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Biological Overfishing of Tropical Stocks

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IN RECENT YEARS there has been a large number of publications describing the growth and subsequent decline of tropical fisheries, with much being written about the relatively well-documented stocks in Southeast Asian waters. Almost none of these publications failed to mention that several, mainly demersal stocks of the region are "overfished." "Overfishing" is indeed the primordial sin, the bankruptcy of fishery management. It is, in fact, the worst epithet a fishery biologist can hurl at the fishing community.

In spite of all this, relatively few attempts have been made to "translate" and apply to tropical stocks those concepts of overfishing that have been developed from considerations pertaining to temperate stocks. Some of these concepts are introduced here, together with some of their application to stocks in the region.

"Overfishing" may occur as a) Growth overfishing; b) Recruitment overfishing; or c) Ecosystem overfishing.

Growth overfishing, which has hitherto received the greatest attention in the Region occurs when the young fish that become available to the fishery (the "recruits") are caught before they can grow to a reasonable size. Thus, to the fishery biologist, the problem is to estimate the most suitable age (and/or size) at first capture and to suggest to the fishing community, e.g., the mesh size, which, by allowing younger (smaller) fish to escape, optimizes the yield that can be obtained from a given number of recruits.

The theory behind the computations used in estimating the optimal size at first capture and mesh size developed

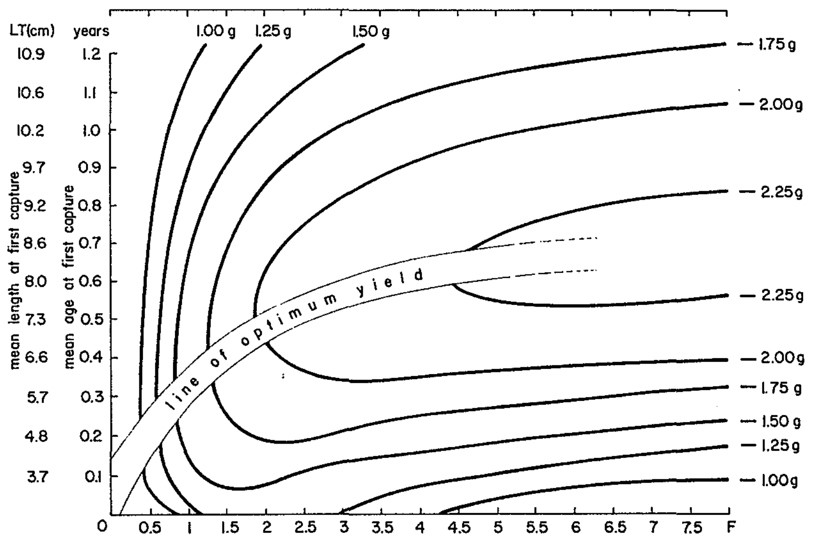

Fig. 1. The yield-per-recruit in relation to size or age at first capture (ordinate) and the force of fishing (abscissa) of the slipmouth *Leiognathus splendens*. The Beverton and Holt method was used to calculate the diagram.

some 30 yr ago by Beverton and Holt, also applies to tropical fish (Fig. 1).

Thus, theoretically it should be possible to prevent growth overfishing in Southeast Asian waters except that at present no method can be conceived which would allow fishermen exploiting multiple-species stocks to catch the fish of each single species at their specific optimal size. This should ensure that we will have for the years to come quite a bit of growth overfishing in the region, especially as demersal fisheries go.

Recruitment overfishing is quite another matter. This is what occurs when the (parent) stock is reduced, by fishing to the extent that not enough young fish are produced to ensure that the stock will maintain itself. Everybody knows that in any fish stock, there will be no young fish (= no recruits) if no parent fish are left by the fishery. These parents must mature, spawn, and fertilize eggs which hatch to larvae, only a very small fraction of which eventually survive and become fully formed young fish (recruits).

Generally the females of most fish species produce several thousands of eggs, sometimes even several millions as in the case of some commercially exploited species in temperate waters. To a certain extent this high fecundity has misled fishery biologists to assume that a very limited number of adult females would, in most fish stocks, be sufficient to replenish the number of recruits that eventually become available to the fishery.

Uncritically applied this assumption has been one of the causes of some of the most spectacular collapses in the

NEXT PAGE ▷

world of fishing. Luckily this belief, that the lack of relationship between parent stock size and number of recruits should be the normal case in fishes is gradually replaced by its very opposite, namely, that most fish do display stock-recruitment relationships, the lack of such relationship being limited to a few groups such as the flatfishes and some gadoids. Strangely enough, apparently no attempt has been made to date to assess whether there is, in tropical stocks, an identifiable relationship between the size of a spawning stock and the number of recruits produced by this spawning stock, although it is true that data which could be used for such a purpose are scarce.*

Using rather conventional methods and data from the Gulf of Thailand demersal trawl fishery, I have established stock-recruitment relationship in a number of species, one of which, pertaining to *Lactarius lactarius*, is shown here (Fig. 2). The curve, which is a very typical "Ricker-curve," depicts the general pattern insofar obtained for most of the stocks I have investigated.

Only a few taxa showed no stock-recruitment relationships. Among these are the flatfishes (again!), one large predator (*Muraenesox*) and—by analogy (exact yield-per-recruit analysis was not performed)—the crabs, the shrimps and especially *Loligo*, whose spectacular increase in the Gulf of Thailand has been discussed by various authors.

Also, it appeared that in these taxa, there was a clear relationship between the number of their recruits (in any given year) and the standing stock size (for the same year) of their potential competitor and predators (as expressed by the biomass of all other taxa).

*Swept-area method for estimating standing stock and fishing mortality, computation of yield-per-recruit and division of Y/R into catch to obtain recruit numbers, plus miscellaneous methods and assumptions for obtaining other parameters estimates and data standardization. The methods will be discussed in detail in a forthcoming paper.

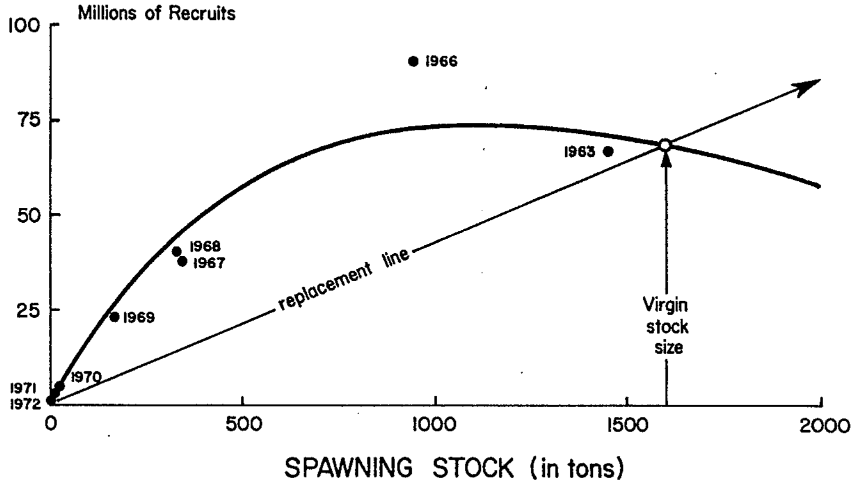

Fig. 2. Stock-recruitment relationship for the stock of *Lactarius lactarius* in the Gulf of Thailand.

This last point—competition and predation between taxa—leads us to the third form of overfishing, namely, ecosystem overfishing. Ecosystem overfishing is a "soft concept," allowing for much loose talk because it is not clearly defined. It may be described here as what takes place in a mixed fisheries when the decline (through fishing) of the originally abundant stocks is not fully compensated for by the contemporary or subsequent increase of the biomass of other exploitable animals.

Thus, as suggested by modern ecological theory, ecosystem overfishing would be the transformation of a relatively mature, efficient system into an immature (or stressed), inefficient system. This, to a large extent, is what happened in the Gulf of Thailand where a (presumably) stable and efficient high biomass system dominated by teleostean fish was gradually turned into a (presumably) unstable and inefficient low biomass stock in which the role of invertebrates has markedly increased (note the reversal of the evolutionary sequence!).

All three forms of overfishing discussed here occur in Southeast Asian waters, and the theory of fishing could well benefit from a study of the experience gained in the region.

Also, as biological processes in the tropics often occur in "pure form," unmediated by strong fluctuations of the abiotic environment (as occur in temperate waters, which are temperate only on the average), it is even thinkable that the theory of fishing, especially as far as multispecies stocks are concerned, could make here in Southeast Asia one step or two into scientifically unexplored territory.

Furthermore, understanding the nature of overfishing should considerably help solve resource allocation problems which have traditionally marred the relationships between artisanal and commercial fishermen in the region. It will, for example, become obvious that the catch, say of 100 t of relatively young fish by artisanal fishermen fishing close inshore has a radically different effect on a stock than the catch of 100 t of older and larger fish by a commercial fishery operating further offshore. This feature should indeed lead to the understanding that rather than having one single maximum yield, a given stock may have several "optimum sustainable yields" whose respective magnitudes depend mainly on the mode of operation of the fishing gear used as well as on the resulting age composition of the catch.

Finally, it is on the basis of the identification of such conflicting "OSYs" that fishery managers of the region can make sound decisions as to which segments of the fishing community should be encouraged or dissuaded from fishing. ●