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## Challenging the ‘artisanal vs. industrial’ dichotomy in French Atlantic fisheries: An organizational typology of multi-vessel fishing firms

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### Abstract :

We put under scrutiny the ‘artisanal vs. industrial’ dichotomy used by French fisheries management for classifying fishing operations. Recent evolutions in the Atlantic fishing sector urge us to question its applicability. In particular the definition of the so-called ‘artisanal fishing model’ is under pressure (e.g., decline of family-based fishing, multi-vessel companies increasingly common, emergence of new forms of firm governance). Using mixed-method research (interviews, multiple correspondence analysis (MCA) and hierarchical clustering), we propose a new typology for classifying multi-vessel fishing firms, based on six organizational attributes (ownership structure, firm structure, management strategy, firm size, fishing strategy and valorization strategy). We have carried out a three-step analysis. First, the MCA suggests that the diversity of organizational forms can be described to a great extent in terms of the profile of the owner and the firm’s management and valorization strategies. The cluster analysis then separates organizational configurations in five types, based on cluster-specific modalities: access to key information, legal form, vessel maintenance and standardization, growth objectives and management structure. The final description of the types draws from additional interview data as well as variables that were not used in the analysis. The typology captures the diversity of governance configurations currently existing in the sector, while providing some insight into their origins and future trajectories. We conclude that the artisanal model is outdated and insufficient for describing the organizational diversity of modern-day fishing firms, especially those in the 12–18 m and 18–24 m segments.

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## Highlights

► The 'artisanal vs. industrial' dichotomy traditionally used in French fisheries management is no longer adequate. ► Multi-vessel fishing firms in France can be classified in 5 types based on organizational attributes. ► There is a high diversity in firm governance and organization across fleet segments. ► Across segments, governance is evolving towards scale increase, rationalization, product valorization, access to information.

**Keywords** : Fishing firms ;Organizational structure; Firm governance; Multi-vessel ownership; Concentration; Artisanal fisheries ;Fisheries management

## 1 Introduction

For the purpose of research and management, capture fisheries are often divided into discrete categories. A commonly used division is that of small-scale versus large-scale (or industrial) fisheries [1–9]. The concept was first introduced by Thomson [1] in an attempt to distinguish company-owned large-investment fishing units from privately owned/managed small-scale units. Thomson's classification was subsequently updated by Maclean [2] and later by Berkes *et al.* [4], to include a description of common characteristics of small-scale fisheries. The conceptual framework was further expanded by Ruttan *et al.* [3] (separation of the two categories on a relative scale, thus providing a more objective definition of small-scale fisheries), Sumaila *et al.* [5] and Therkildsen [6] (inclusion of a number of policy-relevant socioeconomic and environmental impact indicators). While such dichotomies successfully capture some of the worldwide diversity into manageable categories, they are also criticized for oversimplifying reality and for not being able to provide clear boundaries between the two categories [5,10,11]. Especially the formulation of a universal definition of small-scale fisheries has proven to be difficult, given their diversity [10,12] and the fact that they can be highly specific to certain locations [9–11]. This is further complicated by the fact that countries often use their own criteria for defining SSF [9,13].

The main classification used by French fisheries management contrasts 'artisanal' fisheries with 'industrial' fisheries. Hereby industrial fishing operations are seen as capital-intensive [14] and artisanal operations as small to medium-scale, family-owned [15] and requiring relatively low capital investments [7]. Artisanal fishing is usually described using two elements: first, the fisher (*artisan*) is (co-)owner of their fishing vessel, and has the statute of 'embarked owner'<sup>1</sup>. The owner-operator invests their own capital (sole proprietorship) and manages the firm technically and economically [16]. Second, the owner-operator typically has one fishing vessel, which is generally smaller than 12 meters in length, but may be up to 25 m [17]<sup>2</sup>. Crew size is generally small, with a maximum of 5-10 for larger vessels [18]. Other characteristics of the so-called 'artisanal fishing model' include a high degree of family involvement, share-based remuneration, strong anchoring in the local economy and the polyvalence of fishing activity [14–16,18–21]. Industrial fishing operations can be understood as those with gross tonnage >50 GT, and of which the owner does not actively fish [22]. The owner has multiple fishing vessels >24 m (and up to 90 m), each employing between 10 and 70 crew.

French fisheries legislation includes specific provisions for artisanal fisheries [17], and the preservation of the artisanal fishing model is considered of key importance [18,23–25]. Yet, its definition has been named unclear [26,27], as it encompasses a broad range of operations, from subsistence fishing to companies operating multiple trawlers. An increasing trend of multi-ownership [28,29] challenges the '*one man, one vessel*' definition of artisanal fishing. At the same time, family-based fishing is in decline [15,18,30] and new forms of firm structuration and governance are emerging [18] (e.g., joint ventures with corporate fishing firms; [31]). Evidence points towards the existence of a diversity of organizational forms, which to date remain little studied. Evolutions in the industrial fishing sector include horizontal growth

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<sup>1</sup> This statute contrasts fisher-operators (actively fishing) with shore-based managers.

<sup>2</sup> Artisanal fisheries can be further subdivided into a coastal fleet (*pêche côtière*) (≤12 m vessels fishing inshore) and an offshore fleet (12-25 m vessels fishing offshore) (*pêche hauturière*). Our focus in this paper is on the artisanal vs. industrial dichotomy.

through mergers and acquisitions, and backward vertical integration by retailers and processors [32,33]. There is substantial evidence of concentration, most notably in the tuna industry, with the 2011 merger of three fishing companies and the subsequent acquisition by a Dutch corporation in 2017. Foreign investment has increased in recent years, with investments by Dutch, Irish and Icelandic corporations catching the eye [33].

In light of these evolutions, we hypothesize that the traditional “industrial vs. artisanal” dichotomy is outdated. The artisanal fishing model in particular seems to no longer match the structural and organizational complexity of modern-day fishing firms as observed in the field. A better understanding is needed of what drives fishing firms to expand horizontally (adding fishing vessels to the fleet) and vertically (venturing into new activities up or down the value chain), and how such expansion is reflected in (or mandated by) the firm’s organizational structure. Overall, little research has been carried out on the relationship between organizational structure of fishing firms and their investment behavior. Nøstbakken *et al.* [34] have suggested that organizational structure of fishing firms may be an important determinant of investment behavior, and that the firm (not the vessel) is the main decision-making unit, and thus the appropriate unit of analysis.

In this paper, we present a typology of organizational structure of French Atlantic fishing firms operating multiple fishing vessels. The focus on multi-vessel firms ensures that a broad spectrum of operations are included in the analysis, and specifically includes the multi-vessel fishing operations that would otherwise be considered ‘artisanal’ based on other criteria. The aim is (1) to establish an understanding of what defines French Atlantic fishing firms in terms of organizational attributes, (2) to describe in detail the different organizational forms found in the fishing sector today, and (3) reflect on their trajectories (past, present, future).

## **2 The fishing firm as an organizational unit**

More than a production function in which inputs are transformed into outputs, the firm is an organizational unit whose internal governance structure varies with changes in both the institutional environment (external drivers) and the attributes of economic actors (internal drivers) [35]. Starting with the seminal works of Coase [36] and Williamson [37,38], it is now well-established that the organizational structure of firms is an important determinant of firm strategy [39], innovation [40] and performance [39].

Rey *et al.* [26] have developed a classification of French fishing firms based on (1) exploitation strategy (a continuum between profit maximization and diversification/cost minimization) and (2) the mode of unit reproduction (growth-oriented, stable or shrinking). Different systems are then identified based on combinations of two factors of production: labor and (physical) capital. However, in addition to tangible assets (e.g., fishing vessels, warehouses), firms possess a range of idiosyncratic assets that cannot be replicated by the market, but are essential to a firm’s competitiveness [39] – and which we argue must be included when describing the organization structure of fishing firms. *Human capital resources* include training, knowledge and experience of workers and managers in the firm, and the relationships between them. In the fishing sector, this may include formal training (i.e., fishing degrees from deckhand to skipper), tacit knowledge on fishing grounds and fish behavior [41] and skipper-crew relationships [30,42]. *Organizational capital resources* refer to how the firm is organized, both internally and in dealing with the external environment (e.g., competitors, buyers, producer organizations, authorities). It encompasses both formal and informal structures. Formal structures include a firm’s reporting structure, coordinating systems, scale, scope, integration

and hierarchy. Informal structures refer to the firm's organizational culture (i.e., the set of beliefs and expectations including communication, teamwork, flexibility, trust, work ethic, etc.) [39,40].

### 3 Material and methods

#### 3.1 Case study description

In 2018, 2905<sup>3</sup> fishing vessels were registered in France's Atlantic, Channel and North Sea fishing ports<sup>4</sup>, 811 of which were owned in multi-vessel operations, corresponding to 28% of the entire fleet, 38% of total kW and 43% of landed value<sup>5</sup>. There were 2180 vessels (74.6%) <12 m and 725 (24.8%) >12 m. The fleet is diverse, both in terms of vessel size and fishing techniques. The main components are demersal trawlers/seiners (n=591), drift and fixed netters (n=551), vessels using pots and traps (n=388), vessels using hooks (n=296), and dredgers (n=270) (see [43] for a more complete description).

Compared to other fisheries in France, landings from the French Atlantic fleet are characterized by a high species diversity [44]. In 2018, total landings were 410,000 tons for a value of 981 M€, with nearly 75% of this value landed by vessels over 12 m (7 species made up 50% of the landed value). Main species in terms of value are hake (*Merluccius merluccius*), monkfishes (*Lophius spp.*), scallops (*Pecten maximus*), common sole (*Solea solea*), Atlantic cod (*Gadus morhua*) and Norway lobster (*Nephrops norvegicus*). In terms of volume, key species include pelagic species like herring (*Clupea harengus*), sardine (*Sardina pilchardus*), mackerel (*Scomber scombrus*) and saithe (*Pollachius virens*).

Fishing fleets are managed under the regulations of the EU's Common Fisheries Policy (CFP) [45]. This includes the use of Total Allowable Catches (TACs) and national quotas as well as input controls such as gear restrictions and effort limitations aimed at limiting entry to the fishery (kW, GT, licenses) [29]. The allocation of fishing opportunities (quotas, licenses) has been delegated to Producer Organizations (POs) for TAC-managed species, and to Fisheries Committees (*Comités des Pêches*) for non-TAC species [46,47]. While market transactions of fishing opportunities are prohibited by law [17], they can be transferred with the fishing vessel when the vessel is sold [46]. Historical track records (2001-2003) of fishing vessels form the main criterion for allocations by POs [47], creating an incentive for fishers to invest in second-hand vessels with track records attached. Access to the resource is thus directly linked to a fisher's ability to invest – a setup that has created a deep socioeconomic divide between firms, and which has been named unjust towards new entrants and small-scale fishers [31,48,49]. As a mitigation measure, two track records reserves were created (one PO and one national) to be redistributed to these target groups based on specific criteria (e.g., environmental, social and economic) (see Articles R. 921-47 and 48 of the Rural Code [17]). A better understanding of the

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<sup>3</sup> We excluded 16 tuna fishing vessels registered in Atlantic ports but operated in other regions (high seas).

<sup>4</sup> Throughout this paper, we will use the term 'Atlantic' to group the Atlantic (*sensu stricto*), the Channel and the North Sea.

<sup>5</sup> We must note that this picture is still an underestimation of multi-ownership. Data on vessel ownership are collected at the level of the registered *operator*, which may be another entity than the *owner*. An owner (a natural or legal person) may in fact own multiple fishing firms, but this cannot be discerned from the data.

economic organization of fishing firms may thus inform the design of such redistribution criteria in future policy reforms.

### 3.2 Semi-structured interviews and key information

Semi-structured interviews were conducted with operators with two or more fishing vessels (n=80) along the French Atlantic coastline between December 2017 and April 2019 (Figure 1). This group comprised both vessel owner-operators and managers of fishing firms. Throughout this paper, we will use the generic term 'fishers', to encompass both categories. Participants were selected across fisheries according to a quota sampling method, in order to cover the different fishing districts, vessel sizes and fleet segments. As such, our sample captured 315 vessels, representing 39% of vessels and 71% in terms of landed value of the subpopulation (operators with  $\geq 2$  fishing vessels) (Table 1).

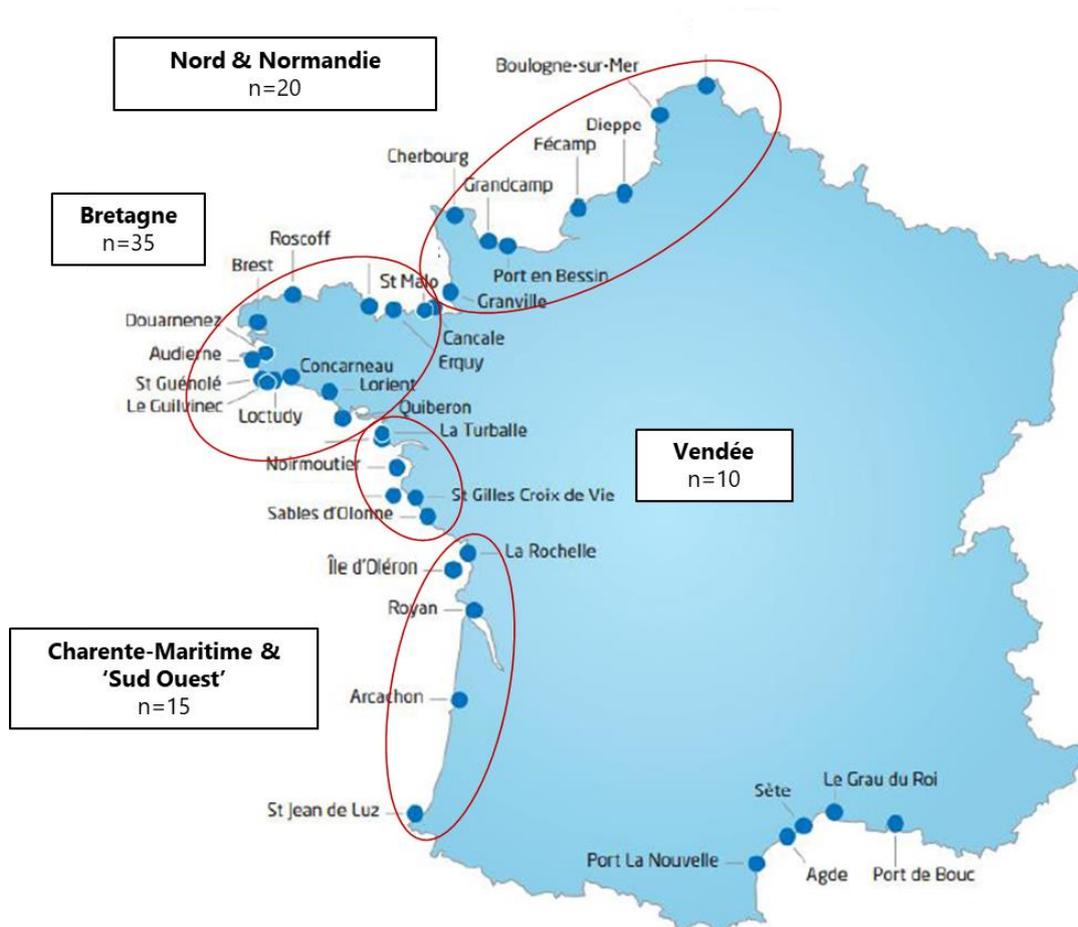


Figure 1: Study area. Interviews (n=80) were conducted with operators with two or more fishing vessels registered in Atlantic fishing ports. Figure adapted from FranceAgriMer [50].

Interview questions were prepared based on theory, expert knowledge and evidence from the field (see further). The interviews were conducted in the homes of fishers, at their landing sites or in their dockside offices. Interviews lasted between 1 and 3 hours. Respondents were asked about key elements related to the organization of their businesses, including ownership structure, firm structuration, funding strategy, management strategy, firm size, fishing strategy, valorization strategy. Additional information was collected about the fisher's personal history (age, education, generational fishing, activities prior to fishing, etc.) and firm development

(access to fishing opportunities, perspectives on fisheries management, involvement in collective action, personal motives for investing, etc.).

Table 1: Ownership structure of the French Atlantic fleet (2018). NB: tuna vessels registered in Atlantic ports but fishing in other regions were excluded. (\*): % of the total population; (\*\*): % of sub-population interviewed. Operators were adjusted based on survey results. Sources: DPMA-Ifremer Fisheries Information System (SIH) (2018) and our survey.

No. vessels/operator	1	2	3-5	5-9	≥10	Total population	Sub-population >1 vessel*	Survey sample**
No. operators	2094	236	64	11	6	2411	317 (13%)	80 (25%)
No. vessels concerned	2094	472	194	72	73	2905	811 (28%)	315 (39%)
Total hp (10 <sup>3</sup> kW)	310	75	46	31	40	502	192 (38%)	115 (60%)
Landed volume (10 <sup>3</sup> tons)	229	52	54	35	39	409	180 (44%)	123 (68%)
Landed value (M€)	560	124	97	91	109	981	421 (43%)	301 (71%)

The interviews were transcribed verbatim. Then, each transcript was read through several times and coded manually following the framework set out by Riessman [51] for thematic narrative analysis. Participants' answers were converted to discrete values (Table 1), and the resulting categorical variables were included in a database for further analysis. Finally, information collected via interviews was supplemented with data that we obtained indirectly (e.g., via other respondents, fishing industry magazine articles, internet broadcasts), as well as data compiled from Ifremer's SIH (*Systèmes d'Informations Halieutiques*) database<sup>6</sup> (landings, fishing activity, characteristics of vessels and operators).

In addition to the interviews with fishers, 20 semi-structured interviews were performed with key actors including fisheries administration (national and regional, n=2), representatives of POs (n=4) and fisheries committees (n=6), business lawyers (n=2), financial experts/vessel brokers (n=2), bank executives (n=2), wholesalers (n=1) and shipyards (n=1).

### 3.3 Selection of firm attributes for typology construction

Commonly used organizational attributes in the field of strategic management include firm size [52,53], ownership and/or management structure [53–57]; organizational culture and values [40,58]; the degree of market power, rivalry and competition [40,59]; the proportion of debt and equity funding [40]; human resource management [60]; and the presence of strategic resources within the firm [39,61–64].

To develop a typology of firm organization adapted to the fishing industry, we also took the following elements into account. First, we consider that fishing firms can grow in two basic ways: either by adding vessels to their fleet (horizontally), or by expanding activities beyond fishing (e.g., processing, developing sales, etc.) (vertically). A second consideration is related to the specifics of fishing as an economic activity (e.g., its rural and family character, the organization of labor, crew remuneration, etc.), its position within a broader socio-economic context, and more specifically, a complex institutional environment (fisheries management). Finally, the French fishing industry exhibits a number of particularities in the way fisheries production is organized: e.g., the common property and the non-transferability of fisheries resources [46,47], the organization of labor in trade unions [65], the strong cooperative tradition [66], and, more generally, labor and fiscal law.

Six attributes (themes) were selected for typology construction: ownership structure, firm structure, management strategy, firm size, fishing strategy and valorization strategy. For each attribute, one or more variables were constructed (17 in total). Then, for each variable, discrete

<sup>6</sup> See <https://sih.ifremer.fr/> (Accessed on 18/12/2020)

categories were decided upon. Table 2 summarizes these themes and variables, and their modalities.

**Ownership structure.** Ownership structure has implications for firm governance and performance [67–69]. In fisheries, the variety of ownership structures is commonly placed on a spectrum, sometimes including elements of geographical location and the mode of production: i.e., from household producers and self-employed owner-operators (private businesses) to “capitalist”<sup>7</sup> fishing firms and (multinational) corporate fishing companies [7,15,42,70–72]. A fishing company may be owned by one or more individuals, a family, or a corporation [15,33,70,73]. In addition to this, different forms of joint ownership exist – between individuals, companies (joint ventures) or a combination of these. The profile of the owner(s) has implications for the way production is organized in terms of crew management and remuneration [15,30,42,70], fishing strategy [74,75], marketing strategy [76,77], local embeddedness [78], and succession of the business [15,71]. Another aspect of ownership structure is access to and use of different sources of funding (debt, equity, corporate).

**Firm structure.** The choice of legal form determines to a great extent the entrepreneur’s outlook in terms of investment opportunities, tax regime and transmission of the company at retirement. Across the EU fishing industry, there seems to be a shift from simple legal forms (sole proprietorship or partnership companies) to limited liability companies (LLCs) [15,79–81]. LLCs have a number of advantages for artisanal fishers, including tax optimization and a better protection of the co-owning partners as well as their spouses against debt, divorce or decease [79]. Under firm structure we also understand the objectives and direction of growth of the firm. Other aspects of firm structure are included as proxies for structural complexity: the presence of holdings, advanced structuration (i.e., a company structure for each vessel, held together by a holding, see [81]). The embeddedness of the entrepreneur and the firm in local, regional and national networks [29] is furthermore included, as well as the objectives and direction of growth [82].

**Management strategy.** In France, family-based fishing has been a key element in the development of the artisanal fleet in the post-war period [15,19,66,83,84]. Family firms are typically characterized by the alignment of ownership, management and control [85,86]. The economic model of family fishing firms in France based on (a) keeping productive capital within the family, (b) securing employment for family members on board fishing vessels and (c) the possibility of drawing upon un(der)paid labor [15]. In non-family firms, the owners (the principals) delegate a part of the decision-making authority to another person (the agent) in order to avoid agency problems due to information asymmetry or moral hazard [55,87]. In its most simple form, the agent is the skipper who is responsible for monitoring the fishing operation at sea. In large fishing firms ownership and control are separated, and salaried managers may be employed to oversee the fishing operations from shore. This constitutes two additional agency relationships: between the manager and the skippers [87], and between the manager and the shareholders [55,56]. For the purpose of this paper, we are particularly interested in the choice of the ‘right type’ of agent (see [87]) (e.g., a family member with a stake in the business versus an ‘external’ skipper or manager) and the incentive contracts that underlie these relationships.

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<sup>7</sup> For an examination of what makes a fishing firm “capitalist”, we refer to St Martin (2007) and McCall Howard (2012), who present different perspectives.

**Firm size.** Decisions to invest or disinvest in physical capital are often based on economic incentives [88–91]. The number and size of vessels are important factors in this decision [92,93] and serve as proxies for firm size in our analysis. Also the total number of crew is taken into consideration.

**Fishing strategy.** Fishing firms may diversify their fishing activity to mitigate risk and maintain profitability [74,94]. Generalist firms aim to keep total variable costs to a minimum so they can easily switch between fisheries. Diversification is commonly accepted as the default for small-scale and artisanal fishing in France [14,20]. Specialization may simply be a consequence of the fishing opportunities available to the firm at a given point in time (and the markets that exist for them), but it may also be part of a broader strategic trajectory. Such trajectory is focused around realizing economies of scale and scope [59] through vertical integration, internalization of peripheral activities (e.g., bookkeeping, crew management, vessel maintenance) and standardization (e.g., a fleet of standardized fishing vessels) [74,95]. These aspects may be associated with significant efficiency gains for the firm.

**Valorization strategy.** In 2001, Guillotreau and Le Grel [96] described a general trend of formalization and contracts along European fish supply chains, in particular for larger companies – a trend that has steadily continued [32,33,73]. Also in other parts of the world, the default modes of selling fish on spot markets and through competitive auctions are being replaced with short and long-term contracts, sometimes involving exclusive dealing and ownership interests in vessels by downstream actors [76,77,97]. In addition to contracts, a trend of full vertical integration (vertical ownership, hierarchy) [57] is observed for both producers (forward integration) and downstream actors (traders, retailers, processors) (backward integration) [41,96]. Empirical studies have shown that transaction costs as well as strategic considerations play an important role in a firm’s decision to vertically integrate [41,76,77,97–99].

### **3.4 Multiple Correspondence Analysis with hierarchical clustering**

We use Multiple Correspondence Analysis (MCA) in combination with hierarchical clustering to reveal patterns in our dataset. In MCA, the dataset is represented as a cloud of points in a multidimensional Euclidean space. This is then transformed into a low-dimensional space in which the relative positions of the points and their distribution along these dimensions form the basis for interpretation. Its power lies in its capacity to uncover groups in complex multivariate datasets without needing to meet any *a priori* assumptions about the data [100]. This makes it a useful tool for typology construction. We selected 10 variables that captured the structure of the phenomenon under study well [101], and for which frequency distributions were balanced and association was low (Cramer’s V kept as low as possible) (see Table 2). In a second step, a cluster analysis was carried out on the MCA results, to separate individuals into groups. The MCA and the subsequent cluster analyses were performed using the FactoMineR package [102] in R Studio (version 1.1.463).

Table 2: Themes and variables considered for typology construction. (-) not included in the quantitative analysis; (S) not included in the quantitative analysis; supplementary variable. Count: number of occurrences in the interviews.

Theme	Variable	Categories	Count	
Ownership structure	Owner profile	OWN1	Individual	40
		OWN2	Family	23
		OWN3	Shared (capital holdings)	11
		OWN4	Corporate	6
	Foreign ownership <sup>(S)</sup>	FOREIGN0	No foreign ownership	70
		FOREIGN1	Foreign ownership	10
	Capital funding <sup>(-)</sup>	FUND1	Mainly own funding	5
		FUND2	Mainly bank funding	66
		FUND3	Mainly corporate funding	4
		FUND4	Mixed	5
Firm structure	Legal definition	LEG1	Sole proprietorship	35
		LEG2	Combination of sole proprietorship and limited liability company	10
		LEG3	Limited liability company	35
	Level of structuration <sup>(-)</sup>	STRUCT1	Simple (little structuration)	39
		STRUCT2	Medium (some structuration; with holding)	20
		STRUCT3	Completed (fully structured; as the owner wants it to be)	16
		STRUCT4	Advanced (company for each vessel)	5
	Growth objective and direction	GROW0	No real growth objectives	42
		GROW1	Focus on acquisition of fishing vessels	32
		GROW2	Acquiring vessels and expanding activities	6
	External advice and information	ADVICE1	Weak (no enabling environment)	38
		ADVICE2	Medium (access to good bookkeeping advice, sometimes also legal advice)	25
		ADVICE3	Strong (enabling environment with high level legal advice)	17
Management strategy	Management strategy	MANSTR1	Simple (owner = manager, embarked)	44
		MANSTR2	Medium (owner = manager, shore-based)	14
		MANSTR3	High (owner ≠ manager, salaried)	16
		MANSTR4	Outsourced (owner ≠ manager; third party)	6
Firm size	Number of vessels <sup>(S)</sup>	VES1	2 vessels	35
		VES2	3-5 vessels	28
		VES3	6-10 vessels	12
		VES4	> 10 vessels	5
	Crew size <sup>(S)</sup>	CREW1	0 to 2	6
		CREW2	3 to 5	17
		CREW3	6 to 10	15
		CREW4	11 to 15	13
		CREW5	16 to 30	11
		CREW6	>30	18
Fishing strategy	Size of vessels <sup>(S)</sup>	SIZE1	<=12m	33
		SIZE2	>12m	35

		SIZE3	Mix	12
<b>Specialization</b>		SPEC0	No specialization strategy	26
		SPEC1	Specialization in a portfolio of target species	17
		SPEC2	Specialization in 1 or 2 target species or species groups	37
<b>Complementarity <sup>(S)</sup></b>		COMPL0	No complementarity of activity	67
		COMPL1	Complementarity of activity	13
<b>Standardization</b>		STAND0	No standardization of fishing vessels	47
		STAND1	Standardization of fishing vessels: one fleet	24
		STAND2	Standardization of fishing vessels: subfleets	9
<b>Vessel maintenance</b>		MAINT1	Simple (most maintenance is externalized)	60
		MAINT2	Medium (manpower dedicated to maintenance)	15
		MAINT3	Strong (internalization of maintenance, incl. workshops)	5
<b>Crew rotation</b>		ROT1	None or opportunistic	57
		ROT2	Extensive	14
		ROT3	Intensive	9
<b>Valorization strategy</b>	<b>Valorization strategy</b>	VALOR1	Spot markets	49
		VALOR2	Direct sales + spot markets	20
		VALOR3	Processing and/or wholesaling	7
		VALOR4	Processing with sourcing strategy and/or backward integration	4

## 4 Results

### 4.1 Multiple Correspondence Analysis and Hierarchical Clustering

In this section, only the main outputs of the Multiple Correspondence Analysis (MCA) and Hierarchical Clustering are included. For a step-by-step description of the analysis, we refer to Annex I. Figure 2 shows the results of the MCA and the hierarchical clustering. A stable five cluster solution was retained. Firms in Cluster 1 are characterized mainly by an embarked owner-operator (95.6% of individuals in the cluster), who is the single owner (84.4%) of a sole proprietorship (77.8%). Entrepreneurs do not benefit from good external advice (84.4%). Firms in Cluster 2 are limited liability companies (86.7%) owned by families (80.0%). Outsourcing of management is found for 40.0% of firms in the cluster. Cluster 3 is characterized by shore-based managers (ex owner-operators; 85.7%) and the valorization through forward vertical integration (processing and/or wholesaling; 100%). Cluster 4 is characterized by 'ownership sharing' between skippers and owners (shareholders) (90.0%), shore-based managers (external, salaried; 100%) and a focus on the acquisition of fishing vessels (100%). Cluster 5 is characterized by backward vertical integration (valorization and supply security; 100%), strong internalization of vessel maintenance (100%) and corporate ownership (100%).

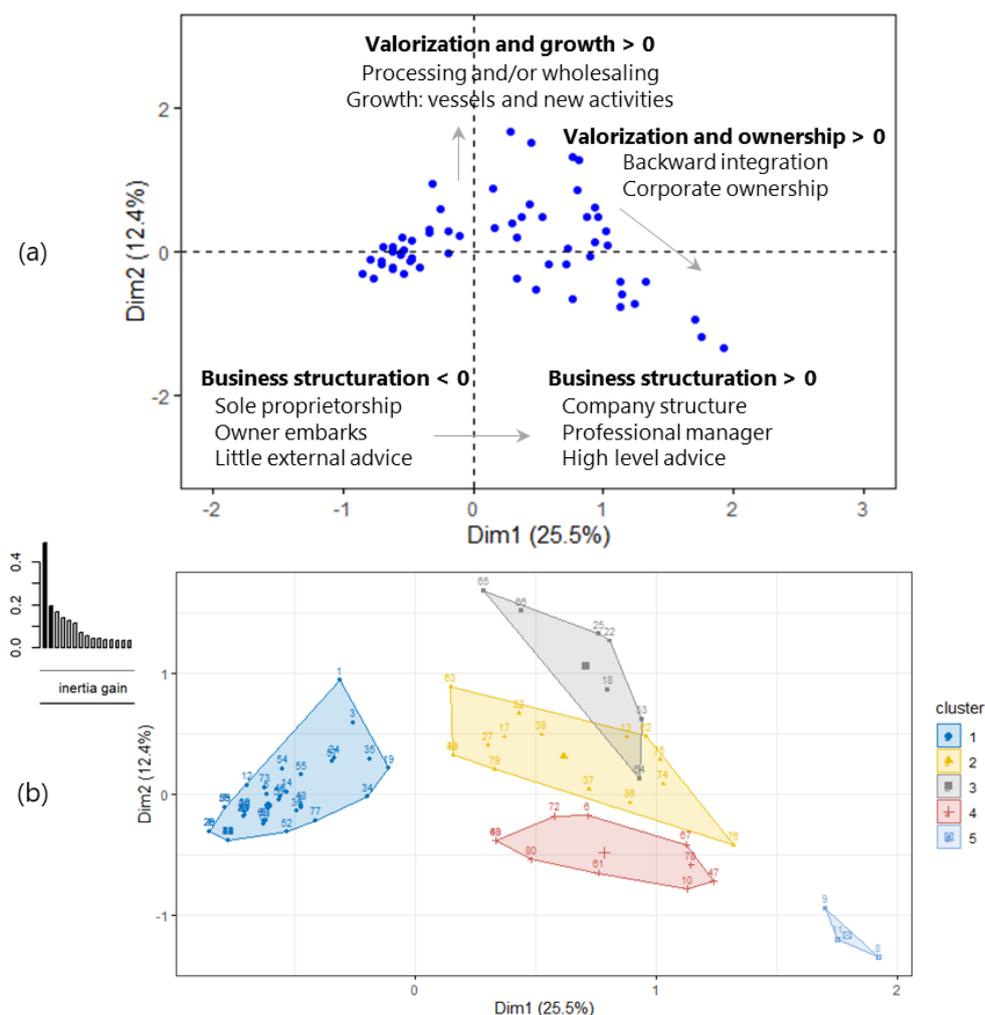


Figure 2: (a) result of the MCA with interpretation of the axes: business structuration on the horizontal axis, valorization on the vertical axis and a third dimension (not plotted) describing ownership structure; (b) result of hierarchical clustering.

## 4.2 Review of organizational types

In this section, the description of the Types based on the MCA and cluster analysis is enriched with additional interview data.

**Type 1: Small-multi-owners** (n=45). This group comprises small fishing firms generally composed of 2 to 3 fishing vessels (n=38) smaller than 12 m (n=32). The firm is owned and managed by an individual, and has a simple legal structure (sole proprietorship). Management is characterized by an embarked owner-operator who either alternates between vessels (often seasonally) or commands one vessel while delegating the operation of their other vessel(s) to someone else (mostly their son). The owner's spouse is rarely involved, and if they are, they have little decision power. There is generally no real growth objective among small multi-owners. They became multi-owner out of practical considerations: access to fishing opportunities (diversification), out of fiscal considerations, or simply when opportunities came up.

Besides the shared characteristics which define Cluster 1 at the selected threshold (WSS=1.09; BSS=0.1, see Annex I), there is quite some variation between the firms, which causes some of them to break away from the core of the cluster. These 'emerging entrepreneurs' (n=9) have grown their companies up to 3 to 4 vessels, and may be on their way to acquire more. As such, they start resembling fishing firms in the periphery of Cluster 2. They often combine sole proprietorship with a company structure, and are in the middle of restructuring the firm and formalizing management roles. Fishing is characterized by more specialization, which sometimes goes hand in hand with a proactive marketing approach (e.g., developing new markets, direct sales).

**Type 2: Medium to large-scale family fishing firms** (n=16). Fishing firms within this group are family-owned and managed. They are characterized by a sole focus on fishing, targeting either a portfolio of target species (n=9) or one specific target species for which strong spot markets exist (auctions) (n=7). The firms are owned by fishing families (n=12), with large fishing fleets up to 16 vessels (5.7 vessels on average; SD=4.2), all >12 m. In most cases (n=14), vessel size is greater than 18 m (18-24 m: 7 firms; 24-40 m: 7 firms). These companies strive towards optimization of production by standardizing their fleets and maximizing vessel time at sea. In its most simple form, the standardization strategy consists in investing in vessels of similar size and equipped for fishing with the same gears. For more profitable firms, a fleet renewal strategy is observed. Vessel replacement with state-of-the-art vessels, often 'sister ships', allows for the internalization of vessel maintenance. This ranges from the allocation of manpower (n=6) to having a proper workshop with a constant stock of spare parts (n=1). Vessel time at sea is maximized by ingenious crew rotation schemes (n=13), either 'extensive' (replacement of a couple of crew members at a time, n=7), or 'intensive' (replacement of the entire crew between fishing trips, n=6). The latter is sometimes combined with 'remote bases' (n=4), satellite fishing ports (in France or abroad) where the vessels regularly dock, fish is landed, and where crew is flown into. These companies often employ a person or a small team for overseeing crew management and other administrative tasks.

A closer look at ownership and management reveals a subgroup (n=6), characterized by the complete outsourcing of management. These are Spanish fishing families that own vessels in both Spain and France, specialized in trawling and mainly targeting European hake. Their French vessels are managed and operated by legal entities in France (required by law<sup>8</sup>), who

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<sup>8</sup> Article R921-4 of the Code Rural.

take care of everything from crew management and bookkeeping to vessel operations, maintenance, negotiations with POs, and bringing the catch to market.

**Type 3: Fisher-processors** (n=7). Fishing firms in this group specialize in one target species or species group (crustaceans: n=2; scallops: n=3; pelagics: n=2). Their specialization strategy encompasses all stages of the production process: harvesting, processing and marketing. First, they have grown their fleet by investing in fishing vessels with interesting licenses and track records attached. They own and operate fishing fleets up to 13 vessels (6.3 vessels on average; SD=3.8). Within firms, vessels are mostly of similar size and equipped for fishing with the same set(s) of gears. This clear focus on growth and standardization has allowed them to establish market dominance in their respective ports or regions. In turn, this has led them to structure their businesses and to venture into new activities, most notably the processing and marketing of their own catch. In terms of firm structure, we see that all firms have a company structure, with a holding overarching the different activities. Administrative tasks such as bookkeeping and crew management are often internalized once the business has reached a certain size. Companies with more than three vessels (n=4) have dedicated manpower to deal with maintenance tasks. Firm management is characterized by a strong involvement of family members. The fisher's spouse often plays a pivotal role in the business. Her responsibilities include tasks like crew management, bookkeeping, managing orders and deliveries. Sometimes the owner's children are involved or being prepared to lead the company when their parents retire. In most cases, the owner is a self-taught manager (n=6), who started their career as deckhand.

**Type 4: Ownership-sharing models** (n=9). Firms in this group all have shared ownership in one form or another, and have a strong focus on the acquisition of fishing vessels (> 12 m) with track records or licenses attached. The firms are heterogeneous in terms of size (crew size, number of vessels) and fishing strategies. This may be explained to a great extent by the relative newness of some of these firms and the uncertainty in which direction they will develop. Most firms in this group (n=6) belong to the cooperative tradition that has historically shaped the French fishing sector. In its original form (n=3), it is characterized by shared ownership between the cooperative structure on the one hand and the skipper-owners on the other. The main aim is to allow skippers to gradually acquire shares until they have full ownership over their vessels. The cooperative is characterized by a hierarchical management structure, with at the top a shore-based manager who has the double responsibility of managing the company (e.g., human resource management, administration, negotiation with banks, etc.) and following up production for each vessel.

Recently, a new type of cooperative emerged from this tradition, including new elements designed to make the cooperative model "more adapted" to the current economic context (n=3). Finally, we also find three private fishing companies for which ownership is shared with skippers. These companies are part of a corporate ownership structure, for which they constitute only a fraction of total production.

**Type 5: Corporate fishing groups** (n=3). Despite the presence of only a few cases in our sample, these fishing firms form a distinct and well-defined group in the Atlantic fishing sector. They operate large vessels ( $\geq 40$  m) in a corporate ownership structure sometimes involving multiple mother companies. Management is overseen by a salaried manager, who mostly runs the fishing company independently of the corporate group. There is a pronounced internalization of vessel maintenance and administrative tasks. Besides employing a team of people in administration, these firms also have their own workshops and a team of mechanics

to oversee maintenance. Similar to firms in Type 2, vessel time at sea is optimized through crew rotation schemes (intensive) and remote bases. Their valorization strategy is based on volume: they specialize in species for which demand is high and for which strong markets and/or integrated value chains exist, such as Atlantic cod (*Gadus morhua*), blue whiting (*Micromesistius poutassou*), and saithe (*Pollachius virens*). The market for saithe is heavily integrated. One fishing company is responsible for 79% of landings, which are bought directly by a processor who then distributes the frozen filets through its own retailing branch.

## 5 Discussion

### 5.1 Growth of “artisanal” fishing firms

Based on literature, we may take the traditional one-vessel, polyvalent and family-based fishing firm – the so-called “artisanal” firm – as the default organizational form (vessels <25 m), from which more modern configurations may arise [14–16,18–20]. This perspective is validated by the interviews. However, the fieldwork also revealed that the development of multi-vessel enterprises and the concentration of capital was more significant than envisaged at the start of the study.

Multi-vessel ownership is a major way to increase resource access and expand production. Expansion happens gradually in artisanal firms, through the stepwise acquisition of second-hand vessels with track records attached. This is in sheer contrast with corporate companies of Type 5, which are able to acquire entire fleets at once through mergers [33]. However, not all artisanal firms grow out to be large companies. Most Type 1 firms did not have an objective of growing beyond their current size (2-3 vessels <12 m). Our results show that investment decisions depend on a range of factors, including the age and personal situation of the entrepreneur, the type of fishery, the availability of fishing opportunities, and the entrepreneur’s financial capacity to invest. Furthermore, the involvement of family members reduces the business’s cost structure. The ability to draw upon un(der)paid family labor has certain economic advantages for family fishing firms [15]. Often, administrative tasks are carried out by the fisher’s spouse, allowing the fisher to focus solely on fishing [103].

The interviews furthermore show that the development of fishing firms happens in phases that are closely linked with the life/career stages of the entrepreneur: they start out as crew members, become skippers and eventually become owner. Once a critical size<sup>9</sup> has been reached, the entrepreneur may decide to shift from embarked owner-operator to shore-based manager (rarely before the age of 50). As the firm grows, incremental changes are made to its structure. Small multi-owners are driven by a logic of risk aversion, income diversification and cost optimization through internalization of maintenance tasks and the outsourcing of bookkeeping [104,105]. Later in the firm’s development, bookkeeping is internalized, people are hired to oversee crew management, etc. Our results show a substantial diversity in the organization of small and medium-sized fishing firms, despite their common origins. This confirms our hypothesis that the artisanal vs. industrial dichotomy is insufficient and outdated.

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<sup>9</sup> The rule of thumb unanimously evoked by interviewed fishers is a minimum of three fishing vessels for this to be worthwhile .

## 5.2 Drivers of horizontal integration

The number of “mass species” for which economies of scale may typically be realized through specialization, standardization of vessels and vertical integration [41,106], is limited. Exceptions include Atlantic cod, saithe, blue whiting, Atlantic herring and Atlantic mackerel, which are harvested by  $\geq 40$  m trawlers (Type 5). Yet, also in other fisheries and fleet segments, firms pursue specialization (species or species groups) and standardization. Their main objective is cost efficiency, which is accomplished through cost reduction (e.g., more efficient engines, modern technology), and sometimes the ability to negotiate fish prices based on volume of landings. All Types are concerned, and include firms specialized in trawling or Danish seine for demersal species in the Channel and the Celtic Sea (18-24 m), scallop dredgers in the Channel (10-16 m), nephrops trawlers (10-18 m) in the Bay of Biscay, and small-scale netters and whelk potters (<12 m).

For most entrepreneurs in Type 1, the strategy of having several vessels is governed by regulatory factors (e.g., license allocation mechanisms, seasonal closures) and their risk averse attitude [75], rather than a search for scale economies. Each vessel is dedicated to one fishery and cannot be used in another (specific vessel/gear combinations; switching costs are high). Examples include coastal fisheries for scallop, glass eel, Atlantic salmon and macroalgae. Recently, fishery bans due to harmful algal blooms (HABs) in coastal areas have forced operators to invest in additional vessels to diversify their income. Specialization/standardization is limited by the financial capacity of operators to acquire second-hand vessels with adequate track records, let alone build new vessels [29,31].

In contrast to small independent firms (Type 1), many larger firms exhibit, in addition to a focus on fleet expansion, a pronounced fleet renewal strategy. This is accomplished through the stepwise replacement of old vessels with standardized *sister ships*, financed by the vessels currently in the company. This, in turn, creates an opportunity for the integration of vessel maintenance. One fishing company in Brittany (Type 2) has its own workshop in which it employs 40 people for maintaining their 16 trawlers. Such full integration of vessel maintenance was seen only in a handful of cases (in Type 2,  $n=2$ ; and Type 5,  $n=2$ ). A more common strategy is to employ someone for day-to-day maintenance tasks and the creation of a stock of spare parts (seen across Types). Finally, companies with large fishing vessels (mainly 24-40 m and >40 m, some 18-24 m) are preoccupied with maximizing vessel time at sea through sophisticated crew rotation schemes (replacement of a large proportion of crew after every fishing trip) and the use of remote bases.

Crew is increasingly found outside the family network, and even outside the communities in which they are embedded. It is not uncommon to see Spanish, Portuguese and Senegalese crew working on board large and even medium-sized (“artisanal”) fishing vessels. This is consistent with [107]), which reports 12% foreign crew at national level (8% EU, 4% non-EU).

## 5.3 Forward and backward vertical integration

The default mode of selling landed fish in France is through auctions, even though direct sales to consumers is also common for small-scale vessels [108]. Of the small multi-owners of Type 1, 14 (33%) use marketing channels outside the auction, and 5 (14%) rely heavily on them (mostly fish stalls managed by family members). For fisher-processors (Type 3), forward vertical integration may be understood as a way to increase efficiency and consolidate market dominance after having gathered vessels with ample fishing opportunities. It mostly concerns

non-TAC species (e.g., crustaceans, scallops) for which markets are traditionally dominated by retailers and processors (e.g., [109]). However, dominant fishing firms may try to capture economic rents by integrating (part of) the value chain (processing, sales). This is implemented through contracts or mutual agreements with buyers, and the establishment of processing and water tank facilities. These give producers more control over the market and give them access to high-end niche markets (live scallops, crabs, lobster).

The acquisition of fishing vessels by processors and retailers (backward vertical integration) can be understood by their dominance in retail markets for a number of high volume species (Atlantic cod, saithe, blue whiting). To consolidate this dominance and achieve a sustained competitive advantage, they seek to control the harvesting sector [41]. Other than strategic, this approach is transaction cost economizing, as the processing companies in the corporate group buy the raw product directly from the company owning the ship (contractual agreements).

#### **5.4 Towards new ownership models**

The past twenty years have been marked by very limited possibilities for the renewal of vessels due to policies aimed at reducing and controlling fleet capacity [110,111]. While the last five years have been more favorable (i.e., new possibilities for vessel construction and a higher supply of vessels on the second-hand market due to a spike in retirement rates), the ban on subsidies for vessel construction and the purchase of second-hand vessels pose greater constraints to the financing of investments. In addition, the price of new vessels is very high for independent entrepreneurs<sup>10</sup>, considering that entering the sector or growing businesses implies the need for acquisition of second-hand vessels and associated fishing opportunities [29]. Most multi-vessel companies only have recourse to bank loans (with the exception of corporate firms which have access to corporate funding), with generally 20% self-financing by the operators themselves or by local actors (shipyards, fish merchants, cooperatives) and in a few cases regional public funds. The general strategy of multi-vessel companies across Types is to repay the loans of a new vessel with the cash flows of vessels that are already paid off [81].

More and more multi-vessel firms are securing their capital by creating as many companies as they own vessels, and by consolidating their management through a holding company, using legal forms such as SAS and SASU<sup>11</sup>. These are considered more adapted to the needs of modern-day fishing firms by financial experts, in terms of investment, depreciation, tax optimization and transmission to children [81]. They also provide a way around the preemption of track records (20%) associated with vessel transactions [31]. To avoid such loss, companies are usually sold in their entirety (all vessels at once). But when companies are large, investments become too heavy for peers (independent fishing firms) to bear, and firms become interesting targets for corporate (and foreign) investors. This point was evoked by multiple respondents. Advanced structuration with a holding is a way around this limitation, as it allows to sell off vessels separately [81] and thus to avoid the loss of (or control over) local fishing capital.

There are few traditional cooperative fishing firms remaining along the Atlantic coast compared to their peak in the 1980s (about 20 structures) [66]. The cooperative model has been of major importance for the development of the 12-24 m segment. It allowed skippers to progressively

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<sup>10</sup> Vessel prices (interviews): 11 m: 0.4 M€ (2016); 16 m: 1.2 M€ (2018); 20.5m: 3 M€ (2017); 22 m: 2.3 M€ (constructed in Morocco in 2019; "30% cheaper than in France"); 24 m: 3.5 M€ (constructed in Spain in 2016) [36].

<sup>11</sup> Respectively Société par Actions Simplifiée and Société par Actions Simplifiée à Associé Unique.

acquire full ownership of their vessel until they were the single owner, while most of the financial risk was borne by the cooperative structure. Additional vessels were financed with the profit generated by vessels already in the structure, and with subsidies. As such, these firms have been severely impacted by the end of EU subsidies for vessel construction and capacity reduction. Our study shows that new models of ownership sharing are arising from the ashes of the cooperative model, organized around private structures, and backed by financial institutions, local investors and POs [31]. They strive to maintain the means of production and associated fishing opportunities in the territory (most cases encountered), and favor access to capital for young fishers (all cases encountered). However, full ownership by skippers is no longer the rule. This has two reasons: (1) equity of skippers is limited relative to investments needed [66], and (2) the lack of subsidies has urged firms to look for investors to match funding, which they usually find locally (value chain actors, see below).

Ownership sharing is also seen by some respondents as a means of retaining skilled skippers and encouraging them to operate and maintain the fishing unit properly. However, for most firms, the share-based remuneration system [112] is considered sufficient as an incentive scheme – and it allows owners to maintain full ownership and control over the vessel and attached track records. Monitoring at sea is difficult and costly, and all the more difficult when shore-based managers are unacquainted with the conditions on board a fishing vessel. Agency problems related to shirking and monitoring of team production are less of a problem in family fishing firms because in most cases, skippers as well as executive managers are the children of the owner [87]. Our results confirm this.

A particular ownership model was introduced in France with the so-called ‘quota hoppers’ that were attracted by freed-up capacity and fishing opportunities in the 1990s. In the case of France, these are mainly Spanish fishing families investing in French fishing capital because of quota constraints in their home country [113]. In 2016 there were an estimated 65 Spanish-owned vessels fishing under the French flag, with a projected further increase [114]. As part of demonstrating a ‘real economic link’ with France, operations need to be run by a “stable establishment situated on French territory, [which disposes of the] infrastructure, material means and human assets necessary to operate and manage a fishing operation in France” (Article R921-4 of the *Rural Code*) [17]. Over the years, this has led to the emergence of specialized companies representing multiple Spanish fishing firms. One such company currently represents 17 vessels and functions as a large organization from which collective scale advantages arise. Their role far surpasses any legal requirement, and includes negotiations with POs over quota opportunities, organizing collective freight transport of fish to Spain, sophisticated crew rotation platforms, collective vessel adaptations, etc. For analytical purposes, the question rises whether they should be treated as separate entities or as *de facto* large-scale fishing companies.

## **5.5 Outlook**

A significant improvement in the economic performance of the French fishing industry in recent years combined with an aging population of vessel owners [115] has fostered a dynamic of creation and growth of multi-vessel companies. The industry benefits from bank loans at historically low rates and strong competition between banking operators, many of which have reorganized internally to more adequately finance blue growth. Some of them offer investment fund mechanisms to finance capital operations. These seem to have limited success, however, as most operators wish to maintain their capital independence and because investment funds

require much higher returns than bank loans. Even though fishing opportunities cannot be integrated into companies' balance sheets as is the case in other countries [79,116], banks report that they do take into account the fishing opportunities portfolios of operators before financing a project. Because fishing opportunities are not considered specific assets, vessels are financed much like any other physical asset, and loans are relatively short term (7 to 12 years) compared to the significant amounts and long-term character of these investments. A high burden of debt repayment could weaken companies, especially if their overall economic situation were to deteriorate.

One of the positive points is that the fishing sector attracts investors. On the one hand, there are the investors already active in the local maritime economy (e.g., fish mongers, shipyards, etc.) investing in the 12-18 m and 18-24 m segments. They are strongly driven by their conviction to keep the vessels and associated fishing opportunities in their territory (fishing port or maritime sector). On the other hand, there are the private investors that have historically been important for the development of the larger fleet segments (24-40 m and  $\geq 40$  m). A well-known example is the retailer *Intermarché* and its corporate group *Les Mousquetaires*, who have their own fishing company, *Scapêche* [32,33,73]. In recent years, *Scapêche* has diversified its fishing portfolio by buying shares in structures operating vessels in smaller fleet segments (<24 m)<sup>12</sup>. This is also seen for other corporate fishing companies. The aim of association with companies or (formerly) independent producers is to secure supplies and capture economic rent generated by fleets for which profit margins are weak. Operators report a significant need for funding to finance fleet renewal. Vessels are often old and, in some cases, repair and maintenance costs can be as high as the loan repayment charge for new vessels [81]. For them, such joint ventures are part of the solution. In all examples encountered, the operators were majority shareholder, and thus the legal owner of the track records attached to the vessel [46].

The uncertainties regarding Brexit negotiations are likely to weaken companies (multi-vessel or other) whose whole or part of their activity is located in the UK EEZ. Dependence on UK waters is estimated at 19% in terms of value and 24% in terms of volume [117], but this dependence could be higher for certain multi-vessel firms. *Dépalle et al.* [118] have considered the implication of effort re-allocation in case of UK EEZ closures, but the medium-long term consequences of the various scenarios (including 'no deal') on companies' (dis)investment strategies is more difficult to anticipate. The same holds for the consequences of the current COVID-19 health crisis, which are expected to be severe [119].

## 5.6 Conclusions and recommendations

We argue that the definition of the "artisanal" fishing model insufficiently captures the organizational diversity found in the field. The diversity can instead best be described in terms of organizational attributes, most notably access to information (knowledge networks), legal structure, vessel maintenance and standardization, growth objectives and management structure. We have furthermore shown that elements that are typically associated with industrial fishing, such as vertical integration, the separation of management and control and accumulation of fishing capital, also make their appearance in smaller fleet segments.

In a context that is marked by recovering fish stocks for French fleets [120], limited fishing opportunities due to entry barriers and increasingly competitive markets [30,72], firms are

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<sup>12</sup> E.g., <https://www.armement-apak.fr/wp-content/uploads/2017/03/P%C3%A0che.-Un-nouvel-armement-artisanal-%C3%A0-Lorient-Mer-LeTelegramme.fr -1.pdf> (Accessed on 17/12/2020)

urged to rethink themselves to remain competitive [121]. We have shown that this can be accomplished in a myriad of ways, but the general response is the same: scale increase, rationalization of management, product valorization and access to information. The role of knowledge networks (POs, Fisheries Committees, shipbroker and fish trading networks) in the development of fishing firms deserves more attention, especially with regards to access to fishing opportunities.

This typology may find a use in fisheries management, as a basis for adjusting public policies such as the allocation of funds through the European Maritime and Fisheries Fund (EMFF) or the allocation of fishing opportunities to specific producer profiles. This is particularly relevant given the failure up until present to redistribute the track records in the national reserve to the fishers they were intended for [31], based on a set of environmental, social and economic criteria [17]. We argue that a similar analysis could be useful for case studies in other EU Member States.

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## ***Annex I***

# **Multiple Correspondence Analysis and Hierarchical Clustering**

## **1 Multiple Correspondence Analysis (MCA)**

A first MCA was performed which included the maximum possible number of dimensions, calculated as the sum of variable categories ( $n=33$ ) minus the number of variables ( $n=10$ ). This yielded 23 dimensions, with a calculated total inertia of 2.3 (the maximum number of dimensions divided by the number of variables). Subsequently, the number of dimensions to retain was determined based on the eigenvalue report. This was done in two steps. First, we examined the scree plot of the eigenvalues following the method proposed by Bendixen (1996)<sup>1</sup>. This suggested the retention of 2 dimensions (Dim 1 and Dim 2 explain 25.48% and 12.39% of the inertia, respectively). A second criterion for retaining a dimension is that its eigenvalue is above 0.2 (Hair, Black, Babin, & Anderson, 2014). This suggested a retention of 3 dimensions (eigenvalues 0.586, 0.285 and 0.205 respectively). Following Gifi (1990), we also examined the MCA biplots and decided to keep the first three dimensions. The three-dimension solution accounted for 46.78% of variance ( $1.076/2.3$ ). Discrimination measures are summarized in Table 1, and Figure 1 shows a biplot of variable categories. Note that in addition to the 10 variables participating in the analysis, 4 supplementary variables<sup>2</sup> are plotted in Figure 2a (FOREIGN, COMPL, VES, SIZE, CREW). These dummy variables were deemed useful for interpreting the results.

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<sup>1</sup> Two metrics were calculated:  $1/(\text{number of individuals}-1) = 1/79 = 1.27\%$  in terms of rows;  $1/(\text{number of variables}-1) = 1/9 = 11.11\%$  in terms of columns. According to Bendixen, any axis with a contribution higher than the maximum of the two metrics, is to be retained.

<sup>2</sup> These were excluded after consecutive rounds of testing, for one or multiple of the following reasons: low representation of variable categories across the population, association with other variables, limited relevance/pertinence according to the research team.

<sup>3</sup> Two metrics were calculated:  $1/(\text{number of individuals}-1) = 1/79 = 1.27\%$  in terms of rows;  $1/(\text{number of variables}-1) = 1/9 = 11.11\%$  in terms of columns. According to Bendixen, any axis with a contribution higher than the maximum of the two metrics, is to be retained.

analysis, 4 supplementary variables<sup>4</sup> are plotted in Figure 1a (FOREIGN, COMPL, VES, SIZE, CREW). These dummy variables were deemed useful for interpreting the results.

Table 1: MCA dimensions and discrimination measures.

	Dim1	Dim2	Dim3	Mean
<i>OWN</i>	0.71	0.26	0.42	0.46
<i>LEG</i>	0.74	0.16	0.04	0.31
<i>ROT</i>	0.47	0.04	0.13	0.21
<i>MAINT</i>	0.33	0.23	0.25	0.27
<i>SPEC</i>	0.41	0.24	0.09	0.25
<i>STAND</i>	0.57	0.22	0.01	0.27
<i>GROW</i>	0.62	0.42	0.13	0.39
<i>ADVICE</i>	0.78	0.12	0.22	0.37
<i>VALOR</i>	0.41	0.58	0.56	0.52
<i>MANSTR</i>	0.82	0.58	0.21	0.54
Active total	5.86	2.85	2.06	3.59
% of variance	25.48	12.39	8.91	15.59

For the first dimension, the strongest contributions were found for MANSTR (0.82), ADVICE (0.78), LEG (0.74) and OWN (0.71), but all variables have a significant contribution ( $p$ -values $<0.05$ ) to the eigenvalue of the first dimension. This may be partly due to the fact that there is considerable association between MANSTR and several other variables (Cramer's  $V$ -test; ADVICE: 0.61; LEG: 0.62, OWN: 0.60). The most discriminant variables for dimension 2 are MANSTR (0.58), VALOR (0.58) and GROW (0.42). Finally, dimension 3 is explained by the variables VALOR (0.56) and OWN (0.42). Taking into account all three dimensions, we could conclude that OWN, VALOR and MANSTR and present the highest discrimination measures overall.

Based on this and visual examination, we may name the dimensions as follows – dimension 1: "Business structuration"; dimension 2: "Valorization and growth" and dimension 3: "Valorization and ownership".

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<sup>4</sup> These were excluded after consecutive rounds of testing, for one or multiple of the following reasons: low representation of variable categories across the population, association with other variables, limited relevance/pertinence according to the research team.

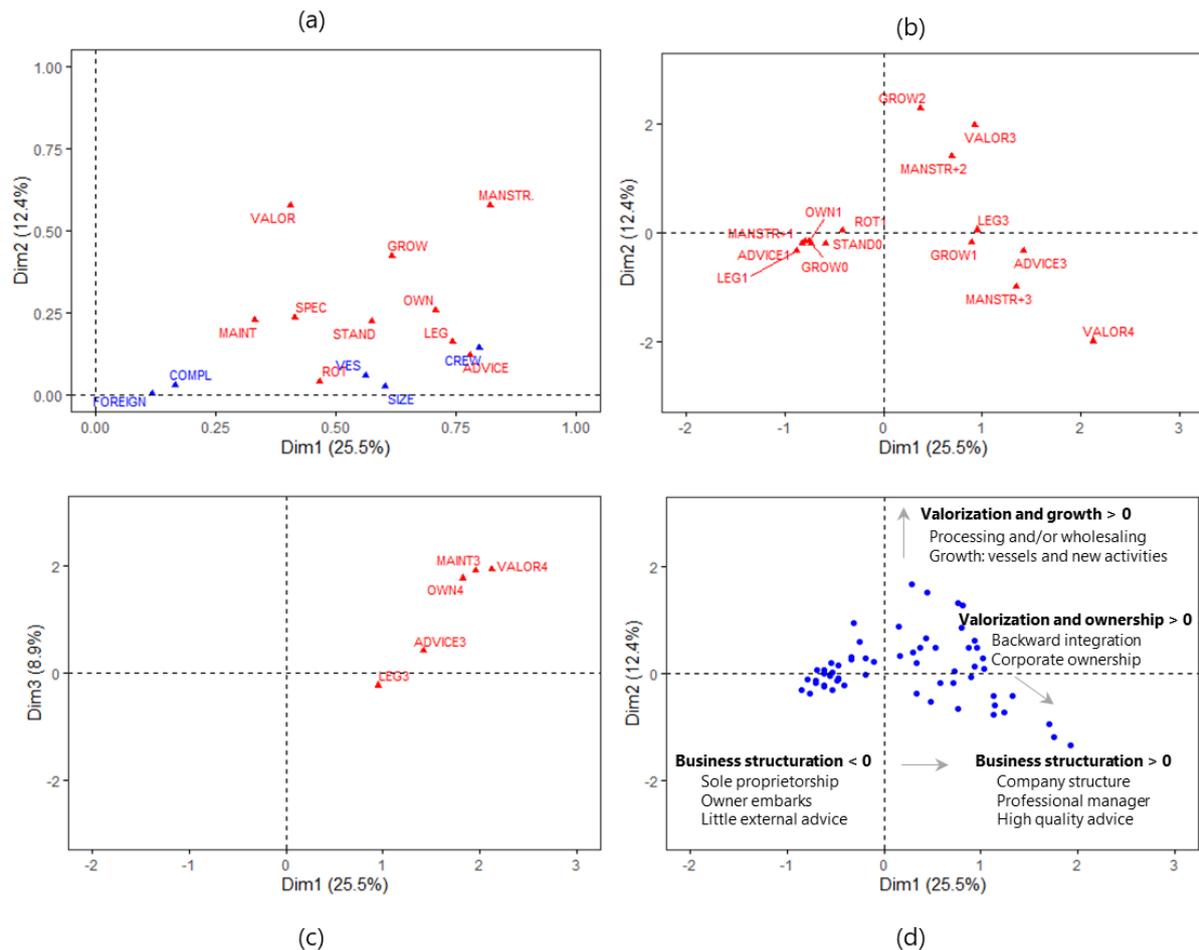


Figure 1: Description of the MCA dimensions (a) Biplot of discrimination measures. Red: participating variables; Blue: supplementary variables; (b) Joint category plot of the variable categories (dim 1 and dim 2). Only the 15 most contributing categories with the highest quality of representation are shown ( $\cos^2 > 0.4$ ); (c) Joint category plot of the variable categories (dim 1 and dim 3). Only the 5 most contributing categories with the highest quality of representation are shown ( $\cos^2 > 0.4$ ); (d) Plot of the individuals and axes descriptions.

## 2 Hierarchical clustering based on the MCA results

A hierarchical clustering was performed on the MCA results. In order to reduce noise in the analysis, only the first 13 dimensions were included in the analysis (representing 90.53% of the total variance). The analysis was performed using the `hclust` function in the FactoMineR package (Lê, Josse, & Husson, 2008). This function uses the Ward method to construct a hierarchy, which consists in aggregating two clusters such that the growth of within-inertia (within sum of squares, WSS) is minimal and between-inertia (between sum of squares, BSS) is kept high (Husson, Josse, & Pagès, 2010). The lower the inertia within a cluster, the more homogeneous it is. Several clustering solutions were explored (3 to 6 clusters). The number of clusters was decided based on the aforementioned inertia considerations, as well as our field observations. As such, a stable<sup>5</sup> five cluster solution was retained (WSS=1.09; BSS=0.14) (Fig. Figure 2).

<sup>5</sup> A stable solution was considered a solution in which the allocation of individuals to a certain cluster did not change when reducing the number of dimensions of the MCA result on which the clustering was performed. This was tested through the step-by-step reduction of the number of dimensions from 23 to 13, for each of the solutions.

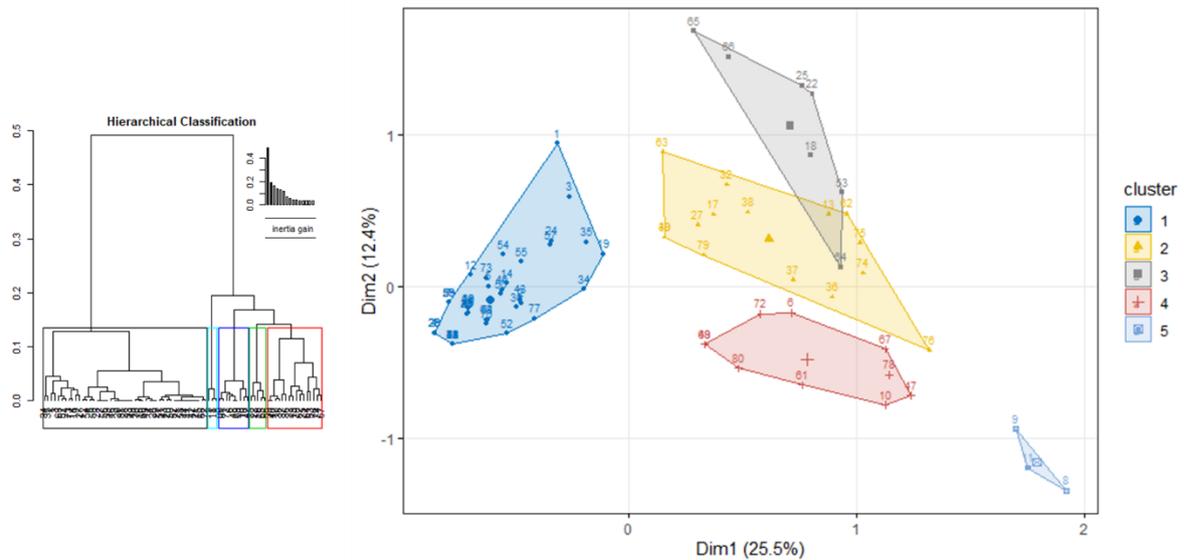


Figure 2: Hierarchical clustering. Left: dendrogram. Right: cluster plot of the individuals.

A Chi-squared test was performed to test the link between the variables and the cluster variable (with  $n_{\text{clust}}$  ranging from 1 to 5). A significant link was found with all variables ( $p < 0.05$ ).

Cluster 1 is characterized mainly by MANSTR1 (95.56% of individuals in the cluster), ADVICE1 (84.44%), LEG1 (77.78%) and OWN1 (84.44%); cluster 2 by OWN2 (80.00%), LEG3 (86.67%) and MANSTR4 (40.00% of individuals in cluster 2, but 100% of all individuals with this category are in this cluster). Cluster 3 is characterized by VALOR3 (100%) and MANSTR2 (85.71%), cluster 4 by OWN3 (90.00%), MANSTR3 (100%) and GROW1 (100%); cluster 5 by VALOR4 (100%), MAINT3 (100%) and OWN4 (100%).

Table 2 summarizes the composition of the clusters based on the variable categories.

Cluster 1 is characterized mainly by MANSTR1 (95.56% of individuals in the cluster), ADVICE1 (84.44%), LEG1 (77.78%) and OWN1 (84.44%); cluster 2 by OWN2 (80.00%), LEG3 (86.67%) and MANSTR4 (40.00% of individuals in cluster 2, but 100% of all individuals with this category are in this cluster). Cluster 3 is characterized by VALOR3 (100%) and MANSTR2 (85.71%), cluster 4 by OWN3 (90.00%), MANSTR3 (100%) and GROW1 (100%); cluster 5 by VALOR4 (100%), MAINT3 (100%) and OWN4 (100%).

Table 2: Description of the clusters based on variable categories. Only the five most significant categories are included. Cla/Mod: proportion of category *s* in cluster *n*; Mod/Cla: proportion of cluster *n* in category *s*; Global: proportion of category *s* in the global population.

	Cla/Mod (%)	Mod/Cla (%)	Global (%)	p-value	v-test
<b>Cluster 1</b>					
MANSTR=MANSTR1	97.73	95.56	55.00	4.80E-19	8.92
ADVICE=ADVICE1	100.00	84.44	47.50	4.66E-16	8.12
LEG=LEG1	100.00	77.78	43.75	5.51E-14	7.52
OWN=OWN1	95.00	84.44	50.00	2.56E-13	7.32
GROW=GROW0	90.48	84.44	52.50	2.55E-11	6.67
<b>Cluster 2</b>					
OWN=OWN2	52.17	80.00	28.75	6.53E-06	4.51
MANSTR=MANSTR4	100.00	40.00	7.50	1.67E-05	4.31
LEG=LEG3	37.14	86.67	43.75	0.000253	3.66
ROT=ROT3	66.67	40.00	11.25	0.001062	3.27
STAND=STAND1	41.67	66.67	30.00	0.001429	3.19
<b>Cluster 3</b>					
VALOR=VALOR3	100.00	100.00	8.75	3.15E-10	6.29
MANSTR=MANSTR2	42.86	85.71	17.50	6.46E-05	4.00
GROW=GROW2	66.67	57.14	7.50	0.000316	3.60
SPEC=SPEC2	18.92	100.00	46.25	0.003241	2.94
STAND=STAND1	20.83	71.43	30.00	0.025568	2.23
<b>Cluster 4</b>					
OWN=OWN3	81.82	90.00	13.75	2.32E-09	5.97
MANSTR=MANSTR3	62.50	100.00	20.00	4.86E-09	5.85
GROW=GROW1	31.25	100.00	40.00	3.92E-05	4.11
LEG=LEG3	28.57	100.00	43.75	0.000111	3.86
STAND=STAND2	44.44	40.00	11.25	0.013054	2.48
<b>Cluster 5</b>					
VALOR=VALOR4	75.00	100.00	5.00	4.87E-05	4.06
MAINT=MAINT3	60.00	100.00	6.25	0.000122	3.84
OWN=OWN4	50.00	100.00	7.50	0.000243	3.67
MANSTR=MANSTR3	18.75	100.00	20.00	0.006816	2.71
ADVICE=ADVICE3	17.65	100.00	21.25	0.008277	2.64

### 3 References

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