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When economy meets ecology, is it truly conflicted? A dashboard approach to assess the sustainability performance of European tropical tuna purse seine fisheries

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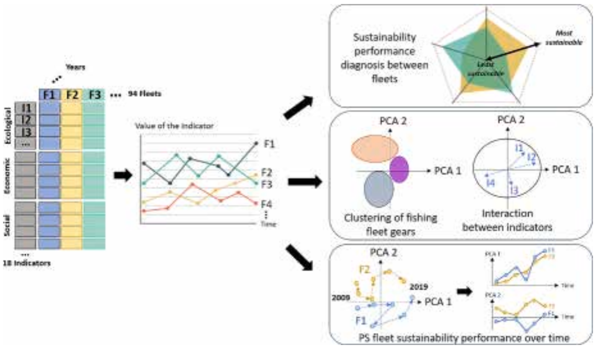
HIGHLIGHTS

- We studied sustainability performances of European tropical tuna purse seine fisheries.
- Ecological performance depends on juvenile catch rate and bycatch (quantity, quality).
- Economic performance depends mostly on energy efficiency and tuna price.
- Ecological and economic performances of European tuna purse seiners seems conflicted.

GRAPHICAL ABSTRACT



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ABSTRACT

The development of an ecosystem approach to fisheries management makes the assessment of the sustainability performance of fisheries a priority. This study examines European tropical tuna purse seine fleets as a case study, employing a multidisciplinary dashboard approach to evaluate historical and current sustainability performances. The aim is to enhance comprehension of the interconnected dimensions of sustainability and pinpoint management policy priorities.

Using 18 indicators, we assessed the environmental, economic and social sustainability performances of European tropical tuna purse seine fleets, comparing them with other industrial tropical tuna fishing fleets in the Atlantic and Indian Oceans. The analysis also explored the temporal trend of sustainability performance for European tuna purse seiners from 2009 to 2019.

Our results suggest that, compared with gillnetters and longliners, purse seiners and baitboats have a greater species-based selectivity, thereby catching fewer endangered, threatened or protected species, but a lower mature tuna catch rate, thus capturing more juveniles. We identify likely gaps in bycatch data reported by fishing

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on fish aggregating devices (FADs), due to results regarding selectivity and discard rates that appear inconsistent in the light of the scientific literature.

The greater use of FADs, likely caused by the global tuna market, by purse seiner seems result in decreased ecological performances, as suggested by an increased carbon footprint per tonne landed. At the same time, it implies a better economic performance on the short-term, with higher net profit, energy efficiency (fuel consumed relative to monetary value created) and catch. For our case study, Ecology and Economy might seem to be in conflict for short-term perspective. However, consideration of the long-term impacts of FAD fishing and market incentives for fishing on free schools should lead purse seiner fleets to reduce drifting FAD fishing and promote more sustainable fishing practices.

1. Introduction

Fisheries, including tuna fisheries, are facing a crisis due to the decades-long increase in fishing power, resulting in a substantial increase in fishing effort and excessive fishing pressure worldwide. This increase has been fuelled by human population growth and rising demand for seafood (Roberts, 1997; Pauly and Zeller, 2003; Pauly, 2008; FAO, 2022). As a major source of protein for humans, several tuna stocks are experiencing overfishing in the global ocean (Xie et al., 2020). In 2020, the global catch of the seven main tuna species, namely albacore (*Thunnus alalunga)*, bigeye (*Thunnus obesus*), bluefin (*Thunnus thynnus, Thunnus maccoyii* and *Thunnus orientalis*), skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*), was 4,8 million tons, representing 6 % of global marine catches (FAO, 2022). A holistic sustainability assessment of these key fisheries for the global seafood market is needed to understand how the biological and ecological status of both resources and ecosystem have changed with the fishery economies and what lessons need to be learned to ensure food supply security.

Tuna fisheries resources are managed by regional fisheries management organisations (RFMOs), which are mandated by members represented by both fishing and coastal countries to assess pelagic resources, especially tunas, tuna-like species (*Scombridae, Istiophoridae* and *Xiphiidae*) and pelagic sharks. Within this framework, the management target agreed upon by member states according to international commitments is the maximum sustainable yield (MSY), defined as the largest amount of biomass that can be extracted over the long term from a fish stock under existing environmental conditions without affecting its renewal process (Schaefer, 1954). The MSY is stock-specific and does not consider ecosystem interactions, although these warrant consideration when assessing the environmental impacts of fisheries. Because tunas are top predators, they are considered keystone species in marine pelagic ecosystems. As such, they play a significant role in open ocean ecosystems due to their influence on marine food web structure and dynamics (Estes et al., 2016; van Denderen et al., 2018). Consequently, their decline can initiate trophic cascades (Heithaus et al., 2008) and jeopardise the resilience and stability of marine resources (Kerr et al., 2017; Artetxe-Arrate et al., 2021). Other important interactions result from the bycatch of non-target species that gets discarded. Such discarding can be done for legal reasons in the case of protected species (sea turtles, marine mammals, some sharks, and rays), or commercial ones, in the case of low value species, which is considered wasteful of marine biomass. To respond to these issues, tuna RFMOs (tRFMOs) are setting up more studies on these interactions and monitoring impacts on non-target species (Juan-Jordá et al., 2018). Technical measures to reduce bycatch should contribute to the development of an ecosystem approach. However, as management objectives and the definition of fishing limits or quotas are still based mainly on MSY, scientists warn of the need for a more precautionary approach (Karim et al., 2020; Hornborg et al., 2019).

The purse seine is the most productive tropical tuna fishing gear. In the Atlantic and Indian Oceans, the main industrial tropical tuna purse seine fleet flags are France and Spain, targeting skipjack (*Katsuwonus pelamis,* SKJ*)* and yellowfin (*Thunnus albacares,* YFT) tuna, with the bigeye (*Thunnus obesus,* BET) as a valuable bycatch specie. The tropical tuna purse seine fishery develops two fishing mode: fishing on free school (FSC) and fishing on drifting fish aggregating devices (FAD). In both these oceans, other industrial tuna fishing gears are also deployed to exploit tropical tuna stocks, including longline, gillnet, and pole and line (Coulter et al., 2020). Each fishing gear has different technical characteristics (mesh size and height of nets, hook type and size for the longline, type of bait for pole and line, time of a fishing operation and whether the technique is active or passive), which lead to different fishing efforts, different direct impacts on exploited stocks and different indirect impacts on the ecosystem.

The goal of the present study is to demonstrate how a dashboard approach can be applied to the various sustainability dimensions in fisheries. Taking the activities of European Union tropical tuna fishing fleets as a case study, we aimed to identify the strengths and weaknesses of different fleets, fishing gears, metiers and fishing strategies. The fleet scale is the highest resolution for data reporting due to anonymisation rules of fishing companies. To improve our understanding of how sustainability dimensions interact, it is necessary to monitor fleet performances over time. This can reveal the strengths and weaknesses of different fishing activities and then allow adapted management strategies to be proposed for those fleets (Capello et al., 2023).

Under the constraint of the data available, the initial step involved constructing a dashboard to allow the comparison of fishing strategies and performance monitoring over time. We then investigated potential factors influencing changes in fishing strategies and their consequences for various sustainability dimensions.

In fisheries management, sustainability has usually been defined with reference to the catch level that can be maintained over time (e.g. maximum sustainable yield assessment) and to ecological impacts of fishing (e.g. on bycatch species or seafloor integrity), without considering economic, human, or social goals. Based on the conservation paradigm of protecting the ecological system, numerous scientific studies have used a multidimensional approach (ecological, economic, social, governance, etc.) to assess the sustainability of fisheries using dedicated scoring (e.g. the FPI method, Anderson et al., 2015; the RAPFISH technique, Pitcher and Preikshot, 2001; the VALDUVIS tool, Kinds et al., 2016). Seafood labelling also uses a multi-criteria approach with a rating based on selected criteria to indicate the degree of sustainability of a fishery (e.g. Marine Stewardship Council, Friend of the Sea or the French *Pêche durable* labels). Not many labelling approaches yet include socio-economic impacts, except Friend of the Sea (FOS) labelling (Lecomte et al., 2017). A few studies have worked on a broad multidimensional dashboard of theoretical sustainability indicators applied to the fishing industry, but none has yet been based on a case study (Danto et al., 2021; Dewals and Gascuel, 2020).

The objective of multi-criteria evaluation methods is to identify, according to selected evaluation criteria, practices of a given fishery that need to be improved, those that need to be promoted, and existing spaces and levers for improvement. They do not tell us whether fleets can perform well in all dimensions simultaneously. In a multidimensional and intertemporal sustainability assessment study based on the RAPFISH methodology, Murillas et al. (2008) warned of the potential negative consequences of seeking better fishing capacity (e.g. by increasing the number of vessels) on the ecological dimension (e.g. by an increase in discards), but could not explain causal relations among different variables.

The challenge is to find how a dashboard approach can highlight multidimensional fleet sustainability performance and how inter-dimensional interactions can be identified for more efficient policy recommendations and fishery management options.

The aim of our study is to respond to this challenge by constructing a relevant and operational dashboard for the sustainability assessment of tropical tuna fisheries that will reveal differences among pelagic fleets, gears and strategies (in the case of purse seiners) exploiting the same

Table 1
Synthetic table of indicators calculated and analysed, and how they should be interpreted.

Dimension	Indicator name	Criteria	Interpretation aid	Analysed Indicators
Biological & Ecological system	Stock assessment reliability	The fleet exploits fishing stocks based on reliable stock assessment	The higher the score, the more the fleet is exploiting a stock whose stock assessment quality is good (Low uncertainty score)	X
	Overfished stocks	The fleet exploits fishing stocks which are not subject to overfishing	The higher the score, the more the tuna stocks, targeted by the fleet, in proportion of catch, are overexploited.	X
	Stock biomass (relatively to Bmsy)	Tuna stock biomass is not overexploited relative to MSY	The higher the score, the more the tuna stocks, targeted by the fleet, have large biomass relatively to Bmsy	collinear
	Spawning stock biomass (relatively to SSBmsy)	Tuna stock spawning biomass is not overexploited relative to MSY	The higher the score, the more the tuna stocks, targeted by the fleet, have large spawning biomass relatively to SSBmsy	X
	Stock biomass (relatively to B0)	Participation capacity of biomass of exploited stocks in the ecosystem in a pristine state (without fishing)	The higher the score, the more the fleet is exploiting stocks whose biomass are close to the virgin state and thus available for the functioning of ecosystem	collinear
	Spawning stock biomass (relatively to SSB0)	Participation capacity of spawning biomass of exploited stocks in the ecosystem in a pristine state (without fishing) - Protection of juveniles	The higher the score, the more the fleet is exploiting stocks whose spawning biomass are close to the virgin state and thuse available for the functioning of ecosystem	collinear
	Mature catch rate	Exploitation diagram is consistent with protection of juveniles	The higher the score, the more the fleet is exploiting mature fish, thus limiting its impact on stocks (Tuna length L > L with 50 % of maturity)	X
	Species-based selectivity	The fishery is selective and impacts only the target species	The higher the score, the more the fleet is selective and less non-targeted species are impacted	X
	Discard rate	The fishery does not waste biomass	The higher the score, the more the fleet discards biomass and the higher the ecosystem impact	X
	Sensitive species catch rate	Minimum impact on the least productive biomass (sensitive species)	The higher the score, the greater the fleet's catch of conservation status species (sharks, turtles) and the higher the ecosystem impact	X
	Bycatch TL mean	Bycatch and discards concern species of low trophic level	The higher the score, the less the fleet has an impact on high trophic levels in the ecosystem	X
	Fuel use intensity	The fuel use intensity is less by landings in weight	The higher the score, the more the fleet consumes fuel by kilo caught, and thus has a potential impact on climate change	X
	Carbon footprint	The carbon footprint is less by landings in weight	The higher the score, the less the fleet emits the most CO2 by kilo caught, and thus has a potential impact on climate change	collinear
Technical dimension	Catch on FSC	Catch rate on FSC is sufficiently important not to impact the resource or ecosystems	The higher the score, the less the fleet has an impact on stocks and on bycatch and sensitive species, and thus on ecosystem	X
Economic & Finance system	Variability in catch	Tuna catch is stable: inter-annual variability of tuna catch is low	The higher the score, the more the significant tuna catch changes from one year to another	X
	Importance of energy costs	The energetic dependence is low	The higher the score, the lower the energetic dependence of the fleet (Lowest energy costs relative to the turnover)	X
	Energy efficiency	The economic productivity of energy is good	The higher the score, the higher the economic productivity of energy of the fleet (Greatest gross added value relative to the fuel consummation)	X
	Margin rate	The economic profitability is good	The higher the score, the higher the economic productivity of the fleet (Highest gross operating profit relative to the gross added value)	X
	Net profit	The economic profitability is good	The higher the score, the higher the economic productivity of the fleet (Highest landings incomes with lowest total costs)	X
	RoFTA	The capital productivity is good	The higher the score, the higher the return of tangible assets (RoFTA) of the fleet (Highest gross operating profits relative to physical capital values)	X
	Variability in YFT's prices	Tuna price is stable: inter-annual variability of tuna price is low	The higher the score, the more the significant yellowfin tuna price changes from one year to another	X
Socio-economic system	Work productivity	The work productivity is good	The higher the score, the higher the work productivity of the fleet (Highest gross added value relative to the number of full-time equivalents)	X
	Created FTE	Employment is stable across successive year	The higher the score, the greater the number of jobs created (in full time equivalent – FTE) from one year to another. It is not the absolute number of FTE.	X
	Average salary	Salary levels are good	The higher the score, the higher the average salary (Greatest salary costs with regard to the number of full-time equivalents)	X

resource and help to understand how indicators from ecological, economic and social dimensions interact. In this way, we can examine whether a fishing fleet must necessarily have an ecological impact in order to be economically and socially sustainable and whether we can find paths for improvement.

In this context, our study (i) compares recent sustainability performances (2015–2019) among different European tropical tuna purse seiner fleets and (ii) among different tropical tuna pelagic fishing fleets (baitboat, gillnet, longline) and (iii) analyses the co-evolution of sustainability indicators for European tropical tuna purse seiner fleets over a longer period (2009–2019).

2. Materials and methods

2.1. Dashboard construction: selection of sustainability assessment indicators

The sustainability of fisheries can be addressed from different angles or dimensions, such as the related biological, ecological, economic, socio-economic, market and finance or socio-cultural systems. In a dashboard approach, the sustainability criteria associated with each dimension are defined as sustainability targets or objectives. For example, in the biological and ecological dimensions, fisheries minimise their impact on stocks, the seafloor, sensitive species, etc. Indicators are mathematical formulations for given criteria and are notably used to determine whether a management objective has been reached. Different indicators can assess the same criterion e.g. the status of the stock targeted by fisheries (in other words, does the fishery base its activity on stocks that are in a good condition?) can be assessed using an indicator of overfished stocks (related to the Fmsy target: the fishing pressure able to deliver, on average, the maximum sustainable yield) and an indicator of the status of the stock biomass (related to the Bmsy target).

Dimensions, criteria and indicators were selected from the peer-reviewed literature on theoretical multidimensional dashboards, and ecological indicators for tuna fisheries identified in literature, technical reports, and fishery statistics (Sup. Mat. 1). From this review, we selected indicators based on criteria ranked as according to: (i) the suitability of the scale of the indicator information to assess the sustainability at the fleet level, (ii) whether public data were available or easy on an annual basis, (iii) whether the scale of public data provided a fleet-level resolution or could be adapted to one (Sup. Mat. 1). Specific ecological indicators for tuna fisheries were related to the main characteristics and challenges for tropical tuna fisheries in both the Atlantic and Indian Oceans and added to the analysis (Sup. Mat. 2).

We compiled an initial list of 24 indicators distributed among the ecological (13 indicators), technical (1 indicator), economic (7 indicators) and socio-economic (3 indicators) dimensions of sustainability for tropical tuna fisheries (Table 1). The dashboard encompasses the following criteria: the status of targeted stocks, the ecological footprint of fleets on targeted stocks and the marine ecosystem, the temporal trend of tuna catches, economic health, and ecologic efficiency of energy (i.e. economic productivity, fuel use intensity), employment stability and wage levels. The procedure of data collection and calculation of indicators are detailed in Sup. Mat. 3. The dataset used for analysis corresponds to indicator results from Table 1 calculated annually for 59 and 43 fishing fleets (flag x fishing gear combinations) in the Atlantic and Indian Oceans, respectively. Ecological indicator results were available for all fleets for the 1950 to 2019 period (except for carbon footprint and FUI indicators) for all fleets. The other indicators (economic, socio-economic and those related to carbon impact) were available for 2008–2019 for the European tuna purse seine fleets (French and Spanish purse seiners in Atlantic and Indian Oceans).

Different indicators can provide redundant information for the same criteria of sustainability. To avoid redundancy in the analysis and keep only uniquely informative indicators, we conducted a pairwise Pearson correlation test between all indicators, using R and RStudio software (R Core Team, 2023; RStudio Team, 2023) (linear correlation matrix available in Sup. Mat. 4). Based on this matrix, we identified collinearity between indicators related to stock biomass (B/Bmsy, B/B0, SSB/SSB0, SSB/SSBmsy) and indicators related to the impact on climate change (carbon footprint and fuel use intensity). We kept the spawning biomass stock indicator (SSB/SSBmsy) to express the current stock status relatively to the SSBmsy target, while avoiding short-term variability due to recruitment changes. We retained the fuel use intensity (FUI) indicator is the most commonly used indicator to indirectly express the impact on climate change (Basurko et al., 2022; Bianchi et al., 2022; Parker and Tyedmers, 2015). Finally, the dataset analysed consisted of nine ecological indicators, six economic indicators and three socio-economic indicators for 59 and 43 fishing fleets in the Atlantic and Indian Oceans, respectively.

2.2. Statistical analysis

We present the current performances of the four European tuna purse seiner fleets based on average figures for the 2015–2019 period and using radar diagrams. Radar diagrams provide an overview of the dashboard results. For each indicator, 0 was assigned to the least sustainable value obtained among the four fleets, and 1 to the most sustainable value based on interpretation of the indicator results in Table 1.

We also used principal component analysis (PCA) for two purposes: (1) characterising individuals (e.g. fishing fleets) based on variables (e.g. indicators of sustainability performance), and (2) identifying correlation links between these variables.

To conduct a PCA, the dataset must have no missing values. In the dashboard dataset, indicator values could be unavailable for certain years and fleets due to a gaps in reported data. For all tuna fleets, 35 % of the ecological indicator values and 7 % of the economic and socio-economic indicator values were unavailable. The “missMDA” R package (Josse and Husson, 2016) was used to replace missing data with plausible and neutral values derived from a model considering both the similarities between individuals and those between variables.

A first PCA on ecological indicators was conducted to examine the contrast of ecological sustainability performances among tropical tuna fishing fleets (94 individuals). This analysis was based on mean values of indicators over the last few years (2015–2019). Since specific ecological indicators, such as discard data, free school catch rate, and fuel use intensity are exclusive to particular fleets, these three indicators were categorised as supplementary variables to mitigate potential biases in fleet typology derived from ecological indicators.

A second PCA was run for the full dataset, considering all indicators for the European purse seiner fleets. We used an economic themascope PCA (Lebart, 1989), in which economic and socio-economic indicators were active variables while ecological indicators were supplementary variables. With the resulting typology of fleet fishing strategies, we aimed to highlight interactions between economic and socio-economic indicators and their potential links with ecological indicators. We considered additional descriptors of the economic environment as supplementary variables in the themascope PCA to examine how economic performances of the fishing fleets were linked to their environment. The variables of the economic environment were: the global average annual price of fuel (INSEE, 2022), skipjack and yellowfin prices (Campling et al., 2022), and the annual total catch by fleet. Economic and socio-economic data were available from 2008 to 2019. This PCA had 40 statistic individuals (four European tropical tuna fleets over 10 years).

3. Results

3.1. Recent average performances of European purse seiners (2015–2019)

Fig. 1 displays the comparative dashboard indicators values of the European purse seiners. The French and Spanish fleets in the Atlantic

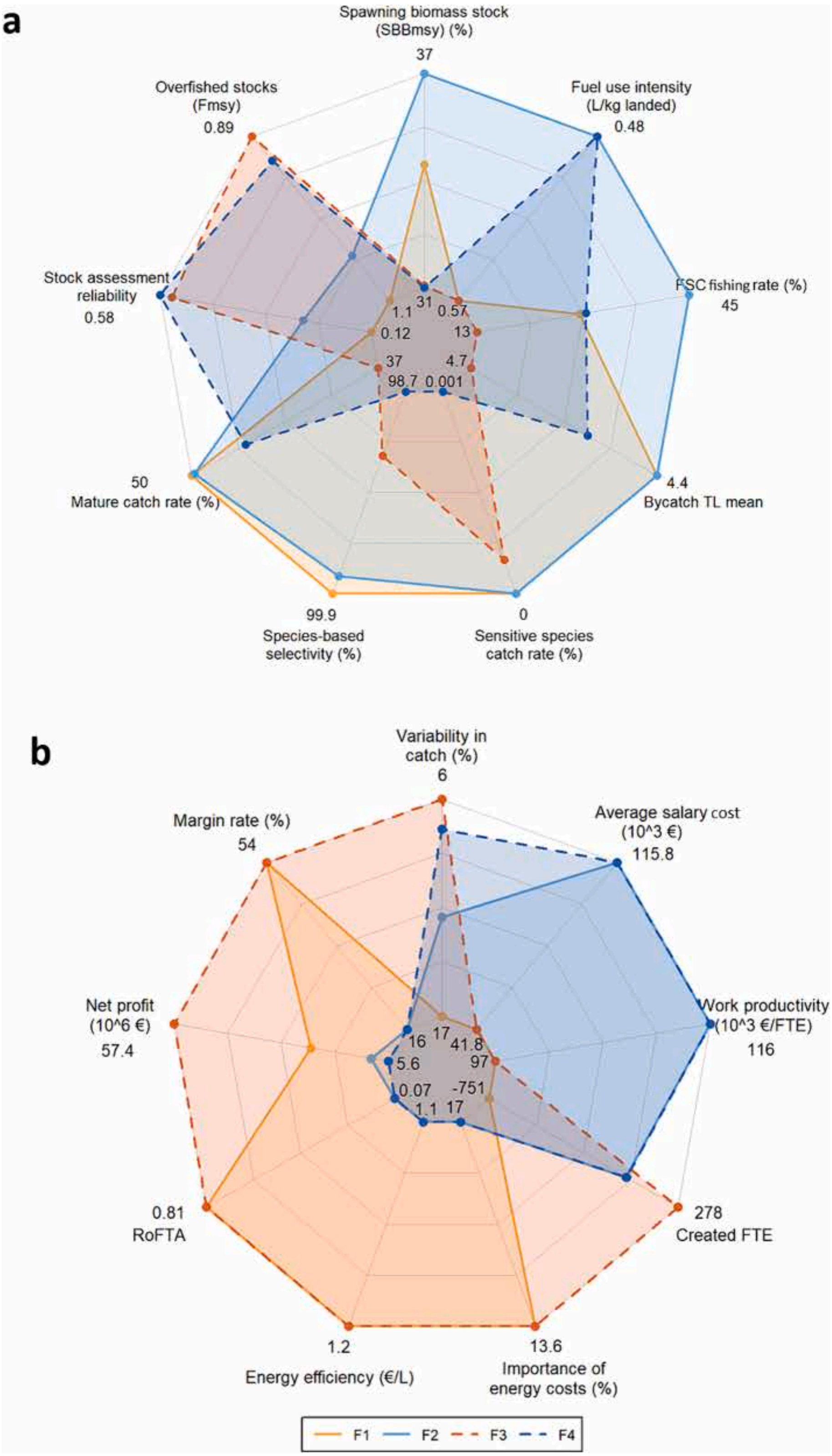

Fig. 1. Current average (2015–2019) of (a) ecological, (b) economic and socio-economic relative performances of European tropical tuna purse seiners (orange shades for Spanish fleets (F1,F3), blue shades for French fleets (F2,F4)) in Atlantic (full lines; F1,F2) and Indian (dashed lines; F3,F4) Oceans. Numbers represent the absolute indicator results. Results shown outside the plot indicate the best performances observed in the population (which can be below the most desirable level).

Ocean show similarly higher performances regarding indicators of spawning stock biomass and ecosystem impact (bycatch TL mean, sensitive species catch rate, species-based selectivity, mature catch rate), while exhibiting rather large ratio of fishing on free swimming school (FSC) (Fig. 1a). The situation is the opposite in the Indian Ocean, where a common pattern between French and Spanish fleets is only found for the indicators of overfished stocks and stock assessment reliability.

In the Atlantic Ocean, the French fleet has higher results than the Spanish one for the spawning stock biomass (37 %), fuel use intensity (0.48 L fuel.kg^{-1} of tuna landed), FSC catch rate (45 %), bycatch TL mean (4.4) and sensitive species catch rate (conservation status species) (0 %), while the Spanish fleet has the highest results on the mature catch rate (50 %) and species-based selectivity (99.9 %); it matches the French fleet for sensitive species catch rate (0 %) and bycatch TL mean (4.4). The Spanish fleet in the Atlantic Ocean has the lowest performance on the indicators referring to stocks and fuel use intensity (0.57 L fuel.kg^{-1} landed, Fig. 1a). Average fuel use intensity (FUI) was 19 % higher in the Spanish fleet than in the French fleet in both oceans for the 2015–2019 period.

With regards to economic indicators, Spanish fleets commonly have higher results than the French ones for the margin rate (54 %), economic productivity of energy (1.2 €.L^{-1} fuel) and the importance of energy costs (13.6 %) (Fig. 1b). The variability in catch and number of full-time equivalents (FTEs) created are higher for the Indian Ocean fleets, particularly for the Spanish Indian Ocean fleets (6 % and 278 FTE created, respectively). The Spanish fleets have lower average fisher salary costs and work productivity compared with the French fleets (work productivity of 97 and 116 10^{3} €.FTE^{-1} and average fisher salary costs of 41.8 and 115.8103 €.FTE^{-1}). The Spanish fleets have higher net profit compared with the French fleets (57.4 10^{6} € and 5.6 10^{6} € respectively).

3.2. Comparison of ecological performances of the various fleets and gears in the different oceans

Axis 1 of the ecological PCA is explained positively by several ecosystem impact indicators: the overfished stocks, mature catch rate, bycatch TL mean, and sensitive species catch rate (Fig. 2). This axis is explained negatively by the spawning stock biomass (based on SSB/SSBmsy ratio) (Fig. 2a). The fuel use intensity describes axis 1. Fishing gears are displayed along axis 1, the longline fleets having positive coordinates on this axis (Fig. 2b). Longliners are characterised by large ecosystem impacts with greater sensitive species catches and a higher mean bycatch TL than other fishing gears, although they caught more mature tuna individuals. This fleet displays the higher dispersion along the axis 1 relative to other fishing gears in both oceans. In contrast, purse seiners and baitboats (i.e. fishing vessels of the pole-and-line fishery) fleets appear characterised by lower ecosystem impacts than other fishing gears, but a greater catch of juvenile tuna catch. Gillnet fleets had intermediate ecosystem impacts. Axis 2 of the ecological PCA is explained positively by the species-based selectivity indicator and partially explained negatively by overfished stocks catch rate indicator.

Axis 2 opposes the Atlantic Ocean fleets and Indian Ocean fleets (Fig. 2c). The overfished stocks catch rate indicator is negatively correlated with indicators of good stocks status, i.e. it is linked to B/B0, B/Bmsy and SSB/SSB0 (§2.1.). Tuna fleets in the Atlantic Ocean are characterised by more catch from overexploited (B/Bmsy) and overfished (F/Fmsy) stocks and a better species-based selectivity than fleets in the Indian Ocean. The French and the Spanish fleets differ regardless of ocean considered. In the Indian Ocean, the difference between fleets is related to Axis 1; in the Atlantic Ocean it is related to Axis 2. In the Indian Ocean, the French purse seine fleet catches more mature fish and shows a higher bycatch TL mean and a higher FUI than the Spanish purse seine fleet. In the Atlantic Ocean, the French purse seine fleet has a higher species-based selectivity with more catches on stocks that have a better status and are less intensively fished.

It should be underlined that the free swimming school (FSC) fishing ratio is not represented on the axe1/axe2 PCA plan, while, due to data limitations, results regarding purse seiner are established on average not considering the fishing practice (fishing on FAD vs FSC). Therefore, positive ecological performances of that fleet compared to longliners may mask within-group or between fishing practices variability and should be considered with cautious.

3.3. Dynamics of economic and social performances of European purse seiners

Axis 1 of the economic PCA is linked to the economic performance of the fleets (Fig. 3a). High values are related to a high capital productivity (return on fixed tangible assets: RoFTA), high economic productivity of energy, high net profit and, to a lesser degree, high margin rate and low share of energy costs in the total costs. The net profit and RoFTA are correlated with high catch, high YFT price and less fishing effort on free swimming schools (FSC rate). Axis 2 (dimension 2) of the economic PCA characterizes the two European fleets (Fig. 3b). This dimension is explained by a high fuel use intensity (i.e. higher fuel consumption per ton of tuna), more FTEs created, lower average fisher salary costs and, to a lesser degree, by work productivity. Indicators related to species-based selectivity, mature catch rate, variability in catch and variability in YFT prices do not contribute significantly to the Axis 1–2 factorial plane.

The French fleets had higher average fisher salary costs and a more stable number of jobs (in full time equivalents: FTEs) than the Spanish fleets. In 2009, the French fleets were characterised by lower economic performances (smaller RoFTA and a higher share of energy costs) than in the other years (Figs. 3b & 4a). In contrast, in 2012, the Spanish fleets were characterised by more FTEs created (i.e. instable number of FTEs), a smaller average fisher salary costs and a higher fuel use intensity. There is no difference between oceans for economic or socio-economic performances. Differences only appeared according to the fleet flag (Fig. 3b, Fig. 4a & b).

3.4. Monitoring the sustainability performances of European purse seiner fishing fleets

The economic performances over time (i.e. the fleets' positions on axis 1 of Fig. 3) show similar dynamics for the French and Spanish purse seine fleets, with higher performances in 2013 and 2017 and lower performances in 2009 and 2015 (Fig. 4a). In 2012, a significant difference between fleets can be noted, with a lower performance for Spanish fleets. Regarding carbon and social aspects, negative coordinates on PCA axis 2 suggest a lower carbon impact, higher average fisher salary costs and less FTEs created by the French fleet (Figs. 3a, Fig. 4b). For this fleet, the carbon and social strategy (i.e. fleets' positions on axis 2 of Fig. 3) trend decreased until 2018 and then started to increase. For the Spanish fleet, the trend was stable over time, except in 2012 when a sharp increase occurs for both FTEs created, and carbon impact (Fig. 4b). In both Atlantic and Indian Oceans, and over the whole studied period, the Spanish fleet fishes more on fish aggregating devices (FADs) than the French fleet (Fig. 4c). A general increase in the fishing rate on FADs is observed over the studied period. Depending on the fleet, it increases from 45 to 60 % in the early 1990s to 55–90 % at the close of the 2000s. This increase is particularly strong for the Spanish fleets in the Atlantic Ocean (from 50 to 70 %) and even more in the Indian Ocean (from 55 to 90 %). For the French fleets, the increase would be only around 10 %, with reported FAD fishing rates at the end of the period around 55 and 70 % in the Atlantic and Indian Oceans respectively. These trends result in a growing contrast between flags, with the French and Spanish fleets displaying close fishing rates on FADs at the start of the period but much higher for the Spanish fleets in recent years.

According to available data, the species-based selectivity would be up to 99.5 % until 2016–2017, except for the French fleet in the Indian Ocean. This latter fleet exhibited a low selectivity of 98.8 % in 2012, a

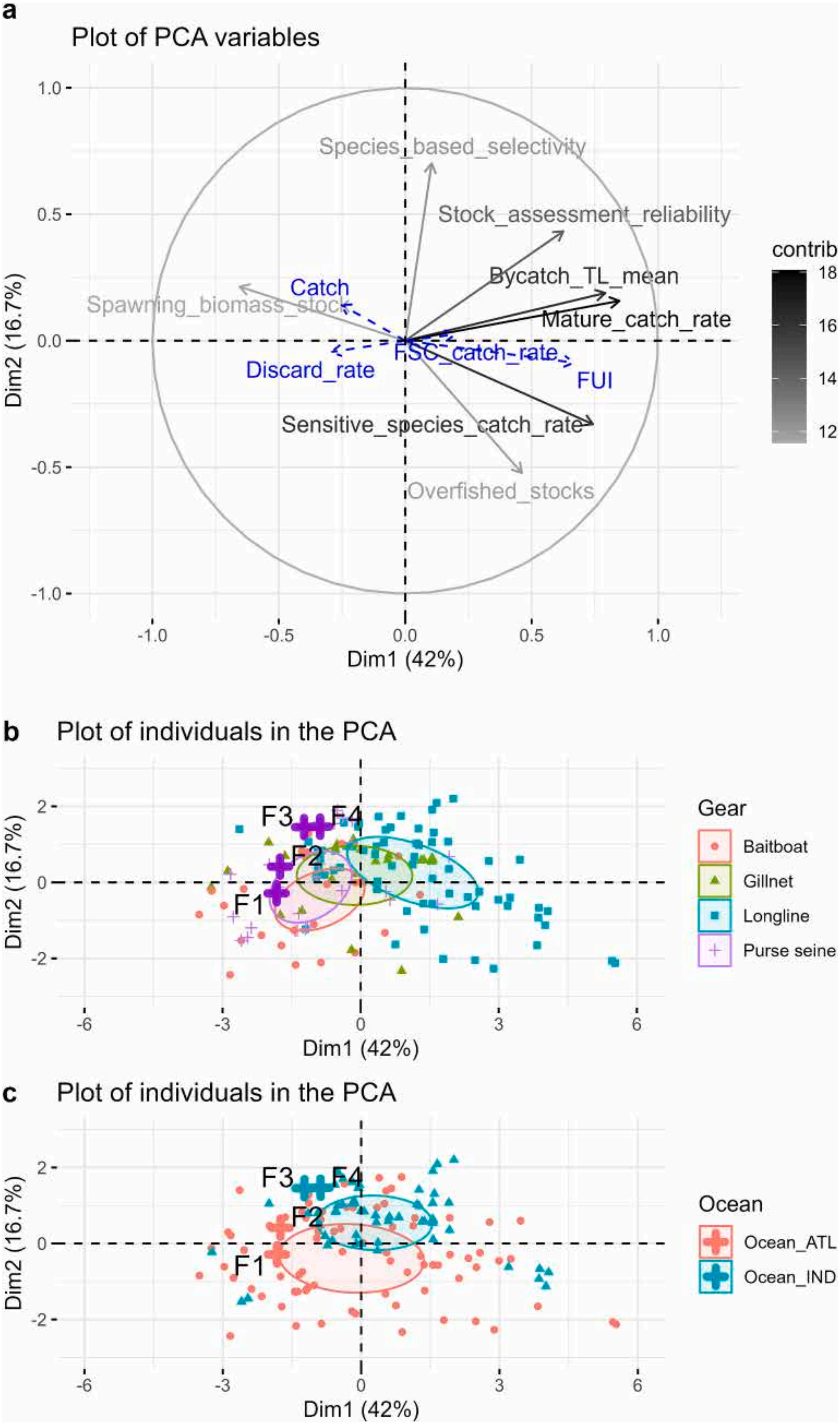

Fig. 2. Principal component analysis of mean ecological indicator scores for the 2015–2019 period for all tuna fishing fleets in Atlantic and Indian Oceans (Spanish fleets: F1 & F3; French fleets: F2 & F4). (a) Plot of variables. Blue dotted arrows show supplementary variables and black arrows show active variables. The degree of shading expresses the percentage contribution of the variable to the total inertia of the plan. (b) & (c) Plots of individuals colour-coded by ocean (b) and fishing gear (c).

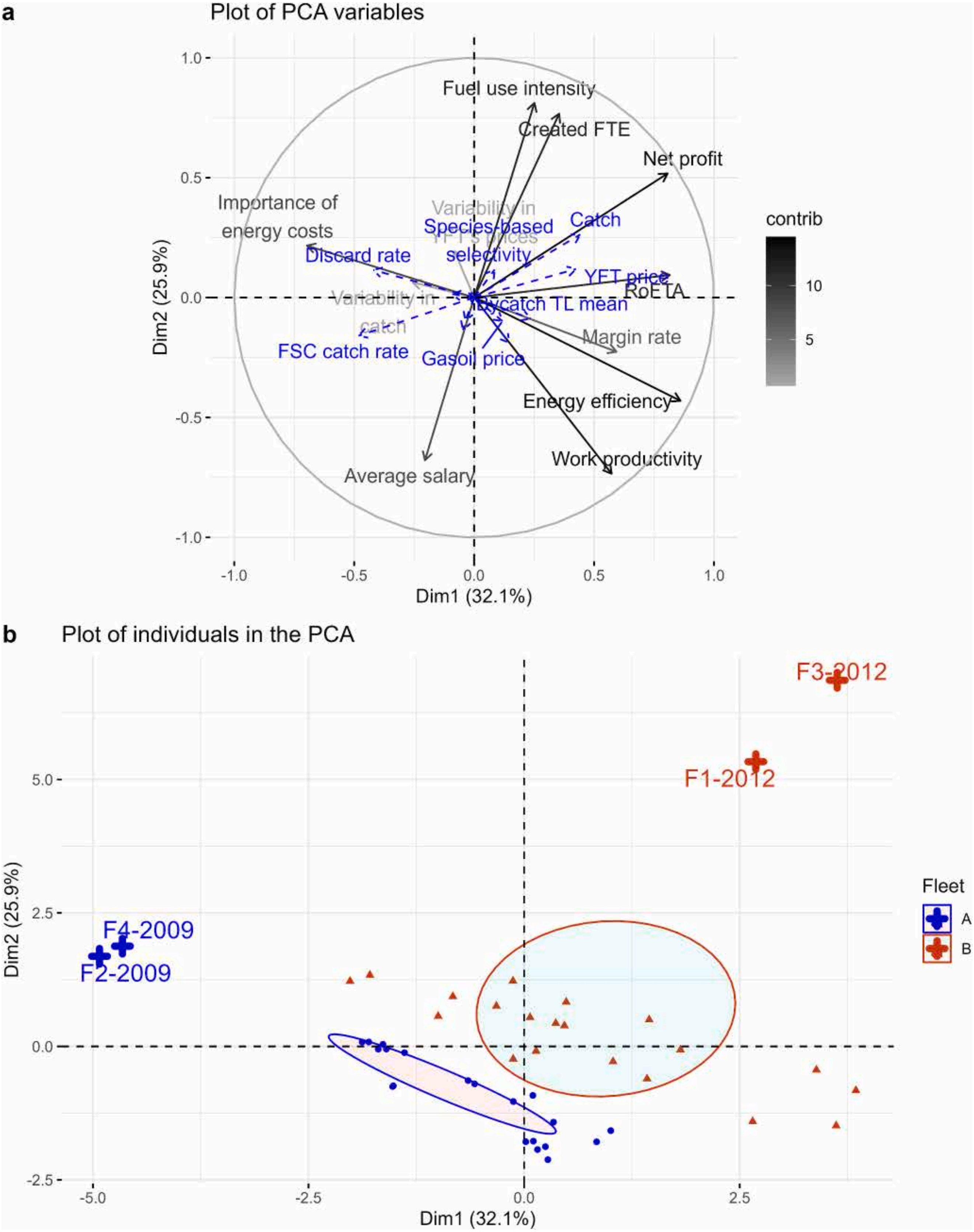

Fig. 3. Plots of variables (a) and individuals (b) from PCA of economic and socio-economic indicators (Table 1) for European tropical tuna purse seiners over 10 years (2009–2019) in Atlantic (F1, F2) and Indian (F3, F4) Oceans. Variables shown with blue dotted arrows are supplementary variables and black arrows are active variables. The ecological indicators are supplementary variables. The plot of individuals is colour-coded by national fleet (A: French, B: Spanish). On the variable plot (a), the degree of shading expresses the percentage contribution of the variable to the total inertia of the design.

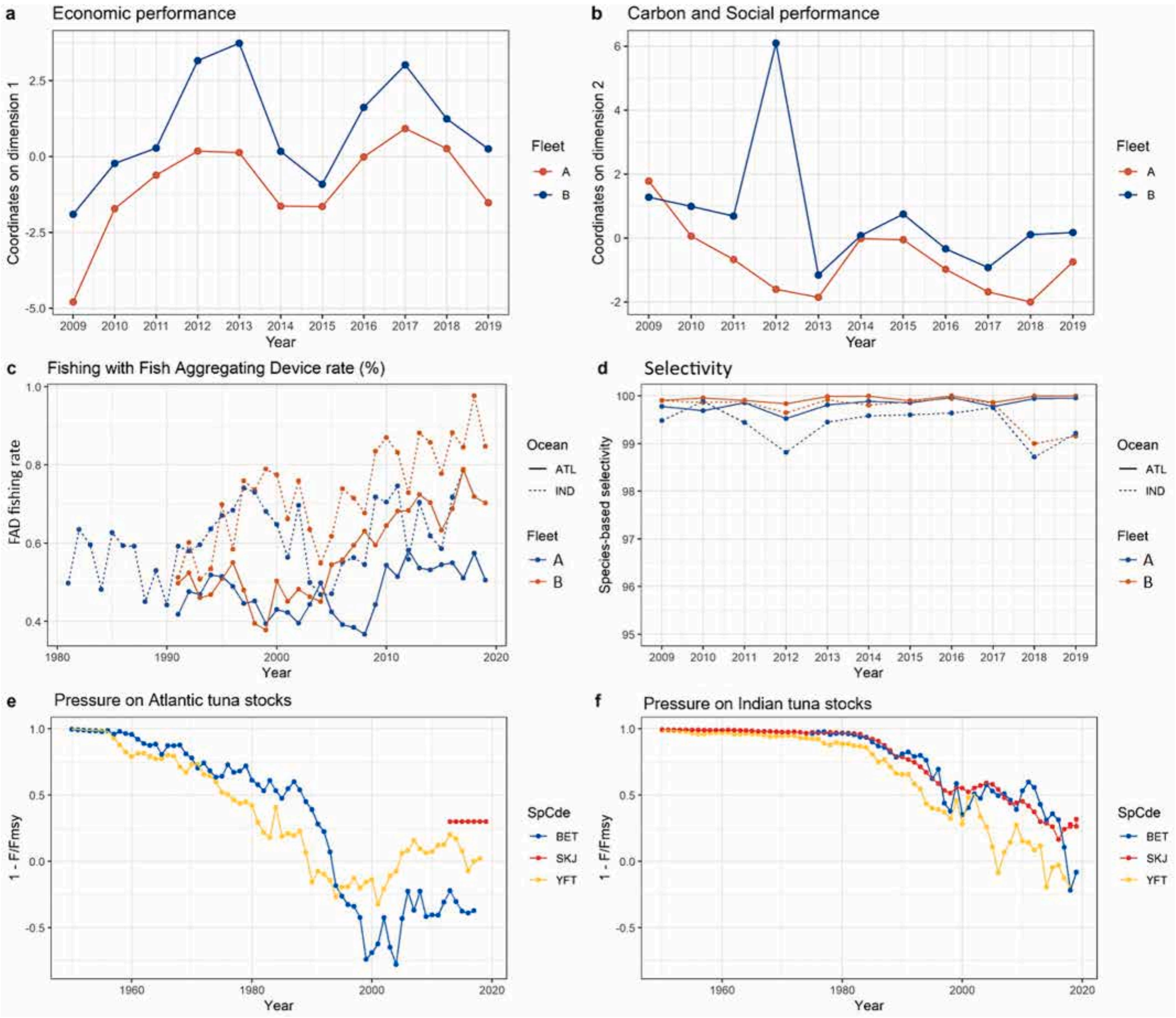

Fig. 4. Plots of performances of purse seine tropical tuna fishing fleets over time. The coordinates on axes 1 and 2 of the economic PCA (Fig. 3) plotted over time for each national fleet (a & b) (A-French fleet, B-Spanish fleet). The two indicators, FAD fishing rate and species-based selectivity, plotted over time by country and ocean (c & d). The fishing pressure on the major tropical tuna stocks (1-F/Fmsy) plotted over time in Atlantic (e) and Indian Oceans (f) for each species (BET: Bigeye tuna, SKJ: Skipjack tuna, YFT: Yellowfin tuna).

year that is also characterised by a low selectivity for the other fleets. The selectivity remained stable in both oceans. In the Atlantic Ocean, the indicator related to stock overfishing (F/Fmsy) increased from the 1950s until the 1990s for the YFT stock and until the 2000s for the BET stock, reaching 1.6 and 1.3, respectively (Figs. 4e & f). Both stocks were suffered from overfishing ($F > Fmsy$) from the 1990s. After 2005, the ratio value stabilised at around 1.3 for the BET and 0.9 for YFT. In the Atlantic Ocean, the SKJ (eastern stock) shows a stable F/Fmsy of 0.6 (Fig. 4e). In the Indian Ocean, the fishing pressure F/Fmsy on the YFT, BET and SKJ stocks increased from the 1980s up to the 2000s, reaching 1.25, 1.1 and 0.65, respectively. The F/Fmsy of the YFT stock was still on an increasing trend. Overfishing of YFT and BET stocks ($F > Fmsy$) started recently, with the first situation of overfishing of the YFT stock occurring in 2006 (Fig. 4f).

4. Discussion

This study analyses the sustainability of European tropical tuna purse seiners (EU-PS) in Atlantic and Indian Oceans using a dashboard approach. This technique allows the study of the sustainability of fisheries in a multi-dimensional and multi-temporal framework providing relevant and useful information for policy makers. The analysis was conducted for three sustainability dimensions – ecological, economic and social – for the period from 2009 to 2019. We compared ecological sustainability of the EU-PS with other fisheries using different fishing gears (longline, gillnet, pole and line) and analysed interactions between indicators of sustainability.

4.1. *Sustainability of tropical tuna fisheries with regard to tuna stocks and the ecosystem*

Concerning the ecological dimension, the dashboard highlights differences in stock-related and ecosystem sustainability performances among the fishing fleets. The ecological sustainability of fisheries depends on the ocean fished and the fishing gear in use. Fleets exhibit a lower species-based selectivity (more bycatch) in the Atlantic Ocean than in the Indian Ocean, independently of fishing gears. This result may be linked to the existence of the "faux-poisson" market in Abidjan, which allows bycatch valorisation (sale on the local market of minor tuna species caught by the tropical tuna fishery but unwanted by tuna canneries) (Amandè et al., 2012). For Romagny et al. (2000), the development of purse seine fisheries on FAD allows for important supply of "faux-poisson", which meets a significant demand for fish from the local populations, resulting in an important local market. A similar market exists in the Indian Ocean due to purse seiners, but is less known. (Quaas et al., 2016) underlined the strong seafood protein dependence of the west Africa region, what could justify a market based on tuna fisheries bycatches. However, we can question this reasoning from an ethical point of view. Thus, the impact of fishing activities on local development, through the catch of marine resources and the indirect effects in structuring the fish market on land, should be explored.

For the time period considered in this study, the Atlantic Ocean fleets differ from those in the Indian Ocean in that they exploit a higher catch proportion from stocks subject to overfishing i.e. the BET stock, which is the stock the most subject to overfishing in the Atlantic Ocean. Overfishing of YFT and BET is intensifying in the Indian Ocean and characterizes the current situation, whereas for YFT the fishing pressure in the Atlantic has remained stable for over ten years and the harvested biomass is close to the MSY management objective. Our results characterise fleet exploitation at MSY, considered as a guarantee of sustainable catches for the fleets. Moreover, stock assessments do not consider the potential impact of global warming on tuna resources or the marine ecosystems that support tuna fisheries (Marsac, 2018). Compared with small-scale fisheries, industrial ones are sometimes considered less vulnerable to the impact of climate change thanks to their adaptive capacities with regard to fishing area, fishing technologies or market conditions. But on the other hand, artisanal fisheries can demonstrate very strong adaptability due to their ability to change fishing gear and target species (Green et al., 2021; Monnier et al., 2020). Thus, indicators of the vulnerability of fishing fleets and their economy to climate change are necessary to complete the present approach (Tokunaga et al., 2022; Belhabib et al., 2016).

The fishing gears show different ecosystem performances in relation to catch criteria, including the mature catch rate, bycatch TL mean and sensitive species catch rate. The mature catch indicator is associated with selectivity concerning juvenile tuna (i.e. greater protection of juveniles), with direct repercussions for the potential total catch and future spawning biomass (Perez et al., 2022). For a given fishing pressure (including the current estimate of Fmsy) or a given catch, the more juveniles are protected, the less the total impact on the biomass of the exploited stock (Beverton and Holt, 1957; Froese, 2004; Froese et al., 2016). Purse seine fishing on FAD induces higher BET and YFT juvenile catch, thus larger potential impact on the stock biomass, particularly on BET (Dagorn et al., 2013). In addition, the high fishing pressure on BET stocks could be a consequence of FAD fishing (Perez et al., 2022). Owing to the substantially smaller stock size of BET compared with YFT, the impact of catches using purse seines with FADs on the BET stock is markedly more serious than on skipjack or yellowfin stocks (Guillotreau et al., 2017). As adult individuals of bigeye tuna constitute the primary target for longliners in tropical waters, the development of juvenile catches on FAD have significantly compromised the longline fishery in two ways: reduction of spawning stock biomass (SSB) and a decrease in MSY (Miyake et al., 2004; Ovando et al., 2021). This outcome highlights an issue regarding the economic sustainability of longliners in the face of increasing of FAD fishing.

The performance of longliners on tropical tuna stocks (i.e. high mature tuna rate) is counterbalanced by their impact on the ecosystem due to their higher catch rate of sensitive species and a higher trophic level (TL) of bycatch. Sensitive species, such as sharks and rays, have a high TL. Longline and gillnet fisheries are the gears principally implicated in this problem and have been studied to develop mitigation methods for the reduction of sensitive species bycatch (Cortés et al., 2010; Shelley et al., 2014; Anderson et al., 2020), and to improve post-release survival rates (Gilman, 2011; Hutchinson et al., 2015). A low species-based selectivity is an issue for the marine ecosystem when the post-release survival rate of species is low and the trophic level high, as for gillnet and longline fisheries (Kiszka et al., 2021; Cortés et al., 2010), but maybe less for FAD fishing (Forget et al., 2015; Escalle et al., 2015; Eddy et al., 2016). Our results show variable longliner ecosystem performances, which could be due to variability in the pelagic longline *métier* (Swimmer et al., 2020). To better assess the ecosystem impact of fishing fleets, post-release survival rate by species, fishing gear and *métier* should be considered and assessed by RFMOs. Finally, we must highlight that our ecosystem impact indicator is highly conservative as based on the species selectivity only while this impact should in priority consider whether the resource-gear interactions lead to fishing mortality or not. In this context, another indicator allowing to assess the fishing mortality on ETP should be developed.

According to our results, purse seiners would have on average a similar ecological impact or would perform better than baitboats, which seems unlikely according to the literature (Gilman et al., 2020). The use of FADs by purse seiners have clear ecosystem impacts compared with pole-and-line and purse seine fisheries operating on free schools, in terms of interactions with endangered, threatened or protected (ETP) species as well as bycatch and discards (Amandè et al., 2017; Miller et al., 2017; Murua et al., 2021). Indeed, species-based selectivity of a FAD set in the Atlantic and Indian Oceans is near to 92.5 and 97 % respectively (Murua et al., 2021). In the Atlantic Ocean, 87 ± 6 % of all purse seiners bycatch, in average on the 2010–2016 period, is caused by FAD fishing (Ruiz-Gondra et al., 2017). Thus, a high species-based selectivity, and so a low discard rate was, expected for purse seiner fleets with a high FSC fishing rate which is not the case. Thus, a similar ecological performance among purse seiners (mostly using FADs) and baitboats suggest or confirm that bycatches (including ETP species) and discards are not yet well reported in the databases (Capello et al., 2023; Gilman et al., 2017; Herrera and Pierre, 2010) or estimated with a low level of both human or electronic observer coverage. Since the 2010s, observer data have been collected under the EU Data Collection Framework (DCF) and national voluntary programs, e.g. the OCUP program for French vessels, which reached a coverage rate of 100 % in the Atlantic Ocean in 2015 and one over 80 %, in the Indian Ocean since 2016. However, data from national programs are not considered by ICCAT and IOTC as public data while they would permit to improve the reliability of bycatch-based indicators of the sustainability ecological dimension of the fishery sustainability.

In addition to bycatch and discard data, discard mortality by species group (e.g. ISSCAP species groups) and fishing gears is still unknown (Eddy et al., 2016) while it represents an essential information to assess the right fishing mortality particularly for sensitive species. Moreover, both baitboat and longliner have an indirect impact on live-bait resources and marine ecosystems, which is not considered in RFMOs data and in this study but could be considered as supplementary bycatch species (Gilman et al., 2020; Litaay et al., 2021).

Another aspect of FADs is that a large percentage of drifting fish aggregating devices eventually drift beyond the fishing grounds, later potentially threatening sensitive areas via stranding (often referred to in the literature as 'beaching' - Imzilen et al., 2021), contributing to ghost fishing due to the ne under the drifting FAD – recent progress should be highlighted on this aspect (Escalle et al., 2023) – and ultimately to the non-biodegradable and specifically plastic waste in the world's oceans. Such additional impacts of FADs should also be considered. This contrast, resulting from a difference in fishing mode, suggests that FSC and FAD fishing should be considered as distinct purse seine *métiers* in RFMO data collection (Imzilen et al., 2022).

4.2. *Climate impact of tropical tuna fishing gears*

In our analysis, the economic performance of EU purse seine fisheries is linked to ecological performances through fuel consumption. Fuel consumption is an indirect indicator of fisheries' impact on climate change and is also their primary expense reported to account for 35–75 % of tuna purse seine fleet annual costs (Parker et al., 2015). The FUI gives information on fuel consumption by weight of tuna. In the literature, the FUI of fleets depends on the fishing gear used. Specifically, small pelagic gears have a range of 0.1–0.3 L.kg^{-1}, gillnetters remain below 0.8–1 L.kg^{-1}, longliners and baitboats range from 0.9 to 1.5 L.kg^{-1} (i.e. hook and line gear type), while bottom trawls range from 1 to 3.5 L.kg^{-1} (Parker and Tyedmers, 2015). Consequently, purse seiners have the better performance in terms of a climate indicator (i.e. lower FUI) compared with other fishing gears (Parker et al., 2018; Parker and Tyedmers, 2015).

Our results reveal a contrast between French and Spanish fleets, with lower FUI observed for the French fleets (Atlantic: 0.50 L.kg^{-1}; Indian 0.48 L.kg^{-1}) compared with the Spanish fleets (Atlantic 0.56 L.kg^{-1}; Indian 0.57 L.kg^{-1}). In the literature, FUI is linked to fishing mode, characterising FADs as fuel-saving tools by that enhance catch rates while reducing search time (Dagorn et al., 2013; Scott and Lopez, 2014). In our results and in the literature, French fleets have higher FSC fishing strategy rate. Therefore, French fleets should have a higher FUI than Spanish fleets, which is not the case. Although the difference between these flags is low relative to variability caused by different gears, this contradiction is interesting. Recent studies have proposed a contrary effect of FADs in the Indian Ocean, probably leading to consistent distances travelled between FADs, but ultimately lower catches than on FSC (Chassot et al., 2021; Basurko et al., 2022; Tolotti et al., 2022). These conclusions are consistent with our results but should be considered with caution because fuel consumption is influenced by the skipper's choice to make sets on FADs or FSC, depending on the information available, and efficiency optimisation (Basurko et al., 2022). However, comparable results using another fuel consumption data source would be interesting because our dataset might be biased due to the fact that diesel loads at sea may not be taken into account (Anom. Pers. Comm. 2024). Assuming this trend and considering the impact on stocks and ecosystems, FSC fishing could emerge as a fishing mode with a higher ecological performance than other tropical fishing gears and *métiers* (i.e., increased catch of mature tuna, reduced bycatch of sensitive species, and perhaps a lower FUI).

4.3. Energy efficiency of European purse seiners

In total, fishing on FAD rather than FSC induces larger ecological impacts (e.g. on juveniles, bycatch and sensitives species), while improving some economic performances of the fleet (e.g. total catch, net profit). In contrast, to avoid a potential conflict between ecology and economy of European purse seiners performances, a higher FSC fishing rate should lead to higher economic and socio-economic performances. In fact, demonstrating such a conflict is difficult because observation needed to assess the direct ecological impact by fishing strategy is currently not available in the RFMO's database.

However, our analysis on economic and socio-economic indicators from 2009 to 2019 reveals that the economic sustainability is linked to a high energy efficiency, tuna price and catches on FADs. However, such a result does not consider the potential adverse effect on FAD use on both the stock status and the ecosystem health. Energy efficiency provides information on the monetary value generated per litre of fuel consumed. In the short term, FAD use has a high set efficiency, i.e. high positive set rate, which leads to lower energy costs, as supposed by Basurko et al., (2022). But in the long term, decrease in stock abundance and MSY may jeopardise such result (Ovando et al., 2021).

The short-term economic performances of EU purse seine fleets (i.e. higher RoFTA, margin rate, net profit and work productivity) correspond to lower energy costs and higher energy efficiency, as supported by the literature (Cheilari et al., 2013; Parker et al., 2015). High economic performances of EU purse seiners were observed in the 2012–2013 and 2017–2019 periods when the world tuna price was high (Guillotreau et al., 2022). The dependance of the economic health of purse seiners on the tuna market is well knew and studies: given the high volatility of YFT prices, changes in tuna prices are not passed on to consumers but absorbed by the fleets, which must still meet the growing demand for catches, primarily facilitated by using FADs (Lecomte et al., 2017; Guillotreau et al., 2022; Miyake et al., 2004). In this context of the global tuna market and condition of the major tuna stocks (YFT in the Indian Ocean and BET in the Atlantic Ocean) a trade-off between FAD and FSC fishing is reached to satisfy one of the main targets of Sustainable Development Goal No.14, however this trade-off still ignores the long-term effects on tuna stocks (Ovando et al., 2021).

4.4. Social performance of European purse seiners

Concerning the socio-economic dimension, our analysis shows a higher social performance of the French fleets, as these provide stable FTEs with a higher average fisher salary costs. For each ocean, the French fleet created less FTEs, indicative of lower turnover, than the Spanish fleets. Inter-annual variability of tuna catches is often considered as a socio-economic indicator, as constant catch opportunities are normally preferred by the industry and provide constant job opportunities (FAO, 2022). Our analysis does not, however, demonstrate this link for EU purse seine fleets. The average fisher salary cost is linked to FSC fishing rate which is probably a consequence of their joint participation in describing nations. The remuneration structure for fishers varies among companies. French companies use a fixed wage system and a share of the catch per ton (not indexed to the price of tuna), while Spanish companies only propose a share of the catch per ton (Maufroy, Com. Pers.). More information on the nature of FTE contracts (short- or long-term) is needed to draw conclusions on the social performance of fleets for fishers. The working conditions of fishers and their social cover remain insufficiently investigated. A recent anthropological study of the use of FADs by fishers reveals the transformation of the profession from, in their words, a 'hunting' activity to a 'gathering' activity (Reyes and Airaud, 2022). A distant-water fleet with individuals of several nationalities on board poses challenges for assessing social inequality and human rights aspects (Belhabib and Le Billon, 2022).

4.5. Perspectives

Our results on European purse seiner fleet performances compared with other tropical tuna fisheries raise questions about how to better assess economic and ecological performances to improve fisheries sustainability. Data on discards and landings by species, fuel consumption and social data by fishing fleet and fishing *métiers* are still needed to directly compare fisheries sustainability performances. Indicators on waste pollution such as plastic could also improve fishing fleets comparison and potentially distinguish purse seiners and baitboats (Guillotreau et al., 2023a, 2023b). For the purse seine fishery assessing direct sustainability performance of different fishing mode is difficult because there are deployed during a same fishing trip and cannot be disentangled (e.g. in the case of FSC and FAD strategies of purse seiners) (Basurko et al., 2022).

The dashboard of indicators proposed in this study can be used to analyse the effect of fisheries management decisions (Capello et al., 2023). Currently, the main management tools considered to limit FAD fishing are restrictions on the number of FADs (Kaplan et al., 2014; Perez et al., 2022) and implementation of multiple time-area drifting FAD fishing moratoria (Goujon and Labaisse-Boclilis, 1999; ICCAT, 1998). Comparing indicators between in and out time-area drifting FAD fishing moratoria could be an interesting direction for future research to quantify the impact of FAD fishing, e.g. on ecosystem indicators, fuel use intensity or economic indicators.

The last moratorium implemented in the Atlantic Ocean was considered effective for YFT and SKJ stocks, but no conclusion could be drawn for BET (Perez et al., 2022). In this study the juvenile fishing rate considered average juveniles for the three species SKJ, BET and YFT. However, considering FAD use impact on YFT and BET juveniles, an operating diagram indicator of the purse seine *métier* should consider only the juvenile rate of these species. During our study period, the IOTC implemented an alternative or complementary management strategy by introducing a total allowable catch (TAC) of YFT since 2017 (IOTC, 2016). In turn, the purse seine fishing companies manage the quota throughout the year by using more FADs (catching few YFT but more SKJ in terms of weight) than before the quota system was set up (Tolotti et al., 2022). For the authors, this rebound effect raises questions about TAC adjustment, that could differentiate adult tuna TAC from juvenile tuna TAC. A dashboard approach could provide information on sustainability performance before and after TAC implementation. In our study, species-based selectivity in the Indian Ocean decreased after this implementation but further studies are needed. More generally, RFMOs should improve data collection quality (i.e. species-based selectivity, discards, catch and, fuel consumption, but also economic and social data), use a dashboard approach to improve monitoring of their tropical tuna fishing fleets' sustainability and assess their Sustainable Development Goal achievements.

Finally, assuming an increase in the number of environmentally concerned consumers, improved practices towards more FSC fishing could be very positive for the sector. Environmental non-governmental organisations are calling for a distinction in trade between canned tuna from FADs, considered unsustainable, and canned tuna from non-FAD fishing practices, considered more sustainable (Failler et al., 2014). The sustainability movement (ecolabelling and voluntary commitment) could encourage stakeholders to adopt more sustainable fishing strategies to meet the current high demand, with higher profitability, but this effect remains limited (Froese and Proelss, 2012; Potts et al., 2016; Martin et al., 2012). Recently, the Marine Stewardship Council's fisheries standards has evolved (V.3.0) requesting non-entangling and biodegradable FAD use but still allows certification of tuna caught under FADs because it is impossible to differentiate fish caught under FAD or FSC in purse seine wells with a high degree of certainty (Lyons, 2022). A time FAD moratorium would allow this distinction. However, it remains to be analysed to what extent these market-based incentives are effective in moving tuna fisheries towards greater sustainability (Guillotreau et al., 2023a, 2023b).

5. Conclusion

This study analysed the sustainability performances of European tropical tuna purse seine fisheries and ecological performances of tropical tuna fisheries in the Atlantic and Indian Oceans using a dashboard approach. This dashboard is a concrete application for fishing fleet case studies and offers potential added value for the management of well documented fishing fleets. A PCA approach was conducted to compare sustainability performance between gears, fishing area and years. Purse seiners and baitboats show better ecological performances than longliners and gillnetters in terms of bycatch and catch of endangered, threatened, or protected species. However, purse seiners and baitboats catch more tuna juveniles than longliners and gillnetters, particularly on fishing aggregating device (FAD). To assess the impact of tuna fisheries on the marine ecosystem, the species-based selectivity and trophic level of bycatch indicators should be interpreted jointly.

Stock-based performance depends on species composition, tRFMO stock management (i.e. the ocean being fished) and should not be interpreted as a direct impact of fisheries on stocks. In the literature, purse seiners have better climate impact performance (in terms of fuel consumed per weight of tuna) than other fishing gears, but we could not consider this indicator in our fishing gears comparison analysis due to lack of fuel consumption data. Social and socio-economic data were not sufficient to compare fishing gears as well.

As suggest in the literature, economic performances of European purse seine fleets are linked to their fishing mode (i.e. fishing rate on FADs). Also, in ecological terms, fishing on FSC should provide a better ecological result (including size-based and species-based selectivity). We demonstrated an important lack of catch data reporting by tRFMO, which can lead to outliers results as in the case of European purse seiners (their species-based selectivity were inconsistent with the literature using observer data). We found climate-impact performance to likely be better in purse seiners with a high FSC catch rate.

Finally, we want to ask whether, when economy meets ecology, it is truly conflicted? For the purse seiners, this is likely for a long-term perspective. We confirm that the global tuna market context induces European purse seiner short-term economy (annually) to be based on catch quantity, allowed by FAD use, rather catch quality (mature yellowfin and bigeye tuna). However, long-term economic performance indicators are needed. This fishery needs to reduce FAD fishing impact on tuna juveniles and biodiversity globally. To assess this impact, data on catch by species and fishing mode is needed. More widely, applying a dashboard method to various fisheries could yield insights into key dynamics, guiding research, and management efforts for enhanced sustainable fishing practices. Aware of this contradiction, the fishery sustainability framework should move away from short-term economic indicators and prioritise ecology and social indicators.

CRediT authorship contribution statement

Sandra Ougier: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Pascal Bach:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Investigation, Formal analysis. **François Le Loc'h:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Formal analysis. **Joël Aubin:** Writing – review & editing, Validation, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Didier Gascuel:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Le Loc'h reports financial support was provided by France Filière Pêche.

Data availability

I have shared the link to my data and datacode at the Attach File step

A multidimensional dashboard dataset on tropical tuna fishing fleet in Atlantic and Indian Oceans (Original data) (Dataverse)

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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