Uruguayan fisheries under an increasingly globalized scenario: long-term landings and bioeconomic trends

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Abstract

The systematic dwindling over time of many commercially important fish stocks in developed countries and the increasing demand of international markets provided a window of opportunity for fishery sector development in many developing countries. Science-based assessments of how market forces impact on fisheries trends are particularly limited in developing countries. This study assessed long-term trends (1960-2013) of the Uruguayan industrial fishery sector, including: (i) landings discriminated by species and resource type; (ii) variations in nominal effort and fleet capacity; (iii) bioeconomic patterns for most important species; and (iv) export and import volumes at the Uruguayan seafood market. Results indicate the sector underwent four phases that depict long-term patterns: development, expansion, stabilization-diversification and declining yields and market contraction. The development of the sector was mainly due to the Argentine hake fishery, which was characterized by a sustained increase in landings, nominal effort and fleet capacity

during the initial decades, but showed a decreasing trend afterwards. In response, a fishery diversification policy based on more valuable target species but with lower trophic levels was developed. Uruguay adopted a seafood net exporter role since the very beginning, with exports increasing linearly through time. More recently, seafood imports, with more competitive prices than locally caught seafood, have been gaining ground in the domestic market, reaching a third of all seafood currently consumed. Nowadays, the Uruguayan fishery sector is facing a crisis that is clearly reflected in the decreasing yields of the main species targeted, exports dwindling and increasing seafood imports. These results highlight the pressing need of the industrial sector to shift its model of fisheries exploitation. This study also provides evidence of the need to consider additional bioeconomic analysis to fully understand the behavior of the fishery sector as a dynamic social-ecological system operating in a globalized seafood trade scenario.

Keywords: Uruguayan fisheries, *Merluccius hubbsi*, *Micropogonias furnieri*, fisheries bioeconomics, market globalization

1. Introduction

Developing countries played a critical role in the rapid increase in global catch after the 1950s. The systematic dwindling over time of many commercially important fish stocks in developed countries (Worm and Branch, 2012) and the increasing demand of international markets, provided a window of opportunity for fishery sector development in many regions (Swartz et al., 2010, Watson et al., 2016). By the beginning of the 1980s, developing countries already accounted for half of global landings (Platteau, 1989). The increasing fishing pressure driven by the international demand in these countries was not accompanied by an appropriate development of science-based management and by accurate assessments of how market forces impact on the status of fish stocks and fisheries trends. Currently, unassessed stocks, mostly occurring in developing countries, provides more than 80% of global landings (Costello et al., 2012), highlighting the mismatch between research needs and fisheries knowledge development. Therefore, there is an increasing need to expand fishery research in the developing world, where better information of fisheries trends at national levels is required to cover existing data gaps (Worm and Branch, 2012; Agnew et al., 2013).

Most fishery research has been aimed to assess ecological issues, while assessments of socioeconomic and market aspects of fisheries are not as plentiful. This situation is exacerbated in developing countries where data acquisition directed to assess the economic performance of fisheries is even more uncommon. Fish products are one of the most traded food commodities (FAO, 2016), and therefore, international trade and market globalization have become a major driver in landings trends worldwide (Asche and Smith, 2010; Swartz et al., 2010; Crona et al., 2015; Gephart and Pace, 2016). Price fluctuations or foreign market variations led to immediate and pronounced effects on fishery products highly embedded in global markets, affecting local fishery sectors and economies (Gephart and Pace, 2016). These market trends

are most profoundly felt in developing countries, where poor institutional adaptability precludes alternative trading strategies to cope with external drivers of change (Berkes et al., 2006; Swartz et al., 2010; Crona et al., 2015). Indeed, weak fisheries governance, which is the prevailing characteristic in most developing countries (Defeo et al., 2016), has traditionally encouraged a trade system in which seafood is exported to developed regions and surplus value is used to purchase other goods and services (FAO, 2016), giving less room to portfolio alternatives such as the development of domestic markets. Another critical barrier for developing countries to overcome relies nowadays on the inability to satisfy constantly evolving import requirements, such as quality, safety, technical standards and ecolabelling (FAO, 2016; Gutiérrez et al., 2016). Recently, developing countries have increased trade among themselves as a strategy to cope with the challenges that pose exporting to developed countries (FAO, 2016).

The foregoing concepts highlight the need to consider interconnected markets and the global seafood trade scenario in order to gain insights about local landing trends. This is particularly important in Latin America, which has historically maintained a positive net seafood exporter role, generating surplus value from this sector of the economy since mid 1970s (FAO, 2016). Nowadays, for each ton of seafood imported, three tons are exported to international markets (FAO, 2016). Therefore, market price time series and seafood trade statistics could complement landing data by providing a rich source of information that has been largely neglected in Latin America fisheries management. This could be valuable in assessing fisheries status and assisting managers to understand fisheries as dynamic social-ecological systems operating under a globalized scenario (Pinnegar et al., 2006; Sumaila et al., 2007).

The aim of this study was to assess long-term trends (1960-2013) of the Uruguayan industrial fishery sector, including: (i) landings discriminated by species and resource

type (i.e., marine fishes, freshwater fishes, mollusks and crustaceans); (ii) temporal variations in the industrial fishing nominal effort and fleet capacity; (iii) bioeconomic patterns for the most important species in terms of landings; and (iv) export and import volumes. We also describe the temporal extractive phases which these fisheries have experienced, and the corresponding economic and managerial scenarios. Finally, we discuss the role of market drivers as potential factors influencing past and current status of Uruguayan fisheries.

2. Materials and methods

2.1. Study area and characteristics of the Uruguayan fishing fleet

The operation area of the Uruguayan industrial fishing fleet covers the Río de la Plata estuary (the widest estuary in the world), its contiguous shelf waters and the Argentinean-Uruguayan Common Fishing Zone (AUCFZ). The AUCFZ includes most of the Exclusive Economic Zone (EEZ) of Uruguay, area that extends beyond the territorial sea and adjacent to this, up to 200 nm (Fig. 1).

The Uruguayan fishing sector is formally divided into small-scale (vessels <10 Gross Registered Tonnage, GRT) and industrial subsectors, which are also clearly separated by the level of technology applied, fishing operation areas and the destination of landings (Defeo et al., 2011). The industrial fleet represents >95% of total landings and currently consists of 60-65 vessels (15-60 m length) with a mean of 360 GRT. Industrial vessels operate, by law, beyond 7 nm offshore. Most industrial vessels use bottom and midwater trawls, although longlines and pots are also used to target pelagic and benthic resources, respectively. More than 50 species are caught by the Uruguayan fishing fleet. Among them, the main ones landed are the Argentine hake (*Merluccius hubbsi*), the whitemouth croaker (*Micropogonias furnieri*) and the stripped weakfish

(*Cynoscion guatucupa*). In addition, Uruguay has an intermittent fleet operating in international waters, mainly targeting tuna species and Patagonian toothfish (*Dissostichus eleginoides*). Industrial fishing rights are assigned in the form of fishing licenses for a five-year period to physical or juridical persons through individual non-transferable quotas. Typically, quota allocations are based on a combination of catch history, vessel characteristics, long-term objectives and socio-economic factors of the recipients.

2.2. Data and analysis

Data sources used in this study include official information about landings and seafood trade statistics published by the National Direction of Aquatic Resources (Dirección Nacional de Recursos Acuáticos: DINARA for its acronym in Spanish) for the period 1960-2013, unpublished reports and media sources compiled and disseminated by DINARA (i.e., booklets and biannual reports). Complementary sources, such as official statistics of the Joint Technical Commission of the Maritime Front and The International Commission for the Conservation of Atlantic Tunas, were consulted to corroborate national statistics. Annual landings for each species were calculated as the sum of the landings recorded in each month. Annual fishing effort was measured by the number of active vessels and by GRT estimates. Export volumes (t) and economic revenues (US\$) were obtained from official reports provided by DINARA for the period 1975-2013, whereas importation records were available since 1999. Unit export prices were obtained as the ratio between export revenues and export volumes. Demand curves were computed using long-term variations in unit price against landing/export volume. For whitemouth croaker and striped weakfish a single demand curve was considered, because these coastal species are targeted jointly by the same fleet and traded internationally under the same trade code. In this case, two demand curves

were estimated: (i) including every year of the dataset; and (ii) excluding the last 4 years, which have a particular behavior when compared with the rest of the dataset (see Results). Unit price for this demand function was estimated by averaging each unit price weighted by annual landings for each species. In order to assess the potential telecoupling (i.e., distal connections) between the Argentine hake fishery and international market variations, unit prices were related to variations in global hake landings provided by Arancibia et al. (2015) for the period 1996-2012, which mainly reflected the decreasing hake supply worldwide. Relationships between price and landings (Argentine hake) or export volume (coastal species), as well as those referred to temporal variations in unit prices, were modeled by linear or nonlinear regressions. In all cases, the model that best explained these relationships was selected based on Adjusted R^2 . An ANCOVA was used to test for differences in price–time relationship of export product types (i.e., fresh, frozen and fillet), using unit price as a dependent variable, year as the covariate and product type as the fixed factor. A Bartlett test was performed to test the assumption of homogeneity of variance of unit price among treatments. Since unit price was heteroscedastic, the logarithm of unit price was used to carry out the analysis. When significant differences were found, a Tukey Honest Significant Difference (HSD) test was performed to assess differences between each pair of group means.

3. Results

3.1. Fishery phases

The historical trend in landings of the Uruguayan industrial fishing sector underwent four phases that depict long-term patterns: development, expansion, stabilization-diversification and a last phase of declining yields and market contraction (Fig. 2a).

1) Fisheries development (Phase I) ran approximately from the late 1960s to the second half of the 1970s. This phase was characterized by relatively low and constant landings close to 14,000 t and a fishing fleet lower than 40 vessels (Fig. 2a). Fisheries tended to operate under open access regimes and the seafood products were mostly channeled to domestic markets. Marine fish was the main target of the Uruguayan industrial fleet during this phase (Fig. 2b), notably including three demersal fishes: Argentine hake, whitemouth croaker and striped weakfish (Fig. 2c).

2) Fisheries expansion (Phase II) occurred during the second half of the 1970s and early 1980s, as a result of the “National Fisheries Development Plan” carried out by the Uruguayan Government (which included the development of the industrial fishing fleet, port infrastructure and processing facilities, and government credits), together with an increasing demand from foreign markets (e.g., Asia, Europe, USA). Consequently, Uruguayan landings increased sixfold between 1975 (26,000 t) and 1981 (147,000 t: historical maximum) and the fishing fleet increased twice (from 46 to 86 vessels) (Fig. 2a). In addition, the total fleet capacity increased threefold, from 5,700 to 15,500 GRT, for the same period (Fig. 3). Following the same patterns as in Phase I, the three demersal fishes mentioned above represented >90% of total landings (Fig. 2c). Argentine hake represented 38% (10,000 t) of the total landings in 1975 and 68% (93,000 t) in 1981. The second important species caught during this phase was the whitemouth croaker, which showed a sustained increase from 5,000 t in 1975 to 26,000 t in 1982. Stripped weakfish landings also increased from 8,000 t in 1978 to 15,000 t in 1981. During this phase, landings of crustaceans, mollusks and freshwater fish were almost negligible.

3) Fisheries stabilization-diversification (Phase III) began in the second half of the 1980s, but gained intensity during the 1990s. Two concurrent phenomena occurred during this phase: (i) Argentine hake displayed a decreasing trend in landings and

fishing yield (Fig. 2c); and (ii) new fisheries were developed on the basis of underexploited stocks of high unit value and increasing international demand. Total landings fluctuated around 110,000-140,000 t, similar to amounts registered in the early 1980s, but the decreasing yields of formerly abundant demersal species were compensated by the increasing captures of non-traditional resources (Fig. 2c). During this phase, the total fleet capacity markedly increased twofold from 1986 to 2000 (Fig. 3). Argentine hake was the most important species landed, although with a marked decreasing trend since the early 1990s (Fig. 2c). This trend was compensated by a sharp increase in total landings of non-traditional resources, particularly the squid *Illex argentinus*, which represented 86% of this category in 1997 (Fig. S1). Crustaceans (notably the deep-sea red crab *Chaceon notialis*) and freshwater fishes also increased during this phase, but at landings below 4,000 t (Fig. 2c, b).

4) Declining fishery yields and market contraction (Phase IV) resulted by the interaction of two factors that negatively affected the Uruguayan fishing sector: (i) a declining trend in landings of traditional and non-traditional species (Fig. 2c); and (ii) a drastic contraction of the main foreign markets for Uruguayan products, generated by the global financial crisis that occurred in the second half of the 2000s. The deleterious effects of this crisis were especially noticeable between 2008 and 2013, when landings fell down from 108,700 to 51,900 t respectively, and the fishing fleet decreased from 99 to 63 vessels (Fig. 2a). Some vessels paused their operations and many others left the country and did not operate anymore under the Uruguayan jurisdiction. As a result of these declining trends, from 2000 to 2013 the fishing fleet was reduced to half of its capacity while mean GRT remained stable (Fig. 3). The three main fisheries (Argentine hake, whitemouth croaker and striped weakfish) reached their lowest values of the last 35 years in 2013 (Fig. 2c), with mollusks and crustaceans also following the same trend (Fig. 2b).

3.2. Exports and demand curves

Historical fluctuations in exported volumes roughly depicted the long-term variations in landings analyzed in Section 3.1 until the end of Phase III. Thus, exports increased by an order of magnitude from 1975 to 1982 at the end of Phase II (expansion) and they were leveled off in about $70,000 \pm 7,000$ t during the 15 following years (1983-1998) included in Phase III (stabilization-diversification). The last phase (declining fishery yields and market contraction) was characterized by two dissimilar patterns: (i) a linear increase in exported volumes from 1999 to 2008; and (ii) a drastic decrease afterwards, until reaching 58,445 t in 2013, the lowest value in the last 23 years (Fig. 4a). Exported values also showed a significant long-term linear increase ($R^2 = 0.87$, $p < 0.01$) in the nominal exported value between 1975 and 2008, even though a declining trend was observed in the last years of analysis¹ (Fig. 4a).

The Argentine hake historically accounted for the highest export earnings among all exported marine products. A main peak was observed in 1981 (38,000 t), decreasing thereafter until reaching <14,000 t in 1999 (Fig. 4a). The exported volume increased again in Phase IV, peaking in 2004 (32,000 t), decreasing markedly afterwards to the lowest value at 2013 (<14,500 t). This reduction was partially compensated by a sustained increase in nominal export earnings between 1977 (<US\$ 5 million) and 2011 (US\$ 77 million), as a result of a significant increase in the unit price (Fig. 4b, see also Fig. 5d). Coastal fisheries showed similar patterns (Fig. 4a): whitemouth croaker showed a sustained increase in export volumes from 1975 (2,000 t) to 2012 (30,000 t), decreasing abruptly in 2013, while export volumes of stripped weakfish remained relatively low and constant throughout time. Export volumes of non-traditional species markedly increased during the stabilization-diversification phase, reaching the highest

¹ Inflation rate in Uruguay averaged 38.03 % from 1975 until 2013, reaching an all time high of 112.53 % in 1999 and a record low of 4.36 percent in 2001 (source: <http://datos.bancomundial.org>, last accessed 19 January 2017) .

values in 2001 and 2008 (60,000 t) and decreasing thereafter until reaching <26,000 t in 2013. Even though this decline was masked by an increasing trend in nominal export earnings from US\$ 120 million in 2000 to US\$ 236 million at 2011, an important drop was observed in the last two years of analysis (Fig. 4b).

The demand functions for the main resources showed different patterns. For the Argentine hake, the price-landings relationship followed a decreasing logarithmic function ($R^2=0.81$; $p<<0.001$), denoting a willingness to pay higher prices mainly at the end of the study period, concurrently with the lowest landings (Fig. 5a). Indeed, the unit price reached in 2013 (3,585 US\$ per t) was almost four times higher than at the beginning of the time series (Fig. 5d). Global hake landings (all species of the genus *Merluccius* included by Arancibia et al. 2015 in their Annex 1, see Fig. S2) followed a decreasing trend since the mid 1990s. The demand function fitted between Argentine hake unit price and global hake landings for this period followed similar trends to those found when considering local landings (Fig. 5b). High unit prices were particularly noticeable for years 1999 and 2011-2013, concurrently with abrupt decrease in global hake supply (Fig. S2). Therefore, regardless of local trends, the increase in unit price reflects a clear telecoupling between the local fishery and international decrease in the global supply of hake. Concerning the relationship between unit price of coastal species and exported volume, both models (all data and excluding years 2010-2013) followed a potential relationship that denotes a willingness to pay higher prices concurrently with high exported volumes (Fig. 5c), particularly at the end of the study period (Fig. 5d). Regardless of the very contrasting demand functions in Argentine hake and coastal fisheries, the unit price of both products consistently increased in the long-term (Fig. 5d) and were significantly cross-correlated ($R^2=0.51$; $p<0.01$). These long-term trends merely reflect the willingness of the global seafood market to pay increasing unit prices for fishery products through time.

The three main export products (i.e., frozen fish, fillet and fresh fish) showed a significant increase in their unit price through time (Fig. 6). Frozen fish unit prices linearly increased throughout the 39-yr time series analyzed, whereas fresh fish and fillet increased exponentially during the same period. For a same year, fillet products had significantly higher unit prices than frozen and fresh products, denoting a willingness of the market to pay higher prices for fillet (ANCOVA with logarithmic values to fulfill assumptions: $F_{2,113} = 216.4$; $p < 0.001$). Multiple comparisons showed significant differences among all product types (HSD Tukey test: $p < 0.001$).

3.3. Imports

The volume of imported seafood entering at the Uruguayan market systematically increased through time, from 480 t in 1998 to 9,200 t in 2013 (Fig. 7a). Prepared fish (i.e., breaded and canned fish) historically represented the most important item of seafood imports, followed by fillets and mollusks and crustaceans, respectively (Fig. 7b). While import volumes of prepared fish and mollusks and crustaceans increased linearly through time, volumes of imported fillets increased exponentially, reaching values 62 times higher when compared with the beginning of the period, denoting a considerable change in consumption patterns. The volume-weighted average price of imported products also increased through time. Price by product type showed an increase in all imported products, with the exception of frozen fish, which markedly decreased at the end of the study period (Fig. 7b).

4. Discussion

This study showed the high interconnection between landings trends and seafood trade statistics that delineated long-term patterns of the Uruguayan industrial fishery

sector. Uruguayan fishing products have been highly embedded in international markets since the expansion phase, and thus global fluctuations of supply and demand become main drivers of local trends. This fact become more acute in the last phase (i.e., declining fishery yields and market contraction), evidencing that market forces significantly contributed to a low resilience of Uruguayan fisheries. This study also provides evidence of the need to consider additional bioeconomic analysis to fully understand the behavior of the fishery sector as a dynamic social-ecological system operating in a globalized trade scenario.

While small-scale and semi-industrial fisheries existed before 1970s (Marín, 2016), it was not until the mid 1970s that Uruguayan industrial fisheries took relevance in the national agenda. The “National Fisheries Development Plan” carried by the Uruguayan government favored a rapid establishment and development of the industrial fishery sector (Astori and Buxedas, 1986), which led to an internationalization of fishery products, switching from almost exclusive domestic to foreign markets. This overemphasis on industrial fisheries through a legal and institutional framework revealed a high-level policy goal of the Uruguayan government to become a net exporter of seafood products, giving less emphasis to the promotion of national markets and small-scale fishery sector development. The engine for the rapid development of the sector was the Argentine hake fishery, which was characterized by a sustained increase in landings, nominal effort and fleet capacity during the initial decades (Lorenzo and Defeo, 2015). However, at the beginning of the 1990s, landings reached an upper ceiling and thereafter displayed a decreasing trend, which was also observed worldwide.

The trends depicted before could be partially explained by the macroeconomic models implemented in Latin America in the 1980s and early 1990s, which fostered privatizations, foreign capital investments and financial and trade liberalization (Thorpe

et al., 2000). In Uruguay, the introduction of this model in the early 1990s led to an abrupt increase in total and mean GRT of the fleet, peaking in 1999 (see Fig. 3) with the acquisition of foreign second-hand vessels to target non-traditionally resources (e.g., Argentine squid, red crab and fine snail). This was promoted by a high-level policy goal that provided strong incentives for seafood exports through a reimbursement system for exports taxes in which refund rates ranged from 4% to 15%². Particularly, export of non-traditional resources (e.g., mollusks) was benefited with the highest rates of refunds. The consolidation of this policy in non-traditional resources led to a significant increase in their relative representation in total landings, partially masking the declining trend in landings of traditional resources, notably Argentine hake. Decreasing trends in demersal species, together with the development of new fisheries based on more valuable target species but with lower trophic levels (i.e., mollusks and crustaceans), reduced the mean trophic level of landings within the AUCFZ (Milessi et al., 2005; Jaureguizar and Milessi, 2008). These trends reinforce recent findings that showed that fishery trends could result from a combined effect of fishery trophic levels and profit-driven fishing (Sethi et al., 2010).

The economic model mentioned above promoted an overcapitalization of the fleets in several Latin American countries, which raised the likelihood of overexploitation of resources. The restoration of economic stability in Argentina (country that shares Argentine hake with Uruguay) during the 1990s encouraged investments in the fishing sector fostered by the exception for trade taxes to new vessels, incorporation of foreign vessels to operate under Argentine flag and joint ventures with European Union (EU) vessels to fish in Argentinean waters in exchange of a two-third reduction in EU tariffs on fish products (Thorpe et al., 2000; Irusta et al., 2001; Bertolotti et al., 2016). These fishing policies resulted in a sharp increase in fishing pressure that led to an abrupt

² Decree N° 125/984. <http://www.impo.com.uy/bases/decretos/125-1984#hb>

increase in Argentinean landings from 435,000 t to 645,000 t in a ten-year period (Villasante et al., 2015) and threatened the sustainability of the resources.

The increase in fishing power of Argentina and Uruguay during the 1990s affected the Argentine hake in most of its distribution range, including the AUCFZ (Irusta et al., 2001). This increase in fishing effort was evidenced in a decrease of three main indicators (Bezzi et al., 1999; Lorenzo and Defeo, 2015): (i) total and reproductive biomass; (ii) catch per unit of effort of Uruguayan and Argentinean fleets; and (iii) mean individual size. In this context, long-term trends in the demand curve for Argentine hake are worrying, because, as anticipated by basic economic theory, deficit of supply relative to demand could push the price up and has driven some species to fishery collapses and local extirpations (anthropogenic Allee effect; Courchamp et al., 2006; Collette et al., 2011). The exponential rise in unit price occurred concurrently with a significant decrease in local and global hake landings, suggesting that fishing pressure should not be increased. In 2011, the Joint Technical Commission of the Maritime Front approved a Management Plan which includes a drastic reduction of the total allowable catch (50,000 t) in the AUCFZ from 2012 onwards.

The worrying situation depicted above was aggravated by the decline in exports of non-traditional resources during the last fishery phase, leading to a general contraction of the sector. Some of the non-traditional resources exploited by the Uruguayan fleet during the 1990s (i.e., Argentine shortfin squid (*Illex argentinus*) and the fine snail (*Zidona dufresnei*)) followed a boom-and-bust dynamics, catalyzed by a strong demand from foreign markets (Fig. S1 and Fig. S3). Of particular interest is the case of the fine snail fishery, whose exploitation began concurrently with the sustained dwindling of Chilean “loco” (*Concholepas concholepas*) landings (Masello, 1998; Gelcich et al., 2010; Defeo et al., 2016). When loco’s supply began to be compromised, seafood brokers, encouraged by the increasing demand of Asian markets, searched new

market opportunities based on substitute unexploited stocks or farmed gastropods (Castilla et al., 2016). As a result of global interconnected markets, a constant flow of fishery products was maintained to cover the unsatisfied foreign demand of high-quality products such as “loco” (Crona et al., 2015). This process, known as dilution (*sensu* Crona et al., 2015), determines a boom-and-bust dynamics in many developing country fisheries, undermining the resilience of high valuable stocks. The rapid development and exploitation driven by market opportunities often undermines the generally poor resilience of government fishery agencies to react on time and to provide sound scientific basis for managing these stocks, driving them to overfishing and collapses before being perceived as threatened by local governments (Eriksson et al., 2015). This is particularly true for sedentary, long-lived resources, like the fine snail, which are prone to overexploitation in the short-term.

Between 1997 and 2013, the declining profitability of some Uruguayan fisheries resulted in 65 vessels exiting the sector. In the Argentine hake fishery, this led to a 56% reduction in fishing effort. This trend was intensified in 2009 during the climax of the global financial crisis, which contracted the demand of Argentine hake in the United States and particularly in the EU (Lorenzo and Defeo, 2015), resulting in a 26% drop in unit price. Currently, approximately 95% of the total production is traded through international markets and most exports are comprised by frozen fish (e.g., 84% for 2012), which has low added value and significantly lower prices than fillet (only 10% of total Uruguayan seafood exports). In addition, the loss of market competitiveness of Uruguayan hake products at the expense of MSC-certified hakes which share the same market segment (Table S1 and Fig. S4) has had pronounced detrimental effects on the access to the main markets where Argentine hake was channeled. This is a main reason why coastal fisheries have been increasingly represented in total exports, particularly channeled to emerging economies (e.g., Brazil, Nigeria), which in turn, determined unusually high unit prices in the last years of analysis (see Fig. 5d).

Demand for national products by the domestic market, even those produced by small-scale fisheries, dropped dramatically as retailers and consumers opted for cheaper imported seafood products (Castrejón and Defeo, 2015). Following the trend generally observed in developing countries (Smith et al., 2010; FAO, 2016), mean unit prices of imported seafood are considerably lower than the respective Uruguayan exported products (see Figs. 6 and Fig. 7), evidencing its competitive advantage within the local market. Favorable market conditions (i.e., appreciation of the Uruguayan currency in the last years) led to an increase in the market share of imported seafood, mainly from Argentina, Ecuador, China, Chile and Vietnam, particularly since 2002. Thus, the relative representation of imported seafood products in the total domestic consumption has increased sharply from being almost negligible in 1999 to represent a third of all seafood currently consumed in Uruguay, consisting mainly in prepared fish and fillets.

In summary, the Uruguayan fishery sector is facing a serious crisis that is clearly reflected in the decreasing yields of the main species targeted, exports dwindling and increasing seafood imports. This crisis was partially due to the critical role that global market forces play in the sector as an external driver, as highlighted by bioeconomic trends for the main exploited species. Although this problem is beyond the national jurisdiction and the strength of management plans, adaptive capacities have not been adopted yet neither from the government nor from the fishing industry in response of this worrying situation, denoting a lack of capacity to anticipate and react to market shocks. Additionally, the obsolescence of the Uruguayan fishing fleet has increased over time, reaching an average age of 31 years. In this context, the fishing industry has no incentives for renewing the fishing fleet, given the market contraction, thus exacerbating a quite worrying situation.

Since the development of the fishing sector, and after 40 years, Uruguay has positioned itself as a net exporter of fishery products. The results of this study highlight the pressing need of the industrial sector to shift its fisheries model. The promotion of national markets and the development of the small-scale fishery sector have been largely neglected, even though some promising signals have been shown in the last 10 years with the implementation of high-level policy goals (Defeo, 2015; Gianelli et al., 2015). Thus, a national policy directed to promote national products and consumption patterns based on local seafood could counteract increasingly imported products. Navigating these transformations, from resource governance to the reconsideration of trading alternatives fostering the production of high value seafood, will require a comprehensive cost-benefit assessment of a potential restructuring of the sector and the whole seafood chain. In addition, increasing multiple uses of the national marine environment have posed new challenges for industrial fishing, such as: (i) off-shore oil exploration; (ii) installation of submarine cables of Uruguay and Argentina across de AUCFZ; and (iii) establishment of a new entry channel for merchant ships, anchorage areas and coastal projects. These activities may have cumulative impacts in the industrial fishery sector, jeopardizing its economic viability. Implementing ecosystem-based management initiatives (Link and Browman, 2014; Dolan et al., 2015) will be essential to address cross-sector trade-offs and to optimize the utilization of ecosystem goods and services produced by different economic sectors in Uruguayan waters. Following the ecosystem perspective, it will also be critical to disentangle the effect of market forces from environmental variability on fish stocks (Cheung et al., 2013; Lam et al., 2016). For this purpose, robust, systematic and sound-science monitoring programs should be established, seeking to forecast the impact of climate drivers on fishing yields.

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Figure 1. The operation area of the Uruguayan industrial fishing fleet comprises the Río de la Plata estuary and the Argentinean-Uruguayan Common Fishing Zone (AUCFZ).

Figure 2. Long-term variations of Uruguayan industrial fleet landings for the period 1960-2013 showing: (a) total fishery landings ($t \times 10^3$) and nominal effort (number of vessels); (b) landings ($t \times 10^3$) discriminated by resource type (MF: Marine Fish, FW: Freshwater fishes, M: Mollusks, C: Crustaceans); and (c) landings ($t \times 10^3$) of the most important species caught (Ah: Argentine hake, Wc: whitemouth croaker, Sw: striped weakfish) and the remaining species pooled into the non-traditional category (Nt). The grey scale differentiates fishery phases of Uruguayan fishery sector.

Figure 3. Temporal variations in total and mean Gross Registered Tonnage (GRT) of the Uruguayan industrial fishing fleet. The grey scale differentiates fishery phases of Uruguayan fishery sector.

Figure 4. Long-term variations (1975-2013) of: (a) total exported volume in $t \times 10^3$; and (b) total exported value (in $US\$ \times 10^6$) discriminated by traditional (Argentine hake, whitemouth croaker and striped weakfish) and non-traditional species exploited by the Uruguayan fleet. The grey scale differentiates fishery phases of Uruguayan fishery sector.

Figure 5. Scatter diagrams showing: (a) mean annual values of hake price as a function of local landings; (b) Argentine hake local price as a function of global hake landings; and (c) unit price of coastal species (i.e., whitemouth croaker and stripped weakfish) as a function of export volume. In this case two models were adjusted: (1) a model including every year of the dataset (dotted line; Series 1; $R^2=0.32$) and (2) a model excluding the last 4 years (black dots; Series 2; $R^2=0.48$). (d) Temporal variations in unit price of Argentine hake and coastal species (i.e., whitemouth croaker and stripped weakfish).

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605 **Figure 6.** Long-term variations (1975-2013) in unit price (price in US\$ x 10³ per t) discriminated by
606 exported product type (fresh fish, frozen and fillet).

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608 **Figure 7.** Variations in (a) total seafood imports and mean price per t; and (b) seafood imports by type of
609 product: prepared fish, fillet, mollusks and crustaceans, and frozen.

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URUGUAYAN INDUSTRIAL FISHERIES: long-term patterns and bio-economic trends

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