Quo Vadimus

The logic of comparative life history studies for estimating key parameters, with a focus on natural mortality rate

John M. Hoenig\(^1\)*, Amy Y.-H. Then\(^1,2\), Elizabeth A. Babcock\(^3\), Norman G. Hall\(^4,5\), David A. Hewitt\(^6\), and Sybrand A. Hesp\(^5\)

\(^{1}\)Virginia Institute of Marine Science, College of William & Mary, PO Box 1346, Gloucester Point, VA 23062, USA
\(^{2}\)Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, 50603, Malaysia
\(^{3}\)University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, USA
\(^{4}\)Centre for Fish and Fisheries Research, Murdoch University, 90 South Street, Murdoch, Western Australia 6150, Australia
\(^{5}\)Department of Fisheries, Western Australian Fisheries and Marine Research Laboratories, PO Box 20, North Beach, Perth, Western Australia 6920, Australia
\(^{6}\)U.S. Geological Survey, Western Fisheries Research Center, 2795 Anderson Avenue Suite 106, Klamath Falls Field Station, Klamath Falls, OR 97603, USA

*Corresponding author: tel: 18046847125; e-mail: hoenig@vims.edu


Received 7 September 2015; revised 11 March 2016; accepted 4 April 2016; advance access publication 24 May 2016.

There are a number of key parameters in population dynamics that are difficult to estimate, such as natural mortality rate, intrinsic rate of population growth, and stock-recruitment relationships. Often, these parameters of a stock are, or can be, estimated indirectly on the basis of comparative life history studies. That is, the relationship between a difficult to estimate parameter and life history correlates is examined over a wide variety of species in order to develop predictive equations. The form of these equations may be derived from life history theory or simply be suggested by exploratory data analysis. Similarly, population characteristics such as potential yield can be estimated by making use of a relationship between the population parameter and bio-chemico–physical characteristics of the ecosystem. Surprisingly, little work has been done to evaluate how well these indirect estimators work and, in fact, there is little guidance on how to conduct comparative life history studies and how to evaluate them. We consider five issues arising in such studies: (i) the parameters of interest may be ill-defined idealizations of the real world, (ii) true values of the parameters are not known for any species, (iii) selecting data based on the quality of the estimates can introduce a host of problems, (iv) the estimates that are available for comparison constitute a non-random sample of species from an ill-defined population of species of interest, and (v) the hierarchical nature of the data (e.g. stocks within species within genera within families, etc., with multiple observations at each level) warrants consideration. We discuss how these issues can be handled and how they shape the kinds of questions that can be asked of a database of life history studies.

Keywords: biological reference points, data selection bias, empirical relationships, \(F\)\(_{\text{msy}}\), hierarchical Bayesian models, indirect methods, intrinsic rate of population growth, life history correlates, mixed effects models, steepness parameter, stock-recruit relationships.

Introduction

The models used by resource assessment biologists, ecosystem modellers and other applied scientists frequently require values of certain key parameters that are difficult to estimate reliably and precisely. In these cases, it is natural to examine similar situations for guidance on possible values of the parameters. Such guidance can be derived from observations from similar locations, species, time periods, observation systems (e.g. fisheries), and so forth. Indeed, even when an estimate of a parameter is believed to be reliable and precise, it is prudent to check its reasonableness by