VARIABILITY IN FISH LANDINGS, UNCERTAINTY AND ECOSYSTEM MANAGEMENT : AN EVOLUTIONARY PERSPECTIVE

K. I. Stergiou

School of Biology, Department of Zoology, Aristotle University of Thessaloniki, Greece - kstergio@bio.auth.gr

Abstract

In this report I briefly discuss some aspects of fish landing variability, which, together with other facts, contribute to the failure of conventional fisheries models and management practices. Consequently, I argue that in evolutionary terms the effects of climate on landing variability differ from those of fishing and that placing fisheries management into an ecosystem framework is the only alternative compatible with an evolutionary perspective.

Keywords : Fisheries, Fishes, Coastal management

Variability in fish landings and uncertainty

Fisheries landings (Fig. 1) are generally highly variable at different time scales and there have been various attempts to describe their variability pattern (e.g. 1,2), the results of which indicate that landings exhibit trends and cycles, with their variability increasing with the length of time over which it is calculated. Such patterns in variability have important ecological and managerial implications (for review see : 3). Firstly, they suggest that there is not any equilibrium yield, the latter being the basis of most conventional models presently used for fisheries management. Secondly, variability, by introducing uncertainty into various estimations, which is not usually taken into account in yield projections, results in increased risk of stock depletions. Thirdly, because variability increases with a decrease in body size, one may assume that fishing, by decreasing body sizes, should increase variability.

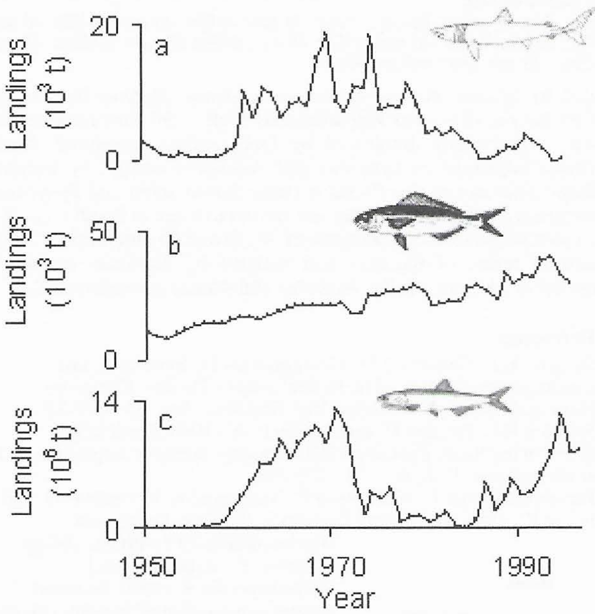

Fig. 1. Landings of (a) *Cetorhinus maximus* in NE Atlantic, (b) *Boops boops* in Mediterranean and (c) *Engraulis ringens* in SE Pacific, 1950-1996 (data from FAO), which although differ by 3 orders of magnitude all exhibit trends, cycles and increasing variability with time (Stergiou unpubl. data).

Thus, conventional fisheries models are inadequate for dealing with the present situation because landings at long time scales do not satisfy the assumption of equilibrium conditions and, secondly, because of fishing-induced increase in uncertainty. In general, fish stocks have adapted to the dynamics of their host ecosystems through long evolutionary processes. Such an adaptation must also concern the pattern of their variability as well as those of their predators and preys. Thus any factor affecting variability may have important evolutionary repercussions for the species or ecosystems in concern. This issue is discussed below.

Factors affecting variability and ecosystem management

Two of the most important factors affecting variability are climate and, in recent decades, excessive fishing mortality expended on fish stocks. Although it is rather difficult to separate the effects of the two factors, they must differ in terms of evolutionary repercussions. In general, no environmental factor is considered *a priori* as unfavourable, and organisms (or ecosystems) have not to resist but simply to react (*sensu* 4). As far as organisms manage to adapt to the new conditions (i.e., the new state is within the evolutionary norm of reaction of the organisms), the imposed "stress" is not only harmless but also constructive [eu-stress; *sensu* Lichtenthaler, cited in (4)] because it results in improved resistance and adaptive evolution. However, if the adaptability of the organism is overtaxed then the imposed stress can be destructive [distress; sensu Lichtenthaler, cited in (4)], leading to permanent damages or even to extinction (i.e., catastrophic events).

Intensive fishing activities, practised with highly efficient, non-selective fishing gears and mass-detection electronic equipment, have imposed, especially during the last decades, new conditions (*e.g.*, heavy size-related mortality rates) at a fast pace and over large geographical areas, thereby potentially affecting all populations of a species at the same time (3,5). On the short-time scale, species may react to fishing pressure by reproducing earlier (*e.g.*, 3,5), which is against previously evolved adaptation patterns and contributes to increased variability. Over the long-term, fishing may increase the overall population variability and decrease the re-colonization chances of extinct populations through dispersal from extant populations (i.e., the rescue effect). This results in a lower viability of the metapopulation than if the new conditions were not imposed to all populations (*e.g.*, 6). Since genetic changes caused by fishing are not easily reversed by altering fishing patterns (*e.g.*, 5), fishing-induced changes in variability, being also size-related, will also not be easily reversed.

Thus, over the long-term scale, fishing, when compared to climate, most likely approximates distress, having the potential to bring about drastic changes in total abundances as well as extinctions. Indeed, fishing has drastically reduced fish abundances (*e.g.*, 3,7) whereas fishing-induced species' extinctions, or near extinctions, are more frequent than previously thought (8). Hence, management models and strategies should be redesigned. Placing fisheries management into an ecosystem framework seems to be the only alternative (*e.g.*, 3,7,9), compatible with an evolutionary perspective. Within such a framework, the use of ecosystem modeling tools such as ECOPATH (9) and the adoption of a variety of "ecosystem" objectives, indicators and corresponding reference points that trigger management actions becomes a necessity (7). The establishment of large-scale (i.e., more than 40% of the fishable management area) marine protected areas, in which fishing will be totally prohibited, satisfies simultaneously the various objectives for ecosystem management (3) and provides a natural laboratory for studying variability.

References

1. Spencer P.D. and Collie J.S., 1997. Patterns of population variability in marine fish stocks. *Fish. Oceanogr.*, 6 : 188-204.
2. Stergiou K.I., 1998. Variability of fish catches in different ecosystems. *In* : Durand M.E., Cury P., Mendelssohn R., Roy C., Bakun A. and Pauly D, eds.,Global *versus* local changes in upwelling systems, ORSTOM Editions, Paris, p. 359-370.
3. Stergiou K.I., 2001. Overfishing, tropicalization of fish stocks, uncertainty and ecosystem management : Resharpening Ockham's razor. *Fish. Res.* (in press).
4. Strasser R.G., 1988. A concept of stress and its application in remote sensing. In (Lichtenthaler H.K., ed.) Applications of chlorophyll fluorescence. Kluwer Academic Publisher, p. 333-337.
5. Law R., 2000. Fishing, selection, and phenotypic evolution. *ICES J. Mar. Sci.*, 57 : 659-668.
6. LaHaye W.S., Gutierrez R.J. and Akçakaya H.R., 1994. Spotted owl metapopulation dynamics in southern California. I, 63 : 775-785.
7. Gislason H., Sinclair M., Sainsbury K. and O'Boyle R., 2000. Symposium overview : Incorporating ecosystem objectives within fisheries management. *ICES J. Mar. Sci.*, 57 : 468-475.
8. Roberts C.M. and Hawkins R., 1999. Species extinctions in marine ecosystems. *Trends Ecol. Evol.*, 14 : 241-246.
9. Pauly D., Christensen V. and Walters C., 2000. Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impacts on marine ecosystems. *ICES J. Mar. Sci.*, 57 : 697-706.