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Biomass assessment of the monkfish *Lophius gastrophysus* stock exploited by a new deep-water fishery in southern Brazil

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Abstract

The monkfish *Lophius gastrophysus* was the first fishing resource that proved abundant enough to sustain profitable deep-water fishing operations off southern Brazil. As a directed fishery was structured in 2001, a preliminary stock assessment was conducted based on biological samples and catch rate data provided by both national trawlers and chartered gillnetters. Catch-at-size, general linearized models (GLM) and depletion models were combined to provide both pristine biomass and abundance index estimates for 2001. Landing statistics and discard estimates, indicated that fishing removed approximately 10,000 t; 16% of the 62,776 t total biomass estimate and approximately 32% of the spawning stock. Alternatively, GLM abundance indices variation, suggested a more severe 30–60% biomass reduction in the main fishing grounds off southern Brazil throughout 2001. The two fishing fleets have (a) concentrated in different areas and (b) exploited somewhat distinct fractions of the available monkfish stock biomass. Hence, fishing mortality, was concentrated both upon (a) fish larger than 60 cm total length (where *F*/*Z* oscillated between 60 and 80%), and (b) most immature 20–60 cm long fish (where *F*/*Z* reached 40%). The adoption of a conservative 2500 t total allowed catch (TAC) combined with biological elements was proposed in order to restrict fishing development to precautionary levels. Despite data-limitations and assumptions, the combination of both catch-at-size biomass estimates and abundance indices variation was shown to provide useful elements for fast precautionary management options in a new, poorly known and fragile deep-water Brazilian fishery.

Keywords: Southern Brazil; Monkfish; Deep-sea fishery; Stock assessment

1. Introduction

Short-term redirections of overcapitalized multispecific fleets towards valuable and previously untargeted fishing resources, have been commonly observed throughout the history of fishing development off southern Brazil (Pezzuto and Borzone, 1997; Perez

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and Pezzuto, 1998; Perez et al., 2001; Perez, 2002). During such "gold rush" episodes (*sensu* Perry et al., 1999), locally and/or seasonally available species, formerly devalued for economic or technological reasons, have been normally subject to sudden fishing mortality increases and rarely sustained the development of structured fisheries.

The region's latest and perhaps most noticeable "gold rush" episode has been characterized by the recent development of deep-water fishing (Perez et al., 2003b). Since the year 2000, landings of mostly high-valued deep-water finfish and shellfish targets nearly tripled, as (a) traditional trawling practices were expanded to slope grounds and (b) chartered fleet operations were authorized by a government deep-water fishing development policy (Perez et al., 2003a). Because deep-water stocks are sustained by generally low productivity environments and are commonly characterized by *k*-strategist life-history features, the sustainability perspectives of such fishing expansion process were uncertain and demanded conservative scientifically-based regulatory actions to be made effective at a very short term (Perez et al., 2003b; Large et al., 2001).

The monkfish *Lophius gastrophysus* was the first fishing resource that proved abundant enough as to sustain profitable deep-water fishing operations off southern Brazil (Perez et al., 2003b). The species was known to constitute a valued component of the trawling fishery off the coast of Rio de Janeiro State (23°S), but biological information was scarce and limited to systematics and distribution studies produced mostly from exploratory surveys on Brazilian shelf and slope waters (Yesaky et al., 1976; Figueiredo and Menezes, 1978; Haimovici et al., 1994, 1996). As a directed fishery was structured in 2001, a total of 8831 t were landed mostly by national double-rig trawlers (58%) and chartered gillnetters (36%), which explored and occupied a fishing area extending along the southern Brazilian slope, from 21°S to 34°S and within the 100–600 m isobaths (Perez et al., 2003a). Generating a total revenue estimated around US$ 21,000,000 in export products, this emerging fishery demanded fast regulatory actions which stimulated: (a) the collection of comprehensive fishing and biological data; (b) a preliminary stock assessment; (c) a public debate involving scientists, government and Brazilian industry; and (d) the definition of a scientifically-based management plan for future monkfish fishing off southern Brazil (Perez et al., 2002).

Crucial for the establishment of this plan, were preliminary estimates of the total biomass available on the fishing area in 2001, as well as the biomass dynamics throughout its first intensive fishing year. The data and analytical procedures involved in such estimation are summarized in this work and particular emphasis has been given to the exploration of three different methods in an attempt to evaluate best cost-benefit approaches for preliminary assessments of new, poorly known and fragile deep-water fisheries.

2. Material and methods

2.1. Data collection

We analyzed data derived from three deep-water fishing monitoring systems, developed as part of a scientific cooperation program established between the Ministry of Agriculture (Brazilian Government) and University of "Vale do Itajaí" (Santa Catarina, southern Brazil). The Santa Catarina Industrial Fishing Statistics Program provided information on catch, effort and fishing areas of 696 national double-rig trawler operations as obtained from log books, sales records and skippers interviews at the main Santa Catarina harbors (Table 1). A chartered vessel observers program and a chartered fleet tracking program provided fishing position, depth and catch/by-catch composition data of all 38 chartered fishing trips conducted by nine vessels and four trawlers off southern Brazil in 2001 (Table 2). Monkfish length samples were obtained both at the landings of the national vessels and during the chartered fleet fishing operations.

Fishing operations of chartered vessels (Table 2) were pooled into four trimesters (January–March, April–June, July–September, October–December), three latitudinal strata (north, 21°–25°S; center, 25°–29°S, and south, 29°–34°S) and two depth strata (<350 and >350 m) (Fig. 1). Fishing records of the national fleet (Table 1) were also pooled into these strata except depth in which the two strata were delimited by the 125 m isobath. In these records, individual tows were normally not discriminated, thus the entire trip was allocated into one trimester or latitudinal stratum. In situations when the trip duration and fishing area