

there is a set of stepped migrations, 0–200 m (diurnal), 0–2 500 m (seasonal), 750–3 500 m (diurnal), 3 000–8 000 m (seasonal) and 100–7 000 m (diurnal). Thus there is a system by which organic material can be transferred from the photic layer directly to the deepest waters. This concept links the ecological processes in the ocean, explains the distributions in depth of biomass and of animal groups and, most important, shows how the food chains depend upon the algae in the photic layer and how they extend in depth to the bed of the ocean. In Moscow, I heard Professor BOGOROV describe this concept as the “crown of Vinogradov”.

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J. A. GULLAND: “*Manual of Methods for Fish Stock Assessment. Part 1. Fish Population Analysis*”. F.A.O. Manuals in Fisheries Science, No. 4. F.A.O. Rome, 1969, 154 pp., 40s.

In the dawn of the era of computerized ecology and resource management, this concise little manual of desk calculator methods for analysing commercial fisheries data is an anachronism. It is, however, the sort of anachronism that for the foreseeable future will be an essential part of the personal library of every fisheries biologist concerned with making practical management decisions. GULLAND explains in plain and eminently understandable language the basic calculus of fish stock assessment as it is practised today by the world’s leading fisheries management agencies. Neither word nor equation is wasted in this exceptionally pragmatic treatment.

In his introduction, the author states

“All the models described in this manual have proved to a greater or lesser extent to be useful models in that they have provided useful quantitative descriptions of events in various fisheries. Most have also been successful in making predictions....”

He goes on to say

“This manual is mainly concerned with studying the effect of fishing on the stocks and on the catches; it is, therefore, essentially concerned with the long-term effects. Also when predicting the catch from a given pattern of fishing the important question is often not the absolute amount of catch but the catch relative to that which would have been taken with some other pattern of fishing. Many fluctuations and variations are therefore irrelevant to the purpose of this manual”.

These two statements characterize the approach taken in this manual. Most of the models presented are deterministic, concerned with average conditions and often depend upon implicit steady-stage assumptions. Most of the methods described were developed out of necessity to solve specific management problems in important fisheries. Furthermore, most have been tested in many different fisheries. The demonstrated usefulness of these models is a refreshing

contrast to the questionable utility of the current deluge of mathematical models of biological phenomena.

Like the models it contains, the manual itself has been well tested. Preliminary versions have been used in courses in fish population analysis in several countries and also have appeared as FAO technical publications. The manual under review incorporates numerous improvements and revisions over the preliminary versions I have seen.

GULLAND has attempted to make the manual self-contained by adding a preliminary chapter which reviews elementary mathematics through integral calculus. For those who have not had the opportunity to examine the manual, the table of contents is listed below:

- I. Introduction
 - A. ESTIMATION OF PARAMETERS
 2. Mathematics, Statistics and Sampling
 3. Growth
 4. Effort and Catch per Unit Effort
 5. Mortalities
 6. Tagging
 7. Recruitment and Selection
 - B. ASSESSMENTS
 8. General Problems of Assessment
 9. The Simple Yield Curve
 10. Special Assessments
 11. Changes in the Parameters
 12. Final Exercises
- Appendixes
- Bibliography

The *Special Assessments* chapter, although too short, contains, among other jewels, what must be the clearest and briefest explanation of the Schaefer yield model ever published. GULLAND's treatment contrasts sharply with WATT's (1968) stylish but confusing treatment of the same topic (PAULIK, 1969).

A set of excellent exercises is given at the end of each chapter. These exercises contain either real or slightly "doctored" data. For some especially complex calculations, worksheet formats are laid out to help the student organize his work. An answer book for the exercises would be helpful for both students and instructors. Many of the exercises can be solved at different levels of completeness and as I worked through some of them, I could not help wondering how many of the possible statistical niceties GULLAND himself would include in his solutions.

Much of this manual is an essential distillation for the working biologist of the wealth of material covered by BEVERTON and HOLT in their elegant but rambling monograph "*On the Dynamics of Exploited Fish Populations*" (1957). Of course, the manual includes as well many new methods developed since the publication of BEVERTON and HOLT's work. GULLAND himself is responsible for the original derivations of a good share of these new methods. While the coverage of the manual is not as broad as in RICKER's classic monograph of

1958, the organization is much tighter and it is more suitable for use as a text.

The level of statistical sophistication in the manual is about the same as that in either RICKER (1958) or BEVERTON and HOLT (1957). For example, non-linear statistical fitting procedures are not used or mentioned; various equations and data are juggled into linear form and simple least-squares estimation procedures employed. In view of the heavy use it receives, the simple linear regression model should be treated in more detail and included in the mathematical and statistical introduction given in chapter 2.

Although a mathematical purist might chafe a little at GULLAND's ruthless disregard for the more esoteric statistical embellishments, the manual is sprinkled with common sense advice on the application of statistics to practical problems. I have not found any flaws in the logic of GULLAND's numerous remarks about the proper use of statistical methods.

The manual's comprehensive bibliography is referred to only occasionally in the text; this makes it difficult to follow up on techniques of special interest. The lack of a general index is mildly annoying and a glossary of symbols would be a welcome addition to future editions. GULLAND does employ the small set of internationally accepted symbols for fish population analysis, but does not hesitate to use new symbols without explicit definition when he believes the meaning is clear from the text, e.g., in the derivations given on pages 124-126. Some students may be inconvenienced, if not confused, by such omissions.

The typographical errors in the text are few and minor. On page 39 in the second equation from the bottom of the page, the W on the left-hand side should be lower case; on page 67 the expression $qf + M$ should be replaced by $qf + MT$; on page 75 the exponential expression in the integrand should contain t , not T ; the first entry in the e^{-x} table has a misplaced decimal.

One conspicuous gap in the manual is the treatment of spawner-recruit relationships. There is a large literature on this topic and it obviously belongs in the manual.

Mr. GULLAND is to be commended for writing this extremely useful manual and FAO is to be commended for publishing it. At a price of \$5 or 40s. it is a rare bargain in today's scientific book market.

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