



BOOK REVIEWS

The Peruvian Upwelling Ecosystem: Dynamics and Interactions, edited by D. Pauly, P. Muck, J. Mendo, and I. Tsukayama, 1989. Manila: International Center for Living Aquatic Resources Management (ICLARM), 438p. Price US\$ 15 (Surface, US\$ 27 (Air Mail). ISBN 971-1022-47-8. [Available from: ICLARM, 2nd Floor, Bloomingdale Bldg., 205 Salcedo Street, Legaspi Village, Makati, Metro Manila 1200, Philippines]

This book is the fourth in a series on the dynamics of Peru's offshore ecosystem characterized oceanographically as an upwelling ecosystem. The book contains the proceedings of the "Workshop on Models for Yield Prediction in the Peruvian Ecosystem" held August, 1987 in Callao, Peru. Its central theme is examination of environmental and biological elements of the Peruvian offshore ecosystem, and the synergism between them, with respect to anchoveta (*Engraulis ringens*) and the ultimate collapse of that fishery. Also emphasized are the ecosystem changes which followed the collapse, and the potential for future management of the Peruvian ecosystem. One shortcoming, however, is the need to read through a number of mostly brief, single-aspect papers, sometimes lacking unifying discussions, in order to obtain an overview of the subject theme.

Papers detailing various aspects of the biology of Peruvian anchoveta are more than one-half (18) of the 32 papers, and constitute nearly one-half of the text pages. One-half of the remaining papers are devoted to relevant oceanographic topics including primary production, zooplankton biology, and *El Niño*. The rest cover a hodgepodge of other topics, including the biology of fur seals. Most all papers are based on data from a time series of measurements taken off Peru over a period of 34 years, from 1953 to 1987. Data from various segments of this same time series have been used in ear-

lier papers by some of the same contributing authors. Although the book contains new papers based on data from this same time series, some of what has already been suggested regarding the decline of Peruvian anchoveta is revisited.

A synopsis gleaned from several papers pertaining to the central theme is offered below. Using virtual population analysis (VPA) to estimate monthly biomass and recruitment of Peruvian anchoveta (northern stock) from 1953 to 1985, Pauly and Palomares demonstrated a high level of inter-annual variation in biomass with a significant reduction of recruitment in *El Niño* years. Evidently, recruitment failure due to overfishing had already begun by the onset of the '72/'73 *El Niño*, even though the twin *El Niños* of '72/'73 and '82/'83 definitely helped finish the anchoveta fishery through recruitment failure.

Onshore encroachment of warm water (> 17°C) in 72/'73 contracted the anchoveta's area of distribution because of the preference of this species for cooler water, making the fish more accessible to the fishery. Csirke's paper showed how this resulted in a steeply increasing catchability coefficient in the face of declining stock biomass. Papers by Muck and others concluded that continued heavy exploitation of anchoveta following the '72/'73 *El Niño* may have prevented rebuilding of the anchoveta biomass, but zooplankton biomass also remained low relative to previous years. Inundation of the anchoveta's habitat with warm water at the peak of the '82/'83 *El Niño* was associated with further dramatic reduction of all planktonic biomass relative to preceding years following the '72/'73 *El Niño*, and a near total recruitment failure of anchoveta.

Collapse of the anchoveta biomass was associated with increased biomasses of Peruvian hake (*Merluccius gayi*), horse mackerel (*Trachurus murphyi*), Pacific mackerel (*Scomber*

japonicus), sardine (*Sardinops sagax*), and pinipeds, and with decreased biomasses of bonita (*Sarda chiliensis*) and guano birds. The greatest predation on adult anchoveta is believed due to the mackerels and hake, whereas the greatest competition is from sardine. However, anchoveta are evidently predators on the eggs and early developmental stages of hake, whereas as adults, hake consume anchoveta. The dramatic decrease of anchoveta biomass during the '72/'73 *El Niño* reduced its predation on the early life stages of hake and allowed hake biomass to increase exponentially. Moreover, the oceanographic conditions of the twin *El Niños* evidently enhanced hake recruitment while diminishing that of anchoveta. Reasons for increased sardine abundance appeared less clear. Muck *et al.* suggested that the differences between sardine and anchoveta in rate of development and first feeding of larvae, *i.e.*, phytoplankton for anchoveta and nauplii for sardines, might competitively favor anchoveta except during *El Niños* when phytoplankton biomass begins to drop in advance of zooplankton biomass.

The management potential based on these findings was also touched upon. Muck suggested trying a directed fishery approach where the predators of anchoveta (*e.g.*, horse mackerel) are fished when conditions favor them and they are present in great abundance. However, this would at best constitute reactive manage-

ment, probably requiring an unwanted lag period before redirection. Proactive or predictive management schemes may be unattainable, however, in light of Bohle-Carbonell's paper. Using a correlated fractal noise process to evaluate the synergistic effects of 8 oceanographic variables on anchoveta biomass (recruits and adults), he showed that except for seasonality, the dynamics of the Peruvian upwelling system have been determined by random events over the past 30 years. I believe that one could infer, therefore, that prediction of biomass or recruitment of anchoveta from an array of physical oceanographic data simply might not be possible for fishery management purposes. Or, perhaps, it's just that a time series of only 30 years is insufficient to develop predictive models for the Peruvian upwelling system, and another few decades of data are needed.

The Peruvian Upwelling Ecosystem contains good reference material for any fisheries research lab or for any individual interested in the details of the Peruvian upwelling ecosystem. On the other hand, it probably would not serve well as a general reference in fisheries oceanography or as a text.

Raymond R. Wilson, Jr.
Department of Marine Science
University of South Florida
St. Petersburg, Florida