Water quality criteria

water temperature

There is a normal range of temperature in the temperate region of 0-30 °C, to which fish are adapted.

Fish differ in their tolerance to high temperature depending on :

1. species.
2. stage of development.
3. acclimation temperature.
4. dissolved oxygen.
5. pollution
6. season and the extent to which the environment is heated .

It is essential to make a distinction between the temperature conditions permissible at different times of the year and to assess not only maximum permissible temperature but also maximum permissible increment of temperature .

Winter

AN increase in water temperature of 2C from about 0C in winter at the time of reproduction would severely affect spawning of *Coregonus sp* .and burbot . Raising the temp. 5_6C in autumn and winter may adversely affect the embryos and fry of salmonids and also induce premature sparing of cyprinids.

Spring

A rise of 5-6C is detrimental to pike embryos . The myority of cyprinids tolerate an increase of temp of 8_ 10 C during the embryonic stage.

Summer

Juvenile and adult fish can usually tolerate a wide range of temp. than embryos. It seems likely that if water temp. gets near the disturbing level most species would continue to feed . For many cyprinids, the permissible increase of temp. is about of 6 C above the natural ambieas values, with an upper limit of 30 C during the warmest season. However at about 28 C and higher, the growth of several cyprinids is inhabited .

For salmonids of the genus *Salmo*, 20 _21C should be accepted as the upper permissible temp. during the warmst season of the year.

Coregonids can withstand a rise of temp. of 5_6C but the maximum for the Summer months should not exceed 22_23C .

The temp. of natural inland waters in the temperate regions generally varies between 0 and 30 C the maximum values occurring particularly in shallow water in summer and the minimum exceptionally falling below zero in winter , Freshwater, fish indigenous to there regions are adapted to such seasonal changes of temp. and they (and also introduced species) may also be capable of with stand changes outside this range, especially those of short term duration, though at the same time they may succumb to unnatural fluctuations within this range .

Industry, primarily that producing electric power uses substantial quantities of water for cooling purposes and the discharge of heated effluent can increase the temperature of the receiving water several degrees above normal and affect aquatic organisms , including fish , both directly and indirectly (for example by affecting the solubility of gases and the rates of oxidation). It is therefore , necessary to know to what extent freshwater fish can survive an artificially warmed environment and what upper limits of temp. would be compatable, not merely with the survival of various species, but with the continued . existence of flourishing fisheries.

Temperature and metabolism.

The rate of metabolism in poikilothermic animals depends upon temp. the oxygen consumption of fish has been taken as an index of their metabolism, and showed a relation to temp.

According to so-call normal carve of krogh. A substantial evidence , has been found that respiratory rates in poikilotherms depend on temp. according to the Arrhenius equation of biochemical process provided that respiration is measured after the animals an fully acclimated to the temp. of exposure. However. taking into account the variability of respirometric measurement both the "normal" curve and the

Arrherius equation predict temperature dependent changes of oxygen consumption equally well, if resting animals are tested. Nevertheless, The relationship is more complex, there being a plateau, describe as the zone of thermal acclimation, in which metabolism increases only slightly in response to increase in temperature. The zone evident only for fish fully acclimated to temp. and therefore it has been associated with the moral temp. range to which the species is adapted, This zone of slight response of oxygen conscription to temp. changes was found in larvae and juveniles of rainbow trout (*Salmo gardenias*).

The metabolic rate of resting fish is easily increased by the excitory effect of extraneous stimuli , and the scope for ~~eat~~ that and any other excess activity over the basal rate has been studied and found to have an optimal value of at temperature root necessarily the same as those for the maximum for the basic rate itself .

Rainbow trout in ponds and raceways did not respond to temp. changes between 11 and / 18℃ but their oxygen consumption varied substantially with variation in feeding activity .

THERMAL ACCLIMATION

From the above remarks it follows that changes in metabolism do not immediately follow changes in environmental temp. , particularly when the change occurs relatively quickly but once a new rate of metabolism has been established, the animal is considered acclimated. However, this is possible only over a limited range of temp. the normal physiological range _ and it effect on animal tissues and on the whole organism at all ages is reflected. in several ways, including an increase in thermal tolerance with increase in acclimation temp. and the converse.

Some authors found that the time for which isolated muscle remained sensitive to electric stimuli increased from 68 to 140 minutes with increase in acclimation temp. from 3 to 26℃. This has been confirmed by kusakina (1962) who also studied the activity of choline esterase in ten species of fish

inhabiting zones of different temp. in. L. Baikal It should, however , be noted that the thermal resistance of tissues and of enzyme system tested in vitro may be higher than that of the intact animal .

It has been considered that heat death results from a disturbed balance between various metabolic processes which might be under nervous control .

Fish Embryos

A.) DEVELOPMENT TIME

The consequence of temp. – dependent metabolism is change in the rate of development with temp. particularly during the early stages. It has been shown that at a temp. of 30℃ the time for embryonic development in common carp is approximately half that at 20℃, and somewhat similar results have been obtained at lower temps, for Atlantic salmon (*salmo solar*) brown trout (*S. trustta*) bream, pike-perch and pike . At the extremes of the range of temperature at which development is possible the development time varies by a factor of 6_7, but within the optimal range it usually varies by a factor of 2.

However , growth may not match development, and at high extreme temp. newly hatched larvae may be smaller in size. Furthermore, at high temp. there may be an increase in abnormalities and mortalities . with common carp the hatch is less than 60 per cent at 22℃ or higher and abnormalities are more than 20% at 27°C and above.

.B.) Acclimation

Short term acclimation in the early stage of development has been investgated for various temp. regions, the criteria most frequently used being the occurrence of abnormalities and mortalities. It has been found that embryos of loach (*Misgurnus fossilis)* from females kept at high temp. (16- 19℃) for short periods of time (12-25 h).

During ovlation Showed reduced resistance to high fluctuating temp. Furthermore , non – lettal exposure of embryos to 21℃ for 2 to 3 hours produced increased resistance to a subsequant

exposure to 25℃ compared with embryos which had never been kept at 21 ℃, the effect being greater after an initial exposures of 3h.

C.) range of tolerated temperatures

Some authers have drawn attention to differences between various developmental stages in resistance to both raised and lowered temps . Lasting for up to 5h. however. pike endured fluctuations between 3 and 24 ℃, bream best survived fluctuations in the range 10- 18 ℃, common carp best survived a change from 20_ 30 ℃ and worst a change from 30 to 20 ℃ while fluctuations on roach spawning grounds within the range 9_21℃ – caused no mass mortalities.

Differences in the range and level of temp. tolerated by embryos of some species are related to conditions in which natural propagation occurs. The most tolerant being those spawning in shallow water which , even in nature ,are expose to fairly high duirnal fluctuations of temperature.

Fish fry and adults

"preferred" temperatures

Another indicator of the thermal requirements of a species is the "preferred" or selected temperature, which is the value at which fish are most frequently found when able to move freely within a thermal gradient that is usually established experimentally. It is partly dependent on the temp. to which the fish are acclimated beforehand , if this has been relatively high , then the selected temp. is lower and vice versa,

So that is one point when the acclimation and selected temps. reidentical this is the final preferred temp. or final preferendum.

Even a few days of prior acclimation to temp. can able the preferred value in the direction of the change of acclimation temp. but , with trust fingerlings transferval from 19 to 6.5_8℃ , the rapid initial fall in selected temp. followed by a gradual increase over a pried ( ) several months , presumably as a regult of further

Optimum temp. range for two selected fresh water fish

Species		acclimation Temperature (C)	upperlimiting Temperature (C)
Cyprinus	carpio (carp)	26	34.0
Gambusia	affinis. (Adult)	25	37.0
		30	37.0
		35	37.9

NTF

Primary productivity

The effects of natural temp. fluctuations on primary protectivity are difficult to define . this is owing primarily to the fact that for those periods of the year when the temp. of the water is warm , the photoperiod is also longer.

Therefore ,the separation of effects on productivity is difficult . studies on natural systems do indicate . however that was the ambient temp. increases, the gross productivity of biological systems increases.

It can therefore be anticipated that if a heated effluent increases the ambient water temp. by a small amoum, an increase in productivity would result.

Temp. changes usually affect several parameters in natural biological communities experiments must therefore be planned so that only temp. is varied to ascertain absolute effects on primary productivity .

It has been shown that photosynthetic response of a natural algal community dominated by Diatoma elongatum was affected by temp. the experiments conducted at 5°C intervals from 10 to 30C showed that there was a broad optimum with rasped to oxygen evolution extending from 10 to 20C . At higher temps the photosynthesis response was markedly reduced , whereas at lower temps the species diversity of the community shifted in favour of diatoms .

Several studies have evaluated the behaviour of aquatic macrophytes in response to temp. fluctuation Anderson (1969) investigated the

response of several macrophytes to thermal changes . his study showed that the occurrence of the algae Ruppia maritima diminished owing to the addition of heated effluent , whereas potamogeton was more tolerant to elevated temp. and replaced the other algae as the dominant form.