Chapter I

INTRODUCTION

The increase of population and industrial developments nowadays cause great demand for electrical power. In the forseeable future, fossil fuel used for producing electric power will decrease gradually and become more expensive. The alternative source of energy is nuclear energy. However, nuclear energy may cause some ecological problems of which one is the thermal pollution. During the nuclear power operation a large volume of cooling water is required. The cooling water after used usually has a higher temperature than that of the ambient sea water. As the cooling water is discharged into the sea, the rising temperature will affect all aquatic organisms. There are two possible ways in which those aquatic organisms respond to thermal increments. First, they may be unable to tolerate the temperature changes and will die consequently. Second, if they can tolerate the changes, they may either escape and migrate from that area or adapt themselves to the new condition.

Most fish and other organisms such as shrimp naturally spawn near the shore and their larvae and young will thrive near the shore for a period of time, i.e., 1-2 months. The cooling water discharging from the nuclear reactor will inevitably affect their spawning, survival, growth.

It is widely known that, in temperate zone, a little increase of temperature can be useful for fish culture, but in tropical zone only a few investigations were about performed and the results were not confirmative. Therefore, it is deem nescessary to study the effect of temperature on the fish growth.

This investigation was undertaken to determine the effect of three levels of temperature; i.e., lower than the ambient, ambient, and higher than ambient on the growth of mullet (Mugil dussumieri Val.), seabass (Lates calcarifer [Bloch]) and spinefoot (Siganus virgatus Cuv. & Val.) at a short duration of laboratory experiment (1-2 months period.)

The results will be used in parts for the consideration of the establishment of standard temperature for the well being of fish, and to prove whether fish cultures in the vicinity near nuclear reactory in tropical area are feasible or not.

LITERATURE REVIEW

Among experimental studies concerning the effect of temperature on aquatic animals, most of them are concerned with fish. When ambient temperature changes, fish will adapt themselves to the environment in two ways : non-genetic adaptation and genetic adaptation. Non-genetic adaptation, in terms of acclimation and acclimatization, is visualized as an ecological phenomenon which results in survival, growth and reproduction. The works on the effect of temperature on fish are as follows :

Sylvester (1974) studied the rate of acclimation and response of *Mugil cephalus* L. It was shown that fishes that lived in temperatures changing from 25°C to 27°C and 29°C were completely acclimated within seven days and to be acclimated to 23°C or 15°C required a maximum of eleven days.

Fisher (1957) studied about the results of acclimation. He explained that the result was the actual change in response mechanisms, requiring time to develop and perhaps involving all levels of organismic functions. Kinne (1960) also indicated that the change in organisms under stress regulation and acclimation might all occur simultaneously and might not be completely separable in all cases.

Anonymous (1971) indicated that the adults of arctic and tropical fish species had a narrow range of thermal tolerance whereas the temperate species had a wide range. In most regions of the United States there were species which could tolerate a relatively wide temperature range. The rainbow trout could survive for a short period between 0°C and 24°C, while tropical species survived near their upper limit.

Jones (1973). stated that for any particular acclimation of temperature, every species of fish had a temperature range within which "existence" for an indefinite period was possible. This range had an upper limit - the thermal death-point or upper incipient lethal temperature above which the animal could not live indifinitely but would survive for some limited period. Similarly, there was a cold death-point or lower incipient lethal temperature (Figure 1).

When fishes are exposed to both upper and lower lethal temperature, they will die. Hielbruin (1952, from Menasveta 1972) suggested that heat death might be caused by coagulation of cell proteins and the inactivation of enzymes. The experiment with skate and founder by Fisher (1957) had shown that heat affected the central nervous system because of the regulation of osmotic pressure.

When fish had a complete acclimation, they might select a temperature and avoid the temperature that is higher or lower than the acclimation temperature. This temperature was called "preferred temperature" (Brett, 1952; Fry, 1947).

The phenomenon of decreasing preferred temperature with increasing acclimation temperature of Atlantic salmon was reported

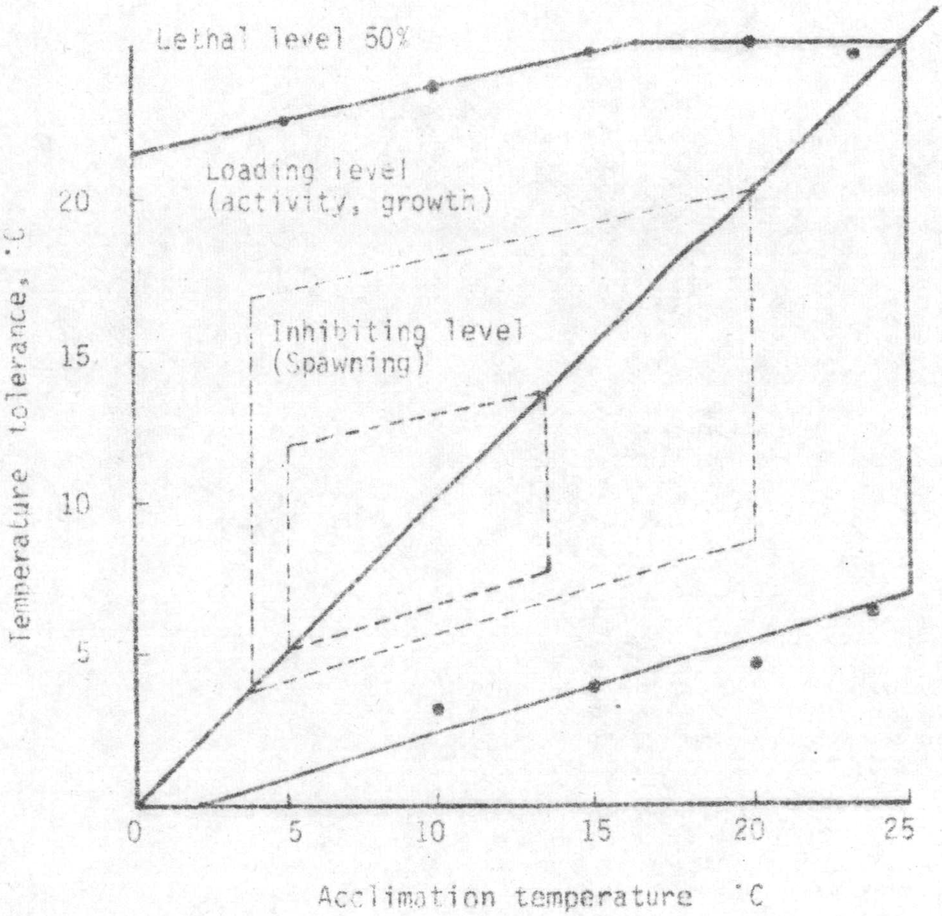

Figure 1 Upper and lower lethal temperatures for young sockeye salmon, the thermal zone outside which growth is poor, and the zone outside which temperature is likely to inhibit normal reproduction. (From Brett, 1960)

in 1958 by Garside and Tait. McCauley and Tait (1970) showed that there was virtually no effect on preferred temperature of young lake trout. It can be concluded that the preferred temperature varied with individual species.

In water, the saturation for oxygen is 9.1 ppm at 20°C, 7.5 ppm at 25°C, 6.5 ppm at 28°C and 6.0 ppm at 30°C. Thus, at warm temperature, less oxygen is available for the activities of fish, yet their dissolved oxygen requirement is greater.

Davison et al (1959) found that limiting oxygen concentration of coho salmon is 1.3, 1.4, 2.0, 2.8 ppm at 16°C, 20°C, 24°C, and 28°C respectively.

Pritchard (1955) found that the oxygen consumption of Hawaiian tuna was corresponding to the increasing of temperature and their activity.

Rajagopal and Kramer (1974) studied the oxygen comsumption on activity, standard and routine of utah chub and speckle dace at 4 levels of temperature. They found that the increasing of temperature had increase the oxygen consumption of the fish in all levels.

The metabolism of fish can be increased by the increase of temperature. Sylvester (1973) reported that moderate and severe heat stress increased the vulnerability of sockeye salmon to predation by coho salmon. Increase in acclimation temperature increased the forage activity of coho salmon. Brief increase of 2°C above acclimation temperature did not affect coho salmon foraging ability.

Winslade (1974) had investigated the behaviour of the lesser sand eel at 5, 10 and 15°C by using a photographic method of recording activity. There was a high level of swimming activity during the high temperature period which fell to a low level at 5°C, and, after the complete acclimation, the swimming activity decreased to a constant level.

Brett and Higgs (1970) note that increased temperature if in combination with activity (swimming) can raise metabolic rates of sockeye salmon ten to 20 times above the rate for these fish while resting if sufficient oxygen is available. Brett (1965) also indicated that larger fish have relatively lower metabolic rates than smaller fish of the same species.

Andrews and Stickney (1972) studied the feeding of channel catfish at 18, 22, 26, 30 and 34°C. It was shown that at 26, 30 and 34°C the increase of feeding rate was from 2 to 4 and 6% of feed consumption.

The food which the fish consumed had different rate of passage through the alimentary canal. Edwards et al (1971) studied the relation between temperature and rate of food passage through the alimentary canal of plaice at 1, 5, 9, 14 and 20°C, and the times for evacuation from the stomachs was 36, 22, 16, 12 and 9 hours, respectively but the time of food reaching the rectum was 148, 55, 37, 26 and 19 hours, respectively.

Magnuson (1969) studied the digestion and food comsumption at temperature between 23.3 to 25.7°C. The passage of food through the alimentary canal was estimated by measuring wet and dry weight of the stomach and intestinal content. The fish ate the equivalent of about 8.6% of body weight. About 10% of the food passed the stomach each hour during the first 8 hours and the stomach was essentially empty within 11 hours at 25.7°C and 12 hours at 23.3°C.

Brett and Higgs (1970) studied about the rate of gastric digestion in yearling sockeye salmon at 3, 5, 10, 15, 20 and 23°C after saturation feeding on abernathy pellets. At any temperature, the rate of digestion appeared to be proportional to the mass of food remaining in the stomach. The time for complete digestion decreased from 147 hours at 3°C to 18 hours at 23°C. The time for one-half sample of fish to exhibit empty stomach corresponded closely to a mean state of 96% gastric digestion providing a simple mean for determining rate of degestion (Figure 2).

Baldwin (1956) studied the food consumption of brown trout at six different temperatures and found that the food conversion rate declined with the increasing temperature since food conversion ratio depended on temperature. In channel catfish, conversion ratio was the same at 22 and 26°C, slightly higher than 30 and 34°C, but at 18°C the food conversion ratio was over 10.0 (Andrews and Stickney, 1972).

Brett _et al_ (1969) studied the growth of sockeye salmon at temperatures ranging from 1 to 24 C in relation to rations of

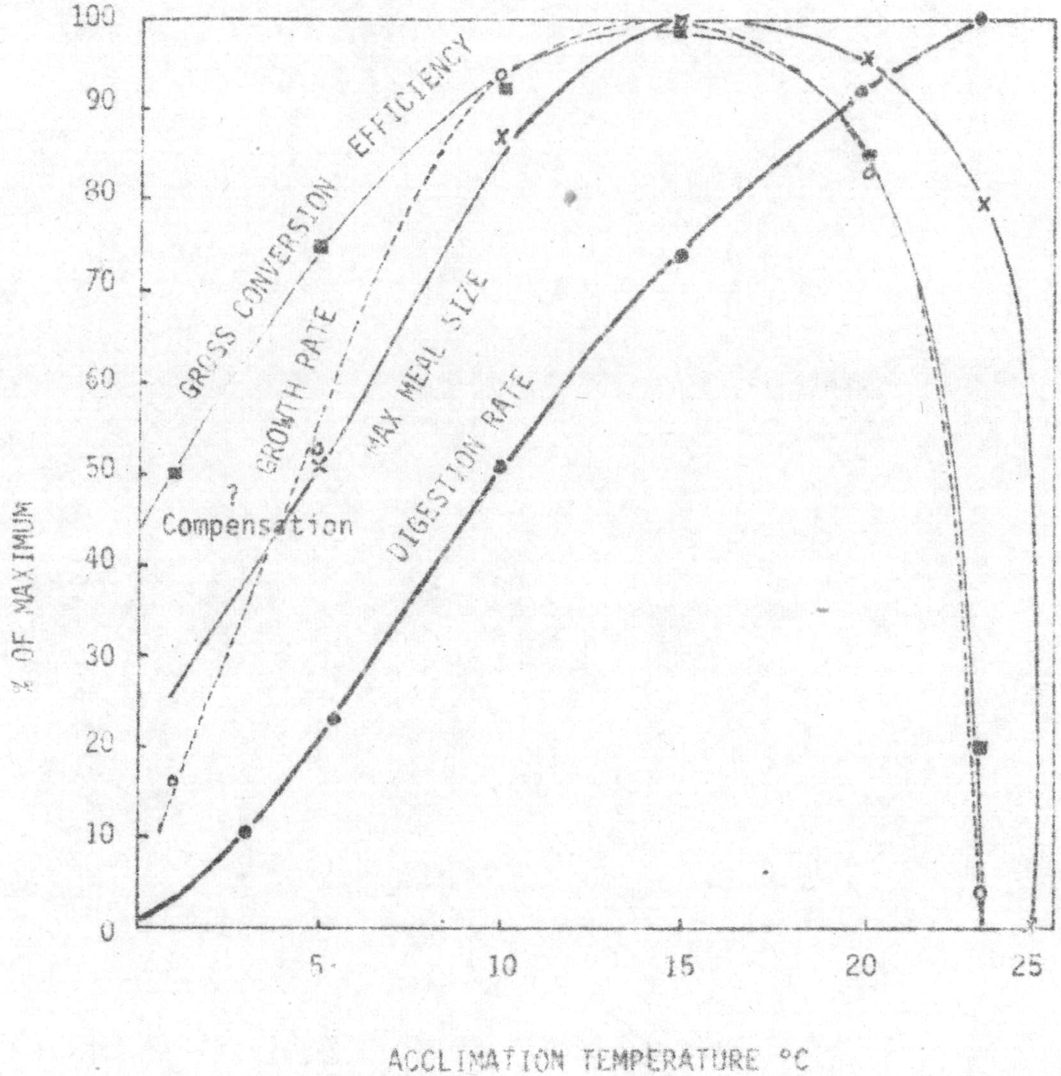

Figure 2 Relative relation of various growth , food and digestion parameters to acclimation temperature. Each rate has be[...] expressed as a percentage of the maximum observed. (From Brett and Higgs, 1970).

0, 1, 3, 4.5 and 6% of dry body weight and at the excess ration. Optinum growth occurred at approximately 15°C for the two highest rations. No growth took place at approximately 23°C despite the presence of excess ration. A maximum gross efficiency of 25% occurred in a small area with a center at 11.5°C and ration of 4% per day. The basis of growth and food conversion efficiency at temperature from 5 to 17°C was the most favorable for young sockeye salmon and that a general physiological optimum occurred in the vicinity of 15°C.

Temperature is a factor influencing the growth of aquatic animals, (Brown, 1946). Gibson and Hirst (1955) found that the optimum temperatures for the growth of pre-adult pupies were at 20, 23, 25, 30 and 32°C. The maximum growth were at 23.0 and 25.0°C, but they grew more slowly at 20, 30 and 34°C.

Kramer and Smith (1960), Strawn (1961) studied the growth of large mouth bass fry at 15.0, 20.0, 22.5, 25.0, 27.5 and 30.0°C. The growth rate at 15.0°C was very slow and it increased with an increasing temperature. Maximum growth occurred at 27.5 and 30.0°C.

Onchi (1969) studied the effect of temperature on the growth of fish by measuring from the scale growth which depended on the growth of body at 7.4, 12.5, 15.8, 17.5, 22.5 and 27.5°C. From the experiment, the rise of the scale at different temperature was 1.3μ at 12.5°C, 4.9μ at 17.5°C, 6.1μ at 22.5°C and 6.6μ at 27.5°C. As for the time required for formation of one ridge in different temperature, it was found to be 22.8 days at 12.5°C, 6.9 days at 17.5°C, 5.8 days at 22.5°C and 4.6 days at 27.5°C. However, distance of ridge was not depending on temperature.

Shelbourn et al (1973) studied the growth of sockeye salmon fry at 5, 10, 15 and 20°C by feeding excess ration and measuring the fish every 12 days. The growth rate increased at temperature from 5°C to 15°C and decreased when the temperature was more than 15°C. Continuous feeding for 15 hours per days produced a significantly greater growth rate than feeding to satiation three times daily.

Pessah and Powler (1974) studied the relative growth rate of pumpkinseed sunfish exposed to six constant temperature regimes. They were 5, 10, 15, 20, 25 and 30°C. The results were clearly separable for the first six weeks. Thereafter, growth declined, becoming uniform between 15 and 30°C and negatively linear at 10 and 5°C respectively. The food uptake increased proportionally to the increasing temperature.

The increasing temperature affected protein in their body. Estimation of the maintenance protein in their body from endogenous nitrogen excretion at different temperature was shown at 7.2, 15.6, 23.9 and 29.4 - 32.2°C. Nitrogen excretion rate was very high at the highest temperature and declined correspondingly with the decrease in acclimated temperature, i.e., from 29.4 - 32.2°C to 15.6°C. The rate were equal at 15.6 and 7.2°C. (Savitz, 1969).