

## ECONOMIC PERFORMANCE OF THE QUOTA SYSTEM IN THE PELAGIC FISHERY OFF CENTRAL-SOUTHERN CHILE

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### ABSTRACT

The present article describes the changes that took place, in terms of efficiency and distributional issues, within Chile's central-southern pelagic fishery industry when the administrative regime evolved from controlling the fishing effort to assigning individual fishing quotas. These changes are described through a set of indicators that reveal variations in the capital stock of the fleet and the actual fishing effort, the unitary fishing costs, and the distribution of the income and quasi-rents in the fishery. The results show increased efficiency and distributive improvements within the industry.

**Keywords:** IFQ, Efficiency, Distributional issues, Fishery indicators, Pelagic fishery.

### INTRODUCTION

Fishery activities in Chile are mainly regulated by Law No. 18.892, or the General Fishery and Aquaculture Law (GFAL), promulgated in 1991<sup>1</sup>. Basically, the GFAL contains a set of conservation measures that directly or indirectly regulate the catch, fishing effort, and access regimes for fishery activities according to the state of exploitation to which the hydrobiological resource of the fishery unit<sup>2</sup> is exposed. The GFAL considers four access regimes for industrial fishery activities: general access, full exploitation, in recovery, and early development.

The general access regime is applicable in fisheries whose resources, by default, do not fall into any of the other three regimes. This regime requires shipowners to obtain a fishing permit for each vessel to be used in the fishery unit. The general access regime supposes open access that is controlled by the fishery administrator. The full exploitation regime is applied when a fishery unit is declared to be in this state<sup>3</sup>. Under this regime, fishing permits can be transferred with the vessels. Once the regime is applied, access to the fishery unit is simultaneously declared closed so as not to increase the existing fishing capacity. The remaining regimes, in recovery and early development, require an extraordinary fishing permit (EFP) in order to exercise the right to fish. Internationally, this is known as an individual transferable quota<sup>4</sup> (ITQ) and it establishes the fraction of the annual global quota that the permit holder has the right to catch; these rights are assigned at public auction<sup>5</sup>. The GFAL established an open-access regime for small-scale fishery activities<sup>6</sup>. However, any fully exploited fishery units with closed industrial access are also closed to the small-scale fleet. The GFAL also reserved a five-mile strip along the coast for the development of small-scale extractive fishery activities. Initially, temporary permits could be granted for the development of industrial fishing within this strip in the absence of small-scale activities or if industrial and small-scale activities did not interfere with each other.

Although all four access regimes have been implemented for the diverse fishery units since 1991, full exploitation with closed access has been the most extensively applied regime. Nonetheless, in 2000, a study of a new individual quota system was undertaken and, in 2001, the Chilean congress approved the regime known as the maximum catch limit per shipowner (MCLS)<sup>7</sup> for a two-year transitional period. In 2002, a new legislative reform<sup>8</sup> extended the MCLS regimen until 2012. This reform terminated any possible incursions of the industrial fleet into the strip reserved for small-scale fleets in the central-southern zone and addressed small-scale fishery issues, regularizing the small-scale registry per fishery in 2001<sup>9</sup> and creating the small-scale extraction regimen (SER) for fisheries with closed access in 2002. This regimen went into operation assigning quotas per zone and later, in 2004, assigning fishing quotas to small-scale fishing organizations.

The present article describes the evolution of industrial efficiency and associated distributive aspects of fishery administration regimes for industrial and small-scale fisheries, from controlled fishing effort to individual quota systems. We use the pelagic fishery off central-southern Chile to illustrate this evolution. This area consists of two main fisheries: i) common sardine (*Strangomera benttincki*) and anchovy (*Engraulis ringens*), coastally distributed species subjected to industrial and small-scale efforts; and ii) jack mackerel (*Trachurus murphyi*), a

species found in the waters of the national economic exclusive zone (EEZ) and the adjacent open ocean and subjected to extraction by the industrial Chilean fleet as well as other foreign fleets.

The following section describes the fishery, including the evolution of the applied management strategies and the reasons for adopting the currently used quota systems, as well as the main concerns addressed prior to their legislative approval. The next section describes the indicators that characterize the fishery's economic performance and the last section presents the evolution of these indicators, revealing the effects of the fishery quota system on efficiency and distributive aspects.

## **THE CENTRAL-SOUTHERN PELAGIC FISHERY AND ACCESS REGIMES**

Two main fisheries sustain the pelagic industry off central-southern Chile: i) jack mackerel, distributed along the length of the Chilean coast, moving seasonally in and out of the EEZ, and ii) common sardine and anchovy, coastal pelagic species distributed within 30 n.m. of the coast. These three resources are the most important in this industry, constituting over 90% of the fishery landings, and are destined for fishmeal production and, recently, canned and frozen fish.

The industry is characterized by a high degree of vertical integration along the productive chain; approximately 70% of the landed catch comes from fleets owned by processing companies. Another 10% comes from independent industrial shipowners and 20% from small-scale shipowners. This vertical integration is associated with the absence of ex-vessel markets (i.e. little or no available raw material supplied), which forced that processing companies had their own fishery vessels in order to operate. However, imperfections in ex-vessel markets, when present, also drive vertical integration as they are risky and unreliable, subjected to factors such as biological and environmental fluctuations and fishery regulations. For example, the Norwegian fish processing industry tends to increase its property in fishing vessels in order to decrease the supply risks associated with imperfect raw material markets [10].

For administrative purposes, the central-southern jack mackerel fishery is geographically subdivided into two fishery units: from 32° 10'S to 39° 23'S and from 39° 23'S to 43° 43'S. The central-southern common sardine and anchovy fishery, considered to be a single unit, covers the entire length of both jack mackerel fisheries.

A large-scale or industrial fleet operates in the jack mackerel fishery. The hold capacities of these vessels range from 150 m<sup>3</sup> to 1800 m<sup>3</sup>; the larger vessels have refrigeration systems for transporting the catch and sophisticated equipment for navigating and detecting schools of fish. A foreign fleet also operates in the jack mackerel fishery. Part of the industrial fleet (vessels up to 800 m<sup>3</sup> hold capacity) also operates in the common sardine and anchovy fishery unit, as do other industrial vessels dedicated exclusively to catching these resources. Furthermore, both common sardine and anchovy are caught by a small-scale "artisanal" fleet, whose vessels have a hold capacity of 20 m<sup>3</sup> to 90 m<sup>3</sup>. Both the industrial and small-scale fleets fish with purse seining nets for all three species.

Jack mackerel biomass has declined steadily throughout its distribution area in the eastern South Pacific since the early 1990s due to the combination of excessive mortality by fishing and environmental alterations. Landings peaked in 1995 and fell drastically until 1998; since then they have fluctuated between 1 and 1.5 million tons annually (Fig. 1.a). Figure 1 also shows the evolution of the fishery access regimens. In 1993, with the implementation of the GFAL, the jack mackerel fishery was declared to be in a state of full exploitation and its access was closed for annual periods; transferable permits were assigned per vessel and per region. Although this regime lasted until January 2001, catches were prohibited between 1998 and 2000, during this period of time a series of controlled fishing expeditions described as a pseudo-individual quota system were carried out [6]. Later, through law 19.713 of 2001, the individual quota system or MCLS regimen was implemented for two years. A new legal reform, law 19.849, extended this regimen until December 2012. Regardless of the access system, the fishery is managed by a minimum catch size.

Common sardine and anchovy biomass and landings are considered together since these fish have the same distribution and location and their vulnerability to the fishing technique used is not distinguishable. Thus, it is not feasible to try to fish for just one species or the other. In both species, biomass is highly dependent on recruitment, which is, in turn, affected by interannual environmental variations; hence the fluctuations in biomass from one year to another (Fig. 1.b). In 1992, the GFAL established a general access regime for these fisheries. Under this regime, access to the fishery remains open but controlled; vessels already in operation as well as new vessels require fishing permits for determined geographic areas. These permits are not transferable. The general access regime remained in place in the central-southern common sardine and anchovy fisheries

through January 2001, at which time the MCLS regime was introduced for two years and then, as in the case of the jack mackerel fishery, was extended until 2012. Previously, in 1999, an obligatory satellite system was implemented for monitoring industrial fishing vessels<sup>10</sup>. This system was designed to supervise incursions of these vessels into the strip reserved for small-scale fishing, where an important part of the common sardine and anchovy fishery is found.

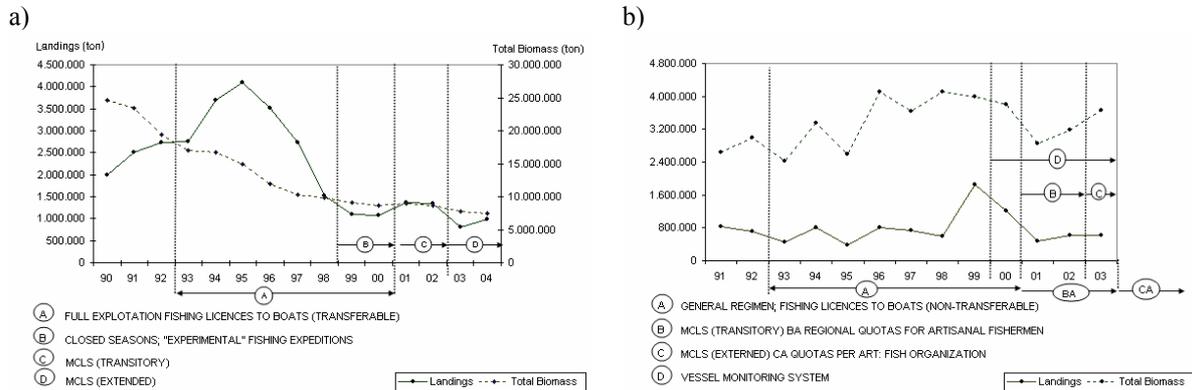


Fig. 1. Fish biomass, landings, and administration regimes  
a) jack mackerel fishery; b) common sardine and anchovy fishery

Under the MCLS, a global annual quota per fishery, or a total allowable catch (TAC), is set annually by the National Fishery Council (NFC)<sup>11</sup>. This is done according to criteria that seek to maintain approximately 40% of the jack mackerel spawning stock free of exploitation or to maintain a spawning biomass per recruit of common sardine and anchovy of nearly 60%. The TAC in these fisheries, after reserving 3-5% for research quotas, is distributed between the industrial and small-scale fleets, as determined by the NFC. The industrial fraction is assigned proportionally between the participating shipowners in each fishery; the initial assignment was based on historical landings and the hold capacity corrected by the authorized fishing areas for all vessels of each shipowner, both equally weighted. Shipowners can opt to combine quotas by forming an annual association that must be recognized by the fishery administrator. Such associations require an agreement between the shipowners and assume the payment of "rentals" for the fishing quotas. The associated shipowners can retire vessels from the fishery either temporarily or definitively, establishing annually which vessels will be operated in order to reach their quota. In the case of a definitive retirement, the authority emits a certificate with the historical catch of the retired vessel; the certificate holder thus retains this as part of the quota or transfers it definitively to another shipowner. Shipowners must pay an annual fishing patent for all the vessels that originated their fraction of the assigned quota; that is, those registered for operation as well as those retired temporarily from the fishery.

In 2001, when the regime of quotas per shipowner was enacted for industrial fishing, the small-scale fraction of the TAC was also distributed in global quotas per region. This system closed the small-scale fisheries by closing the registries to new vessel inscriptions. Vessel substitutions were allowed as long as the vessels had landing histories in the fishery; moreover, vessels in construction could be inscribed. This was known as the regularization of the small-scale vessel registry. As of 2004, this regimen was replaced, at the request of the users, by the small-scale extraction regimen (SER), which consists in assigning annual fishing quotas to small-scale shipowner organizations, a system that can be associated with common fishing quotas.

Fishing quotas were assigned per organization based on criteria such as reported landings per vessel inscribed in each organization, regularity and seniority, and number of vessels. The assignment of fishing quotas amongst the shipowners of each small-scale organization varies depending on its unique characteristics. At least three different ways of assigning quotas within these organizations have been found [17]: egalitarian distribution, historical records, and combinations of these two. A portion of the quotas assigned each organization can be transferred to other organizations with the authorization of the fishery administrator; the volume depends on the scarcity or excess of one organization or another in the use of their quota(s) throughout the fishing season. Such a transfer involves a *de facto* payment, to be negotiated between the organizations. Quota transfers between the small-scale and industrial sectors are not allowed.

The introduction of the quota system, or the MCLS regimen, into the industrial Chilean fishery in 2001 could be due to the inefficiency of the fishing authorization system (whether the permits are transferable or not) in controlling the fishing effort, which was the system's main objective. The replacement of this system with one of

individual fishing quotas (IFQ) follows a characteristic fishery evolution in which IFQ systems are preceded by fishing licensing systems that generally fail to control both the fishing capacity and effort [2].

According to the global review carried out by the IFQ Review Committee of the National Research Council, U.S.A. [14], the general rationale for implementing an IFQ system is based on the activity's economic efficiency, the conservation of fishery resources, and fishery safety. The committee determined that IFQ systems promote economic efficiency, eliminating incentives for excessive application of capital and work factors in the fishery industry; these incentives are greater with transferable fishing quotas. The committee indicated that individual quotas encourage conservation, amongst other factors, as the holder of this right has a stake in the continuity of the fishery and the value of the quota. On this subject, it is indicated that clearly defined and executable property rights (i.e., ITQ) are productive in the sense that they result in productive excesses that are not attained without these rights [9]. Decreased fishing competition allows scheduling fishing activities to avoid both crowding and operating in adverse environmental conditions, thereby augmenting fishery safety.

Other authors include complementary points of view in several articles. For example, with an IFQ system, operators will presumably employ the most economic configurations of capital and work, avoiding some regulatory problems found in closed-access licensing systems [5]. The intervention of a regulator in this plan, whether allowing freedom of technological configuration or restricting technological changes, can motivate the existence of capital stuffing or non-cost-effective technologies; both situations have inefficient social effects. It is also pointed out that part of the increased profitability that is attained with the ITQ programs can be used to recover costs and bring in returns; nevertheless, it is difficult to evaluate these programs based on fishery administration costs [7]. Finally, others think that one of the objectives to evaluate, although not as a property of the ITQ system, is the achievement of an adequate balance between competing interest groups and those that prioritize the preservation of the resources in their natural state [11].

The above citations indicate, in the Chilean case, the reasons for establishing a transitory individual quota system in all the full exploited industrial fisheries. The over-exploitation of the fishery resources, excess capital in fleets and processing plants, the "olympic race" leading to exaggerated fishing efforts, the low added value of the fishery products, employment instability, and fishery regulations that interfere in the decisions that correspond to the private sector and that could produce internal inefficiencies were the arguments given by the authority in 2000 for instituting the adoption of maximum catch limits per shipowner<sup>12</sup>. At the same time, although a fishing quota system had not yet been proposed for the small-scale fishery, it was argued that the existing regulations were ineffective given the sector's objective for socio-economic development. Moreover, for the reform that extended the MCLS law until 2012, the need to increase the stability and legal security of the assigned fishery resources was argued implicitly<sup>13</sup>. In turn, the introduction of the small-scale extraction regimen (SER) was based on reaching greater levels of organization, so that the use of its assigned fraction of the global fishing quota would facilitate stable development over time.

On the other hand, the implementation of IFQ systems by various countries has not been free of controversy. The two main areas of controversy are the system's effect on resource conservation and its resulting socioeconomic changes [14]. Regarding the first, the consensus is that the costs of vigilance and compliance are greater when the fisheries are organized in an IFQ system. This can result in incentives for committing infractions when the expected benefits are greater than the costs of the probability of being detected and penalized plus the costs of the manipulation of the catch (including unreported catch fractions, discarding smaller specimens, and catches exceeding the designated quota). The IFQ system also generates incentives for catching the more valuable specimens. In addition, especially when the number of users is greater in the system, the incentives are greater to conserve the resource at levels less than socially optimum in the long term.

The second topic – whether or not a balance or imbalance is achieved between economic efficiency and IFQ system fairness – is the more controversial of the two. In this area, two elements of IFQ systems are quoted: initial quota designation and transferability [14]. Theoretically, the initial designation has no real relevance on efficiency with a transferable quota. However, the transferable nature of the quota is the source of other controversial topics. The ITQ's may generate rents for the quota holders without making the State receive a portion. This is seen as the "privatization" of a resource of common use, mainly by those not assigned fishing rights under the individual quota system. Transferability could, moreover, generate a concentration of fishing rights, which could be interpreted as "monopolization" of the fishery and could, therefore, result in privileged situations. An IFQ program aimed at improving efficiency, regardless of the level of concentration of the fishing quotas, will result in the loss of jobs in the fishery fleet. Nonetheless, this is not necessarily the case in the fish processing plants, where employment could even improve due to the production of greater added-value products. Another distributive aspect to consider is the remuneration structure of the crew. The ITQ systems may change

this structure by decreasing the shipowner's uncertainty regarding the catch or the quota's greater added value, which could affect remunerations upon transferring or renting the quota [7, 9]. Likewise, that changes can occur in the amounts of the intramarginal returns obtained by the fleet and the fish processors [1]. These arguments regarding changes in the distribution of income mainly refer to fisheries with heterogeneous fleets, characterized by low levels of vertical integration, if any at all. Therefore, due to the rather high levels of vertical integration in the fishery industry, such distributional affects were probably not included in the discussions regarding the implementation of quota systems in Chilean fisheries. However, aspects related to conservation, global effects on the industry structure, and the effects generated by exclusive rights were considered. Some of these such as the enforcement and discarding, the exclusion and concentration generated by the ITQ system, the distribution of the resulting incomes, unemployment risks, and the future of the small-scale fishery have been already mentioned [15].

## **ECONOMIC PERFORMANCE INDICATORS FOR THE CENTRAL-SOUTHERN PELAGIC FISHERY**

From the economic point of view, the central question of fishery management lies in the maximization of the present value of the flow of the resulting interseasonal benefits or the maximization of the resource profit. This is determined based on modelling processes that require a complete understanding of the biology, economy, and environmental phenomena as well as institutional fishery factors, providing prior information with respect to changes in regulation measures or other external factors. However, knowledge of fisheries is, in general, highly incomplete, which limits the use of bioeconomic models for long-term fishery management. As a substitute, it is possible to use short-term bioeconomic simulation models that, given the present external characteristics, can show the fishery administrator the expected impact of a regulatory measure. An example of this is the application to the central-southern jack mackerel pelagic fishery [4].

The fishery administrator is also interested in knowing how fisheries evolve in their different dimensions (biological, economic, social) given the different administration and conservation measures implemented over time. This evolution can be partially verified through the use of contrastable performance indicators in order to manage a fishery. Thus, we propose a set of economic indicators that offer evidence of the effects of changes in the administration policy for the central-southern pelagic fishery. This set is made up of fishing capacity indicators, operational results, and distributional effects constructed according to the available data.

*i) Fishery capacity indicators.* Although technologically fishing capacity refers to production capacity expressed in terms of an optimum catch or target, it can also be expressed in terms of the fleet's characteristics and its capacity to generate fishing effort [8]. In economic terms, these concepts are respectively related to capital stock and capital services. For this work, we use the number of vessels in the fishery fleet and their total hold capacity as indicators of the capital stock, considering those vessels that land catches in every annual period. We also incorporate the concept of a latent capital stock, whose indicator corresponds to the sum of the hold capacity of the vessels that have been retired temporarily from the fishery due to the MCLS regimen and that maintain current fishing permits.

The indicator of the flow of capital services in the industrial fleet is an index of standardized operational effort, defined as  $\text{days-m}^3$ ; this corresponds to the sum of the product of the operating days per vessel in one year and their hold capacity. For the small-scale fleet, we use the same effort index, but given the imprecision of the vessels' hold capacity data, its magnitude should be taken with certain reserve.

The data used to estimate these indicators correspond to the official logs collected by the fishery authority for fishery follow-up and the resolutions of this authority related to fishing permits and vessel inscriptions. The analysis period for the industrial fishery is from 1995 to 2004, which includes subperiods prior to and following the implementation of the MCLS regimen; for the small-scale fishery, the period considered is from 2000 to 2004.

*ii) Operational performance indicators.* Three operational performance indicators are proposed: the annual average catch per unit effort (cpue), a cost per ton index, and an added value index for the landed product. These indicators are evaluated for the industrial and small-scale fisheries in the periods indicated above; the data of fishing cost structures and ex-vessel prices were gathered in the field in 2005<sup>14</sup>, whereas the product prices were taken from the fishery export registry and the National Statistics Institute.

The average annual cpue of vessel  $i$  in year  $j$  corresponds to

$$CPUE_j = \sum_i (\text{catch}_{ij} / \text{days} \cdot \text{m}^3) / N_j, \quad (\text{Eq. 1})$$

where subindexes  $i$  and  $j$  are the  $i$ -th vessel type and the  $j$ -th year, respectively, and  $N$  is the number of vessels. For this parameter, the ratio between the standard deviation of the cpue and the average cpue are calculated as the coefficient of variation of the annual average cpue. In the case of small-scale vessels, the unit of operational effort corresponds to the number of annual trips rather than days-m<sup>3</sup> of hold capacity.

The index of costs per ton corresponds to the total costs of fishing incurred by all the vessels (Eq. 2 and Eq. 3) divided by the total landed catch for a base year (1995 for the industrial fishery and 2000 for the small-scale fishery), which is equal to one. The valorization of costs corresponds to 2005 prices, as does the ex-vessel price of the fishery, which allows us to separate the analysis from the price effect. The cost structures are different for industrial and small-scale vessels, as can be seen in the following definitions:

$$TCi_i = FCi_i + d_i \cdot OD_i + c_i \cdot H_i \quad (\text{Eq. 2})$$

$$TCa_i = FCa_i + d_i \cdot V_i + s(p \cdot H_i - d_i \cdot V_i) \quad (\text{Eq. 3})$$

where

$TCi_i$ and $TCa_i$	total cost of the $i$ -th industrial and small-scale vessels, respectively;
$FCi_i$	total cost of industrial vessel $i$ , consisting of maintenance costs, crew salaries fishing permits, and port costs;
$FCa_i$	annual fixed cost of small-scale vessel $i$ , consisting of maintenance and port costs;
$d_i$	daily operational cost of industrial vessel $i$ and the cost per trip for small-scale vessel $i$ ;
$OD_i$	annual operating days of industrial vessel $i$ ;
$V_i$	annual trips made by small-scale vessel $i$ ;
$c_i$	cost per ton of landed catch, including fishing crew share and certification costs for landing and unloading;
$H_i$	landed catch per vessel $i$ , industrial or small-scale;
$S$	participation in net operating income received by the crew of a small-scale vessel;
$p$	ex-vessel price per ton of landed catch.

Two points should be mentioned regarding the fixed costs. First, these do not include the costs of capital use for industrial or small-scale vessels. Second, although some industrial vessels operate in both the jack mackerel and sardine and anchovy fisheries, 90% of the fishing in these cases is aimed at one fishery or the other and this information is duly identified in the fishery logs. Thus, the fixed costs have been assigned proportionally to the days operating in each fishery. No differences were observed in the share received by the crew in the two fisheries.

One last indicator of operational performance in the industry is related to the variation of the added value of the fishery products between 1995 and 2004. This is constructed using the value contributed by each product to the value of the average product per landed ton of the different species, having considered the volume destined for each processing line and its respective performance; product prices are from 2004.

*iii) Distributive indicators and indexes.* The annual variation in the distribution of incomes per catch by the industrial fleet is described here based on the relative participation of operational costs, the crew income, the recovery of management costs, and the quasi rent of the fishery. In order to determine the effects of the ITQ system on the concentration levels of these, we use the Herfindhal index, according to the two following, equivalent definitions [12]:

$$H = \sum (s_k / S)^2 \quad (\text{Eq. 4})$$

$$H = (cv^2 + 1) / N \quad (\text{Eq. 5})$$

where

- $s_k$  is the fishing quota of the  $k$ -th shipowner;
- $S$  is the total quota for the fishery;

$cv$  is the coefficient of the variation of the average quota per shipowner;  
 $N$  is the number of shipowners participating in the fishery.

Finally, to illustrate the effects of efficiency and distributive policies in the assignment of fishing quotas for the industrial and small-scale fleets that operate in the same fishery (sardine and anchovy), the evolution of the income indexes per fisherman and quasi-rents are described within the analytical framework in [13]. This is based on the description of relative movements towards efficiency and observations of whether this favors one sector or the other, or both, using the Pareto safe criteria [18].

## EFFICIENCY AND DISTRIBUTIONAL EFFECTS OF FISHING QUOTA SYSTEMS IN THE CENTRAL-SOUTHERN PELAGIC FISHERY

In this section, we use the previously described indicators to show how the introduction of two quota systems (MCLS and SER) in 2001 affected efficiency and distributive issues in the central-southern pelagic fishery.

In terms of the industrial jack mackerel fishing capacity, the number of vessels operating in the fishery experienced a sustained drop, with increased total and average hold capacities prior to enacting the MCLS (Fig. 2a). Small vessels were replaced by those with greater hold capacity, in large part because of the decreased resource abundance and its availability in coastal waters. Vessels continued to be removed from the fishery under the IFQ system, decreasing the hold capacity by over 50% with respect to the fishery maximum. In the two years prior to the IFQ system (under the general access regime), the hold capacity for the industrial sardine and anchovy fishery experienced significant growth (Fig 2.b.). This growth was due to the reorientation of vessels previously dedicated to the jack mackerel fishery and, eventually, the inclination of shipowners to anticipate the IFQ, increasing the historical catch for future quota designations. With the implementation of IFQ, the number of vessels operating in the fishery and their hold capacity decreased by nearly 75% with respect to the maximum employed in the previous period. The decrease was also driven by the full implementation of the vessel monitoring system, the total prohibition on industrial vessels entering the strip reserved for small-scale fishing, and the introduction of fishing quotas for the small-scale fleet. Along with these reasons, the objective of organizing the small-scale vessel registry explains the increase in small-scale vessels and their total hold capacity (Fig.2.c).

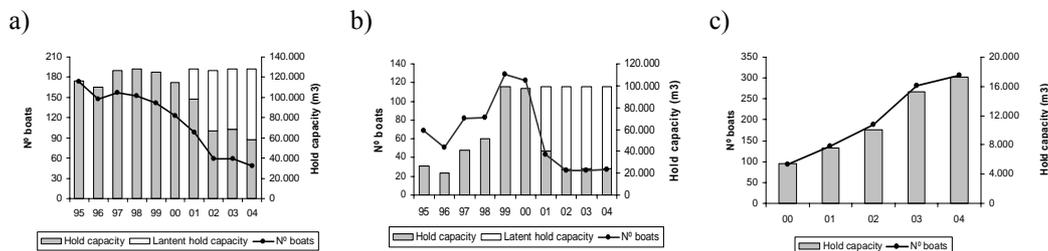


Fig. 2. Number of vessels and operational hold capacity

The removal of industrial vessels from both fisheries is transitory in nature, creating a certain latent fishing capacity, or capital stock, that represents sunk costs for the shipowners. The eventual recovery of the fish biomass would allow this latent capacity to be re-incorporated into the fishery, although this would not necessarily imply an excess capacity in the short term; this situation tends to remain in the measure that the fishing rights inherent under the MCLS regime have a limited duration.

The capital stock service corresponds to the fishing effort; in this case, to the operational effort developed by the fleet and, therefore, is related to its operational efficiency. In the case of the jack mackerel fishery, three periods can be distinguished: prior to 1998 (full exploitation regime), with high total effort indexes and greater average performances; 1998-2000 (full access combined with a quasi-IFQ system), with a decreased total effort index, average cpue, and important increments in the coefficient of variation for the cpue; and, finally, as of 2001 (MCLS regimen), with slight increases in the effort index and a lower average cpue, but stable variation coefficients (Table I). The increased operational effort in this last period can be explained by the longer fishing trips, given the changes in resource availability [17]. In turn, the lower dispersal of the average cpue can be related to the fleet's collaborative searching strategies, which result in economies of scale for the jack mackerel fishery [16].

Table I: Total effort indexes and average cpue in jack mackerel and sardine and anchovy fisheries

	Jack Mackerel industrial			Sardine and anchovy industrial			Sardine and anchovy small scale	
	Total effort index*	Average CPUE	CV of CPUE	Total effort index*	Average CPUE	CV of CPUE	Total effort index*	Average CPUE
1995	13.13	0.257	0.425	0.428	0.267	0.598		
1996	10.76	0.233	0.454	0.817	0.364	0.583		
1997	13.74	0.177	0.364	1.594	0.268	0.862		
1998	9.32	0.141	0.425	2.271	0.154	0.884		
1999	6.63	0.160	0.543	5.241	0.232	1.044		
2000	6.22	0.173	0.653	4.099	0.175	0.804	3.13	0.053
2001	6.52	0.236	0.711	0.400	0.132	0.999	9.23	0.029
2002	7.57	0.139	0.335	0.493	0.307	2.515	21.9	0.016
2003	7.45	0.144	0.360	0.921	0.295	3.471	55.2	0.007
2004	6.78	0.154	0.333	0.868	0.319	1.913	61.1	0.007

\* days-m<sup>3</sup>·10<sup>6</sup>

The operational effort in the industrial sardine and anchovy fishery increased and then fell significantly due to the increased capital stock prior to the MCLS and its subsequent decline. The average cpue tended to decrease during the first period and recover during the second; this behavior is expected, as it agrees with the evolution of the effort. The decrease in industrial fishing effort was compensated by the small-scale effort at a much larger nominal magnitude, coinciding with the introduction of common fishing quotas in this sector. In 2004, the operational small-scale effort increased nominally more than six times the 2000 effort, whereas industrial effort fell by 80%. Thus, the average cpue of the industrial fleet returned to the levels found prior to its expansion, with similar effort levels, and the low (relative to the industrial fleet) average cpue of the small-scale fleet declined due to the increased fishing effort. The fluctuations in the coefficient of variation for the industrial cpue can be attributed to seasonal changes in sardine and anchovy availability as they move in and out of the reserved small-scale fishing area. Likewise, latitudinal changes affect the small-scale fleet's performance between regions.

This is important because it allows one sector or the other to take advantage of the TAC, producing situations, under the SER, in which some regions or fishing organizations rapidly use up their quota in a given season of the year, whereas others do not manage to complete theirs. This is compensated by transfers decreed between regions or organizations. Nonetheless, since quota transfers are not possible between the small-scale and industrial fleets, an increased TAC can be proposed during the season<sup>15</sup>; these are generally granted by the authorities. Such decisions can lead to a failure to comply with the established fishery resource management strategy or, if the quota is not modified, can encourage the under-reporting of catches, as has occurred in the fishery<sup>16</sup>. Clearly, the system must be flexible in this aspect, although the problem of excessive regional small-scale fishing capacity should not be ignored, as it results in the rapid filling of assigned quotas.

Figure 3 presents indexes of fishing costs per landed ton (fcpt), using 1995 as the base year for the industrial fleet and 2000 for the small-scale fleet. The fcpt in the jack mackerel fishery tended to decrease under the MCLS, even with lower abundance and cpue levels than in the previous period. This indicates adjustments in the fishing capacity and its usage that tend to avoid an eventual, short-term excess in the fishing capacity. Although the cpue for the industrial sardine and anchovy fishery tended to improve with lower effort levels under the MCLS, this is not reflected in greater cost efficiency, mostly because increased average vessel capacity implies higher fixed costs. For the small-scale fishery, the fcpt increased continuously due to the increased fleet capacity and decreased cpue. Both fleets have an excess fishing capacity, with that of the small-scale fleet being greater. To calculate the fcpt, the cost structure and technology were assumed to be constant over time. Changes in these two aspects are unknown, although the technological change that resulted in the growth of the average hold capacity of the vessels was incorporated into the nominal effort evolution and, therefore, into the fcpt.

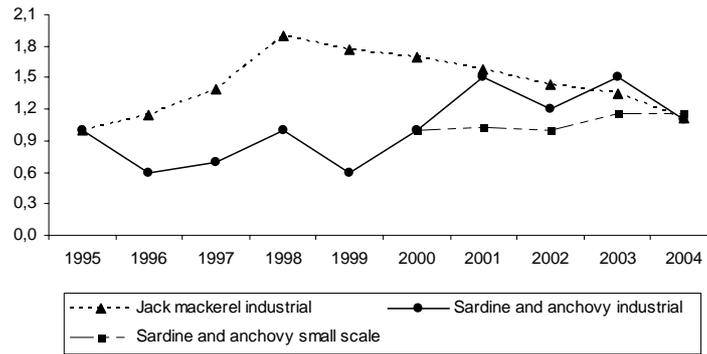


Fig. 3. Indexes of cost per landed ton in industrial and small-scale fisheries

One objective for implementing the MCLS was to increase the added value of fishing products. Figure 4 shows the relative participation of the different products in the gross value generated per ton of fish landed at constant prices, offering some evidence regarding the aforementioned objective. Effectively, canned and frozen products have greater participations under the MCLS; they have more added value than fishmeal and a higher employment level, even considering the lower landings observed in the period prior to the MCLS implementation. Likewise, the industry has begun to produce special fishmeals for high-value animal consumption. These are especially aimed at salmonoids, which require more efficient diets with lower-impact residues in terms of undesirable environmental impacts. These modifications in the variety of products can also be attributed to changes in the market demands. The incorporation of higher value-added products requires technological changes in on-board fish handling, fishing strategies, and processing plants, including the rationalization of these. In fact, new investments have been made in processing plants at the same time that the number of plants has been reduced according to the fishing quota levels [17]. The changes described probably could not have been carried out if the “olympic race” of fishing had not been halted.

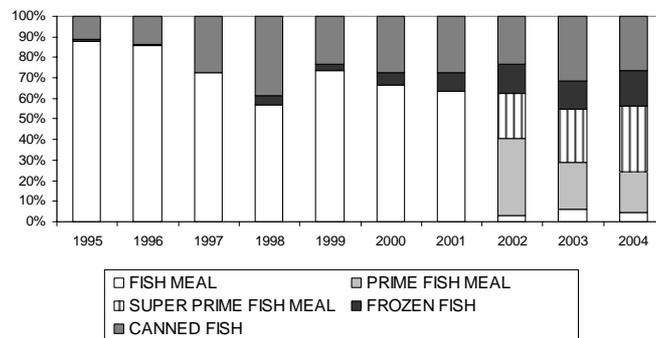


Fig. 4. Relative participation of products in the gross value of a landed ton

One critical matter in the IFQ system is the level of industrial concentration, especially given high levels of integration in the productive chain, as is the case in this pelagic industry. Table II shows the level of fishery quota concentration as of 2000, the year prior to the MCLS, measured with the Herfindhal index (Eq. 4 and Eq 5). The values indicate low concentration levels (fishing quota possession), although some increase can be observed due to the decreased quantity of shipowners with quotas and the coefficient of variation for average participation. Concentration indexes are slightly higher and increase more rapidly at the plant supply level than at the fishing quota level because of the decreased number of firms and shipowner associations formed for the use of the quotas [17]. It should be noted that the industry’s adjustment began before the IFQ was introduced; this was due to the declining jack mackerel biomass and its consequential rise in cost. In any case, this discussion remains open, as the economies of scale observed in the industry, thanks to its vertical integration and the accumulation of fishing quotas, create entrance barriers that facilitate controversial monopoly effects on the fishery resources.

Table II: Concentration index of fishing quotas

	2000	2001	2002	2003	2004
H	0.061	0.068	0.076	0.076	0.081
(CV) <sup>2</sup>	3.19	3.28	3.00	2.43	2.16
N	69	63	53	45	39

The distributional effects of the policies assigning fishing rights consider the distribution of the income generated by the total industrial landings of the fishery<sup>17</sup> as well as the proportion of the income per fisherman and the unitary quasi-rents for both the industrial and small-scale fleets in this fishery. The effects of the MCLS on income distribution in the industrial fleet can be seen in two items: the fleet's operational costs and quasi-rents. The latter is understood to be the difference between total income and total costs, except for capital costs (Table III). The implementation of the MCLS revealed a slight tendency to decrease total costs and increase total quasi-rents, although relative cost levels were greater and quasi-rents lower than those calculated for the years prior to 1998 (control of fishing effort without a global quota). It should be noted that the TAC under the MCLS was lower and more stable than for landings prior to 1998, indicating a rationalization of the short-term fishing capacity and its use under the IFQ system. Previously, quasi-rents were generated at the expense of over-exploitation of the fish biomass. In general, the indicators during the transition period between the two regimens (1998-2000) contributed little to the present analysis. Under the MCLS, cost recovery underwent an important relative increase, mainly due to the rise in fishing license costs. Nonetheless, these do not have a greater impact on the quasi-rents, as they are not designed to extract an income from the fishery resource. The crew's relative income fluctuates some due to variations in its fixed components that are related to changes in the fleet's annual composition and operations. Decreased employment resulting from the removal of fishing vessels has resulted in greater *per capita* income for the fishermen who retained their jobs.

Table III: Income distribution in the industrial fishing fleet

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Operational costs	36.04	41.73	51.90	74.75	55.04	69.76	62.20	54.77	53.91	42.75
Crew income	13.92	14.23	16.08	18.43	16.03	17.73	16.76	17.05	16.54	15.68
Cost recovery	0.03	0.04	0.05	0.09	0.07	0.73	0.72	0.70	0.79	0.82
Quasi-rent	50.00	44.00	31.97	6.73	28.87	11.78	20.33	27.48	28.76	40.75
Landings (million ton)	3.58	2.82	2.70	1.62	2.11	1.61	1.21	1.12	1.10	1.13

Indexes of retained unitary income (Fig 5.a) and retained unitary quasi-rent (Fig 5.b) illustrate the preliminary perception of the distributive effects of the fishing quota designation policy among two fleets with different production scales (industrial and small-scale) in the sardine and anchovy fishery. The first is an index of income per fisherman, industrial and small-scale, normalized by landings; the second is an index of the quasi-rent per ton of total fish landed (calculated at the ex-vessel level for small-scale fishing and at the ex-factory level for processing firms). In both figures, 45° lines with negative slopes define the distribution of the unitary income sets between the industrial (horizontal axis) and small-scale (vertical axis) fleets and the distribution of the unitary benefit sets between the processing sector (horizontal axis) and the small-scale catch sector (vertical axis); efficiency increases to the right of this line. The lines originating at the initial point (2000) define the limits of the Pareto safe area, inside which one finds win-win points. A point on one of these lines indicates that one sector gains without harming the other.

With the introduction of quota systems for industrial and small-scale fisheries, the fraction of the TAC assigned to the latter sector has increased along with the annual quota of sardine and anchovy. Therefore, the income index per fisherman shows an increase, especially during the first year of the system, followed by a gradual decrease in the following years, although always maintaining a level above that existing prior to the system's implementation (Fig. 5.a). This involution is rooted in the greater growth rate of small-scale employment, resulting from the increased fleet, than of the fishing quota. Moreover, the small-scale fishermen retain a greater proportion of the index than initially, in detriment to the industrial fishermen. Consequently, the quota system is perceived as generating a winning situation for the small-scale fishery and a losing situation for the industrial fishery. Nonetheless, since part of the industrial fleet also operated in the jack mackerel fishery, globally, this loss does not occur.

The behavior of the unitary quasi-rents indicates increased efficiency in the small-scale fleet and processing firms<sup>18</sup> with respect to the period prior to the fishery quota system. Fluctuations in efficiency are similar to the evolution of the unitary fishing costs for both fleets described above. Thus, the initial movements towards efficiency come from the small-scale fleet and, later, from the industrial fleet (Fig. 5.b). It should be pointed out that the processing costs and performance per ton of raw material are assumed to be constant; furthermore, they share a single destination: fishmeal. Simultaneously, it is observed that the proportion of the unitary quasi-incomes retained by the small-scale shipowners and the processing firms exceed the initial incomes by 100%, showing, in general, a winning situation for both sectors. However, the trajectory of the points in the Pareto safe area indicates that the improvement of the small-scale shipowners tends to decrease because of an eventual excess fishing capacity, favoring the processing sector. Thus, at least two effects must be considered when implementing MCLS and SER systems in the sardine and anchovy fishery: i) since the cost of industrial fishing is higher and close to or greater than the ex-vessel price, the industry's income is generated in the processing phase; and ii) the absence of a mechanism for transferring quotas between small-scale and industrial fishermen limits efficiency, encouraging under-reporting of the catch and the small-scale sector's financial dependence on the industrial sector.

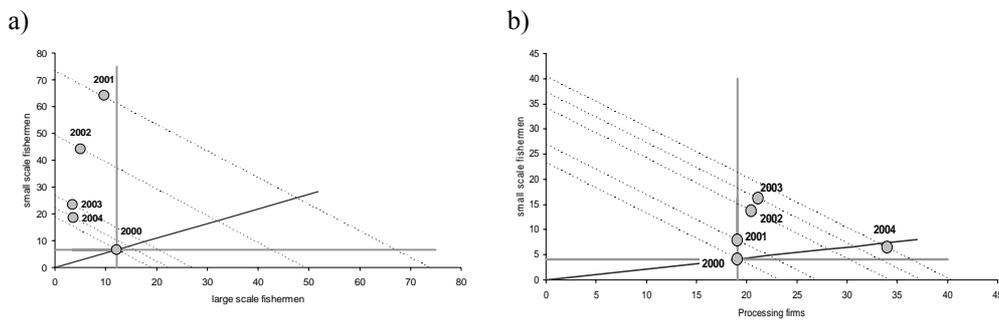


Fig. 5 Indexes of retained unitary income and quasi-rent  
a) income per fisherman; b) quasi-rent

## FINAL CONSIDERATIONS

This article provides evidence of the economic effects resulting from the implementation of fishing quota systems in the central-southern pelagic fishery, using indicators that compare the *ex-ante* and *ex-post* situations with the establishment of these systems. Certainly, in this case, the indicators represent the results of the behavior of the agents and, therefore, do not explain the causes that determine the measurement nor the magnitude of their effects. Still, the treatment effected is adequate for the purposes of the analysis presented. An improvement is perceived in efficiency under individual quota systems in the industrial sector along with a TAC set below the historical landing levels. It seems that the fishing capacity has adjusted, in the short term, to the levels of the total allowable catches. This does not, however, imply the elimination of the excess fishing capacity, as there is a latent fishing capacity and, principally, because the concept of excess capacity is associated with the full use of the fishing fleet according to the long-term, sustainable management objectives for the fishery. On the other hand, the efficiency initially observed in the small-scale fishery when the group quota system was introduced has declined over time. Although in terms of distribution, the small-scale sector has improved its relative position in the fishery, the indicators reveal that this change also tends to move in the opposite direction. If verified, this tendency could compromise the sustainability of the fishery unless improvements are made in the current management system. The identification of future courses of action for improved management of these and other fisheries requires integrated knowledge of biological, economic, and institutional factors and the quantification of their effects under different scenarios of occurrence.

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## ENDNOTES

<sup>1</sup> Law 18.892 was promulgated in 1989, but only became active in 1992 through the publication of Supreme Decree No. 430, after modifications were approved by the Chilean parliament.

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- <sup>2</sup> A fishery unit is defined as the “set of industrial fishing activities executed with respect to a given hydrobiological species in a specific geographic area”.
- <sup>3</sup> A state of full exploitation “is that situation in which the fishery reaches an exploitation level such that the catch of the authorized extractive units no longer leaves a surplus in the remaining productive specimens of the hydrobiological species”.
- <sup>4</sup> For a description and analysis of the application of this regimen, see [3].
- <sup>5</sup> The auction system has been modified by Decrees No. 97 (1996) and No. 73 (2003).
- <sup>6</sup> Extractive small-scale fishery activities consider the use of vessels of up to 18 m length and 50 GRT.
- <sup>7</sup> Law No. 19.713, promulgated in January 2001.
- <sup>8</sup> Law No. 19.849, promulgated in December 2002.
- <sup>9</sup> According to the Regulations for the Small-scale Registry, a fishery is understood to be one or more similar hydrobiological species and associated species within a specific geographic area.
- <sup>10</sup> Regulation of automatic positioning system for fishery and fishery research vessels No. 139 (1998), Ministry of Economy, Promotion and Reconstruction.
- <sup>11</sup> Agents of the fishery sector participate in the National Fishery Council, which has a resolvent, consultative, and advisory nature regarding fishery and aquaculture administration.
- <sup>12</sup> See Message No. 176-342 of the President of the Republic, initiating the legislative discussion of the bill that established the MCLS and the regularization of the small-scale fishery registry.
- <sup>13</sup> See Bulletin No. 3138-21 (2002), with the Message from the President of the Republic that initiates the discussion of the extension of Law No. 19.713.
- <sup>14</sup> These field studies were carried out during FIP project 2004-37, financed by the Fishery Research Fund.
- <sup>15</sup> See Informes Técnicos No. 59 (2002) and No. 43 (2003), Subsecretaría de Pesca.
- <sup>16</sup> See Informe Técnico No. 074 (2006), Subsecretaría de Pesca.
- <sup>17</sup> As a large part of the industry is integrated, we supposed a transfer price for the landed catch that is similar to the ex-vessel price negotiated with third parties in 2005.
- <sup>18</sup> Considering only the processing of the total landings, industrial and small-scale, of sardine and anchovy.