before they are fished.
Successful recruitment of any population is caused by many factors. One of the important factors is food availability during larval stages: Spawning planktotrophic larvae should correspond to the right timing of the right kind of food source production.

Gonad production is difficult to determine in the field. Gonad biomass in relation to the total body biomass that can be measured from the population is called gonosomatic index. Spawning or breeding cycle can be investigated by histological examination of gonads sampled monthly. Gonad index is then calculated based on numerical weights of different stages found in the population. The monthly pattern of the indices indicates the trend of reproductive development. The index will reach the maximum right before spawning and then it will decrease to the background level or the resting period.

Wells and Keesing (1989) have studied reproductive biology of the abalone, *Haliotis roei*. By examining histologically gonad tissues and calculating gonad index, *H. roei* had a short period of intense spawning in July-August, and low levels of spawning until December. *H. roei* became mature at the size of 40 mm.

**Study on *Chicoreus ramosus***

The Tropical Marine Mollusc Programme will concentrate on a study of the muricid gastropod, *Chicoreus ramosus* which is an economically important species in Indo-Pacific waters. The snail is fished for shells and opercula, and meat. Despite the heavy exploitation in Thai waters, *C. ramosus* still maintains sustainable populations in many areas of Thailand. However, the regulation and management of this particular species are needed, before the populations go to the critically low density level. General biology of *C. ramosus* is wanting. *C. ramosus* is carnivorous. The interesting point to be raised is that populations of the snail show little decline. We do not have statistical data on the population density, however we have been told that catches of *C. ramosus* are more or less steady by the fishermen. We speculate that *C. ramosus* probably grow fast, their recruitment success must be high, and the snail has little competition. These hypotheses are remained to be tested. Some preliminary results of three month survey and study (May-July) are presented elsewhere in this volume. We are still in the beginning stage and hope to carry out the population dynamics study of this snail.

**REFERENCES**


