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Kelp harvesting fleet dynamics and the fleet's dependence on *Laminaria* forests in the Iroise Sea (North Finistère, France)

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Abstract: This paper addresses the question of economic viability of a fishing fleet, its dependence on main target species, and its capacity to be adapted to future constraints. The analysis relies on a field survey of a small-scale inshore fishing fleet of the Iroise Sea, in Brittany, seasonally harvesting seaweeds. Kelp forests are important biota both as habitat provider and producer, but are subject to significant threats that can permanently affect their sustainability. Seaweed harvesting has always been a controversial sector and the establishment of a marine protected area in the Iroise Sea has rekindled the debate on the environmental impact of seaweed exploitation. But, the fleet is also exposed to others constraints, be they regulatory or economic.

Résumé : *Dynamique de la flotille de récolte de laminaires et sa dépendance vis à vis des forêts de laminaires en Mer d'Iroise (Finistère nord, France).* Cet article étudie la question de la viabilité économique d'une flottille de pêche, sa dépendance à l'espèce-cible principale, tout en intégrant sa capacité d'adaptation aux éventuelles contraintes à avenir. L'analyse repose sur une enquête de terrain consacrée à la flottille goémonière de la mer d'Iroise, en Bretagne. Les forêts de laminaires sont des biotes importants à la fois comme habitat et producteur, mais sont sujettes à d'importantes menaces qui peuvent affecter de façon permanente leur durabilité. La récolte des algues a toujours été l'objet de controverses et la création d'une aire marine protégée en mer d'Iroise a relancé le débat sur l'impact environnemental de l'exploitation des algues. Outre la menace concernant la ressource, la flottille goémonière est également exposée à diverses contraintes d'ordre réglementaire ou économique.

Keywords: Seaweed harvesting ● Threats ● Adaptative capacities ● dependence ● Kelp forest ● Iroise Sea

Introduction

Kelp forests are important biota playing a key role both as habitat provider and producer along rocky shores, but are subject to significant constraints that can permanently affect their sustainability, their distribution and the biodiversity of associated species. France's most extensive kelp forests are located in the Iroise Sea in the Northwest part of Brittany which is the southern distribution range-limit for both of the principal *Laminaria* species *Laminaria digitata* (Lamouroux, 1813) (Ld) and *Laminaria hyperborea* (Foslie, 1884) (Lh). Kelp harvesting has always

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been a controversial sector, and has been censured for different reasons for more than three centuries (Arzel, 1998). Seaweed production is blamed for harming the ecosystem because of the damage it causes to substrates and to the habitats of certain fishes, to the extent that it has been alleged to cause their extinction. One of the objectives of the French research project ECOKELP[1], financed by the National Research Agency (ANR), was to identify the socio-economic drivers of anthropic pressures on the kelp ecosystem. Throughout human history, seaweed has always been harvested in the first instance for domestic use, serving as fuel, and as a fertilizer in agriculture for example. Its use in industry was secondary, and today the use of seaweeds in the manufacture of special lenses and glass products has largely been superseded by colloidal manufacturing processes (Arzel, 1984). Among the various types of kelp exploitation (direct or indirect), kelp harvesting by boat constitutes the main anthropic pressure. Seaweed harvesting is a seasonal and fluctuating activity for these vessels. All fishermen remark on the irregularity of landings, with important variation in the landings, even though apparently there is no consensus on the underlying causes for this, within either the fishing community or the scientific one. Could these be climate change, weather, and increasingly frequent storms, for example, the proliferation of new seaweeds or its over-exploitation, or other causes? The establishment of a marine protected area in the Iroise Sea (the *Parc Naturel Marin d'Iroise, PNMI*) has rekindled the debate on the environmental impact of seaweed harvesting, increasing tension and suspicion between different users. It has fuelled the worst fears of kelp harvesters, notably regarding a possible ban on the use of mechanical harvesting and also restrictions applied to harvesting zones. "*A kelp field is not just a resource, it is also a habitat for many species, manifesting relatively healthy levels of biodiversity. Any infrastructure associated with the harvesting process has to obey a double imperative: it must provide sustainably optimised revenues to fishermen and to the fishing industry as a whole, and on the other hand conserve the equilibrium that exists between different users depending on the resource*" (Arzel, 1998: 105).

This paper addresses the question of fleet dynamics and its dependency on kelp forest, in order to assess the resilience of the fleet. It appears useful to examine the issue of its vulnerability by looking what are the adaptative capacities of the kelp harvesting fleet if the threats hanging over the *Laminaria* fields should worsen, such as in the event of decreasing industrial demand, or reduced availability of the resource?

Materials and Methods

Anthropic pressure on the Iroise kelp forest

Before assessing the vulnerability of the kelp fleet, the first step is to identify the main causes of anthropic pressure on kelp forests in the Iroise Sea.

A qualitative analysis of the different uses of kelp forests in order to reveal the economic drivers behind anthropic pressure have been undertook (Figure 1). It shows that the kelp harvesting fleet is the primary source of anthropic pressure. As a general rule, seaweed is harvested by small-scale inshore fishing fleets. As a seasonal activity, the kelp fleet is involved in other fishing activities such as shellfish (scallops and clams) harvesting in the *Rade de Brest* (Alban et al., 2001 & 2004; Boncoeur et al., 2003), even though seaweed itself remains the core activity. Kelps are valued for their alginate content, extracts of which are used industrially as thickeners and emulsifiers (*L. digitata*) or gelifiers (*L. hyperborea*). Two processing plants located in the Brest area, owned by two foreign industrial groups, purchase a major share of the total *Laminaria* production in France. While this production activity is purely artisanal, the market for alginates is a global market. Locally, the duopsony market in France affords these two production sites an unusual degree of power over both the setting of prices for the seaweed (Alban et al., 2001), and regulatory issues. For example, they contribute to the establishment of new rules in kelp harvesting by imposing daily quotas calculated in accordance with the handling capacity of the processing sites.

Legal framework for seaweed harvesting

The harvesting of marine vegetation as a commercial activity is regulated by statute n° 90-719 of the 9 August 1990 relating to terms and conditions for fishing, harvesting and gathering of sea vegetation. Three categories of seaweed are distinguished (Pennez et al., 2002):

- Shoreline kelp anchored to the shore, and collected on foot[2] on the shoreline and uninhabited islets
- Kelp growing out at sea, anchored to the sea bottom and unattainable on foot at Spring low tide
- Wreck kelp, uprooted by the action of the sea, floating or beached along the shoreline

While seaweed and wrecks gathering on the seashore is authorised all year round, harvesting by boat is limited to the period between 15 April and 31 December.

[1] The ECOKELP project, the aim of which is to understand the dynamics of kelp forest biodiversity by taking into account ecological, social and economic aspects, was coordonated by Myriam Valero, CNRS-UMPC, UMR7144 and financed by the French "Bioversity 2006" program led by the National Research Agency (ANR 06 BDIV 012).

[2] Statute n° 2001-426 of the 11 May 2001 regulates maritime pedestrian shell-fishing as a professional activity.

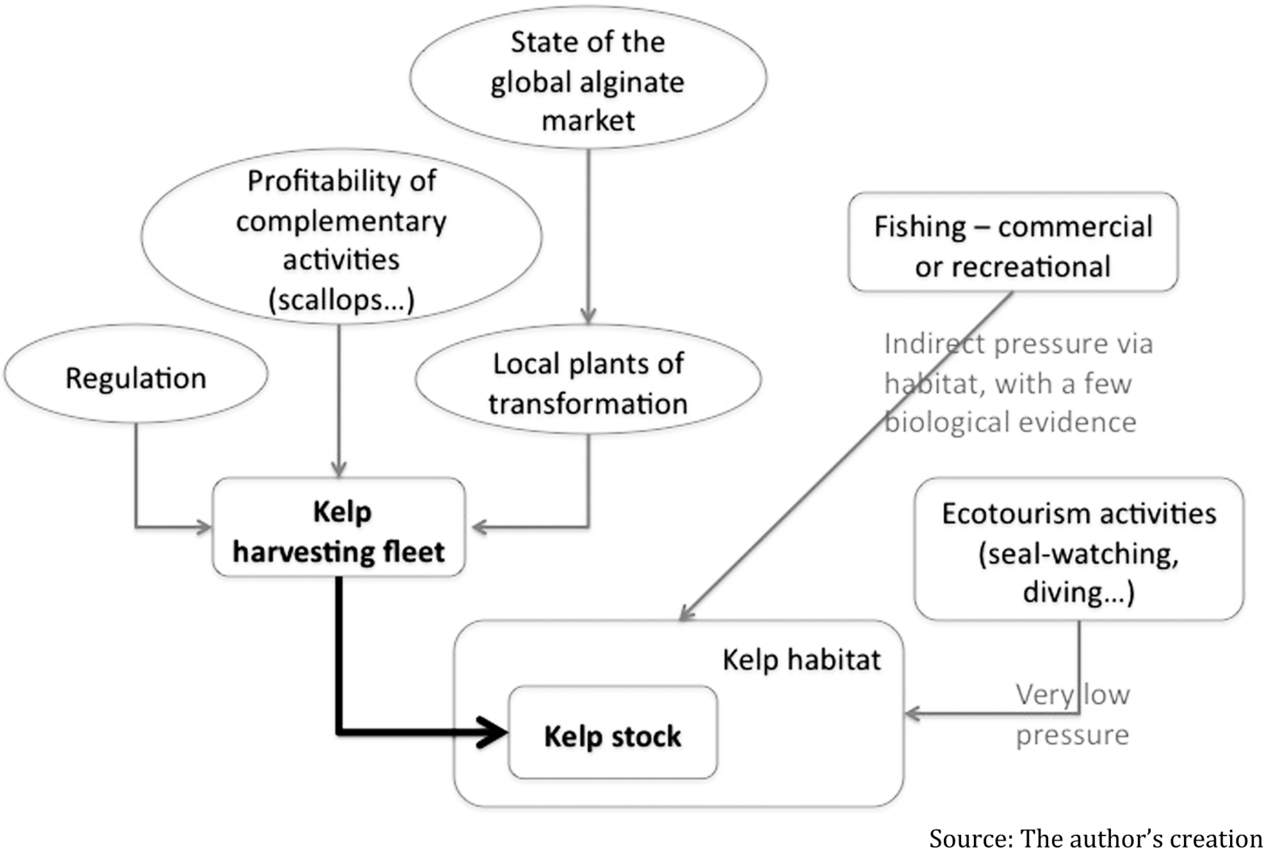

Figure 1. Economic drivers of anthropic pressure on kelp forest in North Finistere, France.
Figure 1. Facteurs économiques de la pression anthropique sur les forêts d'algue dans le nord Finistère, France.

Description of the Iroise kelp fishery

The study area was defined as the North part of the Iroise sea where the largest kelp forest are concentrated (Arzel, 1998). The kelp harvesting activity in that area was analysed over the period 2000-2008.

Data sources

To illustrate the case study, different sources of data will be used. Data analysis about the structure of the fleet were extracted from the "Fisheries Information System" (SIH) developed by IFREMER (Leblond et al., 2008). This fleet data includes technical information for all French commercial vessels registered on December 31 of each year: vessel length and age, engine power, tonnage and maritime district. The fishing tactics and activity data set (gears, season and number of trips) are derived from an exhaustive survey with reconstitution of the annual calendar of activity for all registered vessels.

Whereas kelp landing data and prices are provided by the two local processing plants, others market data set (for fish and shellfish landings) are extracted from auction hall, with landed value and quantity by species for each vessel. Thus, direct sales are not considered in the study even if they can be important for some species landed by coastal small-scale vessels.

In addition, a face-to-face economic survey was conducted among kelp harvesters at the end of the year 2008 through a series of interviews with skipper-owners. A total of 14 fishery vessel owners were interviewed, representing an overall sampling rate of 45% in 2008. The aim was to identify the different types of activities, their profitability, and their dependence on kelp forests. The reference year for the survey is 2008. A previous field survey had been conducted at the end of the year 2000 (Alban et al., 2001), with a sampling rate of 60% and will be used for comparison.

The main difference between the SIH-Ifremer and the survey is that the last one includes kelp harvesting boats operating outside the fleet register. In addition, any assessment of the fleet's economic performance needs to be argued at the level of the fishing enterprise itself, because of the increasing trend towards "multi-ownership", many fishing vessel owners having adopted a strategy of running two boats in parallel.

Kelp fleet typology

Despite the apparent mono-specific characteristics of the kelp fishery, it seems useful to analyse the different fishing strategies of the vessels. According to the methodology developed by the SIH, - homogeneous fishing fleets, or groups of vessels having similar behaviour and fishing strategies, are defined based on input criteria: type of gear and distance from the coast, the latter considered as a proxy for vessel size (Berthou et al., 2003). A fleet is then defined by the unique combination of a fishing gear class and a distance class (Daurès et al., 2009). For this reason, among the kelp fleet, two sub-fleets were distinguished: "Kelp harvesters-dredgers", and "kelp harvesters-non dredgers". To analyse the dynamics of the two vessels groups, the characteristics and performances of these two sub-fleets are compared to those of their proprietary Ifremer fleets, the "Polyvalent trawlers" and "various coastal metiers"[3].

Two main species of kelp harvested in Brittany

The main species of kelp exploited in France is *Laminaria digitata*, with an average annual production of 54,000 tons ± 8,000 tons since the 1990's (47,000 tons in 2008)[4]. *L. digitata* harvesting takes place from mid-May to the end of September (or even mid-October) and is performed mechanically with a "scoubidou", a rotating hook attached to the end of a hydraulic crane[5]. For several years now, few vessels have begun to experiment with the harvesting of a second species[6]: *L. hyperborea*[7], with an annual average harvest of 4,000 tons ± 2,400 tons since 2000. In 2008, the production of *L. hyperborea* increased to 11,000 tons. Benefiting from a special dispensatory clause in the 1990 law[8], the harvesting of *L. hyperborea* takes place from mid-October to the end of March, with the aid of a kind of towed dredge, called "comb". This technic was imported from Norway.

Institutional specificity of the kelp fishery

Unlike all other fishing activities, the key institutional specificity of the kelp activity is that the administrative autorisation (*Permis de Mise en Exploitation* - PME)[9], is not compulsory. As a result, modifications to kelp vessels (or their construction) can be undertaken in such a way as to make them exempt from fishing effort restrictions as implemented by the Common Fishing Policy (CFP). However, the non possession of a PME limits the possibilities for the kelp harvesting vessel to diversify its activity, and in this way affects its value. A boat without a PME loses half of its value (Guyader et al., 2006)[10]. This specificity influences the dynamics of the fleet and also determines the resilience of kelp harvesters faced with changing regulations or declining stocks.

Results

The average number of kelp fishery vessels in the North Iroise Sea was 33 for the period 2000-2008. The average vessel length was 10.2 m, and the average power, 88 kW, and with an average age of 22 years, the fleet can be described as being relatively 'young'.

Major trends in the kelp fishery over the last decade

Figure 2 shows acceleration in the decline of the number of vessels over the last decade: the number has decreased by 28% globally, and by 20% in the Iroise Sea. This trend seems to be specific to the kelp fleet, if we compare it with the decrease of only 3% for the two Ifremer-owned fleets. The ten boats that ceased their activity at the end of 2000 participated in the decommissioning plan established in the framework of the CFP that aimed to decrease the global fishing effort.

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3 Boats in the "Various coastal metiers" fleet are characterized by the practise of shoreline activities such as shellfish gathering, diving, or the harvesting of seaweed using a "scoubidou", to which may be sometimes associated other passive machines to support the activity.

4 Landings of *L.digita* are showing a downward trend with deteriorating quality because of increased levels of stone content.

5 The principle of this tool is to spool the seaweed around a hook, while exerting vertical upwards traction to detach them from the rocks. The seaweed are uprooted and collected (Arzel, 1998).

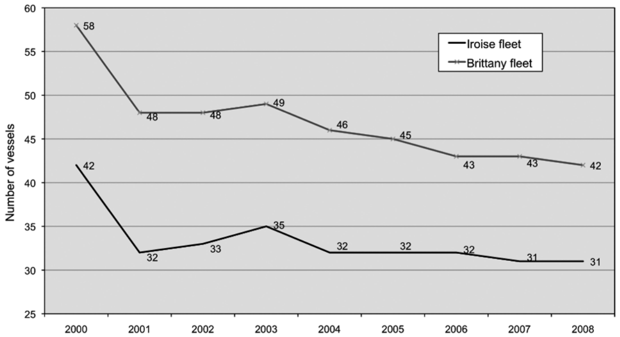
6 The other species are *Ascophylum nodosum* (2,890 t), mixed species of seaweeds, (2,128 t), *Fucus serratus* (581 t), *Himanthalia elongata* (285 t), *Laminaria saccharina* (10 t) *Undaria pinnatifida* (4 t), *Ulva* sp (102 t) *Enteromorpha* sp (3 t), *Mastocarpus/Chondrus* (387 t), *Palmaria palmata* (308 t), *Porphyra* (10 t), *Delessaria sanguinea* (1 t). These shoreline seaweeds are collected on foot, some of them being harvested for human consumption. Only *Undaria* is cultivated in France.

7 The exploitation of *L. hyperborea* started in 1990 on an experimental basis, at the request of the transformation plants in the face of decreasing yields of *L. digitata*.

8 Prospection campaign for the seaweed *Laminaria hyperborea* is authorized on an experimetal basis..

9 An administrative authorisation (in French, the *permis de mise en exploitation* or P.M.E) is required for any vessel equipped for professional commercial fishing, and is issued prior to construction, on importation, or for the fitting out of a vessel that has previously been used for another activity, or whenever any change to holding capacity (power, tonnage) is made, or for a refit of a vessel that has been out of commission for more than 6 months (Statute n° 93-33 of 8 January 1993 concerning the licence to fish commercially). The government ministry responsible for maritime fishing sets quotas annually, expressed in terms of power and capture capacity, for any fishing licences likely to be granted in the course of the civil year, taking into account on the one hand the programmed adaptation of capture capacities for the professional maritime fleet to the available halieutic resources, and, on the other hand, changes in the fishing fleet observed in the course of the preceding year. These quotas aim to ensure that vessel refit projects do not translate into an augmentation of fleet capacity (tonnage and power) in relation to other projects.

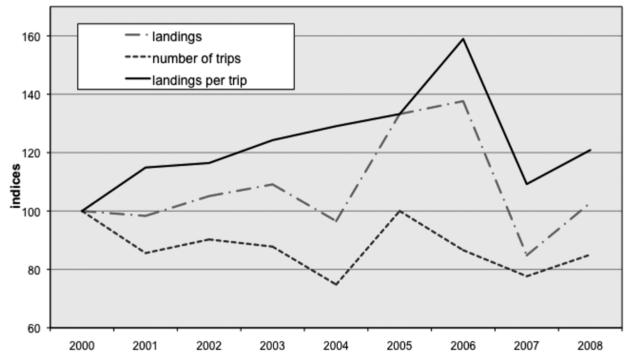
10 Guyader et al. (2006) have demonstrated that fishing rights are incorporated in the selling price of vessels possessing a PME, when sold on the second hand market. The prices of vessels without PME are much lower.



Source Ifremer, SIH

Figure 2. Changes in the number of kelp fishing vessels between 2000 and 2008.

Figure 2. Evolution du nombre de navires de pêche d'algues entre 2000 et 2008.



Source Ifremer

Figure 3. Evolution of landings, number of trips, and production per trip, for the Iroise fleet (base 100 in year 2000).

Figure 3. Evolution des débarquement, du nombre de voyages et de la production par voyage pour la flotte d'Iroise (base 100 en 2000).

Table 1. Comparative evolution of technical characteristics of the kelp harvesting fleet between 2000 and 2008

Tableau 1. Evolution comparée des caractéristiques techniques de la flotte de récolte d'algues entre 2000 et 2008.

	Kelp fleet			
	Iroise		Brittany	
	2000	2008	2000	2008
Length (metres)				
- mean	**9.9**	**10.3**	**9.7**	**10.0**
- standard-deviation	1.5	1.4	1.4	1.4
Tonnage (tjb)				
- mean	**11.6**	**13.1**	**10.7**	**12.1**
- standard-deviation	5.2	6.5	4.9	6.0
Engine power (kw)				
- mean	**73**	**83**	**70**	**78**
- standard-deviation	33	39	32	38
Year of building				
- mean	**1982**	**1986**	**1981**	**1985**
- standard-deviation	7.9	16.0	9.3	14.9

Source : SIH Ifremer

Table 1 shows how few changes there were in the "classical" technical characteristics of the kelp fleet between 2000 and 2008 (length and engine power). It also reveals the ageing trend for the fleet, the average vessel age being 23 years in 2008, as compared with only 19 years in 2000, despite the fact that four news boats joined the fleet in 2007. The major "hidden" fact behind this evolution is the exit of several small boats, and a resulting change in the fleet structure.

Understanding the fishing effort evolution implies to analyse the evolution of carrying capacity and the number of harvesting days (Arzel, 1998). What we find is that the decrease in both the number of boats and the average number of days at sea (which decreased by 15%) suggesting a reduction in the apparent fishing effort for the fleet overall, has been offset by an increase in individual vessels' carrying capacity. As a result, the average daily landings of kelp increased by 21% (Figure 3). These facts highlight the way a change in fleet composition can result in an increase in the average individual carrying capacity of boats. This trend towards larger kelp harvesting vessels has two main explanations: 1) the influence of the regulatory system itself, and especially the restriction to only one trip per day[11] (implemented in 1987 as a mean of controlling fishing effort); 2) the constraints on *L. hyperborea* harvesting during the winter months. The new environmental restrictions applied to both the local processing plants (concerning kelp handling capacity) re-inforce this tendency. The enforcement of the European directive concerning the treatment of wastewater (dating back to 2007) has meant the seaweed processing plant have been ordered to reduce the formol content of their waste-water, formol being one of the compounds used in seaweed processing. Rather than investing in costly systems for purifying effluent, the both processing plants chose to

[11] The choice of a regulatory system is not a neutral one, and can influence the economic profitability of a vessel. In the case of the kelp fleet, Alban et al. (2004) have shown that the observed gap between the profitability of smaller and larger seaweed harvesting boats does not merely reflect genuine differences in economic efficiency, but also differential rents created by distorting fishing regulations, and especially the restriction to one landing per day and the weekly quotas per boat defined as a function of the individual vessel's carrying capacity.

reduce their weekly processing capacity[12]. These environmental constraints are giving the seaweed processing plants an incentive to spread their handling capacity out over the whole of the year. At the highest point of the *L. digitata* season, sites that in the past processed up to 800 tons.day^{-1} will now handle no more than 300 tons.day^{-1}. As a result, weekly production quotas (estimated on the basis of load capacity for each vessel) have been imposed on the fishers[13]. During the winter, when the supply of *L. digitata* runs out, the production sites encourage the kelp harvesters to supply them with *L. hyperborea.* Those vessels capable of supplying the seaweed in large quantities, and for the longest possible time in season, are clearly at a huge advantage. Smaller vessels are therefore at risk of being supplanted by larger vessels[14].

Evolution of prices

The market for alginates is a global one. Because of their minority position on the world market for alginates, the two local processing plants are "price takers". Conversely, the duopsony they enjoy on the French market affords them considerable negotiating power overlooked the kelp harvesters. The latter would try to counterbalance it by negotiating the price of seaweed with the industry collectively at the start of the season[15]. The lack of competition on the local seaweed market explains the way prices have changed. Costing 42 euros per ton in 2008, the price of *L. digitata* - expressed in a constant currency - has slightly fallen since 2000, while for the same period, the price of fresh fish has risen (Fig. 4). This means the average annual turnover was about k€ 1,540, in real terms, for the kelp fleet of the North Iroise Sea during the period 2000-2008, despite large fluctuations.

Economic performance of the fleet

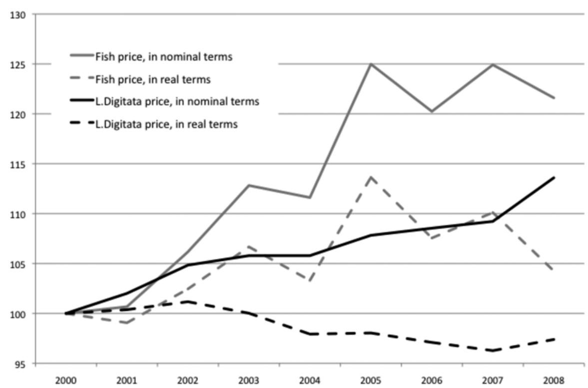
In order to assess the dependency of the fleet on the kelp forest, it was necessary first to assess the fleet's economic performance. To this end, a field survey was conducted. Table 2 shows the economic performance of the kelp fleet in 2000 and in 2008, taking into account complementary activities and revenues. In real terms, global turnover and gross operating income have increased on average by 3.5% per year.

Table 2. Comparative evolution in economic performance (in €K and as a % of turnover) of the Iroise kelp harvesting fleet between 2000 and 2008.

Tableau 2. Evolution comparée de la performance économique (en €K et en % du chiffre d'affaires) de la flotte de récolte d'algue d'Iroise entre 2000 et 2008.

	2000		**2008**	
	k€	**%**	**k€**	**%**
Turnover				
-mean	**75.1**	**100%**	**118.6**	**100%**
-standard deviation	48.8		76.7	
Added Value				
-mean	**57.2**	**76%**	**92.9**	**78%**
-standard deviation	40.3		69.3	
Gross operating profit				
-mean	**16.3**	**22%**	**27.7**	**23%**
-standard deviation	20.2		41.6	
Gross operating income				
-mean	**11.4**	**15%**	**18.0**	**15%**
-standard deviation	19.0		41.5	

Source: UMR AMURE survey / Ifremer SIH



Source Ifremer, SIH

Figure 4. Comparative evolution of the price of *L. digitata* and fresh fish between 2000 and 2008, in nominal and real terms (base 100 in year 2000).

Figure 4. Evolution comparée du prix de *L. digitata* et du poisson frais entre 2000 et 2008, en termes nominaux et réels (base 100 en 2000).

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[12] Set at 1,100 tons weekly, this handling capacity (authorised by the administration) was reduced to 900 tons in 2008 (representing a 20% decrease).

[13] For the first time, the seaweed sector has had to put in place regulatory measures controlling supply, not with the aim of protecting the resource, but in response to the handling capacities dictated by the processing plants.

[14] The reduction in authorised landings in tandem with maintaining the number of harvesting days has the result of keeping production costs the same despite a reduction in revenue. This situation has caused some vessels to stop their seaweed activity, due to the reduced financial performances. Others (the largest concerns) have resorted to harvesting *L. Hyperborea* on a more regular basis.

[15] This practise is in breach of European competition regulations however, and has ceased since 2010. Today, each kelp harvesters negotiates a contract at the start of the season with the processing plants defining the tonnage to be purchased, and the price.

Discussion: how dependent is the fleet on the kelp forests?

Because of these numerous concerns that weigh as much on the kelp resource in the Iroise Sea, as on the sustainability of the activity itself, it is instructive to analyse the way kelp harvesters depend on the *Laminaria* forests.

The dependence of a fleet on a resource can be analysed with regard to three complementary criteria: from the economic point of view, notably, by measuring the contribution seaweed makes to the financial results of the vessels concerned (notably with respect to the turnover), from an institutional point of view by analysing the potential of a fishing vessel owner to diversify and take on other fishing activities in addition to seaweed harvesting, and finally from the socio-cultural point of view through the analysis of how kelp harvesters perceive the future of their metier.

Economic dependency of the fleet on kelp forests

Analysing kelp landings reveals what proportion of the total turnover of the fleet is due to seaweed harvesting. The global rate of dependency of the fleet (estimated in terms of turnover) on kelp forests is 61%. But this figure is strongly interlinked with the other fishing activities that may be practised. Recent downward trends in the kelp landings mean that the strategic importance of complementary sources of incomes is increasing, such as the shellfish fisheries in the Bay of Brest. Following this line of enquiry, two categories of boats have been identified. On the one hand, the kelp-dredger vessels - making up the majority of the fleet - target scallops (*Pecten maximus* Linnaeus, 1758) and warty venus (*Venus verrucosa* Linnaeus, 1758) during the winter (with a dependency rate of 58%). On the other hand, the non-dredging kelp fleet that is inactive during the winter, or that uses passive fishing gear such nets or lines (with a dependency rate of 93%). The proportion of seaweed in the turnover figure increased from 56% in 2000 to 61% in 2008, notably for the larger vessels harvesting *L. hyperborea* in winter.

Institutional dependency of the kelp fleet: opportunities for diversification?

The fleet's dependency on kelp forests also has to be analysed in relation to institutional aspects. Before tackling the question of whether the fleet can, or cannot cope with the possible extinction of *Laminaria* forests, two related sub-questions have also to be asked, and namely how possible it would be for the vessel and its owner to:

- Retrain and convert to an entirely different trade
- Diversify their activity within the fishing industry

The average age of the fishers interviewed was 41 years old, a relatively late age to start a new professional career. The level of academic achievement is also relatively low (only 15% of fishers have academic qualifications beyond high school level). The question remains then of what possibilities exist for diversification.

Ownership of a PME increases the possibilities for diversification enabling kelp vessels to practise different metiers. In 2008, in the Iroise Sea, only 55% of vessels possessed a PME, compared with 76% in the Brittany region. Under these circumstances, kelp harvesters who do not possess a PME for their vessel have only two solutions: either to specialise in their activity and to focus exclusively on harvesting kelp, or to acquire a second vessel that does have a PME, and so that is in a position to diversify into other fisheries (a choice that would nevertheless result in increased production costs for the fisher concerned). The average number of boats per fisher is 1.4 for the fleet as a whole. Ownership of two boats allows a degree of flexibility for certain fishers who don't possess a PME. Ownership of a large vessel is also the only solution possible for harvesting during the *L. hyperborea* season because of the harsh meteorological conditions that predominate in winter. However, most "largest vessels" do not possess a PME. We can conclude that ownership of a PME, and the controls imposed on fishing effort in other fisheries are decisive elements with regard to the opportunities that exist for diversifying into other fishing activities (Fig. 5). But the newer build, larger boats do not possess the infamous PME. This type of boat is sometimes too large to be granted fishing rights in some fisheries. For example, the maximum authorised length for fishing in the Bay of Brest is 11 metres. A contradiction is appearing between the "largest vessels" model (regulation measures and processing plants requirements) and drivers from outside the seaweed harvesting sector that condition the possibility (or not) of diversifying towards other fisheries. But diversification 'outside the seaweed industry' would seem to be the only means of guaranteeing a future for the kelp harvesters.

Fishermen's' perceptions about diversification opportunities and the future of the kelp activity

During the field survey conducted with the kelp harvesters, interviewees were asked questions about the state of the resource, their own possibilities for diversification, and the future of the seaweed activity.

Although the kelp harvesters consider all the *Laminaria* fields to be in a good state 'because they are well managed' by fishers organisation, they insist above all on the unexplained variations in abundance. On the question of the future of the seaweed activity, Table 3 highlights the growing pessimism among kelp harvesters. Those of them that were more optimistic about the future of the seaweed

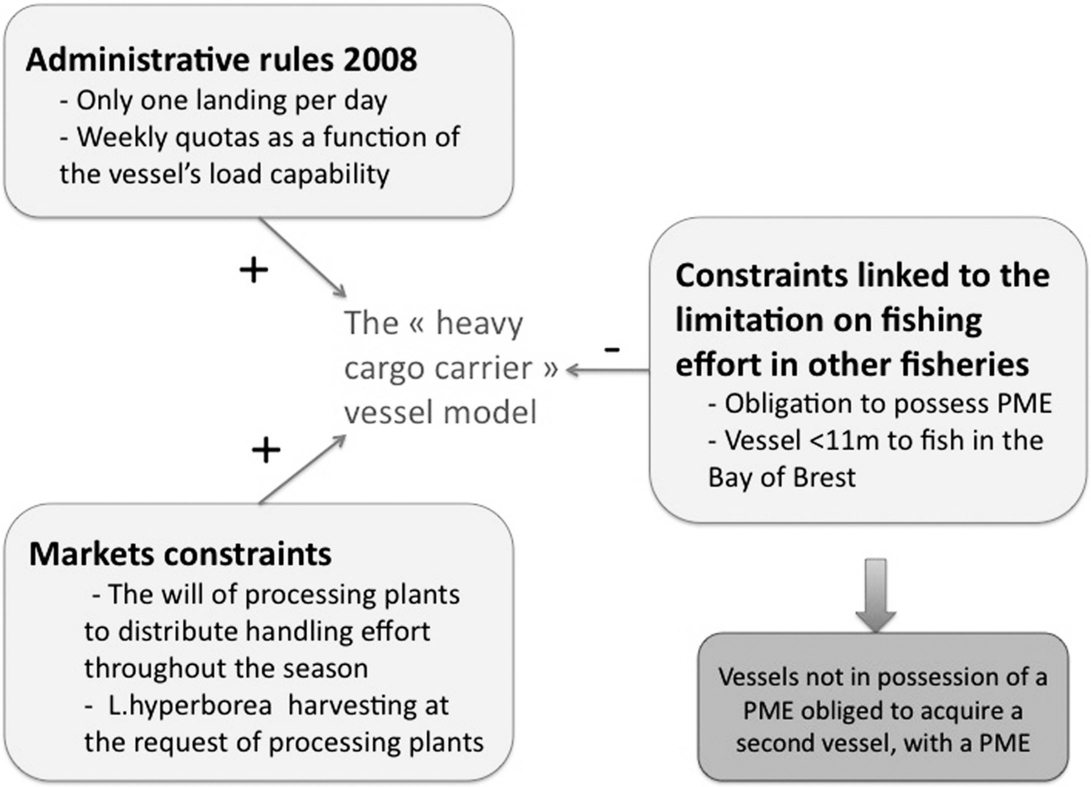

Figure 5. Diversification opportunities.
Figure 5. Possibilités de diversification.

activity agreed on two imperatives nevertheless: good management of the resource, and the continued existence of the two processing plants. For them, the one item that will decide the fate of the trade is the sale of seaweed. "*Conserving the existing processing plants is the main issue that will determine our future*". For all fishers interviewed, the presence of the processing plants in the (Brittany) region and their capacity to absorb the seaweed locally are two important conditions to guarantee the future of the trade. Those who didn't believe in the future of the seaweed activity drew attention to the decline in turnover, the regulatory constraints and the very high cost of vessels, whether newly constructed or purchased second hand (Table 4). Globally, vessel owners interviewed intended to continue their activity right up until retirement, but they emphasized the fragility of their situation in relation to the two local factories. However, some vessel owners expressed a desire that their children did not take over their business, even though, traditionally, kelp harvesters have always handed down their activity from father to son over a number of generations. This raises the question of how the fleet will regenerate in the future.

Table 3. Responses to the question: "Do you believe there is a future for the kelp harvesting trade?"*
Tableau 3. Réponses à la question : "Croyez-vous qu'il y a un avenir pour le commerce de récolte d'algues ?"*

	2000	2008
Yes	88%	64%
No	9%	21%
Don't know	3%	14%
Total	100%	100%

* Frequency of responses.
Source: AMURE surveys in 2000 and 2008.

Concerning the future development of the *L. hyperborea* exploitation, even though most vessel owners are in favour of this, they also express a certain number of fears (Table 5): fear in relation to the *L. hyperborea* resource[16] and the sustainability of the activity; and fear of being driven out of the activity on the part of the smaller boats. In effect, to harvest *L. hyperborea*, you have to own a large vessel. Above all, fishers feel the pressure being wielded by industrial players trying to force them into harvesting of this resource. "There is demand from the processing plants

Table 4. Responses to the question: "Why do you currently not have an investment project in a new boat?"*

Tableau 4. Réponses à la question : "Pourquoi ne pensez-vous pas, actuellement, à un projet d'investissement dans un nouveau bateau ?"*

	2000	2008
Recent purchase of a vessel	10%	14%
Retiring shortly	47%	14%
Satisfied with current vessel	10%	7%
Concern about the stock or the market	10%	21%
Price of boats and constraints linked to the EU fishing fleet register	40%	36%

* Frequency of responses, calculated on the basis of boat owners without any investment project. Non-cumulative frequencies (multiple responses possible). Source: AMURE surveys in 2000 and 2008.

Table 5. Responses to the question: "Are you in favour of the development of the harvesting of *Laminaria hyperborea*?"*

Tableau 5. Réponses à la question : "Etes-vous en faveur du développement de la récolte de *Laminaria hyperborea* ?"*

	2000	2008
Yes	66%	57%
No	34%	29%
Don't know	0%	14%
Total	100%	100%

* Frequencies of responses by vessel type. Source: AMURE surveys in 2000 and 2008.

for *L. hyperborea* because they want to work all year round, but the success of harvesting this particular type of seaweed is always subject to weather conditions". Moreover, prescribing the *L. hyperborea* exploitation gives rise to concern among fishers since this could provoke the construction of larger vessels that are not suitable for the harvesting of *L. digitata*, because they risk upsetting the existing equilibrium. The vessels that are already harvesting *L. hyperborea* consider they are contributing to the reduction in fishing effort on other species (seaweed or shellfish) since, not possessing any PME; they cannot displace their fishing effort onto fisheries other than the seaweed harvesting.

Conclusion

The analysis of the perception of fishermen highlights the strong dependency of this fleet on the *Laminaria* forest, and on the factories that transform the seaweed locally. The generalisation of "largest vessels" model (without a PME) increases this dependency, by accelerating the reduction in the number of vessels in the fishery, but this is not without consequence on the state of the *Laminaria* fields. In reality, there is a risk linked to this dependency of biological over-exploitation of some fields (at least locally) because of the activity being concentrated in a single zone. Traditionally, the smaller boats work along the shore while larger vessels exploit the *Laminaria* fields out at sea. The "largest vessels" model and the increasing exploitation of *L. hyperborea* risk bringing the larger vessels back to land (notably in winter). Among other things, the "largest vessels" model is increasing the concern about the excess capacity of the kelp fleet, and so to economic inefficiency.

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[16] *L. hyperborea* grows back more slowly than *L. digitata* (taking 5 years to regrow), and so appropriate management measures are required, notably with rotation of the exploited fields.

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