




Quota and catch concentration in fisheries under the ITQ system: Insights from bluefin tuna in the Strait of Gibraltar

Manuel Acosta, M^a del Mar Cerbán, Daniel Coronado, Esther Ferrándiz ^{*} 

Department of Economics, University of Cádiz, 11002, Spain

ARTICLE INFO

Keywords:

ITQ
Individual transferable quota
Strait of Gibraltar
Bluefin tuna

ABSTRACT

The Individual Transferable Quota (ITQ) system is widely regarded as an effective policy tool to regulate fishing, to maintain the economic level, and to promote the sustainability of resources. However, its implementation can influence the distribution of quotas, potentially leading to changes in the economic structure of the sector, which raises concerns about the future of small-scale vessels. This study evaluates the impact of ITQs on bluefin tuna (*Thunnus thynnus*) in the Ports of the Strait of Gibraltar, where ITQs have been applied since 2008. To analyze these effects, we use Lorenz curves and Gini indices to examine the evolution of catches and income. The results reveal that the application of ITQs has reinforced the concentration of economic activity in these ports. Based on these findings, we propose a new ITQ distribution to ensure the economic viability of small-scale vessels and to address the concentration caused by the current ITQ system. Our redistribution proposal focuses on reallocating quotas to vessels that no longer catch bluefin tuna as bycatch and those that currently have low allocations. This paper provides insights into the economic consequences of rigid quota allocation systems that may be relevant to fisheries facing similar challenges worldwide.

1. Introduction

Today, most nations use an ITQ system to manage fisheries (for reviews, see [5]). ITQs are implemented to promote fisheries sustainability and improve economic efficiency, but they can also influence quota distribution among vessels [21,22,8]. An extensive review of the advantages and disadvantages of ITQs from various perspectives (social, economic, environmental, and management) can be found in the work of Hoshino et al. [24]. ITQs have been associated with the recovery of fishing grounds and species [10,16,7,9], better economic valuation of the catches [19], and reduced pressure for fishers when setting out to fish [8]. Moreover, when fishery administrations allow local communities to define and manage annual ITQs, a decrease in problems has been observed by applying local solutions to the defects of the system [23].

However, ITQs can also generate challenges, particularly regarding quota concentration. While consolidation can enhance efficiency, it often leads to the exclusion of traditional fishers and a vertical integration of the fishing sector. These problems have led to the establishment of limitations on the transferability of quotas, especially in Norway, the Netherlands and Australia [21,22,8]. The concentration of

ITQs in business groups may also lead to aging of the sector by preventing the entry of new/young fishers and through the exclusion of certain local communities, which, in the Norwegian case, has led to exceptions to the system to prevent these problems [11].

The contribution of this paper is twofold. First, we analyze the effects of ITQs on the economic structure of the fishing sector in the ports of Tarifa and Algeciras (hereafter, Ports of the Strait) and explore whether the system has led to an increase in the concentration of catches and quotas in a few vessels. In 2008, the region shifted to an ITQ system for bluefin tuna (*Thunnus thynnus*). By that time, the Ports of the Strait depended almost entirely on fishing for blackspot seabream (*Pagellus bogaraveo*), a species regulated by a global quota and highly valued economically, and only a few vessels were fishing for bluefin tuna. Both species rely on *Sergia robusta* as their main prey, generating trophic competition (see [37], and [29] for diet analysis of blackspot seabream and bluefin tuna, respectively). However, their feeding strategies differ, linked to the vertical migration of *Sergia robusta* in the water column: bluefin tuna feed on it near the surface, while blackspot seabream prey on it when it descends to the seafloor.

The implementation of the Recovery Plan developed in 2006 has contributed to a progressive rebuilding of the bluefin tuna stock in the

^{*} Correspondence to: Facultad de Ciencias Económicas y Empresariales, Universidad de Cádiz, C/ Enrique Villegas Vélez, 2, Cádiz 11002, Spain.
E-mail address: esther.ferrandiz@uca.es (E. Ferrándiz).

eastern Atlantic and Mediterranean [25,38]. Increased predation by bluefin tuna may have significantly reduced *Sergia robusta* availability at depth, potentially leading to the local decline of blackspot seabream since 2016. Consequently, the vessels that had targeted blackspot seabream and did not have tuna quotas were left with no alternative. The vessels that had historically fished for bluefin tuna retained the quotas allocated to them in the past. As a result of ITQ implementation in this context, there has been a significant reduction in the number of vessels and changes in employment patterns, which this paper examines in detail. For this aim, we analyze the evolution of quota distribution, catches, and income using Lorenz curves and Gini indices. While centered on this specific region, the findings provide broader insights into ITQ implementation and its consequences.

Second, we propose a redistribution model for ITQs that benefits vessels currently assigned low quotas (i.e., those with the lowest quota on List B, which targets bluefin tuna directly) and bycatch fishers (List H), who no longer catch bluefin tuna incidentally. Our proposal is oriented towards providing a feasible solution under the current legal framework to mitigate the observed trend of quota concentration, while preserving the system's potential advantages.

This paper does not explore restricting transfers as a possible solution since in Spain, quota transfers are subject to legal constraints. Instead, we focus on a legally viable mechanism: allocating any future, science-based increases in Spain's national quota (following TAC changes) exclusively to small-scale vessels. This approach preserves existing allocations and provides a realistic path toward improving equity in the fishery. Our results have implications for other regions facing similar challenges, seeking economic sustainability and equity in access to fishing resources.

The structure of this article is as follows. Section 2 describes the implementation and regulatory framework of the ITQ system for bluefin tuna in the Ports of the Strait. Section 3 describes the methodology and data. In Section 4, we provide the results. First, we examine the current distribution of quotas among vessels and identify the potential issues related to the survival of small fishers. Second, we propose an alternative distribution of ITQs and monitor if the new allocation of quotas published in 2024 solves the previously identified problems. In Section 5, we provide the discussion. In the last Section, we summarize our conclusions.

2. Implementation of the ITQ system for bluefin tuna in the Ports of the Strait

Fig. 1 shows the location of the Ports of the Strait. The Food and Agriculture Organization (FAO) fishing area 37 (Division 37.1.1, Balearic) is the operational area for bluefin tuna fishing by vessels based in these ports. Adjacent areas, such as FAO Division 34.1.1 (Morocco Coastal) and ICES Division IXa (within FAO Area 27.9.a, Portuguese Waters – East), are shown for spatial reference. Although there are other ports with significant economic activity in the Atlantic and Mediterranean areas, the characteristics of these two ports make it a special system.

2.1. Evolution of fishing activity

The Ports of the Strait, especially the Port of Tarifa with a larger number of vessels, have concentrated their catches on species settled in the Strait of Gibraltar. Examples of such species are blackspot seabream and bluefin tuna. The rest of the ports in the area catch other types of species, and fish in different and more distant waters. In recent years, the main characteristic of the Ports of the Strait has been the type of species caught and marketed. Although both species were caught in similar quantities at the beginning, until 2016, the income from blackspot seabream was generally higher than that from bluefin tuna (Fig. 2). Since then, Tarifa and Algeciras have gradually become single-species ports focused on bluefin tuna. This shift has been influenced by their

geographic location near the bluefin tuna migration route and regulatory changes.

This change from fishing for blackspot seabream to bluefin had notable economic and employment consequences since it was accompanied by a loss in the number of vessels from 2011 to 2020. For example, vessels landing in Tarifa decreased from 75 to 44. Vessels fishing only blackspot seabream dropped from 44 in 2011 to 5 in 2020, while vessels fishing bluefin tuna rose from 0 in 2011 to 12 in 2020; vessels fishing simultaneously for blackspot seabream and bluefin tuna remained constant. The decline in the number of vessels coincides with the reduction in the number of registered fishers in the Port of Tarifa. Since 2011, registered fishers in the guild have shown a decrease that has stabilized since 2014, although the number dropped from 111 fishers in 2020 to 62 in 2021.

To understand the evolution of catches and vessels in blackspot seabream and bluefin tuna fisheries, it is necessary to know how they have been regulated over time.

2.2. Legal framework

Blackspot seabream has been regulated from the beginning by a general annual quota that affected the Ports of the Strait. When the annual quota volume was reached, fishing was prohibited. In contrast, bluefin tuna has been subject to different regulation. Initially, it was regulated by a general annual quota. In 2008, it was changed to an individual transferable quota system [34]. This national system operates within the framework of the recommendations of the International Commission for the Conservation of Atlantic Tunas (ICCAT) and is implemented in Spain through annual EU regulations that establish total allowable catches (TACs) and allocate quotas to Member States. The distribution of Spain's national quota among fleets and vessels is published by the General Secretariat for Fisheries (Secretaría General de Pesca) in the Official State Gazette, which is the official source of regulations of Spain (see, for example, Secretaría General de Pesca, 2018).

Spain's bluefin tuna management system is based on a specific census that includes all authorized vessels and trap-net systems (*almadrabas*). These are grouped into five independent and closed fleets, with the rod-and-line fleet in the Strait of Gibraltar being one of them and the focus of our analysis ([34], subsequently amended by [36] and [35], replaced by [32]—amended by [33]—and currently governed by [38]).

The allocation process within Spain follows two steps. In the first step, quota allocations are made at the fleet level, after setting aside a small percentage to allow management flexibility during the fishing season.¹ The allocation of the quota is based on “the historical catch of each fleet and the socio-economic and dependency criteria, allocating 60 % of the weight of the distribution to the historical catch criteria and 40 % to the employment and dependency criteria of the specific bluefin tuna fisheries, calculating this last criterion as dependent jobs multiplied by the months of dependence on each fleet” [34].

In a further step, the share of quota and kilograms is assigned to each vessel within the census of the Strait fleet based on the historical catch data in the period 2002–2006 (80 %) and the remaining share (20 %) distributed linearly [49]. The first quota allocation by vessel was established in 2008 based on 2002–2006 data, as there were no reliable data on catches before 2002. The initial allocation of quotas at that time has conditioned subsequent distributions in the Ports of the Strait.

The current quota system ultimately establishes a catch percentage for each vessel, which, as in most countries, is intended to remain constant over time. An individual quota percentage per vessel was first established in 2008 and remained unchanged until 2018. In 2019, the distribution was slightly modified due to the inclusion in the census of some vessels that had previously been omitted by mistake. Since then,

¹ Originally referred to in the 2008 regulation as the “*fondo de maniobra*”. In subsequent regulations this reserve was replaced by an explicit bycatch reserve.

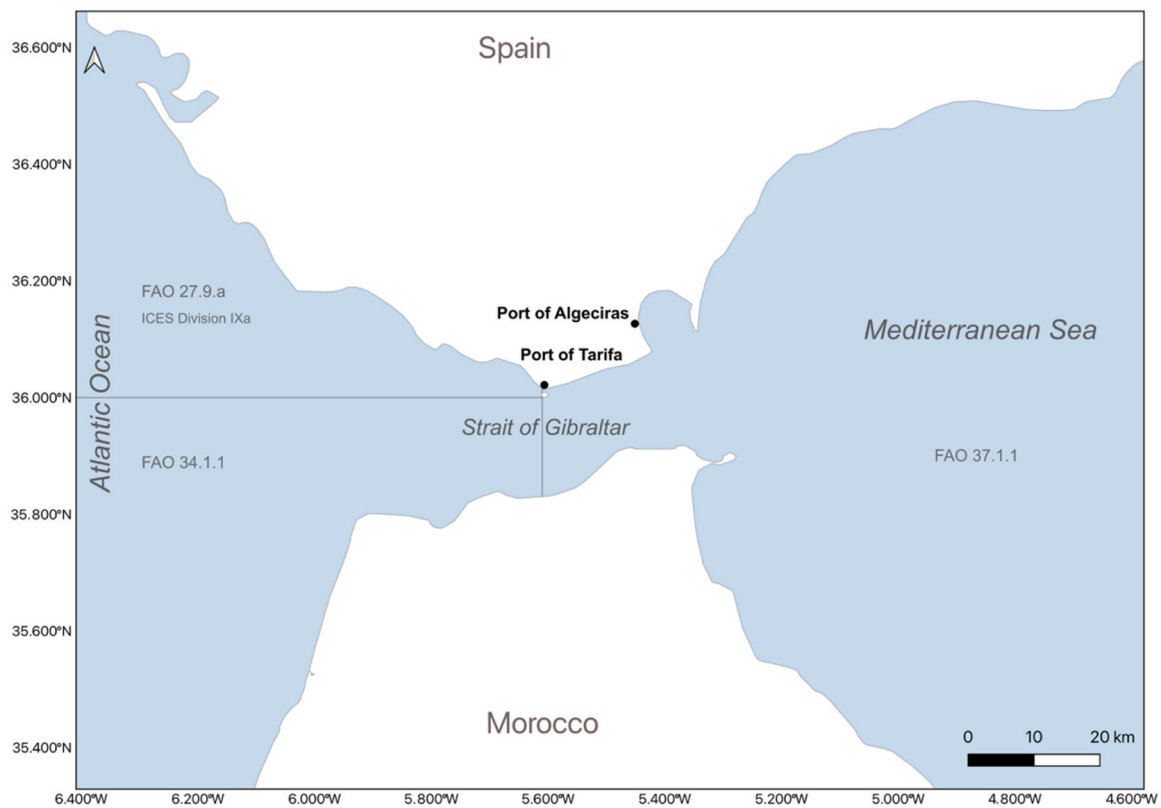


Fig. 1. Location of the Ports of the Strait, with adjacent fishing areas.
Source: Own elaboration based on FAO [15].

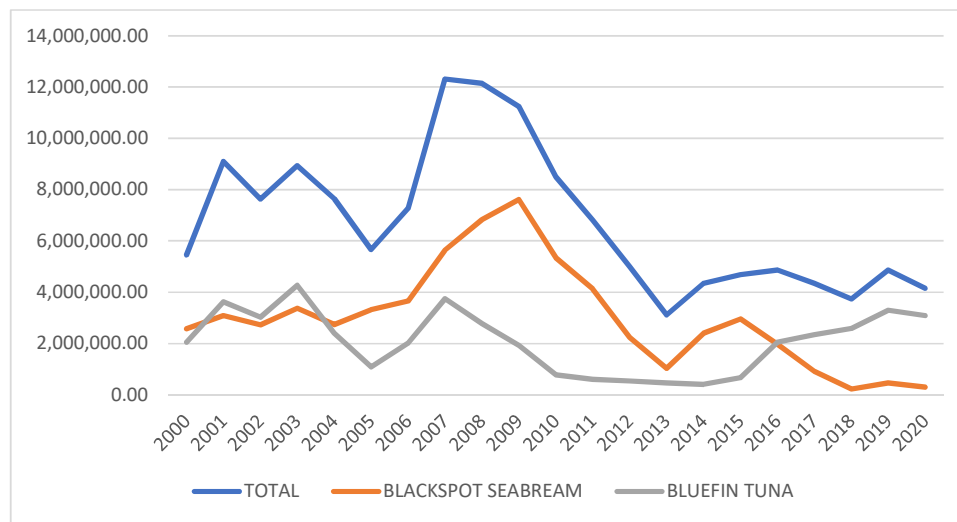


Fig. 2. Total catches (in euros) in the Ports of the Strait from 2000 to 2020.
Source: Own elaboration based on data from Sistema de información andaluz sobre datos de comercialización y producción pesquera (IDAPES). Junta de Andalucía.

the allocation has remained unchanged² (see Table 1). Although the percentage distribution of existing vessels does not change, the kilograms ultimately assigned to each vessel may vary if the total allowable

² In some years, vessels on the list are replaced due to name changes or the decommissioning and purchase of a new vessel by the same owner. When a vessel is replaced, its unused quota may be absorbed by the new or renamed vessel, ensuring that it does not exceed its allowed limit. Therefore, in practice, there is no change in the distribution of quotas among owners.

catch (TAC), and thus the quota allocated to Spain, increases. The vessel-assigned quota (kg) is calculated as the percentage quota assigned to the vessel / 100 × the quota allocated to Spain (kg).

In 2009, the List C for artisanal vessels was introduced [36]. This list was later renamed List H, which refers to vessels with “incidental catch” (bycatch) that only catch bluefin tuna occasionally. As a result, they receive a lower, residual quota compared to vessels on List B. From 2010–2017, it operated under an “Olympic fishing” system. Under this system, the group shares a collective quota. One vessel may use the entire quota, or the quota may be split equally among multiple vessels or

Table 1
Bluefin tuna quotas for vessels in the Strait of Gibraltar (List B), 2011–2021 (% of Spain's national quota).

VESSEL NAME	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALFONSITO CHICO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
ARCANGEL SAN RAFAEL		0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.37	0.37	
AVE SIN PUERTO	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
BARBARA Y SANDRA	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.27	0.27	0.27
CABO NEGRO	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10		
DASERBE	0.12	0.74	0.86	0.86	0.86	0.86			0.03	0.03	0.03
FERNANDEZ Y MORENO	0.61	0.61	0.61	0.61	0.78	0.78					
GELUAN	0.15	0.15	0.15	0.15	0.15						
GRANT DEL MAR	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.25	0.25	0.25
GURE SANTA ANA	0.74										
HERMANOS BRALO	0.12	0.12									
JOSE Y SORALLA	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
MARIA INMACULADA	0.22	0.22	0.22	0.22	0.22	0.22	0.48	0.48	0.43	0.43	0.43
MARLUZ	0.17	0.17	0.17	0.17	0.17	0.42	0.48	0.48	0.82	0.82	0.82
MI JOSELITO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
NUEVO ADRIAN	0.62	1.36	1.36	1.36	1.36	1.36	1.36	1.36	0.82	0.82	0.82
NUEVO BAMBY	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.08	0.08
NUEVO FONTANILLA	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03
NUEVO JULIA	0.10	0.10	0.10	0.10	0.10	0.10	0.16	0.16	0.14	0.14	0.14
NUEVO JULIO CHICO	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
NUEVO MAR NEGRO	0.06	0.06	0.06	0.06	0.06	0.06					
NUEVO MAR ROJO	0.11										
NUEVO MARI CARUCHI	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
NUEVO REAL MADRID	0.06	0.06	0.06	0.06	0.06						
NUEVO ROMANA	0.62										
PIRAÑA	0.06										
PUERTO DEL TERRON	0.04	0.04	0.04	0.04	0.04						
RINCONCILLO	0.04	0.04	0.04								
SALADILLO	0.13	0.13	0.13	0.17							
UNION VAZQUEZ BLANCO	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.28	0.28	0.28
VILLA DE NOJA	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05			
YALOBAY PRIMERO	0.65	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.68	0.68	0.68
ROMAN Y MARTOS							1.32	1.32	1.17	1.17	1.17
ELISA MARIA									0.06	0.06	0.06
FELIPE Y MARUJA									0.05		
HERMANOS SANCHEZ									0.05	0.05	0.05
JOSE Y ANA									0.05	0.05	0.05
MUÑI									0.04	0.04	0.04
NUEVO GABANCHO									0.09	0.09	0.09
PUNTA ALMINA UNO											0.37
SERGIO Y ANITA											0.03
YONI MARIA											0.10
TOTAL STRAIT QUOTA (%)	5.94	5.87	5.86	5.86	5.86	5.86	5.86	5.86	5.57	5.47	5.94
QUOTA ALLOCATED TO SPAIN (tons)	2410.00	2411.01	2504.45	2504.45	2956.52	3534.43	4243.57	5000.28	5532.16	6107.60	6107.60

Source: Own elaboration based on data from Secretaría General del Mar/ Secretaría General de Pesca [54,40,41,43,42,44,45,46,47,48,50,51].

distributed in varying proportions. The distribution depends only on the order of the catches as they are landed. In 2018, vessels on List H were individually assigned 1000 kg per vessel [39]. In 2019, List H formally transitioned to a system of individually assigned quotas and the fleet was renamed from *Incidental catch* to *Limited catch*, while keeping the same, significantly lower individual allocation of kg per vessel [38]. Quotas are not transferable between Lists H and B. Within List H, transfers of quota between different owners are not allowed, although quota concentration is permitted when multiple vessels belong to the same owner.

3. Material and methods

3.1. Data

We mainly rely on two sources of data. First, the actual fishing data provided by the managers of Organización de Productores Pesqueros Artesanales del Estrecho (OPP78, Organization of Artisanal Fishers of the Strait) and Cofradía de Pescadores de Algeciras (Fishermen's Guild of Algeciras). Second, the data on bluefin tuna fishing quotas published by the General Secretariat for Fisheries for each vessel and year in the Official State Gazette (Boletín Oficial del Estado, BOE). This study focuses on data from 2011 onward because earlier years lack detailed information.

The annual bluefin tuna quota allocations per vessel on List B (2011–2021), which holds most of the total quota (in tons), are presented in Table 1. Table 2 shows that from 2010 to 2017, vessels on List H operated under an “Olympic fishing” system, sharing a collective quota. Since 2018 individual quotas have been assigned, which are significantly smaller than those assigned to vessels on List B.

Table 2

Bluefin tuna quota for vessels in the Strait of Gibraltar (List H), 2010–2021.

YEAR	NO. OF VESSELS	INDIVIDUAL QUOTA (kg)	GROUP H QUOTA (kg)
2010	33	Olympic quota	7070
2011	19	Olympic quota	6447
2012	33	Olympic quota	6780
2013	39	Olympic quota	13500
2014	55	Olympic quota	13500
2015	60	Olympic quota	37210
2016	60	Olympic quota	44470
2017	59	Olympic quota	40300
2018	46	1000	47470
2019	40	1273	50920
2020	40	1370	54800
2021	40	1370	54800

Source: Own elaboration based on data provided by OPP78.

Lists B and H together comprise the vessels authorized to fish for bluefin tuna. There are about 24 vessels on List B and 40 on List H.

3.2. Methodology

The available data on actual catches and quotas per vessel are analyzed using Lorenz curves and Gini indices. While these instruments were initially proposed to analyze income and wealth distribution [17, 28], they have also been largely used to analyze inequality in quota allocation (e.g. [2,3,4,6,12,13,14,20,26,27,55,1]).

To obtain Lorenz curves, we plot a graph showing the cumulative share of catches (or quota) from different cumulative shares of the population. In a scenario of perfect equality, each share of the population holds an equal share of the total catches (or quota). For instance, 20 % of the vessels with the lowest catches would have 20 % of the total catches. This would be graphically represented by a 45-degree line, which is known as the line of perfect equality. The larger the area between the line of perfect equality and the Lorenz curve, the greater the level of concentration.

The Gini index is calculated as the area delimited by the Lorenz curve and the line of perfect equality divided by the total area under the line of perfect equality [17]. The index ranges from 0 (perfect equality) to 1 (maximum inequality). Following Gini [18], we calculate the Gini index as:

$$Gini = \frac{\sum_{i=1}^{n-1} P_i - Q_i}{\sum_{i=1}^{n-1} P_i}$$

Where P_i is the accumulated share of population and Q_i is the accumulated share of catches (or assigned quota, depending on the figure).

4. Results

4.1. Analysis of quota distribution (2011–2020)

Figs. 3–6 share the same lower section, which depicts the evolution of total income (€), along with income derived from blackspot seabream and bluefin tuna catches in the Ports of the Strait. The upper panels of these figures display Lorenz curves and corresponding Gini indices (GIs), where each point represents a vessel, across different years: for actual total catches (Fig. 3), blackspot seabream catches (Fig. 4), bluefin tuna catches (Fig. 5), and assigned bluefin tuna quotas (Fig. 6). It is important to note the difference between Figs. 5 and 6. Fig. 5 shows Gini indices and Lorenz curves based on actual bluefin tuna catches (in €). In contrast, Fig. 6 displays the same indicators based on assigned quotas (in % and kg), which may or may not be fished, depending on the actual use of quotas and their transferability.

The data indicate that, between 2011 and 2020, total catches became increasingly concentrated among fewer vessels, with the Gini index rising from 0.489 in 2011 to 0.690 in 2020 (Fig. 3, upper panels). This suggests a shift towards a more unequal distribution of catches over time. The lower section shows that from 2011 to 2016, most vessels continued to target blackspot seabream, which generated the majority of the income in the Ports of the Strait. Only a few vessels fished for bluefin tuna, and their contribution to total income was minimal. From 2017 onward, blackspot seabream catches declined steadily until disappearing, while bluefin tuna became the dominant source of income.

If the same analysis is performed only for blackspot seabream catches, the Lorenz curves are less pronounced, and the Gini index increases only slightly from 0.457 in 2011 to 0.541 in 2020 (Fig. 4, upper panels). This indicates that blackspot seabream catches have historically been more evenly distributed among vessels. By contrast, bluefin tuna catches show a higher level of concentration. The Gini index for bluefin tuna ranges from 0.597 in 2011 to 0.729 in 2020, remaining high throughout the period (Fig. 5, upper panels). This pattern is observed

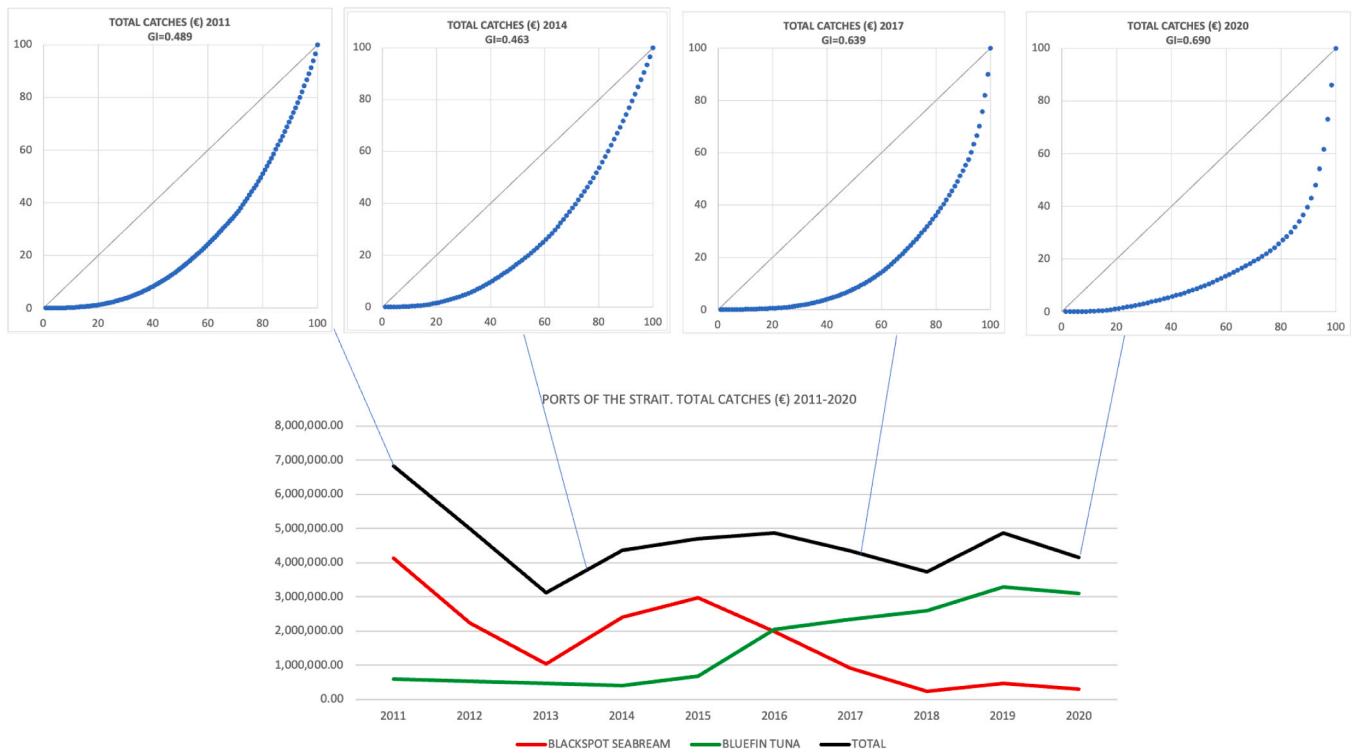


Fig. 3. Concentration of total catches (€) per vessel in the Ports of the Strait (2011–2020), with annual catch evolution (€) in the lower section. Source: Own elaboration. Lower section based on data from IDAPES (Junta de Andalucía); upper panels based on data from OPP78 and Confradía de Pescadores de Algeciras.



Fig. 4. Concentration of blackspot seabream catches (€) per vessel in the Ports of the Strait (2011–2020), with annual catch evolution (€) in the lower section. Source: Own elaboration. Lower section based on data from IDAPES (Junta de Andalucía); upper panels based on data from OPP78 and Cofradía de Pescadores de Algeciras.

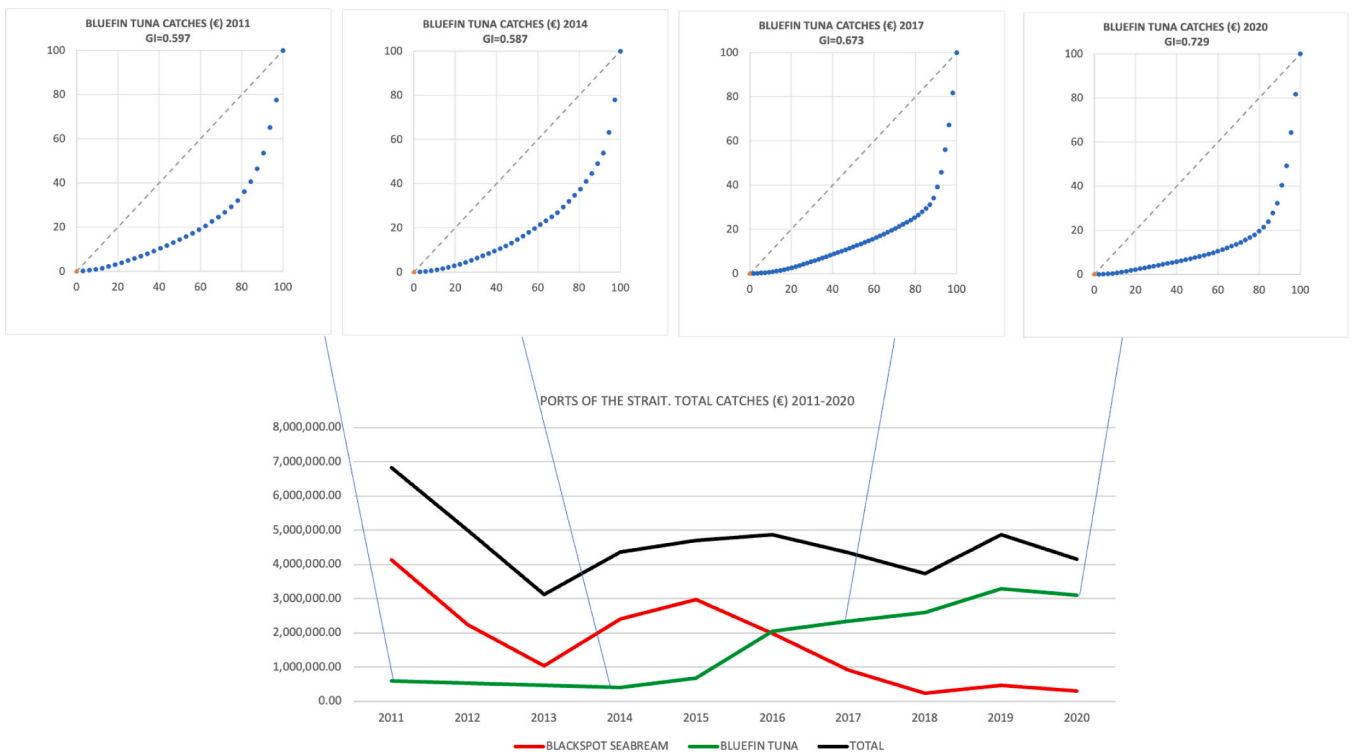


Fig. 5. Concentration of bluefin tuna catches (€) per vessel in the Ports of the Strait (2011–2020), with annual catch evolution (€) in the lower section. Source: Own elaboration. Lower section based on data from IDAPES (Junta de Andalucía); upper panels based on data from OPP78 and Cofradía de Pescadores de Algeciras.

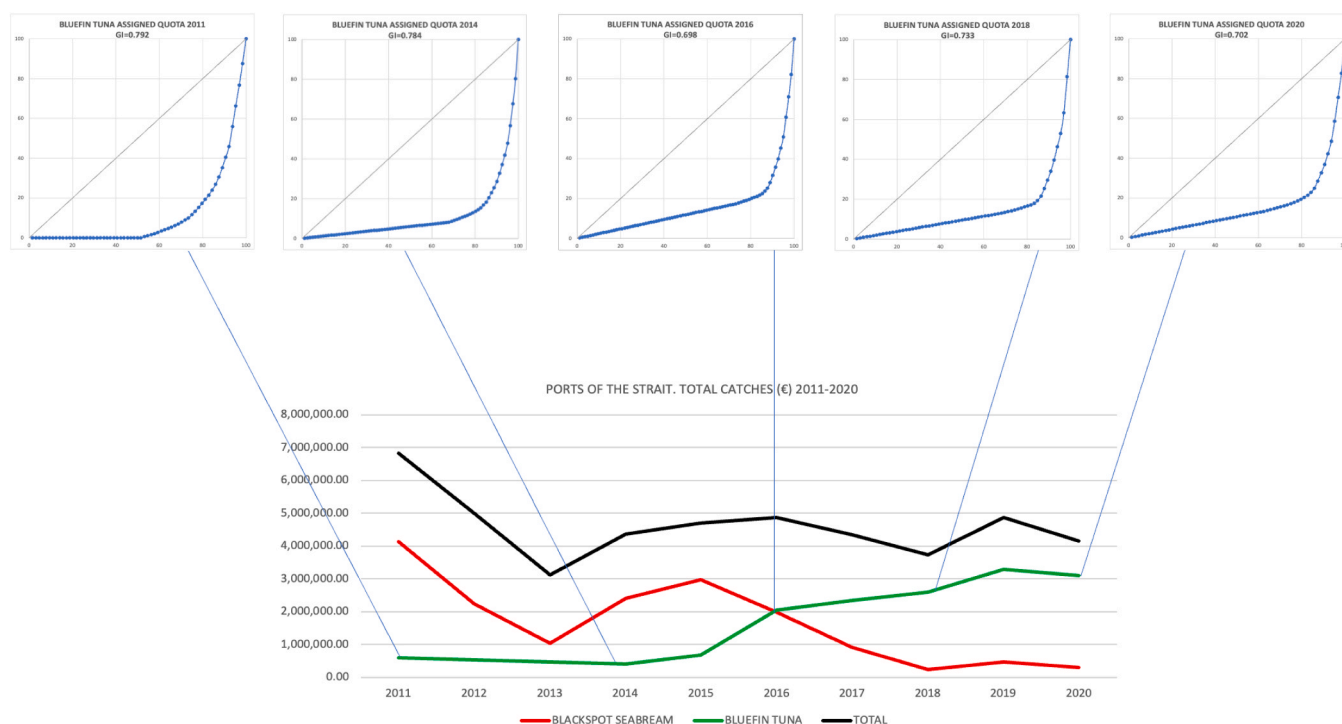


Fig. 6. Concentration of assigned bluefin tuna quotas per vessel in the Ports of the Strait (2011–2020), with annual catch evolution (€) in the lower section ^(*). From 2011 to 2017, vessels on List H are represented assuming that the quota is equally distributed among all vessels. Since 2018, Olympic fishing no longer applies, so there is no need for such assumption. Vessels on List B have individually assigned quotas.

Source: Own elaboration. Lower section based on data from IDAPES (Junta de Andalucía); upper panels based on data from Secretaría General del Mar/Secretaría General de Pesca [54,40,41,43,42,44,45,46,47,48,39,50,51].

both in the early years, when total catches and income were lower, and in later years, when both increased.

The roots of the differences in concentration of blackspot seabream and bluefin tuna catches (Figs. 4 and 5) are linked to the introduction of the ITQ system for bluefin tuna in 2008. As mentioned earlier, the initial bluefin tuna quota allocation in 2008 was based on historical data (2002–2006). Since at that time only a few vessels targeted bluefin tuna fishing, the concentration of quotas was high from the beginning (Fig. 6, upper panels). As the initial quota allocation established in 2008 has been maintained, the quotas have remained highly concentrated among a limited number of vessels. By 2020, just six vessels accounted for 63.2 % of the total quota. The concentration curves and the Gini indices for assigned quotas shown in Fig. 6 are very similar over time because the assigned quotas of List B vessels remain constant throughout this period, except for a minor adjustment in 2019 (see Table 1). The differences between the GIs for 2011, 2014, 2016, 2018, and 2020 are solely due to the variation in the kilograms allocated to List H vessels (bycatch). In 2011, each vessel could catch approximately 340 kg; in 2016, 741 kg; and in 2020, 1370 kg. For 2011–2017, we assume that the quota was equally distributed among all vessels in the List H, as no individual quotas existed. Since 2018, individual allocations have been applied. These quantities are small relative to the total quota, so their variation produces only minor changes in the curves and Gini indices in Fig. 6. Therefore, the decrease in the Gini index from 0.792 in 2011 to 0.702 in 2020 is due only to changes within List H. Regardless, a value of 0.702 still reflects a very high level of concentration.

The legal modification of 2019 maintained the distribution criteria of the first regulation. The slight differences in concentration between years are due to the general increase in kilograms allocated to Spain, which is distributed among vessels with more and less quota, benefiting in terms of kilograms those with more quota assigned. Both the regulation and the data show that the system has no corrective mechanisms.

Upper panels in Figs. 10–12 (in the Appendix) replicate the analysis

presented in Figs. 3–5 but represent catches in terms of kilograms instead of euros. Discrepancies between income and kilograms-based results in the total catches graphs are related to price differences between species: blackspot seabream are typically sold for over €20 per kg, while bluefin tuna averaged around €10 per kg. Income-based analysis is generally more suitable for assessing the economic impact of quota distribution, especially when species with different market prices are involved. However, the analysis in kilograms provides a valuable complementary view, particularly from 2017 onwards, when tuna became the only species caught in the Strait. In the case of bluefin tuna, income-based analysis avoids artificial differences between vessels due to pricing mechanisms. Vessels with higher quotas sell bluefin tuna through supply contracts at fixed prices (€8–9 per kg) to the large distributors, while those with lower quotas sell at free market prices at the auction. Moreover, the regulatory control of tuna fishing and quotas is defined in weight (kg), not in value (€). Nevertheless, our main findings remain largely consistent regardless of the unit of measurement (kg or €).

In the next section, we propose a change in the allocation of quotas and kilograms with the intention of allowing the vessels that catch the least, and which currently cannot survive, to maintain their activity by catching bluefin tuna.

^(*)From 2011–2017, vessels on List H are represented assuming that the quota is equally distributed among all vessels. Since 2018, Olympic fishing no longer applies, so there is no need for such an assumption. Vessels on List B have individually assigned quotas.

4.2. ITQs redistribution proposal

Our redistribution proposal is guided by two principles. First, the protection of rights. The redistribution of quotas must respect the rights acquired by the main beneficiaries in previous years while increasing catch opportunities for vessels with lower allocations. The proposed system does not affect the quotas assigned to vessels on List B, as their

2021 quota levels are maintained. Instead, it increases the quota for vessels on List H and some on List B, leading to an increase in Spain's general quota and a subsequent additional allocation to the Ports of the Strait. Second, the support for small-scale vessels to ensure minimum economic viability. The quota proposal for vessels on List H is based on

an amount that makes bluefin tuna fishing economically attractive, allowing for crew hiring and the reactivation of vessels previously idle due to insufficient quotas. We identified the subsistence minimum through interviews with skippers and sailors from the Port of Tarifa, which was set at 5000 kg per vessel. This amount is considered the

Table 3

Proposed redistribution of bluefin tuna quotas in the Ports of the Strait for 2023.

VESSEL NAME	CODE	LIST	QUOTA 2021 (kg)	PROPOSED INCREASE IN QUOTA (kg)	PROPOSED QUOTA 2023 (kg)
ALFONSITO CHICO	26613	B	1853.78	3146.22	5000
AVE SIN PUERTO	2567	B	2169.05	2830.95	5000
BARBARA Y SANDRA	22287	B	16749.3	0	16749.3
DASERBE	22025	B	2005.98	2994.02	5000
ELISA MARIA	54165	B	3670.55	1329.45	5000
GRANT DEL MAR	27245	B	15031.41	0	15031.41
HERMANOS SANCHEZ	4877	B	3241.18	1758.82	5000
JOSE Y ANA	25738	B	2973.55	2026.45	5000
MARIA INMACULADA	4889	B	26181.33	0	26181.33
MARILUZ	4896	B	49965.24	0	49965.24
MI JOSELITO	26935	B	1810.29	3189.71	5000
MUÑI	25672	B	2664.99	2335.01	5000
NUEVO ADRIAN	25336	B	49965.24	0	49965.24
NUEVO BAMBY	26254	B	5165.87	0	5165.87
NUEVO FONTANILLA	26477	B	1989.67	3010.33	5000
NUEVO GABANCHO	27387	B	5706.51	0	5706.51
NUEVO JULIA	27114	B	8507.83	0	8507.83
NUEVO JULIO CHICO	26481	B	2767.05	2232.95	5000
NUEVO MARI CARUCHI	26608	B	1837.47	3162.53	5000
PUNTA ALMINA UNO	27200	B	22392.17	0	22392.17
ROMAN Y MARTOS	26015	B	71509.37	0	71509.37
SERGIO Y ANITA	26884	B	1810.29	3189.71	5000
UNION VAZQUEZ BLANCO	24295	B	17347.29	0	17347.29
YALOBEBY PRIMERO	23687	B	41294.28	0	41294.28
YONI MARIA	1541	B	5849.43	0	5849.43
AMALIA	4900	H	1185	3815	5000
AMANCIO	3683	H	1185	3815	5000
ANA ISABEL SEGUNDO	27431	H	1185	3815	5000
ANA SEGUNDA	11543	H	1185	3815	5000
ANTONIO Y CARMEN	26651	H	1185	3815	5000
ANTONIO Y LUISA	5132	H	1185	3815	5000
DON AURELIO	24992	H	1185	3815	5000
EL MARBELLA	26341	H	1185	3815	5000
EL MELENA	1522	H	1185	3815	5000
FRANCISCO Y JOSE	4890	H	1185	3815	5000
GELUAN	25393	H	1185	3815	5000
GOMEZ RIERA	1989	H	1185	3815	5000
HACHOMAR	22210	H	1185	3815	5000
INESITA	20839	H	1185	3815	5000
JOSE MANUEL	14467	H	1185	3815	5000
JUAN Y RAUL	20851	H	1185	3815	5000
JULIAN LACERA	7335	H	1185	3815	5000
LA NIÑA	12255	H	1185	3815	5000
LEONOR	14490	H	1185	3815	5000
MANOLITO E ISABEL	13906	H	1185	3815	5000
MANUEL Y PATRICIA	25911	H	1185	3815	5000
MARIA DEL CARMEN	4893	H	1185	3815	5000
MARIA TERESA SEGUNDA	21737	H	1185	3815	5000
MI JOAQUINITO	22865	H	1185	3815	5000
MI MADRE DOS	25646	H	1185	3815	5000
MIRIAN Y LORENA	24471	H	1185	3815	5000
NUEVA ENCARNACION PRIMERO	22970	H	1185	3815	5000
NUEVO MAR NEGRO	25629	H	1185	3815	5000
NUEVO MIGUEL ANGEL	26385	H	1185	3815	5000
NUEVO TOTOÑO	27215	H	1185	3815	5000
PEDRO GETARES	26811	H	1185	3815	5000
PEDRO Y ANA	21410	H	1185	3815	5000
RAMITO	10706	H	1185	3815	5000
RAQUEL Y SHEILA	26253	H	1185	3815	5000
RINCONCILLO	24913	H	1185	3815	5000
RUA MAR	23669	H	1185	3815	5000
SALADILLO	25349	H	1185	3815	5000
SAN MANUEL	12261	H	1185	3815	5000
SEGUNDO JUAN	21823	H	1185	3815	5000
TENORIO MEDINA	10773	H	1185	3815	5000
TOTAL			411859.12	183806.15	595665.27

Source: Own elaboration based on data from Secretaría General de Pesca [52].

minimum required for profitability, ensuring sufficient fishing days to compensate the crew and maintain the vessel's economic viability. The rationale for this increase is that the concept of bycatch on List H is no longer relevant after the disappearance of blackspot seabream, leaving bluefin tuna as the only viable species in the Strait. The quotas, which cannot be modified due to acquired rights, serve as the baseline for redistributing additional kilograms. The proposal aims to use any future increase in the TAC by Spanish Ministry of Fisheries based on scientific advice, to adjust quotas only for low-quota and bycatch vessels. By not increasing the allocation for vessels that already hold large quotas, their catches remain unchanged, while vessels with lower current allocations receive an increase.

Following these principles, List B vessels with quotas below 5000 kg would see their allocation raised to this threshold, while the rest maintain their 2021 and 2022 quotas. In the Ports of the Strait, the redistribution affects: 40 vessels on List H (bycatch) each currently allocated 1370 kg; 25 vessels on List B, of which 12 hold quotas below 5000 kg and would be adjusted accordingly. This redistribution results in an additional allocation of 176,406.15 kg of bluefin tuna, leading to a final total quota of 595,665.27 kg for vessels on Lists B and H (see Table 3). Note that this new distribution does not eliminate the large quotas accumulated by certain List B vessels. To avoid legal claims, their quotas remain unchanged, and only the new kg increase for the Strait is allocated to vessels with fewer kilograms.

This scenario is feasible, as future increases in the TAC are likely, given that bluefin tuna has become an established species in the area in recent years. The International Commission for the Conservation of Atlantic Tunas (ICCAT) has acknowledged that “the current status of the stock no longer appears to require the emergency measures introduced under the Recovery Plan for bluefin tuna in the Eastern Atlantic and the

Mediterranean” ([25], p. 1).

Next, we compare the initial situation in 2021 (Fig. 7) to the final situation in 2023 if our proposed system was implemented (Fig. 8). The expected final result of the proposed system for 2023 is a quota distribution that facilitates a shift from the extreme concentration in a few vessels, with a Gini index of 0.702 in 2021 to a lower concentration with a Gini index of 0.423.

Additionally, if the objective is to improve the economic viability of vessels with lower quotas by limiting excessive quota concentration, the new quota allocation system could incorporate several protective mechanisms to address past concerns:

- Limitation of the maximum quota that a vessel can accumulate to 20 % of the total kg of List B. Additionally, quotas could be prevented from being split from one vessel into multiple vessels. This mechanism aims to prevent the excessive concentration of quotas among a few vessels, as has occurred in the past.
- Permission to buy quota both within and outside of List H, as is currently the case with List B. This mechanism aims to endow equal treatment between vessels on the different lists, since currently vessels on List H cannot transfer their rights, they can only exploit them jointly with another vessel on the same list. The transfer of quota would be conditional on the distribution of income between the shipowner, the skipper, and the crew of the vessel, in accordance with the most widespread distribution mechanism in the sector (2/5, 2/5, 1/5). This formula is intended to facilitate the sharing of the benefits of the transfer of rights with the crew, who would see their lack of activity compensated by ceasing to fish.

Once contrasted, we submitted our proposal in 2022 to the fishery

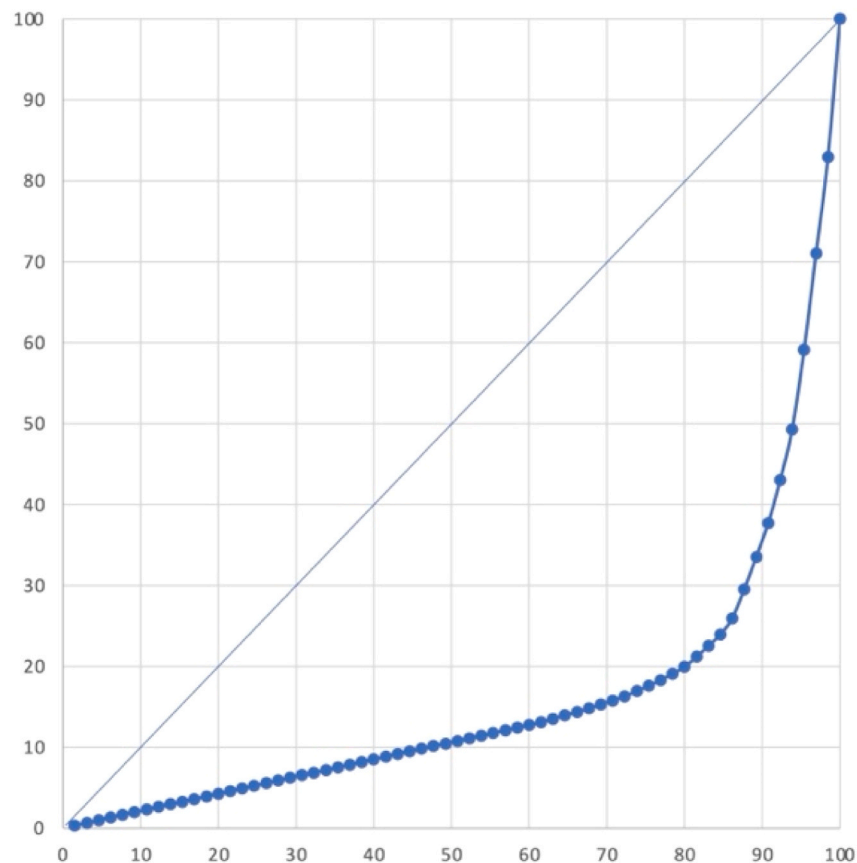


Fig. 7. Lorenz curve for assigned bluefin tuna quotas in 2021 (Gini index = 0.702). Source: Own elaboration based on data from Secretaría General de Pesca [52].

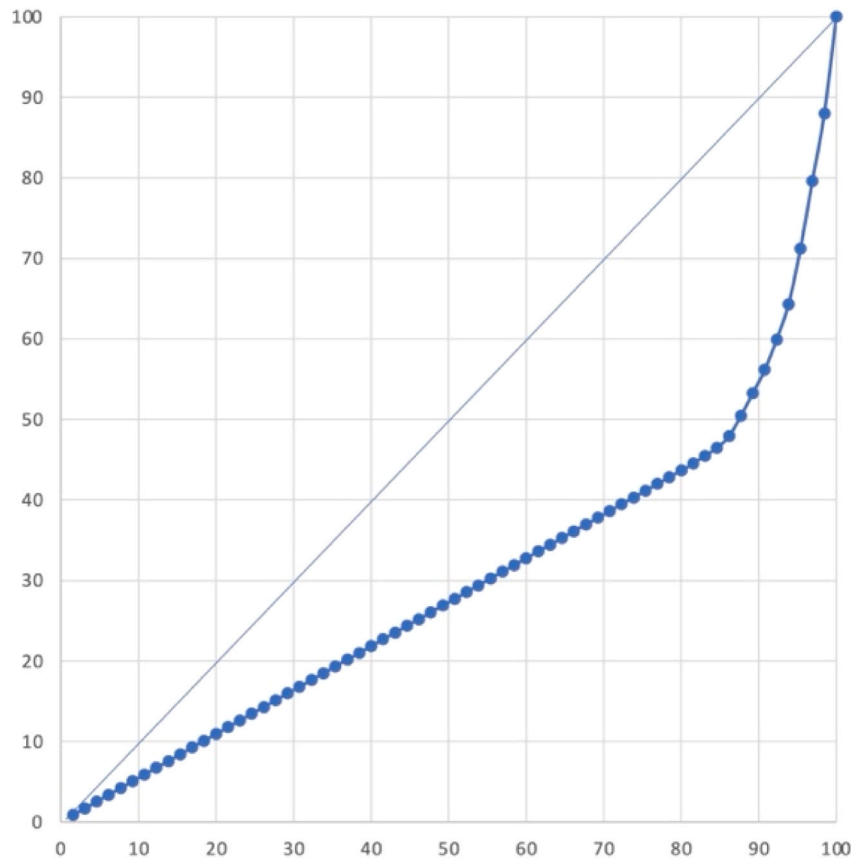


Fig. 8. Lorenz curve for bluefin tuna quotas in 2023 if our proposal for quota redistribution were implemented (Gini index = 0.423). Source: Own elaboration.

managers of the Strait and the Spanish authorities. In the next section, we analyze the new distribution of quotas for bluefin tuna in the Ports of the Strait, which was published in the BOE on March 20, 2024, and has maintained the previous distribution.

4.3. Follow-on analysis: The 2024 distribution

As the works of Cullenberg et al. [11] and Brinson & Thunberg [8] point out, the ITQ system needs exceptions to be allowed and, above all, to be permanently reviewed. An automatic allocation system without periodic control can degenerate into an excessive concentration of quotas that means that many vessels have no incentive to fish. Therefore, it is important to keep periodic tracking of the functioning of the ITQ system, so we reproduce our analysis of concentration for 2024.

With an increase compared to 2021 of more than 40,000 kg of bluefin tuna allocated to the Strait, the Spanish fishing authorities were reproducing the formula of previous years: the increases in allowable catch were distributed proportionally based on the percentage of quota held by vessels in 2021 [53]. The Lorenz curve maintains its deeply curved shape and the Gini index is 0.696 in 2024 (Fig. 9), very close to the 2021 value of 0.702. These results indicate that the current quota allocation structure remains largely unchanged after the renewal process, concentrating quota allocation among certain vessels in line with previous distributions.

5. Discussion and conclusions

The Ports of the Strait (Tarifa and Algeciras) have traditionally depended on fishing for blackspot seabream, a species highly valued in the market and which, for many years, generated income, more or less evenly distributed among the different vessel owners in the area. The

disappearance of blackspot seabream in the Strait has diverted catches to bluefin tuna, currently the only species that provides income to the vessels operating in these waters.

The shift from blackspot seabream fishing to bluefin tuna has resulted in only a few vessels in the fleet maintaining their activity, while most face challenges in securing sufficient quotas to guarantee their subsistence. Only the 8 or 9 vessels that caught the most bluefin tuna between 2002 and 2006, when almost all were fishing for blackspot seabream, have a quota sufficient to guarantee their economic profitability with bluefin tuna. The rest of the vessels, part of List B and all of List H, do not have enough quota to ensure their economic survival.

Our analysis reveals critical challenges in the ITQ system for bluefin tuna that threaten the viability of smaller vessels in the Ports of the Strait. Considering the characteristics of the ITQ system for bluefin tuna, an alternative distribution approach should be evaluated if the objective is to improve the economic viability of vessels with lower quotas and limit excessive concentration. We propose allocating possible increases in catch quotas to those vessels that have the lowest quota, while keeping unchanged the quota of vessels that already had an ITQ above that amount. We evaluate this proposal using Lorenz curves and Gini indices, and the results indicate that it would lead to greater equity.

Although we communicated this problem in 2022 and proposed a new distribution, in 2024 the Spanish authorities maintained the same allocation system as in previous years: the increase in TAC (in kg) is allocated to vessels proportionally, based on their existing quota shares. This means that the final distribution of kilograms favors those with the highest quota and puts at a disadvantage those with lower quotas or fixed allocations (List H). In 2024, the Gini index for the ITQs established by the Spanish fishing authorities is 0.696. As in previous years, the observed trends indicate a loss of vessels and employment. If the ITQ distribution system is not made more flexible and reviewed annually

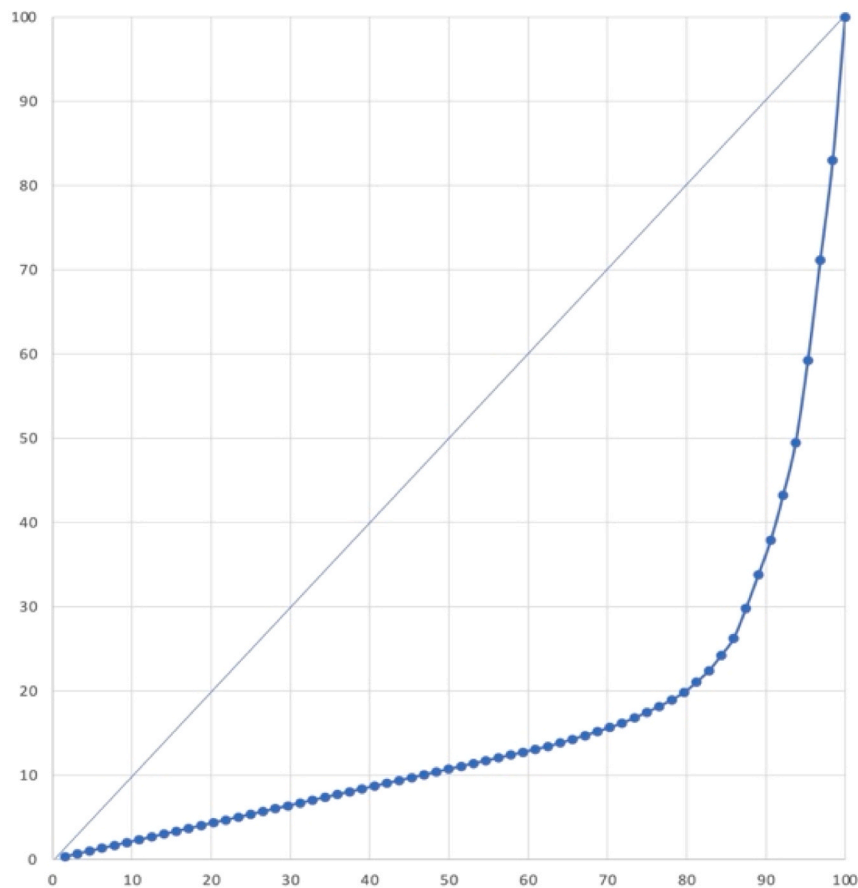


Fig. 9. Lorenz curve for assigned bluefin tuna quotas in 2024 (Gini index= 0.696). Source: Own elaboration based on data from Secretaría General de Pesca [53].

based on economic and social criteria, only those 8 or 9 vessels (out of 65) that currently have a sufficient quota to ensure their economic profitability will remain active in the Ports of the Strait. The rest, including all vessels listed under List H and most of those under List B, possess quotas insufficient to sustain their operations.

Our findings raise an essential question: What would be the

Table 4

Bluefin tuna catches, fishing days and productivity (kg/day) by vessel and fishing days in the Ports of the Strait (2024).

Vessel ID	List	Catch (kg)	Fishing days	Catch (kg/day)
1	H	1368	10	136.8
2	H	1546	9	171.78
3	H	1567	8	195.88
4	H	1575	12	131.25
5	H	1575	16	98.44
6*	H	3027	18	168.17
7	B	3100	13	238.46
8	B	3124	21	148.76
9	B	3087	28	110.25
10	B	6338	23	275.57
11	B	8920	27	330.37
12	B	47455	79	600.7
13	B	47464	83	571.86
14	B	78869	142	555.42

* The vessel with ID number 6 from List H catches twice as much as the others from the same list because its owner holds another vessel and transfers that vessel's quota to vessel 6. When a vessel owner holds more than one vessel, it is permitted to concentrate the quotas of several vessels from List H into a single one.

Source: Own elaboration based on data provided by OPP78 and Cofradía de Pescadores de Algeciras.

employment implications of allocating quota increases to small-scale vessels, rather than reinforcing existing concentration? Although we lack historical data on the employment effects of quota increases over time, Table 4 provides indirect insights. The limited data available on catch (kg) and fishing days for some vessels in 2024 shows that these variables are not linearly related. Instead, as vessels fish more, they do so in proportionally fewer days. This suggests that catch growth in high-quota vessels is associated with increased productivity, not increased employment. Proportionally, the same increase of only between 1329 kg and 3815 kg per vessel will generate more additional fishing days, and therefore more employment, in vessels with low quota than in vessels with high quota.

Our proposal would maintain quota allocations for vessels with high quotas and allocate any future increase in the TAC to increase the kilograms for vessels currently below 5000 kg. This would mean an increase of 3815 kg for those on List H and a variable increase for vessels on List B depending on their current quota. The likely result would be more fishing days, leading to new contract days for vessel crews. In many cases, this would mean more than doubling the allocated fishing kilograms for many vessels. In contrast, under the current system, future TAC increases would be allocated according to existing quota shares. As a result, the majority of the catch would go to vessels already holding a high percentage of the quota. These vessels are unlikely to go out fishing for more days (generating employment), but would instead catch more bluefin tuna in the same fishing days (increasing productivity rather than employment).

Similar debates have taken place in Nordic countries, where policymakers have had to balance the economic efficiency objectives (often associated with concentration) against the need to preserve small-scale fisheries [31]. Such fisheries may be essential for the social cohesion of

remote coastal communities [31]. Nielsen et al. [30] provide a comparative analysis of how this balance between economic efficiency and the preservation of small-scale fisheries has been approached in several Nordic fisheries.

In line with this, our proposal to allocate quota increases to small-scale (low quota) vessels should be understood as one policy option aimed at sustaining employment and social cohesion, rather than as a purely efficiency-driven solution.

The political decision now lies between two paths: 1) maintaining the current system, in which quota increases benefit vessels with already large quotas, likely without generating new employment, or 2) allocating increases in kilograms exclusively to small-scale vessels, which require more fishing days and would thus likely generate new employment.

This challenge could similarly affect other regions with rigid quota allocation systems, and further research could provide more evidence for different geographical areas. Additionally, in this paper we have not questioned the transferability of bluefin tuna quota, as our focus has been on proposing a legally feasible redistribution within the framework of the current ITQ system. Future research could examine the potential effects of modifying current transferability rules, for example, by introducing restrictions within List B to prevent allocations to vessels that already hold large quotas.

CRedit authorship contribution statement

Daniel Coronado: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **M^a del Mar Cerbán:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Manuel Acosta:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Esther**

Ferrándiz: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Funding

This work has been carried out within the framework of project PCM_00026. This project (PCM_00026) has been funded by the Recovery and Resilience Facility «Next Generation EU» through Spain's Recovery, Transformation and Resilience Plan, and co-financed by the Ministry of University, Research and Innovation of the Regional Government of Andalusia. The views and opinions expressed are solely those of the author(s) and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Acknowledgments

This work has been carried out within the framework of project PCM_00026. This project (PCM_00026) has been funded by the Recovery and Resilience Facility «Next Generation EU» through Spain's Recovery, Transformation and Resilience Plan, and co-financed by the Ministry of University, Research and Innovation of the Regional Government of Andalusia. The views and opinions expressed are solely those of the author(s) and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

We sincerely thank the anonymous reviewers for their valuable comments and suggestions, which have greatly improved the quality and clarity of this work. We also wish to thank OPP78 and Cofradía de Pescadores de Algeciras for their collaboration and support during the development of this research. We are also grateful to the participants and organizers of the MSEAS 2024 symposium (Yokohama, Japan) for their constructive feedback and discussions.

APPENDIX

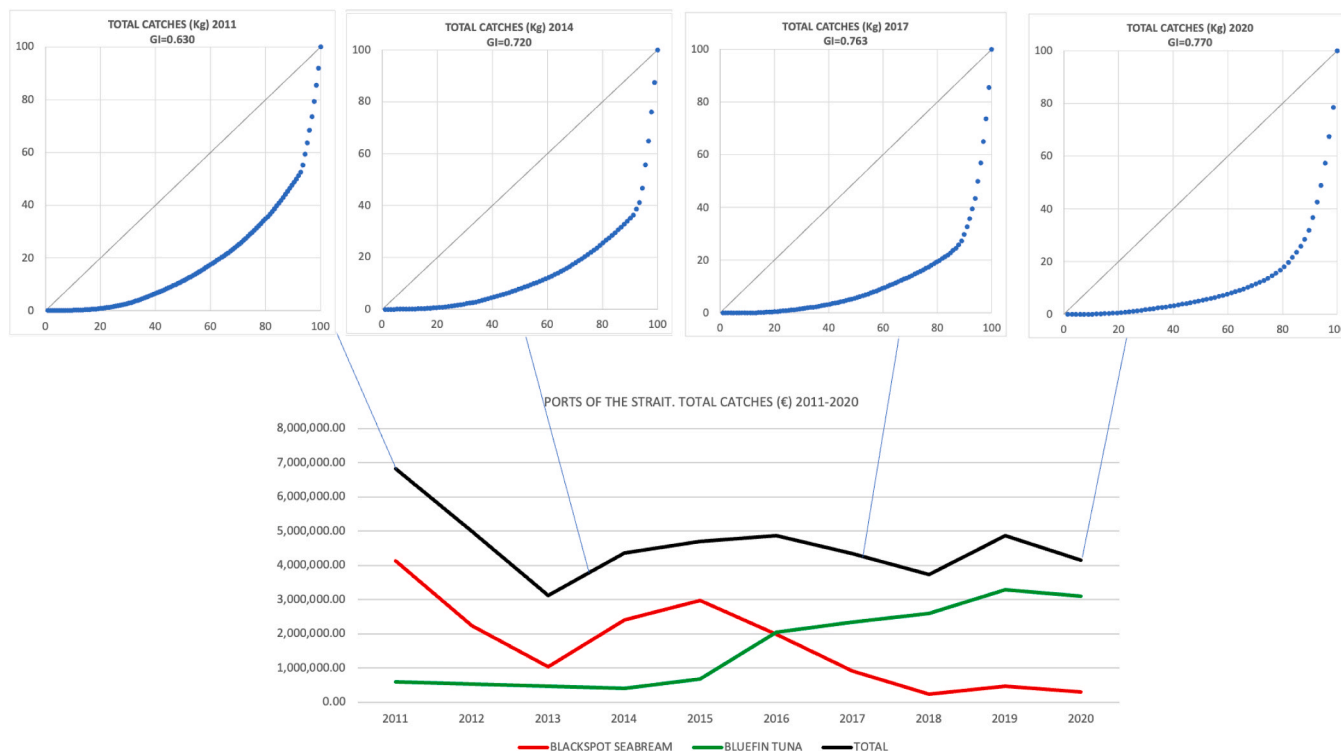


Fig. 10. Concentration of total catches (kg) per vessel in the Ports of the Strait (2011–2020), with annual catch evolution (€) shown in the lower section

Source: Own elaboration. Lower section based on data from IDAPES (Junta de Andalucía); upper panels based on data from OPP78 and Cofradía de Pescadores de Algeciras.



Fig. 11. Concentration of blackspot seabream catches (kg) per vessel in the Ports of the Strait (2011–2020), with annual catch evolution (€) in the lower section

Source: Own elaboration. Lower section based on data from IDAPES (Junta de Andalucía); upper panels based on data from OPP78 and Cofradía de Pescadores de Algeciras.

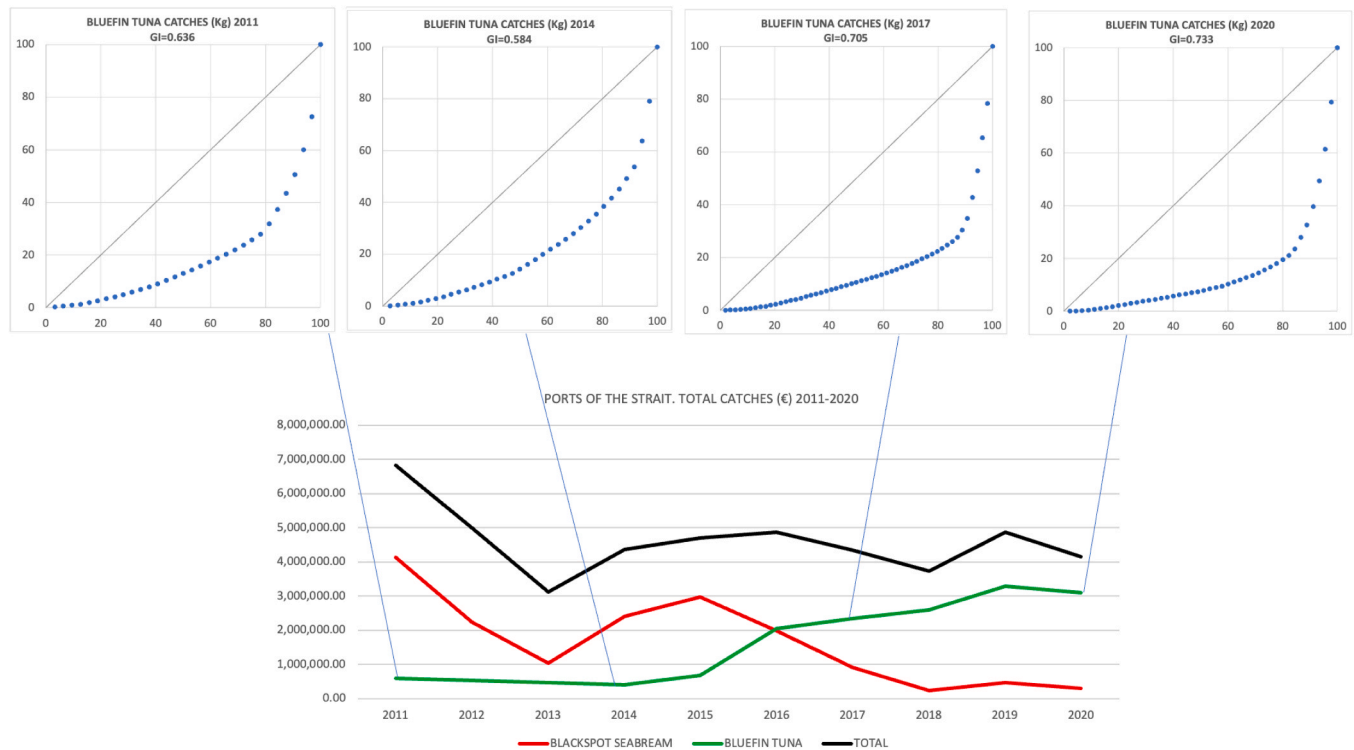


Fig. 12. Concentration of bluefin tuna catches (kg) per vessel in the Ports of the Strait (2011–2020), with annual catch evolution (€) in the lower section

Source: Own elaboration. Lower section based on data from IDAPES (Junta de Andalucía); upper panels based on data from OPP78 and Cofradía de Pescadores de Algeciras.

Data availability

The data that has been used is confidential.

References

- [1] K. Abayomi, T. Yandle, Using conditional Lorenz curves to examine consolidation in New Zealand commercial fishing, *Marine Resources Economics* 27 (4) (2012) 303–321.
- [2] K. Abe, L. Nøstbakken, M.F. Wold, Quota consolidation in Norwegian coastal fisheries, *Environ. Resour. Econ.* 87 (5) (2024) 1295–1326, <https://doi.org/10.1007/s10640-024-00866-x>.
- [3] A. Adelaja, J. Menzo, B. McCay, Market power, industrial organization and tradeable quotas, *Rev. Ind. Organ.* 13 (1998) 589–601, <https://doi.org/10.1023/A:1007799229046>.
- [4] S. Agnarsson, T. Matthiasson, F. Giry, Consolidation and distribution of quota holdings in the Icelandic fisheries, *Mar. Policy* 72 (2016) 263–270, <https://doi.org/10.1016/j.marpol.2016.04.037>.
- [5] R. Arnason, H.H. Gissurarson, Almenna bókafélagið, *Individ. Transf. Quotas Theory Pract.* 4 (2017).
- [6] M. Bellanger, C. Macher, O. Guyader, A new approach to determine the distributional effects of quota management in fisheries, *Fish. Res.* 181 (2016) 116–126, <https://doi.org/10.1016/j.fishres.2016.04.002>.
- [7] T.A. Branch, How do individual transferable quotas affect marine ecosystems? *Fish Fish* 10 (1) (2009) 39–57, <https://doi.org/10.1111/j.1467-2979.2008.00294.x>.
- [8] A.A. Brinson, E.M. Thunberg, Performance of federally managed catch share fisheries in the United States, *Fish. Res.* 179 (2016) 213–223, <https://doi.org/10.1016/j.fishres.2016.03.008>.
- [9] C. Chu, Thirty years later: the global growth of ITQs and their influence on stock status in marine fisheries, *Fish Fish* 10 (2) (2009) 217–230, <https://doi.org/10.1111/j.1467-2979.2008.00313.x>.
- [10] C. Costello, S.D. Gaines, J. Lynham, Can catch shares prevent fisheries collapse? *Science* 321 (5896) (2008) 1678–1681, <https://doi.org/10.1126/science.1159478>.
- [11] P. Cullenberg, R. Donkersloot, C. Carothers, J. Coleman, D. Ringer, Turning the tide: how can Alaska address the “graying of the fleet” and loss of rural fisheries access? Alaska sea grant, University of Alaska Fairbanks, 2017. (<https://seagrant.uaf.edu/bookstore/pubs/M-215.html>).
- [12] J.M. Da-Rocha, J. Sempere, ITQs, firm dynamics and wealth distribution: does full tradability increase inequality? *Environ. Resour. Econ.* 68 (2017) 249–273, <https://doi.org/10.1007/s10640-016-0017-3>.
- [13] K.N. Edvardsson, C. Pástráv, K. Benediktsson, Mapping the geographical consolidation of fishing activities in Iceland during the maturation of the ITQ fisheries management system, *Appl. Geogr.* 97 (2018) 85–97, <https://doi.org/10.1016/j.apgeog.2018.05.013>.
- [14] T.J. Emery, K. Hartmann, B.S. Green, C. Gardner, J. Tisdell, Does ‘race to fish’ behaviour emerge in an individual transferable quota fishery when the total allowable catch becomes non-binding? *Fish Fish* 15 (1) (2014) 151–169, <https://doi.org/10.1111/faf.12015>.
- [15] Food and Agriculture Organization of the United Nations, FAO major fishing areas for statistical purposes, FAO Fisheries and Aquaculture Division, 2024. (<https://www.fao.org/fishery/geonetwork?uuiid=ac02a460-da52-11dc-9d70-0017f293bd28>).
- [16] C. Gardner, K. Hartmann, A.E. Punt, S. Jennings, In pursuit of maximum economic yield in an ITQ managed lobster fishery, *Fish. Res.* 161 (2015) 285–292, <https://doi.org/10.1016/j.fishres.2014.08.015>.
- [17] Gini, C. (1912). Variabilità e mutabilità: Contributo allo studio delle distribuzioni e delle relazioni statistiche. C. Cuppini.
- [18] C. Gini, Sulla misura della concentrazione e della variabilità dei caratteri. *Atti del Reale Istituto Veneto di Scienze, Lettere ed Arti* 73 (1914) 1203–1248.
- [19] C.A. Grainger, C. Costello, Distributional effects of the transition to property rights for a common-pool resource, *Mar. Resour. Econ.* 31 (1) (2016) 1–26, <https://doi.org/10.1086/684132>.
- [20] K.G. Hamon, O. Thébaud, S. Frusher, L.R. Little, A retrospective analysis of the effects of adopting individual transferable quotas in the tasmanian Red Rock lobster, *jasus edwardsii*, fishery, *Aquat. Living Resour.* 22 (4) (2009) 549–558, <https://doi.org/10.1051/alr/2009039>.
- [21] R. Hannesson, Norway’s experience with ITQs, *Mar. Policy* 37 (2013) 264–269, <https://doi.org/10.1016/j.marpol.2012.05.008>.
- [22] M. Hanstén, P. Haapasaaari, S. Kuikka, A realist evaluation of the individual transferable quota system used in Finnish herring fisheries, *ICES J. Mar. Sci.* 78 (10) (2021) 3603–3614, <https://doi.org/10.1093/icesjms/fsab196>.
- [23] E. Hoefnagel, B. de Vos, Social and economic consequences of 40 years of Dutch quota management, *Mar. Policy* 80 (2017) 81–87, <https://doi.org/10.1016/j.marpol.2016.09.019>.
- [24] E. Hoshino, I. van Putten, S. Pascoe, S. Vieira, Individual transferable quotas in achieving multiple objectives of fisheries management, *Mar. Policy* 113 (2020) 103744, <https://doi.org/10.1016/j.marpol.2019.103744>.

- [25] ICCAT, Recommendation by ICCAT establishing a multi-annual management plan for bluefin tuna in the eastern atlantic and the Mediterranean (Rec. 18-02), International Commission for the Conservation of Atlantic Tunas, 2018. (<http://iccat.int/Documents/Recs/compendiopdf-e/2018-02-e.pdf>).
- [26] M. Kourantidou, P. Hoagland, A. Dale, M. Bailey, Equitable allocations in Northern fisheries: bridging the divide for Labrador inuit, *Front. Mar. Sci.* 8 (2021) 590213, <https://doi.org/10.3389/fmars.2021.590213>.
- [27] Liew, D.S.K. (2000). Measurement of Concentration in Canada's Scotia-Fundy Inshore Groundfish Fishery. *FAO Fisheries Technical Paper*, (2), 279-287. Food and Agriculture Organization of the United Nations (FAO), Rome.
- [28] M.O. Lorenz, *Methods of measuring the concentration of wealth*, *Publ. Am. Stat. Assoc.* 9 (70) (1905) 209–219.
- [29] A. Magro López, *Biología reproductora, ecología trófica y bioacumulación de microcontaminantes en atún rojo (Thunnus thynnus) del estrecho de Gibraltar* (Doctoral dissertation, Universidad de Cádiz), Univ. de Cádiz. (2024). (<https://www.educacion.gob.es/teseo/imprimirFicheroTesis.do?idFichero=mpgshAmjnHg%3D>).
- [30] M. Nielsen, P. Andersen, F. Asche, H. Ellefsen, C. Hammarlund, A. Hoff, D. M. Kristofersson, R. Nielsen, H. á Rógvi, K. Roll, H. Sævaldsson, J. Virtanen, S. Waldo, Can small-scale fisheries survive market-based management? *Nordic evidence*, *Fish Fish* 23 (3) (2022) 633–649, <https://doi.org/10.1111/faf.12614>.
- [31] M. Nielsen, E. Larsen, H. Ellefsen, H.A. Rógvi, J. Sandager Hansen, S. Espersen Schrøder, K. Teilmann, J.H. Møller, D.M. Kristófersson, E. Marinósdóttir, S. L. Tveteraas, C.-C. Schmidt, The pay systems for commercial fishers in nordic fisheries, *Nord. Counc. Minist.* (2022), <https://doi.org/10.6027/temanord2022-530>.
- [32] Orden APM/264/2017, de 23 de marzo, por la que se regula la pesquería de atún rojo en el Atlántico Oriental y Mediterráneo. *Boletín Oficial del Estado*, 72, 22593–22603. (<https://www.boe.es/eli/es/o/2017/03/23/apm264>).
- [33] Orden APM/400/2018, de 17 de abril, por la que se modifica la Orden APM/264/2017, de 23 de marzo, que regula la pesquería de atún rojo en el Atlántico Oriental y el Mediterráneo. *Boletín Oficial del Estado*, 94, 40468–40471. (<https://www.boe.es/eli/es/o/2018/04/17/apm400>).
- [34] Orden ARM/1244/2008, de 29 de abril, por la que se regula la pesquería de atún rojo en el Atlántico Oriental y Mediterráneo. *Boletín Oficial del Estado*, 105, 22366–22368. (<https://www.boe.es/eli/es/o/2008/04/29/arm1244>).
- [35] Orden ARM/496/2010, de 2 de marzo, por la que se modifica la Orden ARM/1244/2008, de 29 de abril, por la que se regula la pesquería de atún rojo en el Atlántico Oriental y Mediterráneo. *Boletín Oficial del Estado*, 56, 22545–22547. (<https://www.boe.es/eli/es/o/2010/03/02/arm496>).
- [36] Orden ARM/956/2009, de 16 de abril, por la que se modifica la Orden ARM/1244/2008, de 29 de abril, por la que se regula la pesquería de atún rojo en el Atlántico Oriental y Mediterráneo. *Boletín Oficial del Estado*, 95, 35789–35791. (<https://www.boe.es/eli/es/o/2009/04/16/arm956>).
- [37] Polonio Povedano, V. (2008). Hábito alimenticio del voraz [Pagellus bogaraveo (Brünnich, 1768)] en aguas del Estrecho de Gibraltar (Master's thesis, Universidad de Cádiz). Universidad de Cádiz.
- [38] Real Decreto 46, De 8 de febrero, por el que se regula la pesquería de atún rojo en el Atlántico oriental y el Mediterráneo, *Boletín Oficial del Estado* 35 (2019) 12423–12435. (<https://www.boe.es/eli/es/rd/2019/02/08/46>).
- [39] Pesca. Secretaría General de, 21 de mayo). Resolución de 21 de mayo de 2018, de la Secretaría General de Pesca, por la que se establecen disposiciones para la campaña de atún rojo 2018, para los buques artesanales del Estrecho, *Boletín Oficial del Estado* 124 (2018) 52736–52738.
- [40] Secretaría General de Pesca, Resolución de 26 de enero de 2012, de la Secretaría general de pesca, por la que se publica el censo específico de la flota autorizada para el ejercicio de la pesca del atún rojo, 26 de enero, *Boletín Oficial del Estado* 26 (2012) 9035–9039, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2012-1525), 26 de enero.
- [41] Secretaría General de Pesca, Corrección de errores de la Resolución de 26 de enero de 2012, de la Secretaría general de pesca, por la que se publica el censo específico de la flota autorizada para el ejercicio de la pesca del atún rojo, 9 de febrero, *Boletín Oficial del Estado* 34 (2012) 11972–11975, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2012-1970), 9 de febrero.
- [42] Secretaría General de Pesca, Resolución de 25 de abril de 2013, de la Secretaría general de pesca, de corrección de errores de la de 23 de abril de 2013, por la que se publica la asignación de cuotas de atún rojo y del censo específico de la flota autorizada, 25 de abril, *Boletín Oficial del Estado* 106 (2013) 32846–32871, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2013-4676), 25 de abril.
- [43] Secretaría General de Pesca, Resolución de 22 de abril de 2013, de la Secretaría general de pesca, por la que se publica la asignación de cuotas de atún rojo y del censo específico de la flota autorizada para el ejercicio de la pesca del atún rojo creado por la orden AAA/642/2013, de 18 de abril, 22 de abril, *Boletín Oficial del Estado* 98 (2013) 31371–31375, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2013-4352), 22 de abril.
- [44] Secretaría General de Pesca, Resolución de 10 de marzo de 2014, de la Secretaría general de pesca, por la que se publica la asignación de cuotas de atún rojo y del censo específico de la flota autorizada para el ejercicio de la pesca del atún rojo creado por la orden AAA/642/2013, de 20 de abril, 10 de marzo, *Boletín Oficial del Estado* 69 (2014) 24892–24903, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2014-3045), 10 de marzo.
- [45] Secretaría General de Pesca, Resolución de 11 de febrero de 2015, de la Secretaría general de pesca, por la que se publica la asignación de cuotas de atún rojo y del censo específico de la flota autorizada, 11 de febrero, *Boletín Oficial del Estado* 41 (2015) 13026–13034, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2015-1591), 11 de febrero.
- [46] Secretaría General de Pesca, Resolución de 23 de febrero de 2016, de la Secretaría general de pesca, por la que se publica la asignación de cuotas de atún rojo y del censo específico de la flota autorizada, 23 de febrero, *Boletín Oficial del Estado* 50 (2016) 16088–16095, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2016-2007), 23 de febrero.
- [47] Secretaría General de Pesca, Resolución de 15 de febrero de 2017, de la Secretaría general de pesca, por la que se publica la asignación de cuotas de atún rojo y del censo específico de la flota autorizada, 15 de febrero, *Boletín Oficial del Estado* 45 (2017) 12493–12501, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2017-1815), 15 de febrero.
- [48] Secretaría General de Pesca, Resolución de 2 de marzo de 2018, de la Secretaría general de pesca, por la que se publica la asignación de cuotas de atún rojo y del censo específico de la flota autorizada, 2 de marzo, *Boletín Oficial del Estado* 64 (2018) 29949–29957, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2018-3566), 2 de marzo.
- [49] Secretaría General de Pesca, Memoria del análisis de impacto normativo al real decreto por el que se regula la pesquería de atún rojo en el Atlántico oriental y Mediterráneo, Ministerio de Agricultura, Pesca y Alimentación, 2019.
- [50] Secretaría General de Pesca, Resolución de 4 de marzo de 2019, de la Secretaría general de pesca, por la que se publica la asignación de cuotas de atún rojo y el censo específico de la flota autorizada creado por el real decreto 46/2019, de 8 de febrero, 4 de marzo, *Boletín Oficial del Estado* 61 (2019) 23709–23730, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2019-3549), 4 de marzo.
- [51] Secretaría General de Pesca, Resolución de 6 de febrero de 2020, de la Secretaría general de pesca, por la que se publica la asignación de cuotas de atún rojo y el censo específico de la flota autorizada, 6 de febrero, *Boletín Oficial del Estado* 37 (2020) 13644–13665, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2020-2096), 6 de febrero.
- [52] Secretaría General de Pesca, Resolución de 27 de enero de 2021, de la Secretaría general de pesca, por la que se dispone la asignación de cuotas de atún rojo y publicación del censo específico de la flota autorizada para el ejercicio de la pesca del atún rojo, 27 de enero, *Boletín Oficial del Estado* 28 (2021) 12232–12253, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2021-1524), 27 de enero.
- [53] Secretaría General de Pesca, Resolución de 8 de marzo de 2024, de la Secretaría general de pesca, por la que se dispone la asignación de cuotas de atún rojo y publicación del censo específico de la flota autorizada para el ejercicio de la pesca del atún rojo creado por el real decreto 46/2019, de 8 de febrero, por el que se regula la pesquería de atún rojo en el Atlántico oriental y Mediterráneo, 8 de marzo, *Boletín Oficial del Estado* 70 (2024) 32846–32871, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2024-5591), 8 de marzo.
- [54] Secretaría General del Mar, Resolución de 29 de julio de 2011, de la Secretaría general del mar, por la que se publica el censo específico de la flota autorizada para el ejercicio de la pesca del atún rojo, 29 de julio, *Boletín Oficial del Estado* 193 (2011) 91826–91830, (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2011-13810), 29 de julio.
- [55] R. Villanueva-Poot, J.C. Seijo, M. Headley, A.M. Arce, E. Sosa-Cordero, D.B. Lluch-Cota, Distributional performance of a territorial use rights and co-managed small-scale fishery, *Fish. Res.* 194 (2017) 135–145, <https://doi.org/10.1016/j.fishres.2017.06.005>.