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Minutes of the Percis II working group

Population dynamics of percid fish

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1. Introduction

Percid population dynamics are, as other fish populations, governed by growth, mortality, recruitment, and migration. Sampling must be designed to yield unbiased information on the particular parameters being studied. For example, data from commercial, sport or subsistence fisheries may be selective in different ways, e.g. for size, and thus bias growth and mortality estimation. It may sometimes be preferable to take samples during the spawning season but at other times (or for other purposes) those taken at the end of the growing season will be better. Samples taken specially for research purposes using special methods may often be essential.

2. Growth

The methodologies for determining age from hard structures were generally accepted, even if some doubt was raised concerning use of scales alone. As it may be difficult to count all the rings on the operculars of the old fish in slow growing populations; otoliths should for these be used as a check. It was also stressed that the effect of selectivity should be included in growth analysis, as fishing mortality of faster growing fish may be higher, thus causing a bias in growth analysis. Similar bias would occur when using size selective fishing gear.

The value of bioenergetic models was agreed and there is a need for a review of the models now available for percids and their future development and improvement. Ideally the models should include, in addition to temperature, the age and size of the feeding fish. Furthermore, the models should include the influence of activity, the size, quantity and quality of food items (e.g. invertebrate or fish) and also behavioural aspects (e.g. searching, capture and handling times for different prey in different environments).

Growth was generally accepted to be affected by temperature and population density. The most important factors for the variability of growth were attributed to intra- and inter-specific competition (e.g. cyprinids, centrarchids, catastomids and other percids) and the availability of food particle sizes in relation to ontogenetic requirements.

Slow growth rates are most often found in small waterbodies, whereas both slow and fast growth rates have been found in larger waterbodies. The growth rate is not uniform but the fish may shift from slow to fast growth when becoming piscivorous. It was originally supposed that lake size is likely to affect growth. A general agreement was however that it is not likely to be the size of the waterbody but the habitat variability in larger lakes that enhances growth. When predation avoidance is a factor affecting growth, fish inhabiting large lakes may have an advantage since large lakes are more likely to provide greater habitat variability resulting in greater habitat segregation among size groups and species.

Somatic growth may be a poor indicator of the costs associated with production. It may be a useful analytical approach to calculate production, in the sense used by Ivlev, Ricker and the International Biological Programme, and then attempt to partition this into its various fates, such as somatic growth, gonad products and consumption by predators. The question still remains; what drives the trade off between production? Including particle size may provide some clues. Growth could be modelled in a three dimensional system through predation/competition and structural complexity with particle size as the over riding factor.

3. Mortality

Virtual population analysis was generally accepted as providing good estimates of mortality rates, though it was noted that simpler data on age structure or length distribution could provide useful approximations in heavily fished populations.

Partitioning of mortality into the components of fishing and natural causes and the further analysis of the various causes of natural mortality was considered important. These causes were believed to be: predation, starvation (prey availability), oxygen depletion, lack of light in “winter kill”, disease, spawning activities and pollution. There are suggestions that, in many populations, natural mortality tends to be constant after maturation and this should be further explored. Some slow-growing populations appear to have a low mortality rate and faster-growing populations in rivers seem to have a high mortality rate. However, it should be noted that in some cases, increases in growth have been accompanied by a decrease in mortality, and slow growth does not always result in delayed mortality.

4. Recruitment

Much more information is needed on the stock–recruitment relationship for percids. So far, no confirmed evidence of a stock–recruitment curve has been presented, even if this must be the underlying function of the recruitment. Therefore no recommendations on the management of optimum population size may be given, but it should be borne in mind that if a stock is severely depleted, it will be subject to the vagaries of recruitment and the risk of population crash is increased.

The year class strength (YCS) is considered to be established during the first two years of life for most percids. There is a great deal of evidence that both temperature development and predation may influence the YCS. As predation affects the recruitment there should also be an underlying stock–recruitment function, and a limit to the population growth, also indicated above; where individual growth is influenced by competition. Simple correlation analysis may not be the proper method for detecting the influences of population size on recruitment. When recruitment is dependent on a variety of abiotic (temperature, pollution) and biotic (predation, food availability, habitat) factors, the effect of population (intraspecific competition, fecundity, egg quality) may frequently be overruled, thus breaking down any single stock–recruitment curve. However, it has been shown that usually a precondition for a strong year class is a weak population.

While it is generally suspected that the YCS ruling factors operate after hatching, mortality in the egg stage and factors affecting the number, size, quality and fertility of the eggs produced by the parents should not yet be ruled out from having any influence on the YCS.

The impact of population size may be significant for long term management of percid populations. Therefore models based on the stock–recruitment curve including abiotic and biotic variability may provide a useful tool revealing the effects of the management decisions upon the population dynamics. These models need further development. To accomplish this, there is a need for more research on the first two years of life, and the modelling of stock–recruitment relationships and factors affecting the YCS. The bioenergetics of feeding and growth in larvae and young fish as well as adults should be studied and advantage taken of new techniques such as counting the daily rings on otoliths. In northern areas prolonged snow cover or cold summers, with slow growth, may lead to starvation of 0-group fish because the light intensity is too low to allow them to feed; this needs further investigation.

5. Migration

Migration is generally studied by tagging fish or attaching radio-transmitters to the fish. Also other methods based on the principal of catch (or rearing) and recatch have been used (colour, branding, fin clipping, radio isotopes). Besides giving information on the movement of fish, tagging also provides information on mortality.

The effects of migrations on population dynamics occur primarily in large lakes and coastal areas where both perch and pike-perch appear to undertake quite long migrations. There is evidence that they home to the same spawning site each year. Also in long linear waters, such as navigation canals and navigated rivers, the effects of migrating large percids may be important. The degree of migration may change with the age or size of the fish, with larger fish migrating larger distances. Thus, both in the study of population dynamics and in the management of fisheries, the possible existence of several relatively discrete stocks needs to be recognised.

Also, more needs to be known about the special spawning migrations shown by some populations (e.g. from the Baltic Sea into lakes), and the influence these migrations have on recruitment.

6. Genetics

Evidence presented at Percis II and elsewhere indicates there are differences in spawning behaviour, and morphological and meristic distinctions, between populations of percid species in different parts of their ranges and in different waters. However, it is not known to what extent these differences are genetic. Some differences almost certainly are due to genetics. It can be anticipated that there may be genetic differences in reproductive strategies (behaviour of early life stages, homing) and growth rates.

These differences imply that all populations are not equally fit for stocking in all areas. Genetic aspects should therefore be considered for protection of local stocks and behavioural aspects when stocking. Research using modern techniques is thus needed on the genetic differences between stocks, especially on genetic influence on their population dynamics. Until more is known about percid genetics, great care should be taken to use fish of local origin in any artificial stocking; and strains bred for aquaculture should not be released into the wild.

7. Impact studies

Since Percis I, research has provided information on population dynamics in altered environmental conditions, where most information is available on acidification and eutrophication. Acidification generally decreases the recruitment, whereas eutrophication (fertilisation) increases the growth rate and age structure of the population. Recent research has been on the topic of restoring waters to former conditions. Even if the anthropogenic impact has been reduced, the fish communities have not always returned to their former structure. Some changes may be irreversible and are probably caused by changes in habitat and the structure and function of food webs. In these ecosystems biomanipulation may be needed to reinforce the old population structure. Populations have been dramatically restructured through species introductions, however, biomanipulation has not worked in all cases. This logically raises the question of whether there are thresholds regulating the population dynamics.

8. Conclusions and recommendations for future research

As our understanding and predictive nature of population dynamics is limited, we can not easily detect changes at the population level and it is even more difficult to identify an anthropogenic cause. It is desirable to work towards a more predictive approach to fish populations, where modelling may provide a useful tool. The fundamental aspects of population dynamics are recruitment, growth, mortality and migration, where migration usually plays a less significant role. These factors, to be included in models, are affected by population density, food size and availability, environmental characters, biological factors and fishing activity. Stochastic models, based on empirical data, may produce the greatest advance in our understanding of population dynamics and identify possible thresholds important for the management of percid populations. While general trends may become apparent, due to the number of percid species involved, their great plasticity, the variety of habitats they occupy and their wide geographic distribution, it is likely that individual situations may show some deviation.

In conclusion, it may be said while there is much information on percids, there remains much to be clarified. In particular, the following aspects are in most urgent need of further research:

— bioenergetic models of growth in larvae, young fish and adults
— the partitioning of natural mortality between different causes
— the relationship between the rates of growth and mortality
— stock–recruitment curves
— homing behaviour and the existence of discrete stocks within single lakes
— genetic differences between stocks of percids throughout their ranges.

Research should be planned to lead eventually to the availability of sound models of percid population dynamics that will enable fisheries to be better managed and successful predictions made of the impacts of changes in natural and anthropogenic environmental factors.