Changes in a seafood market: substitution and elasticity of fish categories behavior in SE Brazil

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Abstract

Substitution and elasticity give about the history of supply and the demand structure for fish and seafood. It is also relevant to the detection of change in a particular exploited marine ecosystem. The purpose of this paper is to test if market elasticity of substitution of seafood categories can further elucidate on potential shifts in species composition of the Southeastern (SE) Brazil ecosystem. The paper is based on the hypothesis that seafood price can be elastic. In order to test such hypothesis, we used a time-series from the São Paulo city seafood wholesale market (1968-2007). A 97x97 matrix of linear correlation coefficients of market price and quantities between seafood categories based the analyses. Significant positive relations were found between some of the correlations. An elasticity analyses was run, and we show a case study of the category "sharks". Inelasticity for income and elasticity of sharks categories, among others, reveals important considerations for management perspectives, such as the effect of possible conservation measures or ecosystem change.

INTRODUCTION

Signals of overexploitation and change in the marine ecosystem have been evidenced generally based on bio-ecological data [1, 2, 3, 4]. However, the history of a seafood market can also indicate signals of ecosystem change [5, 6, 7, 8, 9]. Being the aspect of the fishery system that links the natural and human dimensions, the market behaviour can suggest both fishing trends [6, 10] and, ecosystem pressure dictated in part by the seafood demand.

In previous studies focused on the South Brazil Shelf Large Marine Ecosystem, we identified that the pricing and increase of market importance over time of some previously undesired seafood categories was an evidence of change. This was associated with the continuous scarcity of the fleet's target-species and of some high trophic level categories [9]. It raised the issue of eventual substitution processes occurring between seafood market categories particularly triggered by the scarcity of some. Therefore, the purpose of this paper is to explore the potential market substitution of the seafood in the South Brazil Bight region.

Brief conceptual background: Substitution and elasticity give about the history of a market's supply and demand structure for specific products [11]. It can be also relevant to the detection of change in a particular exploited marine ecosystem and its interpretation. Some implications of economic theory about the elasticities could be used as a reference point: goods with constant budget share and no substitutes will be considered as inelastic. In the case of aggregated goods, the budget shares are often constant, and there are few substitutes. This may suggest that many demand elasticities are likely to be inelastic. It is also of interest to note that the value of a market is at its highest when it is inelastic. If the supplied quantity increases above the level that is considered as ineslastic, the value of the market will fall. Finally, the more elastic the demand, the more substitution possibilities, and therefore the keener the competition [11].

In particular, few studies have been carried out on the demand for fish and seafood in developing countries [11]. Moreover, market databases of prices and quantities of fishery resources are usually scattered, incomplete, and unavailable for scientific research. This has often been cited as an important gap towards ecosystem-based fisheries management schemes [12, 13].

Study area: We analyze a seafood market time-series originated mainly from fishery landings from the South Brazil Bight. It corresponds to almost 200 categories that are historically sold in the São Paulo Wholesale Market, located in the megacity of São Paulo (Brazil), one of the biggest of the world. It represents a key local supply.

This region located between 23º and 28º S, is a crescent shaped area of the South Brazil Shelf Large Marine Ecosystem (Fig. 1). Trawling and purse-seining are the most important fishing activities in the region and currently behave as opportunists (multispecies) mainly due to the over-exploitation of the target species (i.e., sardines, shrimps and some demersal fish). A raising potential for the oil industry is also under development.

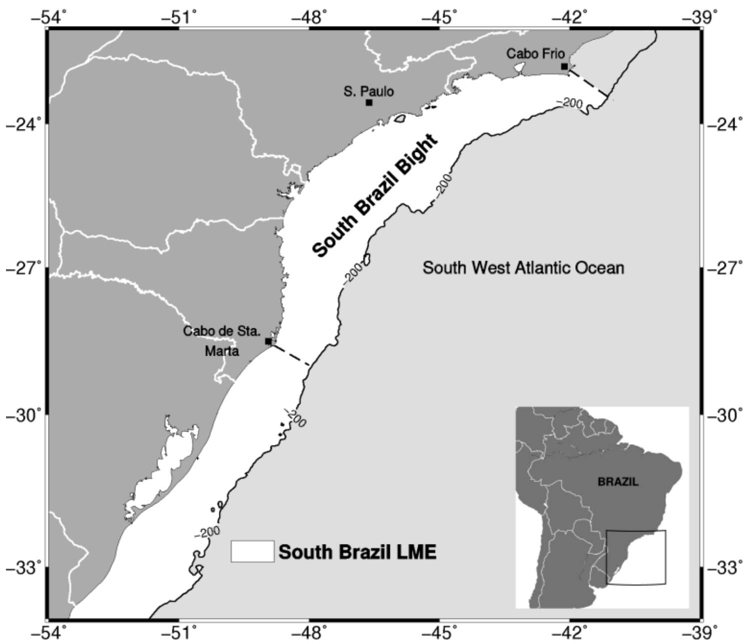

Fig. 1. Study area: South Brazil Bight and the Large Marine Ecosystem.

MATERIALS AND METHODS

In order to elucidate the possible market substitution a time-series (40-year period) of seafood market categories in the South Brazil Bight area were analyzed. An unprecedented compilation of monthly seafood market data for the period 1968-2007, including prices (P) in Brazilian currency (R$ Kg^{-1}) and quantities (Q, in Kg) of 97 seafood category, was undertaken from the São Paulo Seafood Wholesale Market (SPSWM). For the whole period, the Consumer Price Index was adopted as price's deflator.

Initially, a matrix of 97x97 Pearson's linear correlation of these market price and quantities between seafood categories (quantities of *i versus* market price of *j*) and its significance were constructed. This analysis was based on the fact that in terms of the variation ratio, Δx_i is the demand function represented by the market quantity of category *i* and Δp_j is the price of category *j*. Therefore, the significant positive correlations between *i* and *j* were identified from the matrix as possible substitute goods. Years with missing values were excluded.

From these positive correlations a preliminary elasticity analysis was applied for a specific group – *sharks*, as a study case. This analysis was based on two different types of models: (1) the Vector Autoregressive Theory – VAR (E-view 5.0 program) adopted for the cross-price elasticity between categories and (2) a simple autoregressive model (E-view 5.0 program) for the price and income elasticity. The Gross Domestic Product (GDP) series was used to represent the income variable. The variables were log-transformed. In this particular case, missing values were interpolated by *ad hoc* knowledge.

The coefficients of the first model give the price and income elasticity of sharks while the coefficients of the second model give the price and cross-price elasticity.

RESULTS AND DISCUSSION

In the first analysis, the Pearson's correlation matrix detected 1177 strong significant positive correlations from 9409. However, only 45 appeared to show major economical sense based on similar characteristics, within 15 different seafood groups (Tab. 1).

Table 1. List of the seafood categories that showed significant positive correlations between 0.6 and 1.0 and have major economical sense. "Winners" refer to the substitute category and "losers" to the replaced category.

Winners	Losers
sand tiger shark (*Carcharias taurus*)	sharpnose shark (*Rhizoprionodon porosus*) spinner shark (*Carcharhinus* spp.) rays (Rajidae, Rhinobatidae, Myliobatidae, Gymnuridae, Narcinidae and Dasyatidae) hammerhead (*Sphyrna* spp.) Brazilian guitar fish (*Rhinobatos horkelli*) shortfin mako (*Isurus oxyrinchus*)
bigtooth corvina (*Isopisthus parvipinnis*)	acoupa weakfish (*Cynoscion acoupa*) whitemouth croaker (*Micropogonias furnieri*)

kingfish (*Menticirrhus americanus*)	whitemouth croaker (*Micropogonias furnieri*) smalleye croaker (*Nebris microps*) guachanche barracuda (*Sphyaena* spp.) king weakfish (*Macrodon ancylodon*) green weakfish (*Cynoscion virescens*) Jamaica weakfish (*Cynoscion jamaicensis*) big weakfishes (Sciaenidae) stripped weakfish (*Cynoscion guatucupa*) medium weakfish (Sciaenidae) small weakfish (Sciaenidae)
Brazilian hake (*Urophycis* spp.)	common hake (*Merluccius hubbsi*)
black grouper (*Mycteroperca bonaci*)	jewfish (*Epinephelus itajara*)
jewfish (*Epinephelus itajara*)	black grouper (*Mycteroperca bonaci*) snowy grouper (*Epinephelus niveatus*, *Polyprion americanus*) grouper (*Epinephelus marginatus*)
Spanish mackerel (*Scomberomorus brasiliensis*)	tuna-like (*Auxis thazard*, *Katsuwonus pelamis*, *Euthynnus alletteratus*) king mackerel (*Acanthocybium solandri*, *Scomberomorus cavalla*) chub mackerel (*Scomber japonicus*)
Atlantic thread herring (*Opisthonema oglinum*)	Brazilian sardine (*Sardinella brasiliensis*)
Atlantic moonfish (*Selene setapinnis*)	crevalle Jack (*Caranx hippos*) horse-eye Jack (*Caranx latus*)
leatherjack (*Oligoplites* spp.)	crevalle Jack (*Caranx hippos*) horse-eye Jack (*Caranx latus*)
yellowtail (*Seriola lalandi*) - olhete	horse-eye Jack (*Caranx latus*)
yellowtail (*Seriola lalandi*) - pintagola	Atlantic moonfish (*Selene setapinnis*) crevalle Jack (*Caranx hippos*) horse-eye Jack (*Caranx latus*)
greater amberjack (*Seriola dumerili*)	blue runner (*Caranx crysus*) yellowtail (*Seriola lalandi*) – olhete
Atlantic bumper (*Chloroscombrus chrysurus*)	blue runner (*Caranx crysus*) Atlantic moonfish (*Selene setapinnis*) leatherjack (*Oligoplites* spp.) yellowtail (*Seriola lalandi*) – olhete greater amberjack (*Seriola dumerili*) crevalle Jack (*Caranx hippos*) horse mackerel (*Trachurus lathami*)
horse mackerel (*Trachurus lathami*)	crevalle Jack (*Caranx hippos*) horse-eye Jack (*Caranx latus*)

The *sharks* elasticity analysis related to its own price and related to the income could be considered as inelastic. Its equation is showed bellow with an adjusted R-squared of 0.13:

$$\ln Qs_t = 13.4 - 0.6 \ln Ps_t + 0.7 \ln GNP_t \quad \text{(Eq. 1)}$$

where Qs_t is the quantity of sharks (considering all them) commercialized in the period *t*, Ps_t is price of sharks (considering all them) in the period *t* and GNP is the Gross National Product in the period *t*.

The elasticity analysis considering sharks as general (sharpnose shark, spinner shark, spinner shark, rays, hammerhead, Brazilian guitar fish and shortfin mako) being replaced by the sand tiger shark could be considered as elastic. Its equation is showed bellow with an adjusted R-squared of 0.71:

$$\ln Qst_t = 5.5 + 0.3 \ln Qst_{t-1} - 1.5 \ln Pst_t + 3.5 \ln Ps_t^* \quad \text{(Eq. 2)}$$

where Qst_t is the quantity of sand tiger shark in the period *t*, Qst_{t-1} is the quantity of sand tiger shark in the period *t-1*, Pst_t is the price of sand tiger shark in the period *t* and Ps_t* is the price of all sharks (* excluding sand tiger shark) in the period *t*.

CONSIDERATIONS

The correlation analysis was important to identify possible substitute goods in a large dataset. In the case of sharks, as general, the income and price variation apparently did not change the sharks quantities, but between the group, price variation of one category could cause variation in the quantity of others. In the whole market, other seafood categories possibly followed the same pattern of sharks (see correlation analysis). Therefore, the elasticity analysis appeared to be useful for the detection of an expressive number of possible substitutions.

Next steps will include the improvement of the analyses through the application of more robust models (e.g. the exploration of discrete-choice models of product differentiation).

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