Stock Assessment of the Anchovy *Cetengraulis mysticetus* (Pisces: Engraulidae) in the Inner Part of the Gulf of Nicoya, Puntarenas, Costa Rica

FARID A. TABASH
RIGOBERTO VÍQUEZ
JORGE A. RODRÍGUEZ

Abstract

A study of the population dynamics of the anchovy *Cetengraulis mysticetus* is presented, based on two sets of length-frequency dates from the artisanal fishery of the Gulf of Nicoya, Costa Rica, between 1989/90 and 1992/93. Covered are growth, length-weight relationships, fishing and natural mortality, gear selection and yield-per-recruit analysis.

Introduction

The Gulf of Nicoya, Costa Rica, ranks among the larger Central American Pacific coast estuaries. Within Costa Rica, it supplies roughly 90% of the commercial fish landings (Estes 1976) but is characterized by the nearly complete absence of a management system.

Various aspects of the fisheries resources of the Gulf of Nicoya have been documented (Peterson 1956; Britton 1966; Erdman 1971; León 1973; Bartels 1981; Phillips 1983), and this study is a contribution toward scientific criteria for managing these resources.

Materials and Methods

Samples of *C. mysticetus* for establishment of length-frequency composition were obtained randomly from various areas exploited by small-scale fishers within the Gulf of Nicoya (Fig. 1). Samples were taken monthly from June 1989 to February 1993, except in 1991.

The freshly caught anchovies were transported in ice boxes to our wet laboratory, then sorted according to species. Total length (mm) and total weight (g) were determined, as required for estimating parameters a and b of length-weight relationships.

The estimation of growth parameters from length-frequency data was carried out using the Compleat ELEFAN package (Gayanilo et al. 1988), and subsequently verified using the Length Frequency Distribution Analysis (LFDA) package (Holden and Bravington 1992). Seasonal growth oscillations were then considered (Pauly and Gaschütz 1979; Somers 1988).

A length-converted catch curve, based on pooling the per cent samples, was used to estimate total mortality (Z) and to derive approximate probabilities of capture by length (Pauly 1984). Natural mortality (M) was estimated using Pauly's empirical relationship. The values of M obtained were multiplied by a correction factor of 0.8 to account for the effect of schooling on M, as suggested by Pauly (1980).

Other outputs presented below (recruitment patterns, ϕ' values, etc.) were estimated using standard methods previously described in *Fishbyte*.

Results and Discussion

Tables 1 and 2 give the parameters of the length-weight relationships and growth curves that were estimated.

Fig. 2 reproduces LFDA response surfaces for the two periods considered here. As might be seen (once account is taken of the different scales), the two solid black areas cover similar L_∞ and K ranges, suggesting similar growth parameters between the two years.

Table 3 compares our results with those obtained for other stocks of the same species, using the growth performance index $\phi' = \log_{10}K + 2\log L_\infty$ (Pauly and Munro 1984).

The length-converted catch curves (not shown) led to the results in Table 4.

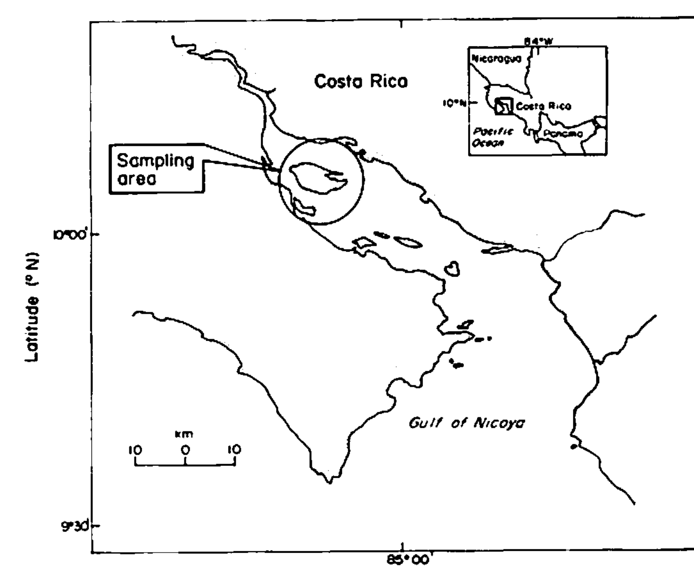

Fig. 1. Map of the Gulf of Nicoya showing where samples of Cetengraulis mysticetus *were obtained.*

Table 1. Length-weight relationships of *C. mysticetus* in the inner part of Gulf of Nicoya.

Year class	No. of individuals	Range (TL; cm)	a	b	r*
1989/1990	3,065	12.0-21.4	-6.035	3.474	0.96
1992/1993	3,810	8.9-20.9	-5.859	3.404	0.99

*Correlation coefficient of double logarithmic plot.

Table 2. Growth parameters of *C. mysticetus* in the inner part of Gulf of Nicoya during two successive periods.

Parameter	1989-1990	1992-1993
L_∞ (TL; cm)	23.1	22.0
K (year^{-1})	0.70	0.76
C	0.80	0.54
WP	0.76	0.80

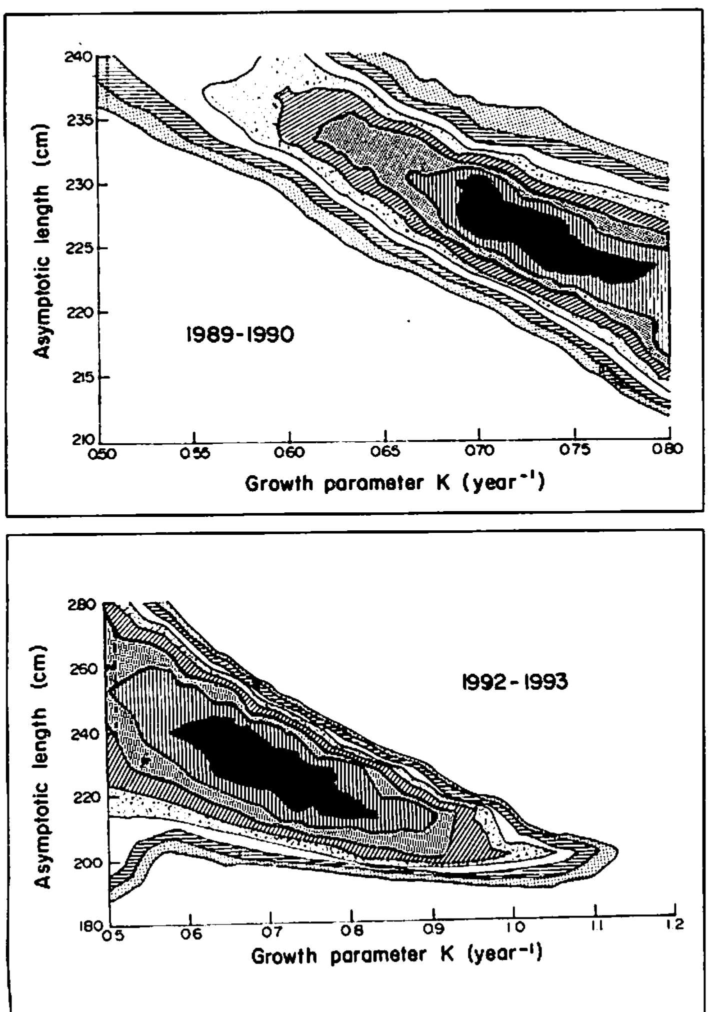

Fig. 2. Estimation of growth parameters in Cetengraulis mysticetus *for the inner Gulf of Nicoya: response surface output by the LFDA software; the dark areas indicate similar regions of good fit between the two periods considered here.*

Table 3. Comparison between growth performance (ϕ') reported in *C. mysticetus*.

Zone	L_∞ (mm)	K(year^{-1})	ϕ'	Reference
Almejas Bay (Panamá)	16.6	1.23	4.53	Bayliff(1967)
Guaymas Bay (Panamá)	14.2	2.58	4.71	Barrett and Howard (1961)
Gulf of Panamá	15.0	2.36	4.72	Howard and Landa (1958)
Gulf of Panamá	17.0	1.31	4.57	Bayliff (1964)
Gulf of Fonseca	15.4	2.92	4.83	Barrett and Howard (1961)
Colombia	14.3	2.09	4.63	Barrett and Howard (1961)
Ecuador-Perú	14.5	1.34	4.45	Barrett and Howard (1961)
Golf of Nicoya	22.0	0.76	4.57	This study (1992-1993)
Golf of Nicoya	23.1	0.70	4.57	This study (1989-1990)

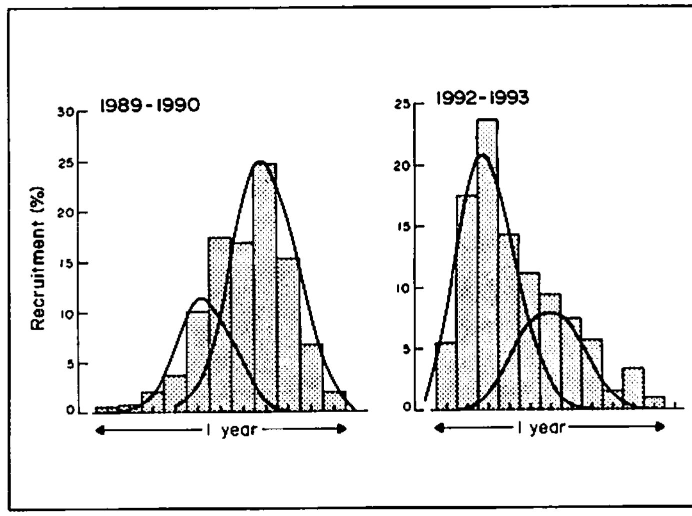

Fig. 3. Recruitment patterns of Cetengraulis mysticetus *in the inner Gulf of Nicoya. The peaks may occur in March for 1989/90 and in May 1993, but this needs to be verified, as line parameter "t_0," could not be estimated with precision.*

Table 4. Estimates of total fishing and natural mortality, and of mean length at first capture (L_c) for *C. mysticetus* in the inner part of the Gulf of Nicoya.

Parameter	Period 1989-1990	Period 1992-1993
Z (year^{-1})	2.887	3.455
M (year^{-1})	1.671	2.154
F (year^{-1})	1.216	1.301
L_{50} (cm)	17.9	16.3

While the parameters in Table 4 varied between periods, both sets imply a very high exploitation rate (0.58 for 1989/90, 0.62 for 1992/93). Further studies, notably of the fishery itself, will have to be conducted, before this finding can be translated into management action.

Acknowledgements

This work was financially supported by the Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICIT) and Ley de Pesca (Law # 6267) under administration of Escuela de Ciencias Biológicas in the Universidad Nacional (UNA). We thank Captain O. Torres, Y. Asch, R. Soto and M. Durán for their assistance in collecting the data, and Roxana Víquez for her suggestions.

References

Bartels, C.D. 1981. Occurrence, distribution, abundance and diversity of fishes in the Gulf of Nicoya, Costa Rica. University of Delaware, Newark. 120 p. M.S. thesis.

Barrett, I. and G. V. Howard. 1961. Studies of the age, growth, sexual maturity and spawning of populations of anchoveta (*Cetengraulis mysticetus*) of the coast of the eastern tropical Pacific Ocean. Inter.-Am. Trop. Tuna Comm. Bull. 8(3):167-197.

Bayliff, W.H. 1964. Some aspects of the age and growth of the anchoveta, *Cetengraulis mysticetus*, in the Gulf of Panama. Inter.-Am. Trop. Tuna Comm. Bull. 9(1):1-51.

Bayliff, W. H. 1967. Growth, mortality and exploitation of the Engraulidae, with special reference to the anchoveta, *Cetengraulis mysticetus*, and the colorado *Anchoa nasa*, in the eastern Pacific ocean. Inter.-Am. Trop. Tuna Comm. Bull. 12(5):385-432.

Britton, M. 1966. A small collection of the shore fishes from the west coast of Costa Rica. Ichthyologia 37:121-134.

Erdman, D.S. 1971. Notes on fishes from the Gulf of Nicoya, Costa Rica. Rev. Biol. Trop. 19:59-71.

Estes, T.S. 1976. Proceedings of the seminar-workshop on artisan fisheries development and aquaculture in Central America and Panama, San José, Costa Rica. Int. Cent. Mar. Res. Dev., Univ. Rhode Island, Kingston. 182 p.

Gayanilo, F.C., Jr., M. Soriano and D. Pauly. 1988. A draft guide to the Compleat ELEFAN. ICLARM Software 2, 70 p.

Holden, S. and M.V. Bravington. 1992. The L.F.D.A. package: Length Frequency Distribution Analysis (ver. 3.1). User Manual. Fish. Man. Sci. Prog. U.K. 68 p.

Howard, G.V. and A. Landa. 1958. A study of the age, growth, sexual maturity and mortality of sardines. F.A.O., World Sci. Meet. Biol. Sard. Rel. Species. Proc. 2(2):553-561.

León, P.E. 1973. Ecología de la ictiofauna del Golfo de Nicoya, Costa Rica, un estuario tropical. Rev. Biol. Trop., 21:5-30.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters and mean environmental temperatures in 175 fish stocks. J. Cons. CIEM 39 (3):175-192.

Pauly, D. 1984. Length-converted catch curves. A powerful tool for fisheries research in the tropics (Part 2). Fishbyte 2(1):17-19.

Pauly, D. and G. Gaschütz. 1979. A simple method for fitting oscillating length growth data, with a program for pocket calculators. ICES CM 1979/G: 24. Demersal Fish Cttee. 26 p.

Pauly, D. and J. Munro. 1984. Once more on growth comparison in fish and invertebrates. Fishbyte 2(1):21.

Peterson, C.L. 1956. Observations on the taxonomy, biology and ecology of the engraulid and clupeid fishes in the Gulf of Nicoya, Costa Rica. Inter.-Am. Trop. Tuna Comm. Bull. 1:139-280.

Phillips, P.C. 1983. Diel and monthly variation in abundance, diversity and composition of littoral fish populations in the Gulf of Nicoya, Costa Rica. Rev. Biol. Trop. 31(2): 297-306.

Somers, I.F. 1988. On a seasonally oscillating growth function. Fishbyte 6(1):8-11.

F.A. Tabash, R. Víquez and J.A. Rodríguez are from the Laboratorio de Ciencias Pesqueras, Escuela de Ciencias Biológicas, Universidad Nacional, P.O.B. 86-30000, Heredia, Costa Rica.

Software Review

PASGEAR : A Database Package for Experimental Fishery Data from Passive Gears by Jeppe Kolding, Dept. of Fisheries and Marine Biology, University of Bergen, High Technology Center N-5020, Bergen, Norway

PASGEAR is a specialized database system for capturing data from experimental passive gears such as traps and gillnets. Like NAN-SIS (developed and distributed by FAO for trawl data), it does not require sophisticated computer hardware configuration to run but includes the fundamental database management functions such as storing, editing, manipulating, and preprocessing data. It can be installed in almost any microcomputer available in the market — a rare feature nowadays for new software releases with the introduction of new technologies in the information industry.

Software users often do not realize that there is a difference between an analytical software such as the ELEFAN (Electronic LEngth Frequency ANalysis) suite of routines, LFSA (Length-based Fish Stock Assessment) and FiSAT (FAO-ICLARM Stock Assessment Tools) and a database system such as PASGEAR or NAN-SIS. Analytical software emphasize data analyses and allow only limited data storage. Only data required by the analytical routines incorporated in the software will be accommodated. The type of data and how it is analyzed are usually left to the discretion of the software user. On the other hand, database systems specialize in the efficient storage of data and effective retrieval while allowing limited data analysis.

PASGEAR is an arsenal of basic but fundamental data-exploration routines for the type of data it supports. This includes the calculation of the CPUE, index of relative importance, monthly changes in maturity stages, gear selectivity, length-weight relationship and temporal and spatial changes in CPUE to name a few. To supplement these preliminary data analyses, it includes a feature to export data in a form that can be imported by other software such as LFSA, The Compleat ELEFAN and FiSAT. This feature is well described in the accompanying documentation making the software a good complementary package to have if one would like to store more data than can be accommodated by one's favorite analytical software.

There is, of course, room for improvement. PASGEAR developed and compiled for use with MS DOS is not optimized to run on MS Windows environment (although it is possible to run the software in MS Windows). A big percentage of computer users is now adept in using MS Windows. The number of fishery scientists who are not familiar with the use of DOS-based software (and in some cases refuse to use it) is growing. It has become the norm to most that new software packages are developed for MS Windows. Translating the software to effectively utilize the potentials of MS Windows will be a huge step forward. The annoying use of codes and symbols in PASGEAR can be easily eliminated when the program is compiled for MS Windows using commercially available relational database systems.

PASGEAR introduces abbreviations (or symbols) I have encountered in fisheries texts, but which carry a different connotation. Abbreviations such as "GE" to refer to gear type in the program (not well defined in the manual) and "INV" to refer to the per cent of fish investigated out of the total catch are examples of these. Coupled with the absence of help messages describing the data fields, this makes the software manual crucial while working with the software; reading of the user's manual is a prerequisite. Moreover, the many prompts that the user of PASGEAR has to sequentially respond to is annoying. The use of dropdown menus or function keys would greatly reduce the prompts and allow the user to proceed to the desired action directly.

Quibbles such as those mentioned above cannot be overshadowed by the fact that PASGEAR works as it was intended and functions as described by the author. PASGEAR will be a software one would like to have, most specially for scientists and researchers working with passive gears. *F.C. Gayanilo, Jr., ICLARM*