

## Letter to the Editor

A recent newsletter article, "Biological overfishing of tropical stocks," by Daniel Pauly (Vol. 2(3): 3-4) prompted this letter from Dr. Barry Goldman. Dr. Pauly's reply follows. Both letter and reply have been slightly abbreviated. Ed.

Dear Sir:

On the whole, this article gives a very good and readable picture of the traditional (temperate fishery) view of overfishing. The author acknowledges the problems of management of multi-species fisheries, but he fails to credit the importance of several factors which are of paramount importance in the management of tropical reef fisheries. They may also be equally important for tropical pelagic and trawl fisheries.

Firstly, Dr. Pauly states that "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." While the concepts of "overfishing" may be translatable, the mathematical bases for stock assessment and exploitability are not. The statistics developed by Beverton and Holt, and others, are based, very importantly, on the concept of a unit stock, which implies that the total population can be "estimated" from sampling methods, such as catch/effort data, and that it has definite limits.

And while the statistics are fairly robust, I believe that the biological nature of tropical reef communities precludes even an approximation to the use of statistics based on the unit stock concept. For instance, the unit stock concept requires that adults within the stock are responsible for producing recruits to that stock. There is evidence to believe that this is not the case with tropical reef fisheries, i.e., recruits to a population may be spawned by fishes from a neighbouring population some distance away (cf. recruitment overfishing). Secondly, fairly accurate ageing is required for most fishery statistics and this is facilitated in temperate waters by discrete "cohorts" which can be followed through a population and which result from discrete breeding periods. In the tropics, breeding is spread more evenly throughout the year, with the result that discrete "recruitment cohorts" are not readily identifiable. Ageing is also more difficult in tropical marine fishes.

Thirdly, it is now known that a great many tropical reef fishes undergo sex changes. Thus, sex ratios are not constant throughout the population (another argument against the use of traditional statistics—unless perhaps the sexes are treated as different species). More importantly, as fishing pressures depress the age and size structure of the population, they will dis-

proportionately affect the sex ratios and fecundity of the population.

It may be more beneficial to reverse traditional practice and put a maximum size on some reef fish species, over which individuals are not to be taken. This in effect is what happens in many Pacific Island artisanal fisheries—by default.

In conclusion, I would strongly caution the use of traditional Beverton-Holt type statistics for multispecies tropical fisheries management, e.g., estimates of optimum size at first capture, fecundity, maximum sustainable yield, etc. Perhaps some simple descriptive statistics, such as catch per effort (localised) or catch per area, or catch constitution—such as size ranges of the constituent species, species composition, or even sex ratios—may prove sufficient to indicate that the fished population(s) are stressed and may need spelling.

Dr. Barry Goldman  
Director  
Lizard Island Research Station  
Cairns, Australia

I would like to thank Dr. Goldman for his concerned comments on my Newsletter article; also, I would like to stress that my reply is by no means intended as a "rebuttal," but rather as the onset of dialogue which we hope the ICLARM Newsletter will help promote among those concerned with tropical aquatic resources.

Yet, there are points where I disagree with Dr. Goldman's comments.

The "traditional" view of overfishing is indeed founded on the concept of a "unit stock," and I certainly do not believe that this concept should be scrapped when dealing with reef fishes. We either deal with a "unit stock," with its own definable range and which produces its own recruits, or we don't.

In the first case, recruitment overfishing will be the result of excessive exploitation, when too many of the breeders are removed, i.e., the large fishes which Dr. Goldman writes "are not to be taken." In the second case, when the recruits to one population are spawned by fishes from another population some distance away, recruitment overfishing cannot occur in the former "population" and the point there is to prevent growth overfishing.

The problem with Dr. Goldman's use of the term "population" is that it may, or may not, receive recruits from another "population." But nothing will be gained by replacing the concept of "unit stock" by a loosely defined "population"—although I would grant Dr. Goldman that it is not easy to actually define a specific unit stock when dealing with coral reef fishes.

The suggestion that "simple descriptive statistics," such as "localized" catch per effort, size of species in the catch, or sex-ratio, "may prove sufficient to indicate that fished populations are stressed and may need spelling," is, however, in contradiction with Dr. Goldman's statement that "the biological nature of tropical reef communities precludes even an approximation to the use of statistics based on the unit stock concept."

A decline in the "catch per effort (localized)" in a population receiving a constant or randomly fluctuating number of recruits is quite easily explainable, in terms of Beverton and Holt's model. It is in fact the very case they have studied!

Similarly, it is Beverton and Holt who demonstrated in quantitative terms that a decrease in the mean size of the fishes of an exploited unit stock is an index of fishing mortality, indeed putting at the disposal of those working on tropical stocks one of their most useful methods for determining when "fished populations are stressed."

Changing sex-ratio in an exploited stock also may tell us something about the state of exploitation in a stock, and there are papers dealing specifically with this question. But again, we find formulae based on the work of Beverton and Holt.

It seems as a whole that research, since the publication of Beverton and Holt's 1957 classic work—as in the case of most great scientific achievements—has narrowed more and more the field of applicability of the model, while at the same time confirming its basic tenet: that fish stocks grow and decay according to identifiable patterns, the knowledge of which can be used for purposes of fisheries management.

Almost certainly, these basic elements of Beverton and Holt's theory of fishing will eventually become incorporated into a generalized theory which will take stock interactions into account, as well as those features specific to tropical fishes, e.g., delayed recruitment.

It is to promote the emergence of such a generalized theory of fishing that ICLARM has scheduled an international "Workshop on the Theory and Management of Tropical Multispecies Stocks."\* We sincerely hope that this workshop will, among other things, help to solve some of the questions raised by Dr. Goldman.

Daniel Pauly, ICLARM

\*Described in the ICLARM Newsletter, January 1980.