CHAPTER IV

DISCUSSIONS

Growth of *Amusium pleuronectes*

The population of *A. pleuronectes* in the Thai waters, based on this study, shows relatively higher growth as well as higher asymptotic shell height, L_{∞} = 11.4 cm and K = 1.3, than the same species in the Philippines waters reported by del Norte (1986), with L_{∞} = 10.6 cm and K = 0.92, and by Llana (1988), with L_{∞} = 10.0 cm and K = 0.94 per year. The growth parameters and ϕ' value estimated from this present study, however, are similar to those of another *Amusium* species, *A. balloti* from the Australian waters (Heald and Caputi, 1981; Williams and Dredge, 1981), and comparable to other populations of *Amusium* (Appendix B).

Scallop samples collected for this study have the maximum shell height measured more than 10.0 cm (between 10.0-10.5 cm), thus, the estimated asymptotic shell height (L_{∞}) should not be smaller than 10.5 cm. Through the Wetherall's modified method in ELEFAN II, using original data with adjusted class interval to 1.0 cm, the estimated L_{∞} is 9.5 cm with Z/K = 1.381. This L_{∞} is too low, but in those studies of del Norte (1986) and Llana (1988) this method for estimation of L_{∞} gave the results which were well compared to the L_{∞} estimated from ELEFAN I.

There are many reports demonstrating the variation in growth parameters among bivalves, including scallops, from different areas and times. According to various literatures, numerous environmental factors are known to influence growth rate in scallops. Heald and Caputi (1981) concluded that the external factors such as latitude, temperature, salinity, dissolved oxygen and light levels, turbidity, phytoplankton and detritus availability, population density, current speed and water exchange, and internal factors such as age, parasitic infection, disease and physiological condition contribute varying degrees of influence to growth rate of scallops. Many of those factors are inter-dependent and thus should not be considered in isolation when determining the importance of each.

In this study, the corresponding environmental factors have not been recorded. The data on some environmental factors around Chang Islands and the adjacent areas are reported in some literatures, e.g. Songchitsawat (1989), but only in the surface water, not the bottom which is more considerable for the benthic living. Thus, no attempt is made on correlation between growth and environmental factors in this present study. However, as there are also slight variations in the growth parameters estimated for scallop populations in different areas in this study, or comparing to other studies, the growth of scallop must be related to some environmental factors. For this study, the inner and outer regions are different as the former lays between islands and mainland while the latter encounters the open sea. Thus, inner region is less affected by wind and wave than the outer, but more influenced by river runoff which not only provides nutrients but also transports some pollutants to the area. These environmental conditions may reflect to variation of scallop growth. However, the difference between the inner and outer populations are not obvious.

For longevity or lifespan, the scallops of the genus *Amusium* are considered to be a short-lived bivalves with the lifespan of about 2-4 years. (Heald and Caputi, 1981; del Norte, 1986; Llana, 1988). From this present study the longevity of *A. pleuronectes* determined from growth curve was the same approximately 2 years as was estimated for this same species in the Philippine waters (Del Norte, 1986; Llana, 1988).

Mortality

In the exploited population, the total mortality (Z) is caused mainly by fishing mortality (F), while natural mortality (M) plays an inferior role. Natural mortality is caused by all possible causes of death except fishing. In the fish population dynamics, the exponential coefficient of natural mortality (M) is certainly one of the parameters which is most difficult to obtain good estimates. Direct estimates of M can be obtained only from completely unfished stocks (Pauly, 1980a), but almost all the estimation of natural mortality in the scallop populations have generally been obtained from areas that are being fished. Dickie (1955) estimated the M value from the ratio of paired valves of dead scallops to live animals. Baird (1966) attempted to obtain a more reliable estimate from an unfished population of *Pecten maximus* but found it was difficult because of uneven annual recruitment.

The mortality determination routine in ELEFAN II, through catch curve analysis, gives estimate of the natural mortality (M) based on the empirical relationship obtained from the study carried out by Pauly (1980a) dealing with many different fish stocks. That relationship was stated to provide highly reliable estimates of M for any given fish stock. However, it may be of limitation for shellfish.

As M is closely related to the growth parameters of a given stock, especially the parameter K of the von Bertalanffy growth formula (Pauly, 1980a), therefore, the value of M used in this study is substracted from the mean M/K values of other bivalves, and is acknowledged to be an approximate.

The results obtained fron catch curve in ELEFAN II give estimation of Z = 4.363, and M = 2.868 for mean water temperature 30 C. Therefore, if this computed M value is used, the fishing mortality (F) will equal 1.495. This F value is much lower than M, that the fishing mortality is lower than the natural mortality. When using the M calculated from mean M/K value, M = 1.82, the fishing mortality is equal to 2.543 which seems to be more reasonable. The study area, Chang Islands is one of the rich fishing grounds and still in quite good condition that natural mortality of the scallop would probably not higher than fishing mortality.

Recruitment

Although the spawning and recruitment are certainly the different events (Munro, 1983), the reproductive cycle or spawning pattern of *A. pleuronectes* (Figure 19) gives a biological basis to recruitment pattern derived from length-frequency data using

ELEFAN II (Figure 11). Recruitment pattern generally reflects the number of spawning season per year in the population (Pauly, David, and Ingles, 1981). The year-long recruitment occurs because continuous spawning can be observed throughout the year. The major and minor peaks in the recruitment pattern also reflect the bimodal spawning behavior of the species. The recruitment pattern also explains the existence of a secondary cohort, as manifested in the secondary growth curve defined by the length-frequency data.

From this study, the absolute time when recruitment actually occurs is not known. Result obtained fron ELEFAN II provides only percent recruitments and relative time for one year. This is also similar to the result obtained from scallop population in the Philippines waters (del Norte, 1986). Although the smallest height class of scallop in catch data is 1.50-1.99 cm in February, it is not clear how close this is to the time and size at recruitment. Determination of the recruitment time would be based on the knowledge on the length of the larval period via larval rearing experiments in laboratories and size at settlement through *in situ* spat collection studies (del Norte, 1986).

Size-weight relationships

The relationships between shell height and various weights derived from *Amusium pleuronectes* show that weights increase exponentially with increasing shell height. Fitting equations for the interrelationships of shell height, and various weights of scallop allow predictions of the average weight or meat yield from a known height over the weight range examined.

Scallop *Amusium pleuronectes* is a fleshy bivalve, having relatively high percentage of flesh or soft body part, which is about 50 % of total weight. Adductor muscle is about 10 % of total weight. Monthly size-weight relationship equations derived from this study, are found to vary slightly according to the condition of scallop.

Reproduction

The major peak in spawning activity found in this study occurring around January to March, the period during cool season, could be associated with low or decreasing temperatures. As being suggested by Sastry (1970), and Sastry and Blake (1971), temperature acts as a triggering stimulus for initiation of gametogenesis in scallop *Aequipecten irradians*. In *A. pleuronectes*, therefore, higher temperatures probably accelerated gametogenesis up to maturation stages and the sudden drop in the levels of temperature brings about widespread spawning activity.

Spermatogenesis, as is often the case in mollusks, is known to proceed earlier, as well as more rapidly than oogenesis (Sastry, 1966; Llana, 1980). Redeveloping of the testicular part would probably be more rapidly than the ovarian part as well. As found in this study, the testicular part mostly shows higher condition index, and more mature than ovarian part. Evidence of protandry is shown not only by the asynchrony of discharge of spermatozoa and oocytes, which prevents self-fertilization, but also by the fact that the testicular portions of the gonad reach the active spawning stage ahead of ovarian portions. Similar conclusions were also made by Llana and Aprieto (1980) and del Norte (1986).

Del Norte (1986) stated that spawning in *A. pleuronectes* were predominantly enhanced by low temperature, and also significantly correlated with bottom salinity, but not the dissolved oxygen level. Significant correlations with pH were also derived from the same study but it was not considered as equally important as temperature and salinity. Non significant relationship between gonad index and lunar phases was derived for *A. pleuronectes* (del Norte, 1986), but the effect of the moon on ripening of sexual products and gametogenesis cannot be absolutely discounted. Amirthalingham (1928) postulated that in *Pecten maximus*, spawning will occur mainly at full moon, as long as temperature remains favorable to the animal. To distinguish closely this effect and to further characterize the duration of the gametogenesis cycle of the species, samples collected at closer intervals, say weekly, are necessary as averaged monthly gonad indices could not highlight this. The effects of environmental parameters on the spawning pattern of *A. pleuronectes* are not taken to be probable, until proven experimentally in the laboratory. The slight differences in the peaks of spawning showed between this study and those of Llana and Aprieto (1980) and del Norte (1986) for the same species are attributed to variabilities of local conditions in these three different geographic locations.

The values assigned to different stages of gonadal development (qualitative gonad index) are intended to quantify the reproductive state of the population as objectively as possible. Average index values above 2.0 indicate the presence of ripe scallops, increasing numbers of which would bring the index closer to 3.0. Below 2.0, the index reflects the presence of spent and immature scallops.

The gonad index determined in this study shows that the population as a whole does not undergo a sexually inactive phase, and that synchronized maturation towards a limited spawning season as in temperate species does not occur. Consistent spawning through the year is shown by index values that fluctuate around 2.0.

The size at which *A. pleuronectes* reaches sexual maturity as deduced from this study (about 4.8 cm shell height) is smaller than the reported size in other studies for the same species which is about 5.4 cm (Llana and Aprieto, 1980; del Norte, 1986). Fortunately, the marketable sizes of this scallop are above 6 cm. Average sizes of scallop in commercial harvests is usually bigger than 5 cm, therefore, most scallops can breed at least once before they are caught by commercial trawls.

<u>Association with Pea Crab</u>

Various degrees of pea crab infestation have been reported for different species populations of bivalve mollusks (Lopez, 1982). Comparison of infestation rates in different species population of bivalve mollusks is shown in Appendix C. The percentage of infestation found in this study (7.46 %) is rather low comparing to others, but not the study of Llana (1979) with the same species *A. pleuronectes* in the Philippines which was 2.15 %.

Infestation rates are a function of the ratio between the number of invasive crabs and available hosts, or of environmental quality, especially in the quality or quantity of available nutrients (Lopez, 1982).

According to this study, infestation rates of pea crab in *Amusium pleuronectes* are high in scallops smaller than 5.5 cm sizes, and decreasing in larger size scallops. In opposition, some authors reported that frequencies of pea crab infestation in mussels increased with host sizes (Seed, 1969; Lopez, 1982). Increasing infestation rates with increasing host size might be related to the amount of water filtered by the host or simply to the length of time the latter is exposed to the source of infestation. Where decreasing infestation in larger hosts was defined as correlating with host selection on the basis of its metabolic rate (Christensen and McDermott, 1958).

From this study, all the infestations found are single, i.e. one pea crab in each scallop, as similarly reported in the work of Llana (1979) with the same species of scallop. The double or multiple infestations have been reported for some other bivalve species such as *Pinnotheres modiolicola* in *Modiolus metcalfei* (Lopez, 1982) and *P. ostreum* in *Crassostrea virginica* (Christensen and McDermott, 1958).

Infestations of pea crab have been stated in several literatures as parasitism, as it affected the decrease in meat content of the host as well as caused growth stunting (Nascimento and Pereira, 1980; Prezenger, 1981; and several works quoted in Lopez, 1982). In this study, although there is no statistical significant for the effect of infestation on gonad indices of *Amusium pleuronectes*, the observation also suggested some influence by this commensal crab, such as the deformation of gonads. Therefore, the pea crab should also be considered as parasitism for scallops.