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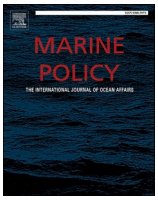

Long-term trends in striped venus clam (*Chamelea gallina*) fisheries in the western Mediterranean Sea: The case of Ebro Delta (NE Spain)

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ABSTRACT

All clam fisheries in the western Mediterranean Sea have dramatically declined in the last few decades. Recently, most have collapsed in Spain, resulting in job loss for hundreds of small-scale fishers. However, insufficient attention has been given to the profound significance of this socio-ecological crisis. We evaluated the historical, social, and ecological context of the striped venus clam (*Chamelea gallina*) fisheries in the western Mediterranean Sea, focusing on one of the main productive areas of this region (the Ebro Delta, Catalonia, NE Spain) to detect possible causes of the decline in clam landings. Different governance systems (self-governance, centralized governance, and *de facto* co-governance) had been successful in maintaining striped clam fisheries since they were established in the 1940s. However, since the industrialization of fishing fleets in the mid-1970s, a lack of reliable management (*e.g.*, free access; conflicts between different interested parties) and a progressive increase in fishing capacity, fishing effort, and technological enhancements across the small fishing grounds have increased the vulnerability of the exploited stocks and set them on a collapse trajectory. We recommend the following management measures to promote the recovery of the striped venus clam stock and mitigate the loss of its ecological, social, and economic value: (1) the closure of the fishery in the Ebro Delta; (2) the preparation and implementation of a Spanish Management Fishery Plan to restore the striped clam fishing grounds; (3) the establishment of a supra-regional Management Plan for the striped venus clam on the Mediterranean coast of Spain.

1. Introduction

Bivalves (mainly clams, cockles, mussels, and oysters) represent 14% of total global food production in marine ecosystems [1]. Eleven percent of marine bivalve production comes from wild fisheries, whereas 89% comes from aquaculture [2]. The global market value of marine bivalves is about 21 billion Euros per year [3]. However, the full economic value is much higher due to the economic benefits from secondary products and services (*e.g.* shucking and packaging houses, transport, manufacture of prepared products, and retail sales) [3,4]. Clams are among the most valued and commercially exploited bivalve species in the European Union: total fisheries production is 0.18 million tonnes per year, representing 28.87% of the bivalve fisheries production of the EU [5].

Most commercial clam species inhabit estuarine and coastal areas (intertidal and subtidal). They are a nutritious source of protein, easily accessible, relatively simple to harvest and therefore have been historically harvested and subjected to significant fishing pressure [6–8]. Clams are the target of different types of commercial fisheries in the EU, with most being small-scale fisheries (SSF) (*i.e.*, they use small vessels in shallow coastal waters performing daily fishing trips). These SSF play an essential role in some EU regions, such as in the Mediterranean and Black Sea, where they represent over 84% of the total fishing fleet and employ nearly 62% of the entire workforce [9]. They represent 64% of the Spanish fleet in the Mediterranean Sea [10] and contribute to societal well-being, playing an essential social and economic role [11]. They are important in terms of employment compared to industrial fisheries, offer more equitable economic benefits, are locally important in economic terms and provide fresh, high-quality seafood to local, regional, national, and international markets [12]. SSF reinforce the attachment people feel for their territory, enhancing social stability in rural and peripheral areas [13]. However, the importance of SSF has historically been undervalued and underestimated, as a result of the fact that most of these fisheries are poorly assessed, managed, and studied in Europe at national and supranational levels and information is scarce and

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scattered [11]. The reasons for this situation are: 1) they are considered of low importance, both in terms of economic value and landings, in relation to large scale fisheries; 2) it has been traditionally assumed that they have a relatively low impact on the exploited stocks compared to the more important fisheries; 3) the high number of fishing units and its fragmentary distribution across many ports along the coastline make the monitoring of the SSF extremely complex [14]. Only recently has interest focused on SSF with an increasing recognition of the extent and significance of small-scale fisheries [12]. Unfortunately, these fisheries are generally data-poor and their management success requires case-specific solutions [15].

SSF targeting on clams constitute complex social-ecological systems (SES), where economic, cultural, historical, and political aspects interact with the biophysical component of the system, with interdependent feedback relationships [8]. Inherent features of SES are resilience, adaptability, and transformability [16], *i.e.*, the ability to maintain structure and function in the face of change (resilience); the management capacity of the system (adaptability); and the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable (transformability). Understanding SES dynamics is critical to fulfilling their potential as engines of social and economic development (*i.e.*, sustenance, development, employment, and cultural value to human communities) and, at the same time, to ensure ecosystem health [17]. There are no magic recipes for the management of these SES, as adaptation to local conditions is essential to achieve sustainability [18]. Long-term assessments in these coastal clam fisheries are scarce, because of a lack of centralized enforcement capacity and data collection is frequently missing [19].

Among the clams targeted in the EU, the striped venus clam (*Chamelea gallina*) is one of the most highly valued species [20]. Striped venus clam is an Atlantic-Mediterranean warm temperate species that has been recorded from the British Isles to northwestern African coasts [21]. It is a shallow-burrowing, suspension-feeding round-shaped bivalve inhabiting clean sandy shallow grounds in coastal waters. It inhabits a wide variety of sediment types (sand, sandy-mud, and mud), and is preferentially distributed on the coastal well-sorted fine sand between 3 and 12 m in the Mediterranean and Black Sea [22] and between 5 and 20 m in the Atlantic Sea [23]. Striped venus clams have high growth rates and short life spans (*i.e.,* 4 years) [24,25], making their population sizes very dependent on the success of spawning and recruitment. Clam recruitment seems to be strongly related to climate variability at local and regional scales [26]. It is commercially harvested in four geographical regions: (1) eastern Mediterranean and Black Sea (Greece, Bulgaria, and Turkey); (2) Adriatic Sea (Italy, Slovenia, and Albania); (3) Western Mediterranean Sea (Mediterranean Coast of Spain and Sardinia, Italy); and (4) Atlantic Ocean (Portugal, Spain, France, and Netherlands). The world production of striped venus clam has progressively increased from 3100 t/year in the 1950 s to 59,364 t/year in 2018, peaking in 2013 with 80,000 t/year (Fig. 1**A**) [2]. However, this increasing trend has not been homogenous throughout its geographical range. In the western Mediterranean region, where the striped venus clam has been harvested for centuries, landings strongly declined, and most SSF collapsed. The striped venus clam has traditionally been gathered along the Mediterranean coast of Spain (*i.e.,* Andalusia, Murcia, Valencia, Balearic Islands, and Catalonia) and in Italy (Sardinia), with the Ebro Delta (Catalonia) one of the main productive areas in this Mediterranean region.

The striped venus clam is often subject to large inter-annual fluctuations in landings influenced by many environmental stressors (*e.g.*, salinity, temperature, oxygen, and summer blooms of phytoplankton) [27,28], infectious diseases [29], anthropogenic stressors (*i.e.*, pollutants [30]), and poor management (*e.g.*, open access, poor monitoring, control and surveillance) [31]. Sharp declines in striped venus clam landings over the last decades have been observed in the western Mediterranean, Spain (Atlantic coast), and north Adriatic [2,32]. The causes of these declines are still poorly understood, but are probably the result of the combined effects of multiple stressors acting simultaneously [20]. The purpose of the present study was to evaluate the historical, social, institutional and ecological context of the striped venus clam fisheries in the western Mediterranean Sea, focusing on one of the main productive areas of this region (the Ebro Delta, Catalonia) to detect possible causes of the decline in bivalve landings. To this end, we: (1) evaluated the regional framework of the western Mediterranean striped venus fisheries by political and administrative boundaries; and (2) assessed long-term trends (1940–2018) of the striped venus clam fishery in Ebro Delta, providing data on governance, management, landings, fleets, and fishing gear development.

2. Material and methods

2.1. Regional framework

World annual production and western Mediterranean production of striped venus clam were obtained for 1950–2018 [2,32]. Spanish and Italian local annual production were obtained for 1983–2018. Spanish production data were collected by autonomous communities (*i.e.* political and administrative divisions) (Andalusia: Dirección General de Pesca y Acuicultura; Murcia: Consejería de Agua, Agricultura, Ganadería, Pesca y Medio Ambiente; Balearic Islands: Institut Mediterrani d'Estudis Avançats - IMEDEA; Valencia: Informes del Sector Agrari Valencià (Conselleria d'Agricultura, Desenvolupament Rural, Emergència Climàtica i Transició Ecològica); and Catalonia: Idescat. Anuari estadístic de Catalunya (Departament d'Agricultura, Ramaderia, Pesca i Alimentació). The Italian local annual production for the western Mediterranean Sea was collected by the GFCM (Mediterranean and Black Sea) [32].

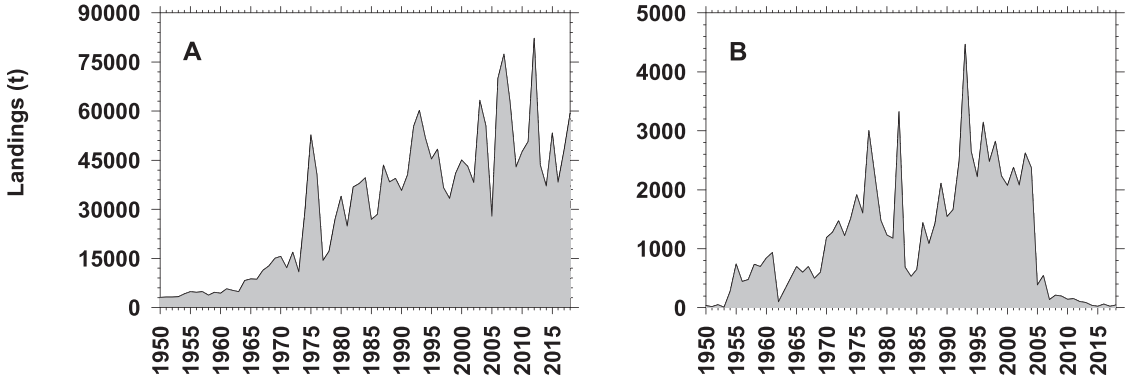

Fig. 1. Striped venus clam: (A) World annual production; and (B) Western Mediterranean annual production from 1950 to 2018.

2.2. The case of Ebro Delta

Our study site is located in the sea off the Ebro Delta (NW Mediterranean), in the northeastern part of the Spanish coastline, between 40º 48′N and 40º 32′N and 0º 45′E and 0º 38′E **(**Fig. 2**).** The Ebro Delta is an alluvial plain of about 35,000 ha, mainly devoted to intensive agricultural activities, notably rice culture. Its coastline extends approximately 50 km and is surrounded by a wide continental shelf, with high biological productivity resulting from the nutrients provided by the Ebro River and the mixing effect of the Liguro-Provençal-Catalan front at the continental slope [33]. This area sustains one of the most important commercial fisheries of the Western Mediterranean [34]. The main fishing ports in the study area are Sant Carles de la Ràpita, Alcanar, Deltebre and l′Ampolla.

The reconstruction of striped venus clam landings and the analysis of the governance and management was made using official information from the Catalan Government, and from gray and scientific literature from 1940 to 2018. Monthly data on Ebro Delta obtained from1955 to 1959 [35] and from 2000 to 2018 (Catalan Government database, unpublished) were used to assess long-term trends in clam landings. The data come from daily auctions by species and fishing gear (clam dredges and towed dredges), and from the fishing ports Sant Carles de la Ràpita and l′Ampolla. Monthly landings per unit of fishing effort (LPUE, kg/vessel/day), and mean prices were also calculated from daily auction information. As the fishing grounds for both ports are in the same area, data were pooled for analysis.

3. Results

3.1. Regional framework

The striped clam beds in the western Mediterranean region are widespread in isolated small fishing grounds. However, there is no unique governance system for this resource. The competencies on fisheries governance and management, including striped venus clam fisheries, are transferred to the local authorities (Comunidades Autónomas) in Spain. Since the mid-1980 s, each local authority has had its own governance system (centralized management, co-governance, *etc.*) and management rules (*i.e.*, appropriation rules, management plans, *etc.*). In the western Mediterranean region, the first landing records are from the 1940s. Landings showed an oscillating trend until the 1990s, peaking in 1993 with more than 4000 t and decreasing afterward, until petering out at the end of the analyzed period (49 t, 2018) (Fig. 1**B**). The decline in landings caused the progressive closure of fishing grounds by the local authorities: the first was Murcia in 1998, Balearic Islands in 2003, and Valencia in 2017. The fishery in Catalonia has not been closed but there is no fishing activity. The closures of the striped venus fisheries showed a clear southwestern to northeastern temporal trend. There are two areas in the western Mediterranean region where fishing activity continues (Andalusia and Sardinia), although the landings have also decreased.

The entire clam fishing fleet along the Mediterranean coast of Spain was composed of 429 active vessels (365 using mechanized dredges and 64 using towed dredges) and 986 active fishers in 2001 (only Spain). By 2018, it was composed of 132 active vessels (111 vessels using mechanized dredges and 21 using towed dredges) and 264 active fishers. Currently, most of this fleet is in Andalusia (109 vessels) and Catalonia (23 vessels). However, these vessels target not only clams but also other species. Those vessels using mechanized dredges target mainly the common octopus (*Octopus vulgaris*) using other fishing gears (traps), with clams being less than 30% of the total landings (striped venus clam only represents a small portion of that percentage). Focusing on the vessels using towed dredge, all of them operate in the Ebro Delta and they rarely target the striped venus clam.

3.2. The case of Ebro Delta

3.2.1. Long-term trends in fishing effort and technology

The Ebro Delta was likely one of the first areas to see the establishment of a striped venus clam fishery in the western Mediterranean region. A small striped venus fishing ground (30 km^2) was discovered after the Civil Spanish War in the 1940 s when commercial exploitation began. At this time, larger engine vessels were used to tug many small rowing vessels from the port (only from the Sant Carles de la Ràpita port in these early years) to the clam fishing areas early in the morning, and then back to the dock at noon. This fishery soon became popular, and the number of fishing vessels and fishers grew extremely fast (*e.g.*, 61 fishing vessels and 190 fishers by 1955) (Fig. 3). These rowing vessels towed a unique clam dredge (“*ancient clam dredge fisheries*”) to target the striped venus clam. The duration of the tows was between 20 and 25 min. The clam dredge was dragged by a hand-operated winch installed on the vessel. Dredges had a metallic or wood frame, a toothed lower bar, and a rectangular metallic or wood grid box (width 75 cm; height 25 cm; depth 44 cm; mesh size 11 × 11 mm) closed at the back. The toothed lower bar had between 30 and 35 teeth with a length of 14 cm and a diameter of 8 mm [35].

In the mid-1970s, with the introduction of new technology and engine vessels, “*the modern clam dredge fisheries*” (*i.e.*, the mechanized clam dredge fisheries) began, and shortly after the “*ancient clam dredge fisheries*” disappeared (Fig. 3). This new fishery emerged again at the Sant Carles de la Ràpita fishing port but quickly spread to all fishing ports in

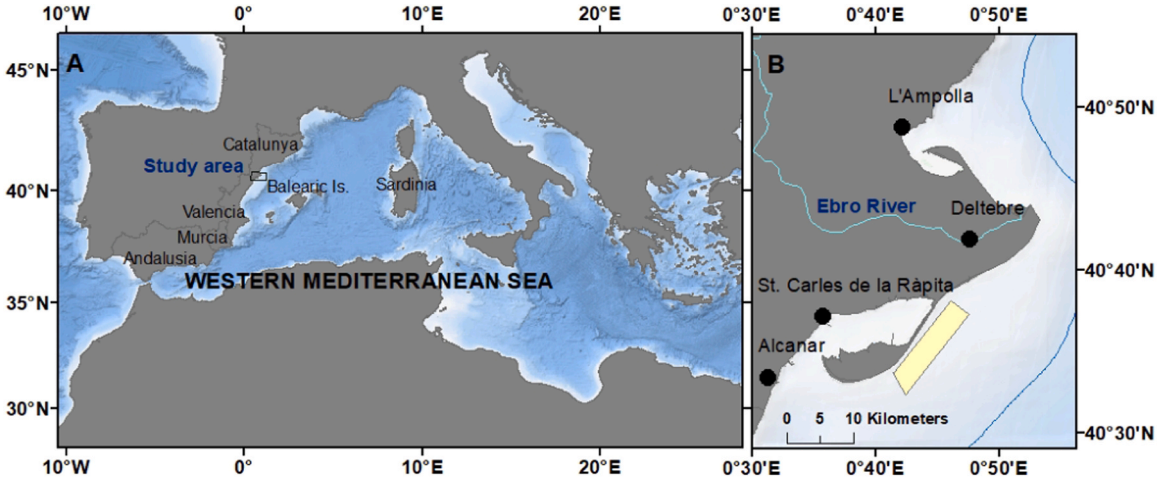

Fig. 2. (A) Location of the study area in the Western Mediterranean Sea. (B) Map of the study area in the Ebro Delta. Black dots indicate the striped venus clam fishing ports, the yellow box indicates the striped venus clam bed.

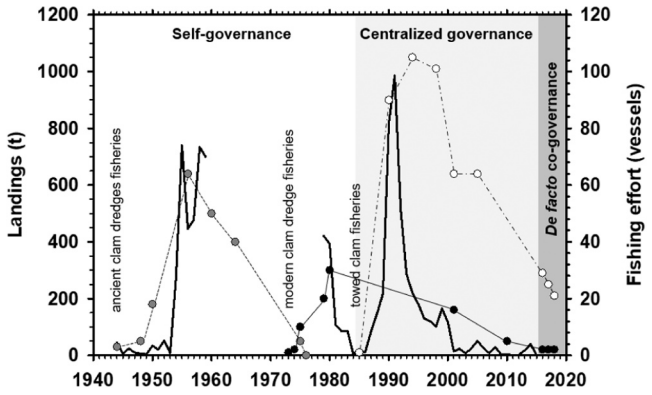

Fig. 3. Long-term trends in governance, landings and fishing effort (fishing vessels using different technologies) of striped venus clam in the Ebro Delta Area. Landings data from 1960 to 1978 is missing. The line with gray dots indicates the ancient clam dredge fleet (rowing vessels); the line with black dots indicates the modern clam dredge fleet (mechanized clam dredges); and the line with white dots indicates the towed clam fleet.

the Ebro Delta area (*e.g.,* l′Ampolla, Deltebre and Alcanar) and along the Spanish Mediterranean coast. This fleet was composed of 20–30 fishing vessels in the 1970–1990s, 15 in the 2000s and 3 by 2018. Currently, these 3 fishing vessels mainly target other species and only occasionally harvest clams. They use passive-attractive gears (*e.g.*, traps and clay pots) to target the common octopus (*Octopus vulgaris*) and bottom-set stationary gears (*e.g.*, gillnets, trammel nets, longlines) to target fish and crabs. Furthermore, these boats target other commercial clam species such as the wedge clam (*Donax trunculus*) but not the striped venus clam. The vessels are 7–11 m long and an engine power of 59.31 ± 5.62 HP (N = 58; in the 1990s). Currently, vessels cannot exceed an engine power of 134 HP. Fishing is done by dragging four clam dredges along the bottom (Fig. 4**A**). Usually, tows are performed parallel to the shore, at a towing speed of 1–2 knots and a duration 15–20 min. Dredges of approximately 30 kg consist of a metallic frame, a toothed lower bar, and a rectangular metallic grid box (width 60–70 cm; height 50–55 cm; depth 120–140 cm; mesh size 11 × 11 mm/19 × 19 mm) closed at the back. The toothed lower bar has between 18 and 25 teeth with a length of 10–20 cm and a diameter of 20 mm. There are also two metal bars welded to the dredge mouth where the towing cable is attached.

In the mid-1980s, another new and more efficient clam fishery began using new technology and more powerful engines, leading to "*the towed dredge fisheries*". These improvements notably increased fishing effort, resulting in a large increase in landings by tow. This fishery soon became immensely popular due to its high economic revenue and many small-scale vessels using other fishing gears converted to using this fishing gear. The fleet peaked in the 1990s with 105 vessels (from Les Cases d′Alcanar, Sant Carles de la Ràpita, Deltebre and l′Ampolla fishing ports), but has progressively declined to 21 vessels in 2018. The towed dredge fleet targets not only the striped venus clam, but also the purple dye murex *Bolinus brandaris*. Currently, the towed dredge fleet is responsible for over 95% of striped venus clam landings in the Ebro Delta area (2000–2019). The vessels have a length of 7–11 m and an engine power of 148 HP. Fishing is done by dragging two gear units (dredges) side by side from the stem. Usually, tows are performed parallel to the shore, at a towing speed of 1–2 knots and a duration of 5–10 min to target striped venus clams, with a duration of 1–1.5 h to target purple dye murex. The dredges (Fig. 4**B**) have three parts: the mouth, the bag, and the cod-end. The total length of the gear varies between 6 and 8 m. The mouth is a rectangular or semi-oval metal frame, with a 2 m maximum horizontal aperture and a 40 cm vertical aperture. The upper part of the bag consists of netting and the lower part of 13–16 tickler chains. The cod-end (60–70 mm mesh size) measures 1.5–3 m. The lower part of the bag is made of thicker and more resistant mesh, while the material in the upper part is lighter to keep the net open during the trawl.

3.2.2. Governance and management

3.2.2.1. Self-governance. The Spanish Government historically had competencies for fisheries management, including the striped venus clam (Fig. 3), until 1982. When the striped venus clam fishery was first established in the 1940s, the lack of management by the Spanish Government encouraged fishers to define a structure of self-governance with their own management rules. This bottom-up community-led management system involved and benefited legitimate users through participatory incentives. These users (clam fishers using rowing vessels) were

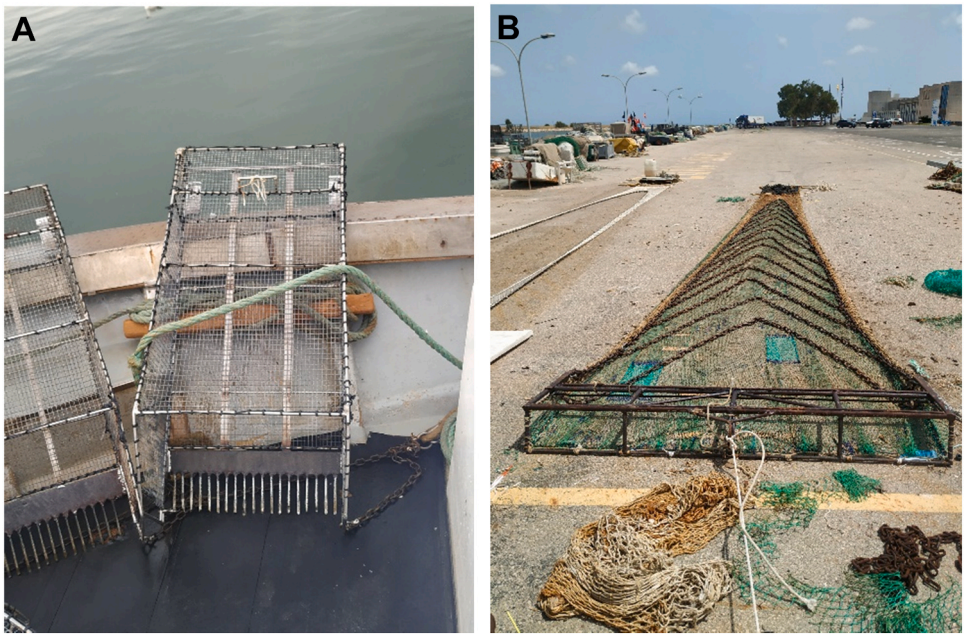

Fig. 4. (A) Clam dredges used by the "*modern clam dredge fisheries*" (mechanized clam dredge fisheries) in Ebro Delta. (B). Dredges used by the "*Towed dredge fisheries*" in the Ebro Delta.

located in one fishing port and Fishing Guild ("Cofradía de Pescadores"), both in Sant Carles de la Ràpita. They had several mechanisms to participate in modifying operational regulations. They held regular meetings, that included most legitimate users (> 90%), to discuss their operational rules. The first fishers landed a mean of 74.33 ± 13.64 kg/vessel/day (between January 1955 and June 1955). The high economic revenue attracted many other fishers using other fishing gears to target the striped venus clam, which led to a sharp increase in fisher numbers. This increase produced a rise in landings and a sharp decline in clam price. Legitimate users decided to lower the effective fishing effort by reducing the effective fishing time (from 5 to 3 h) until price recovery. As a result, the striped venus clams landed by vessels decreased by a mean of 48.89 ± 2.48 kg/vessel/day (showing high regularity between July 1955 and December 1959) and the price increased again [59].

The introduction of new technology and engine vessels let the emergence of the "the modern clam dredge fisheries" (mechanized clam dredge fisheries) in the 1970s. The high profits produced by this new fishery drew the attention of fishers from all other fishing ports in the Ebro Delta area and it became widespread in only a few years. At that time, there were many fishing vessels from different fishing ports targeting the same fishing ground. The new legitimate users (the "new" clam fishers) tried to maintain the regulation of the effective fishing time (3 h), but this appropriation rule was soon broken. The lack of social cohesion, self-organization, and cooperation between fishers from different fishing ports was frequent. Users had little access to low-cost options for conflict resolution between fishers, worsening the striped venus clam fishery's governance. Management continued with a bottom-up system, but now with open access to the fishery. There is no information on the mean landings by vessel or day for this fleet in the Ebro Delta area in the period 1970–1980 (Fig. 5). However, Ramón [36] observed that fishers landed a mean of 37.34 kg/vessel/day during the period January 1986 - June 1992 using the same fishing gears in Cullera (Valencia, Mediterranean coast of Spain).

The "Towed dredge" fishery began in the mid-1980s. The socioeconomic impact of the new fishery was enormous. Fishers obtained extremely high landings (gathering 60 kg of clams in 10 min) with higher economic revenues in a much simpler way than before. These led again to fishing vessels from different fishing ports targeting the same fishing ground. However, this time there were an additional two fleets targeting the same fishing ground (a mechanized clam dredge fleet and a towed dredge fleet). This concentration of vessels only complicated the management. For instance, some of the new users (a towed dredge fleet from Sant Carles de la Ràpita Port, the largest fleet) defined new appropriation rules to ensure the stabilization of prices, which were continuously decreasing due to the substantial increase in landings. They divided the fishing area into three subareas, and fished for four months in each area, restricting the allowed tows per vessel and day to one and two days. However, these rules were not defined even followed by all users. This led to many conflicts among different users and led to an absolute lack of control of the striped venus clam fishery. At that time, management was open fishery access with many different "legitimate users".

3.2.2.2. Centralized governance. The Catalan Regional Government assumed the competencies for fisheries management in 1982, but its activity started in 1984. Since that time, the Catalan Regional Government has been the only authority that can officially limit appropriation and regulate provisions for the clam fisheries in the Ebro Delta area. Clam fisheries followed a top-down (centralized) management regime (Fig. 3), defined by regional authorities (Catalan Regional Government) and fishers' participation. It was often limited to sporadic consultations until 2015. From 1984–2015, the Catalan Regional Government carried out several activities related to fisheries: (1) it defined many appropriation and provision rules; (2) it set geographical limits for the clam fishing areas; (3) it issued fishing licenses including special fishing licenses for gathering clams; (4) it defined the target species for each fishing gear and fleet; (5) it defined the fishing time per day and the fishing days; and (6) set limits on the engine power by vessel, among other regulations. However, no specific regulations were detailed for the striped venus clam in the Ebro Delta. The first regulation on activity regarding towed dredge fisheries was in 1987 (Order of July 17, 1987), but all rules focused exclusively on the purple dye murex *B. brandaris*, including several appropriation rules (*i.e.*, a special license to use this fishing gear; a limitation of fishing time, fishing days, engine power by vessel and limited fishing activity at 5 m depth). The Catalan Regional Government introduced several amendments and modifications to the Order 17 of July de 1987 in subsequent years, *i.e.,* 1994, 1998, 2001 and 2009, but again, with no reference to the striped venus clam. In regard to general fishing rules and laws targeting clams for the whole Catalan coast, Decree 9/1987 of 15 January on seafood farming and harvesting specifies that fishers require a special license to gather shellfish. The Order of 20 September 2000 fixed the geographical delimitation for all clam fishing areas on the Catalan coast. The Law of 2 February 2010 authorized several fishing gears to target bivalves and established sanctions for breaking the rules. The lack of a specific management for striped venus clam perpetuated an open access regime to this fishery in the Ebro Delta area.

The information on LPUE and prices for daily shellfish auctions in the Ebro Delta area is only available between the years 2000 and 2015. Focusing on the striped venus clam, total annual landings of the towed fleet showed strong fluctuations over this period (2000–2015), with years of high total landings (up to 25 tonnes, reaching 116 tonnes in 2000) and periods with low landings (less than 5 tonnes). The LPUE oscillated from 2.40 to 259 kg/vessel/day (Fig. 5**A**). Total annual landing data and LPUE in the Ebro Delta (2000–2018) were highly positively correlated ($r = 0.83$; $p < 0.001$), showing not only similar trends but also remarkably similar fluctuations over the study period

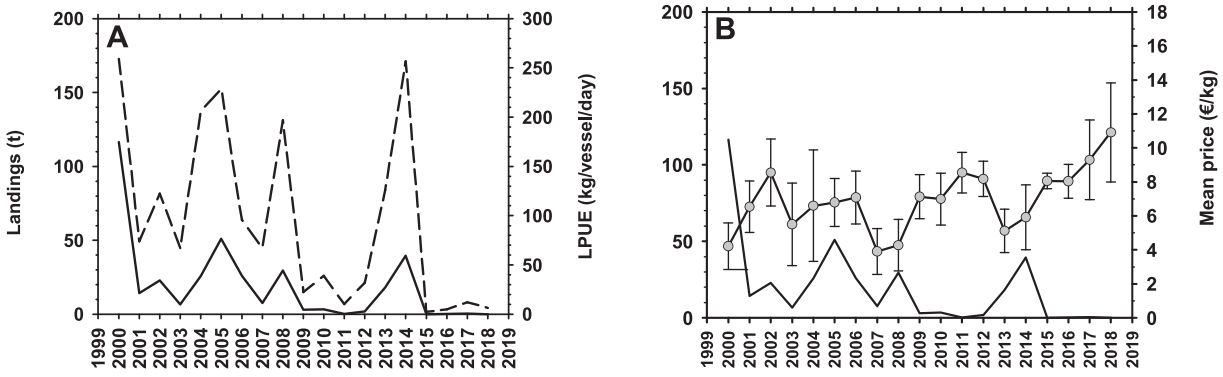

Fig. 5. Long-term trends in; (A) total annual landings (solid line) and LPUE (dashed line) of the striped venus clam in Ebro Delta (only the towed dredge fleet); and (B) total annual landings (solid line) and mean (±SE) price (€/kg) (black line with gray dots) of striped venus clam at the daily auctions at fishing ports of Ebro Delta.

(2000–2018). Unit prices on daily shellfish auctions in the Ebro Delta area (Fig. 5**B**) showed an upward trend from 4.22 €/kg (2000) to 10.90 €/kg (2018). However, there were significant oscillations of higher and lower prices. The price of striped venus clam in daily shellfish auctions in the Ebro Delta area and total annual landings were significantly negatively correlated ($r = -0.65$; $P < 0.001$), showing lower prices when more striped venus clams were gathered.

3.2.2.3. De facto co-governance. Two new management plans replaced all previous laws and rules in clam fisheries between 2014 and 2015 (Fig. 3): the first for mechanized clam fleets and the second for the towed dredge fleet. Both included the striped venus clam as a target species for each fishing gear and involved users in the management process. These co-management plans clearly defined (1) resource boundaries (fishing areas) and fishing gears; (2) regulations on appropriation and provision rules and local conditions for each fishing gear (specific catch limits, reduction of fishing effort, including number of vessels and engine power, and fishing measures to maintain the biomass level of exploited populations within safe biological limits); (3) collective-choice arrangements (*i.e.*, legitimate users can participate in making and modifying their operational rules) involving clam fishers, scientists, and administrators; (4) monitoring the status of all fishing grounds; and (5) graduated sanctions for users who violate the operational rules. However, a management plan covering both fishing fleets that target the striped venus clam in the Ebro Delta area is missing. In addition, rapid access to low-cost arenas for conflict resolution between fishers is still lacking.

From 2015–2018, the striped venus clam fishery collapsed, with the total annual landing declining to <0.5 tonnes/year and the price of striped venus clam in daily shellfish auctions in the Ebro Delta area increasing from 8.05 €/kg (2015) to 10.90 €/kg (2018) (Fig. 5**A-B**).

4. Discussion

The collapse of the striped venus fishery is not an isolated case in the western Mediterranean Sea. Most clam fisheries in this region have collapsed in recent decades (*i.e.*, the smooth clam *Callista chione* and the wedge clam *D. trunculus*), except in Andalusia. Unfortunately, little attention has focused on this crisis, which has led to job losses for hundreds of small-scale fishers. Our study in the Ebro Delta area exemplifies what has occurred across all clam fisheries in the western Mediterranean Sea. Weak governance and ineffective management over the decades progressively increased the vulnerability of the exploited stocks and led it along a collapse trajectory. Some governance systems have been successful since the fishery was established, *i.e.*, fisher's governance, centralized governance, and *de facto* co-governance, but in the end, the resource collapsed. The collapse of a clam fishery can trigger impacts to the entire ecosystem, because clam beds can play a keystone role in the ecosystem, and a decline in the population of these species may lead to unpredictable changes and cascading effects and can have significant social and economic consequences [31].

The "spotlight" focused on SSF (including clam fisheries) in the European Countries of the Mediterranean Basin in the mid-2010s. At that time, new management plans and *de facto* co-governance and co-management were implemented and widespread. Unfortunately, it was too late in the case of the striped venus clam. SSF are globally responsible for half of the catches intended for human consumption [37]. However, their relevance is decreasing in different parts of the world [38], and they face an uncertain future in Europe [39] due to conflict or competition with other users of coastal living resources and limited economic profit [40]. Our study highlights the progressive increase in fishing capacity (the ability of a fleet to catch shellfish), fishing effort (the amount of fishing, *i.e.*, the size of the fishing fleet) and technological advances (*e.g.*, in navigating, in fishing efficiency, better fishing gears and more effective fishing operations) from the 1950s to the 1990s. Beyond that period, because of the drop in landings, fishing effort (the size of the fishing fleet) declined but technological advances and fishing capacity continued to improve until the 2010s. This trend in the size of the fishing fleet was widespread across Europe [41]. The increase in the fishing capacity, fishing effort and technological advancements over small clam grounds led the fisheries to an unstable tipping point. Under these conditions, small variations in environmental factors (that would be tolerable in other circumstances) can drive a system to collapse [42]. As an example, Romanelli, Cordisco and Giovanardi [27] reviewed the literature related to the striped venus clam fishery in the Adriatic Sea and suggested that fishing pressure and the reduction in primary production both played an important roles in the decline in clam landings. Long-term studies in coastal ecosystems in the Adriatic Sea showed a consistent decrease in phytoplankton abundance and biomass over the last 20 years [43,44].

McLachlan and Defeo [8] described a general trend in landings of clam fisheries, characterized by six temporal phases: (1) development (low and consistent landings); (2) expansion (an important rise in landings resulting from increasing demand and low management regulations); (3) overexploitation (strong decline in landings); (4) closures (variation in intensity and duration based on the fishery and capacity for resilience in the harvested stock and the ecosystem); (5) stabilization/institutionalization (the formal development of management plans with scientific advice), and (6) consolidation (the sustainable exploitation over time). In our review, we observed in the striped venus clam fishery a first phase (development) when only rowing vessels targeted clams and fishers successfully managed the resource. We also observed a second phase (expansion) that involved the introduction of the clam dredge fleet and the towed fleet, with subsequent increases in catches produced by both events. There was also a third phase, namely the overexploitation and subsequent collapse of the fishery at the beginning of 2000 s. The fourth phase (closure) has not yet been implemented in our study case, but was across all other regions of the Mediterranean coast of Spain. This included a permanent closure in Murcia, the Balearic Islands and Valencia and temporary closures in Andalusia. The fifth phase occurred in our study area with the enforcement of new management plans (based on scientific advice and *de facto* co-governance and co-management). Unfortunately, the sixth phase has not been reached, as striped venus clams have not recovered.

The striped venus clam fishery is a good example of "*The tragedy of the commons*" (Hardin [45], in which users (fishers using different fishing gears, from different fishing ports) acted historically independently for their own wellbeing, and contrary to the common good of all users. This led to the destruction and depletion of the shared resource. Open access to the fishery has frequently been considered among the most important factors responsible for fisheries collapse [46]. Hardin [45] proposed two ways to avoid this tragedy: (1) assigning the ownership of the resource system (*e.g.*, striped venus clam) to the state or government; or (2) dividing the resource system into parcels assigning them to individuals (as private or individual property). The privatization of the small-scale clam fisheries has been used in recent decades as a method to control open access to the clam stocks worldwide, but not in the Mediterranean Sea. For example, individual transferable quotas (ITQs) have been successfully implemented in the Atlantic surfclam, *Spisula solidissima* and the ocean quahaugh *Arctica islandica* on the east coast of the U.S. Ostrom [47] noted that a third option is also possible through co-governing institutions to redress overexploitation of common pool resources. We observed successful self-governance in the early stages of the fishery with "*ancient clam dredge fisheries*". Baeta, Breton, Ubach and Ariza [31] analyzed all clam fisheries management on the Catalan coast based on the methodology proposed by Ostrom [47]. These authors found many management failures and factors inhibiting the sustainability of clam fisheries over time, including, amongst others, the near absence of resource monitoring or enforcement rules; a lack of conflict resolution mechanisms among fishers and other coastal users; the incongruence between appropriation and provision regulations; and

deficient nested enterprises. We observed all of these factors at play in the striped venus clam fishery in the Ebro Delta area, and across all clam fisheries on the Mediterranean coast of Spain, until the implementation of the new management plans in the 2010s. Striped clam fisheries are SES that integrate both natural and human components [18,48] and their management require a multidisciplinary approach for their sustainable exploitation [49,50]. In fact, SES are composed of multiple subsystems and internal variables within these subsystems at multiple levels that interact with each other [48]. In these SES, the resource frequently collapses when open access is allowed, the harvesters are diverse, they do not communicate, and they fail to develop rules and norms for managing the resource [48]. Currently, the new management plans include most of these aspects, being *de facto* a co-management system. This new management strategy may have better results but demands intensive fisher participation [51]. With most fishing grounds collapsed, all management actions should focus on the recovery of the striped venus clam, restoring the ecosystem and boosting the clam fisheries and their social and economic role.

The fishing grounds closed in Murcia in 1998 and in the Balearic Islands in 2003 and have not recovered after 20 years. Clams inhabiting soft bottoms such as striped venus clam are sedentary. Their stocks are structured as "metapopulations", *i.e.,* isolated subpopulations interconnected through pelagic larvae. Bivalve fisheries tend to exploit geographical areas that may be associated with subpopulations [52]. On the western Mediterranean Sea, striped venus fishing grounds were small, isolated, and productive, but probably interconnected through pelagic larvae. A recent study on the genetic structure of the wedge clam (*D. trunculus*) with a similar distribution to *C. gallina* found two different populations along the Mediterranean Coast of Spain, the first in the western Mediterranean (*i.e.,* Catalonia, Balearic Islands, Valencia, and Murcia) and the second in the Alboran Sea (Andalusia) [53]. As the striped venus clam is still being fished in Andalusia and all other fisheries along the Mediterranean coast of Spain are closed or non-operational, this suggests that striped venus clam has similar biogeographic boundaries, and consequently should be considered as two different management units (Andalusia and the other areas). Therefore, the same resource is distributed in four different Local Political Administrations (Comunidades Autónomas). Maximizing its yield requires a coordinated management strategy for Catalonia, Balearic Islands, Valencia, and Murcia. This strategy should be implemented to recover the stocks of the striped venus clam.

The recovery of bivalve beds is not an easy task. Even with a fishery closure and the end of fishing activities there is no assurance that affected populations will rebound, because as population density decreases below a threshold level, depensatory effects may render the population effectively sterile [54]. Many bivalve fisheries have collapsed worldwide from 1890 to 2000 s *e.g.*, [55–57]. In recent decades, many programs focused on wild restocking or mariculture techniques have been implemented to recover depleted clam populations [58].

We recommend the official closure of the striped venus clam grounds in Ebro Delta, and the implementation of two Management Plans for striped venus clam fisheries. The potential socioeconomic impact that could be caused by the official closure of striped venus clam grounds in Ebro Delta nowadays will be low. Fishers have progressively adapted to target other species. Management Plans should include all fishing gears targeting this species and all Local Political Administrations (Comunidades Autónomas) from the western Mediterranean region, *i.e.*, the first for Catalonia, Valencia, Balearic Islands and Murcia and the second for Andalusia. Finally, we advocate for the creation of a supra-regional Management Plan (maintaining the current *de facto* "co-governance" system) for the striped venus clam along the Mediterranean coast of Spain. At the same time, to restore depleted populations Local Political Administrations should implement a coordinated restocking and stock enhancement program, which should include the participation of fishers. Once recovered the stocks, we suggested the establishment of no-take zones (protected areas closed to fishing) in the most productive areas (*i.e.*, Ebro Delta) as a spatial management strategy for sustainable harvesting.

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Conflict of interest declaration

The authors declare no competing financial interests.

References

[1] FAO, The State of World Fisheries and Aquaculture. Contributing to Food Security and Nutrition for All, Food and Agriculture Organisation of the United Nations, Rome, 2016, p. 200.
[2] FAO, **Capture production 1950–2018**, Rome. ⟨http://www.fao.org/fishery/statistics/global-capture-production/en⟩, 2020.
[3] J.W.M. Wijsman, K. Troost, J. Fang, A. Roncarati, Global production of marine bivalves. Trends and challenges, in: A.C. Smaal, J.G. Ferreira, J. Grant, J. K. Petersen, Ø. Strand (Eds.), Goods and Services of Marine Bivalves, Springer International Publishing, Cham, 2019, pp. 7–26.
[4] D.M. Schug, K. Baxter, K. Wellman, Valuation of Ecosystem Services From Shellfish Restoration, Enhancement and Management: A Review of the Literature, Northern Economics Inc, 2009, p. 58.
[5] Eurostat, **Fisheries**, ⟨https://ec.europa.eu/eurostat⟩, 2020.
[6] O. Defeo, Marine invertebrate fisheries in sandy beaches: an overview, J. Coast. Res. (2003) 56–65.
[7] C.A. Gray, Assessment of spatial fishing closures on beach clams, Glob. Ecol. Conserv. 5 (2016) 108–117.
[8] A. McLachlan, O. Defeo, Chapter 14 - Fisheries, in: A. McLachlan, O. Defeo (Eds.), The Ecology of Sandy Shores, Third edition.,, Academic Press, 2018, pp. 331–374.
[9] EC, **The Common Fisheries Policy (CFP). Small scale fisheries**, 2020.
[10] MAPA, **Informe anual de la flota pesquera 2020 (datos 2019): equilibrio sostenible entre la capacidad pesquera y las posibilidades de pesca. Plan de acción para segmentos con sobrecapacidad**, Ministerio de Agricultura, Pesca y Alimentación. Gobierno de España, 2020.
[11] S.M. Garcia, E.H. Allison, N.J. Andrew, C. Béné, G. Bianchi, G.J. de Graaf, D. Kalikoski, M. R, J.M. Orensanz, **Towards integrated assessment and advice in small-scale fisheries. Principles and processes**, Rome, 2008.
[12] C. Pita, P.-F. J, M. Bavinck, Small-scale Fisheries in Europe: Challenges and Opportunities, Springer, Cham, New York, NY, USA, 2020.
[13] O. Guyader, P. Berthou, C. Koutsikopoulos, F. Alban, S. Demanèche, M.B. Gaspar, R. Eschbaum, E. Fahy, O. Tully, L. Reynal, O. Curtil, K. Frangoudes, F. Maynou, Small scale fisheries in Europe: a comparative analysis based on a selection of case studies, Fish. Res. 140 (2013) 1–13.
[14] A. Quetglas, G. Merino, F. Ordines, B. Guijarro, A. Garau, A.M. Grau, P. Oliver, E. Massutí, Assessment and management of western Mediterranean small-scale fisheries, Ocean Coast. Manag. 133 (2016) 95–104.
[15] E. Ostrom, M.A. Janssen, J.M. Anderies, Going beyond panaceas, Proc. Natl. Acad. Sci. USA 104 (2007) 15176–15178.
[16] B. Walker, C.S. Holling, S.R. Carpenter, A. Kinzig, Resilience, adaptability and transformability in social–ecological systems, Ecol. Soc. 9 (2) (2004) art5.
[17] N.L. Andrew, C. Béné, S.J. Hall, E.H. Allison, S. Heck, B.D. Ratner, Diagnosis and management of small-scale fisheries in developing countries, Fish Fish. 8 (3) (2007) 227–240.
[18] X. Basurto, S. Gelcich, E. Ostrom, The social–ecological system framework as a knowledge classificatory system for benthic small-scale fisheries, Glob. Environ. Change 23 (6) (2013) 1366–1380.
[19] O. Defeo, M. Castrejón, R. Pérez-Castañeda, J.C. Castilla, N.L. Gutiérrez, T. E. Essington, C. Folke, Co-management in Latin American small-scale shellfisheries: assessment from long-term case studies, Fish Fish. 17 (1) (2016) 176–192.
[20] M. Baeta, Ecology of Some Keystone Invertebrates Inhabiting Shallow Soft Bottom Communities of the Maresme Coast (NW Mediterranean Sea), University of Barcelona,, 2015.
[21] M. Huber. Compendium of Bivalve, ConchBooks, Hackenheim D, 2010.
[22] J.M. Pérès, J. Picard, Nouveau manuel de bionomie benthique, Recl. Des. Trav. De. la Station Mar. D. 'Endoume 31 (47) (1964) 5–137.
[23] M. Delgado, L. Silva, P. Moura, R.F. Sánchez-Leal, B.G. Miguel, **Variation of growth performance of the striped venus clam *Chamelea gallina* (Mollusca: Bivalvia) (Linnaeus, 1758) in relation to environmental variables along the southern part of its geographic range**, , Vie Et. Milieu - Life Environ. 65 (4) (2015) 1–10.
[24] M. Ramón, C.A. Richardson, Age determination and shell growth of Chamelea gallina (Bivalvia: Veneridae) in the western Mediterranean, Mar. Ecol. Prog. Ser. 89 (1) (1992) 15–23.

[25] G. Bargione, C. Vasapollo, F. Donato, M. Virgili, A. Petetta, A. Lucchetti, **Age and growth of striped venus clam *Chamelea gallina* (Linnaeus, 1758) in the Mid-Western Adriatic Sea: a comparison of three laboratory techniques**, Front. Mar. Sci. 7 (2020) 807.

[26] G. Manta, M. Barreiro, L. Ortega, O. Defeo, **The effect of climate variability on the abundance of the sandy beach clam (*Mesodesma mactroides*) in the Southwestern Atlantic**, J. Coast. Res. 33 (2016) 531–536.

[27] M. Romanelli, C.A. Cordisco, O. Giovanardi, **The long-term decline of the *Chamelea gallina* L. (Bivalvia: Veneridae) clam fishery in the Adriatic Sea: is a synthesis possible?** Acta Adriat. 50 (2) (2009) 171–205.

[28] M. Monari, J. Foschi, R. Rosmini, M.G. Marin, G.P. Serrazanetti, **Heat shock protein 70 response to physical and chemical stress in *Chamelea gallina***, J. Exp. Mar. Biol. Ecol. 397 (2) (2011) 71–78.

[29] J.M. Valencia, Bivalve Mollusc Parasites in the Balearic Islands: Detection of Marteilia Refringens and Perkinsus Mediterraneus using Molecular Techniques, University of the Balearic Islands, 2015, p. 187.

[30] P. Visciano, G. Scortichini, G. Suzzi, G. Diletti, M. Schirone, G. Martino, **Concentrations of contaminants with regulatory limits in samples of clam (*Chamelea gallina*) collected along the Abruzzi region coast in central Italy**, J. Food Prot. 78 (9) (2015) 1719–1728.

[31] M. Baeta, F. Breton, R. Ubach, E. Ariza, A socio-ecological approach to the declining Catalan clam fisheries, Ocean Coast. Manag. 154 (2018) 143–154.

[32] GFCM, **Capture Production 1970–2018**, Rome. ⟨http://www.fao.org/fishery/statistics/GFCM-capture-production/query/en⟩, 2020.

[33] J. Salat, Review of hydrographic environmental factors that may influence anchovy habitats in northwestern Mediterranean, Sci. Mar. 60 (S2) (1996) 21–32.

[34] M. Irazola, A. Lucchetti, J. Lleonart, A. Ocaña, J.M. Tapia, S. Tudela, La pesca en el siglo XXI: propuestas para una gestión pesquera racional en Catalunya, CCOO, CEPROM i FORCEM (1996) 289.

[35] F. Vives, P. Suau, **Sobre la chirla (*Venus gallina* L.) de la desembocadura del río Ebro**, Investig. Pesq. 21 (1962) 145–163.

[36] M. Ramón, **Estudio de las poblaciones de *Chamelea gallina* (Linnaeus, 1758) y *Donax trunculus* Linnaeus, 1758 (Mollusca: Bivalvia) en el Golfo de Valencia (Mediterráneo occidental)**, University of Barcelona, 1993, p. 412.

[37] J. Jacquet, D. Pauly, Funding priorities: big barriers to small-scale fisheries, Conserv. Biol. 22 (4) (2008) 832–835.

[38] J.J. Alió, L. Marcano, S. Soomai, T. Phillips, D. Altuve, R. Alvarez, D. Die, K. Cochrane, **Analysis of industrial trawl and artisanal fisheries of whitemouth croaker (*Micropogonias furnieri*) of Venezuela and Trinidad and Tobago in the Gulf of Paria and Orinoco River Delta**, in: F.F.T. Report (Ed.) 2000, pp. 138–148.

[39] O. Guyader, P. Berthou, F. Daurès, Decommissioning schemes and capacity adjustment: a preliminary analysis of the french experience, Fish. Buybacks (2007) 105–132.

[40] F. Maynou, B. Morales-Nin, M. Cabanellas-Reboredo, M. Palmer, E. García, A. M. Grau, Small-scale fishery in the Balearic Islands (W Mediterranean): a socio-economic approach, Fish. Res. 139 (2013) 11–17.

[41] J.D. Bell, R.A. Watson, Y. Ye, Global fishing capacity and fishing effort from 1950 to 2012, Fish Fish. 18 (3) (2017) 489–505.

[42] R. Cudney-Bueno, X. Basurto, Lack of cross-scale linkages reduces robustness of community-based fisheries management, PLOS ONE 4 (7) (2009) e6253.

[43] P. Mozetič, C. Solidoro, G. Cossarini, G. Socal, R. Precali, J. Francé, F. Bianchi, C. De Vittor, N. Smodlaka, S. Fonda, Umani, **Recent trends towards oligotrophication of the northern adriatic: evidence from chlorophyll a time series**, Estuaries Coasts 33 (2) (2010) 362–375.

[44] Ž. Ninčević Gladan, I. Marasović, B. Grbec, S. Skejić, M. Bužančić, G. Kušpilić, S. Matijević, F. Matić, Inter-decadal variability in phytoplankton community in the Middle Adriatic (Kaštela Bay) in relation to the North Atlantic Oscillation, Estuaries Coasts 33 (2) (2010) 376–383.

[45] G. Hardin, The tragedy of the commons, Science 162 (3859) (1968) 1243–1248.

[46] B. Worm, R. Hilborn, J.K. Baum, T.A. Branch, J.S. Collie, C. Costello, M.J. Fogarty, E.A. Fulton, J.A. Hutchings, S. Jennings, O.P. Jensen, H.K. Lotze, P.M. Mace, T. R. McClanahan, C. Minto, S.R. Palumbi, A.M. Parma, D. Ricard, A.A. Rosenberg, R. Watson, D. Zeller, Rebuilding global, Fish., Sci. 325 (5940) (2009) 578–585.

[47] E. Ostrom, **Governing the Commons: the evolution of institutions for collective action**, 1990.

[48] E. Ostrom, A general framework for analyzing sustainability of social-ecological systems, Science 325 (5939) (2009) 419–422.

[49] J.B.C. Jackson, M.X. Kirby, W.H. Berger, K.A. Bjorndal, L.W. Botsford, B. J. Bourque, R.H. Bradbury, R. Cooke, J. Erlandson, J.A. Estes, T.P. Hughes, S. Kidwell, C.B. Lange, H.S. Lenihan, J.M. Pandolfi, C.H. Peterson, R.S. Steneck, M. J. Tegner, R.R. Warner, Historical overfishing and the recent collapse of coastal ecosystems, Science 293 (5530) (2001) 629–637.

[50] G.H. Engelhard, R.H. Thurstan, B.R. MacKenzie, H.K. Alleway, R.C.A. Bannister, M. Cardinale, M.W. Clarke, J.C. Currie, T. Fortibuoni, P. Holm, S.J. Holt, C. Mazzoldi, J.K. Pinnegar, S. Raicevich, F.A.M. Volckaert, E.S. Klein, A.-K. Lescrauwaet, He.E. Anderson, ICES meets marine historical ecology: placing the history of fish and fisheries in current policy context, ICES J. Mar. Sci. 73 (5) (2015) 1386–1403.

[51] S. Jentoft, R. Chuenpagdee, Fisheries and coastal governance as a wicked problem, Mar. Policy 33 (4) (2009) 553–560.

[52] J.M. Orensanz, A.M. Parma, S.J. Smith, Dynamics, assessment, and management of exploited natural scallop populations, in: S.E. Shumway, G.J. Parsons (Eds.), Developments in Aquaculture and Fisheries Science, Elsevier, 2016, pp. 611–695.

[53] M.D. Amandine, C. Lejeusne, E. Karapatsiou, J.A. Cuesta, P. Drake, E. Macpherson, L. Bernatchez, C. Rico, **Implications for management and conservation of the population genetic structure of the wedge clam *Donax trunculus* across two biogeographic boundaries**, Sci. Rep. 6 (1) (2016) 39152.

[54] S.A. William, B. Norman J, H. Melissa M, M. Dan C, P. Melanie L, P. Sarah C, S. Don E, **Restoration of bay scallop (*Argopecten irradians* (lamarck)) populations in Florida coastal waters: planting techniques and the growth, mortality and reproductive development of planted scallops**, J. Shellfish Res. 24 (4) (2005) 883–904.

[55] M.P.J. Oreska, B. Truitt, R.J. Orth, M.W. Luckenbach, **The bay scallop (*Argopecten irradians*) industry collapse in Virginia and its implications for the successful management of scallop-seagrass habitats**, Mar. Policy 75 (2017) 116–124.

[56] N. Tezuka, S. Kamimura, M. Hamaguchi, H. Saito, H. Iwano, J. Egashira, Y. Fukuda, T. Tawaratsumida, A. Nagamoto, K. Nakagawa, **Settlement, mortality and growth of the asari clam (*Ruditapes philippinarum*) for a collapsed population on a tidal flat in Nakatsu, Japan**, J. Sea Res. 69 (2012) 23–35.

[57] D. Smyth, D. Roberts, L. Browne, **Impacts of unregulated harvesting on a recovering stock of native oysters (*Ostrea edulis*)**, Mar. Pollut. Bull. 58 (6) (2009) 916–922.

[58] J. Beseres Pollack, A. Cleveland, T.A. Palmer, A.S. Reisinger, P.A. Montagna, A restoration suitability index model for the eastern oyster (*Crassostrea virginica*) in the Mission-Aransas Estuary, TX, USA, Plos One 7 (7) (2012) e40839.

[59] F. Vives, P. Suau, Sobre la chirla (*Venus* gallina L.) de la desembocadura del río Ebro, Inv Pesq 21 (1962) 145–163.