

Small pelagic fish in Senegal: a multi-usage resource

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Abstract

The objective of this article is to analyse the marketing of small pelagic fish in Senegal and the issues involved in context of growing national and regional demand and the emergence of new uses, particularly the processing of fish meal. The method consisted of compiling and analysing data (2009 - 2018) on national small pelagic fish production, foreign trade and the Senegalese population. In Senegal, fish consumption is largely supported by small pelagic fish, which account for 82% of consumption. This represents an average consumption of 13 kg per individual over the period 2009 - 2018. At the same time, artisanal processing, which is an important element of Senegal's food security, is mainly fed by small pelagics. However, the emergence of non-food uses and export trends of coastal pelagics threaten national food security and the sustainability of small pelagic stocks. Export levels of these species have increased from less than 71,000 tons to over 200,000 tons over the same period coupled with annual industrial non-food processing (fishmeal) of over 20,000 tons. All these mechanisms are responsible for the decline in per capita consumption of small pelagics in Senegal, from 18 kg in 2009 to 9 kg in 2018. As a food safety net in Senegal, the new uses of coastal pelagics threaten the supply of fish products to the local market. The drop in supply to the artisanal processing sector also threatens the employment of thousands of women and compromises their livelihoods.

Keywords: Sector - fishmeal - processing - supply - consumption

1. Introduction

Small pelagics make up 25% of world landings, mainly through anchovy, sardinella, sardines and herring (Berchie et al., 2021; Dème et al., 2021a; Allison et al., 2001). Known for their abundance in upwelling regions, the area of the Canary Current, which covers Morocco, Mauritania, Gambia and to a lesser extent, Guinea-Bissau beyond the Senegalese coast, is marked by a strong presence of pelagic fish (Failler et al., 2014a; Failler et al., 2014b; Failler et al., 2014c; Ahaj et al., 2004). In Senegal, small pelagics make up around 72% of landings. Over the period 2009 - 2018, an average of 315,000 tons of small pelagic fish were landed each year and fed the various production and consumption sectors. Small pelagics are thus a

multi-purpose resource. Distributed fresh on the national market, they are the most accessible source of animal protein for Senegalese in terms of availability and cost (Dème et al., 2019a ; Dème et al., 2012). Over the decade, the apparent availability of small pelagic fish has averaged less than 180,000 tons per year and a per capita consumption of 13 kg. Furthermore, frozen small pelagics largely dominate Senegalese exports of fishery products. More than 80% of the volume of fish exported are small pelagics. Senegal's trade surplus in fishery products is largely supported by small pelagic fish. In addition to this decisive contribution to human consumption, small pelagics are the raw material for artisanal and industrial processing (fish meal) (Greenpeace, 2019; Mahfoud et al., 2012). This multi-use characteristics of small pelagic fish and their main role in the different fish distribution chains justify their decisive contribution to the country's economy, through job creation, the improvement of the livelihoods of thousands of Senegalese and their important contribution to the food security (Dème et al., 2019b; Dème, 2018; Failler et al., 2014b). However, the emergence of non-food uses and the trend of exporting frozen pelagic fish to West Africa and to European and Asian countries pose a threat to the social character of these fisheries. This threat is accentuated by the overexploitation of small pelagic stocks, their sensitivity to climate change, the subsequent growth of the Senegalese population, and the demand for fishery products on the national market.

The objective of this article is to analyse the marketing of small pelagic fish in Senegal and the issues involved in context of growing national and regional demand and the emergence of new uses, particularly the processing of fish meal. Work on small pelagics has been mainly limited to the study of the ecological and biological dynamics of the species in the context of climate change and their distribution (Baldé et al., 2019; Brochier et al., 2018; Diankha et al., 2018; Thiaw et al., 2017; Dème et al., 2012; Atta-Mills et al., 2004). The present work provides a new reading by focusing on the economy of small pelagics in Senegal. In doing so, it aims to contribute to improving the value of small pelagic catches in order to replace frozen small pelagic exports with artisanal and industrial processed products suitable for human consumption and offering added value and employment.

The working method consisted in setting up a nomenclature of data on landings, foreign trade in small pelagics and population growth over the period 2009 - 2018. These data are mainly drawn from the CRODT, DPM and ANSD databases, supplemented by field surveys. The data were processed to map the marketing of small pelagic fish, to analyse the trade surplus, and to determine the apparent availability and individual consumption in order to assess their contribution to food security.

The article is structured in three parts. The first part contextualises the research. The second part presents the research method. The third part analyses the results of the research with a mapping of small pelagic fish marketing, presents the annual landings from 2009 to 2018, and determines the contribution of pelagics to food security through apparent availability and individual consumption. The discussion raises the current challenges of effectively and sustainably managing small pelagic stocks and the need to increase the value of the resource. Finally, the study concludes with the formulation of public policies to improve the added value of landed small pelagics in order to improve the livelihoods of stakeholders in the various sectors and to increase the contribution of the resource to job creation and the country's economy.

2. Research context: small pelagic exploitation in Senegal

2.1 Maritime fisheries in Senegal

Senegal has a major fishing area, both in terms of human numbers and catch volume (Dème et al., 2019a; Diankha et al., 2018). Fishing is therefore central to the economic and social life or socio-economic development of the country (Dème, 2018; UNEP, 2004). The Senegalese are major consumers of fish. Fishing provides nearly 75% of the animal protein consumed (Dème et al., 2019b; Dème et al., 2012). In Senegal, there is a clear distinction between artisanal and industrial fishing, with the former largely benefiting (Dème et al., 2019a). This supremacy of artisanal fishing is reflected in the presence of a large population of artisanal fishermen (60,000 individuals), who are dynamic, possess know-how associated with the mastery of around twenty types of fishing and are capable of adapting to the changing conditions of exploitation of marine resources (Dème et al., 2021a; Dème et al., 2020). It also refers to the relative weakness of the necessary investments compared to the industrial sector, as well as to the state support offered for decades through tax breaks that reduce the operating costs of fishing units. This fiscal policy is part of a threefold desire to satisfy national demand for animal proteins at a reduced cost, to create wealth and to consolidate employment in a difficult context marked by endemic unemployment in Senegal (Dème, 2018). Artisanal fisheries provide more than 80% of Senegal's fish landings and are deployed in the various EEZs (Exclusive Economic Zones) of the coastal states of the West African sub-region under partnership agreements (Dème et al., 2021b). With fishing gears specialised in the capture of small pelagics and taking into account the ecology and ethology of the species, (Dème, 2018), the availability and abundance of small pelagics in Senegalese waters (Bâ et al., 2019; Diankha et al., 2018) linked to environmental parameters, the most important of which is coastal upwelling (Saraux C., et al., 2019; Mangin et al., 2018), Senegalese artisanal fishermen dominate the sub-regional artisanal fisheries due to their know-how.

2.2 Small pelagic exploitation in Senegal

Small pelagics are mainly exploited in Senegal by an artisanal fleet of purse seines¹ and encircling gillnets². Semi-industrial fisheries, which have never exceeded five sardine boats in recent years, have almost disappeared from the Senegalese fishing landscape. Adopting a policy of exclusive exploitation of small pelagic resources by nationals, Senegal has not granted any fishing opportunities to foreign fleets since 2012. According to the latest census of the fishing fleet conducted by CRODT in 2020, 1,249 purse seine units and 875 encircling gillnet units disproportionately distributed in the country's various fishing centres exploit

¹ The purse seine unit is usually composed of two pirogues. The small pirogue is between 16 and 18 metres long and carries the net and crew. The large pirogue is 18 to 21 metres long and has a capacity of 16 to 25 tons and carries the catch. The pirogues are propelled by outboard motors with a power of between 40 and 50 hp. The net is 400 to 800 metres long with a drop of 40 metres and allows fish to be caught by encircling them (Dème, 2012).

² The representative encircling gillnet unit consists of a 16-metre long, 5-tonne capacity dugout canoe, powered by a 40 hp outboard motor and fitted with a 300-400 metre net with a 10-20 metre drop (Dème, 2018).

small pelagics. The purse seine fishing units operate almost exclusively in the marine environment, unlike the encircling gillnet fishing units, whose preferred area is the estuarine environment (Dème, 2018). The fishing area between Dakar and the northern Gambia border concentrates most of the fishing activities (Touron-Gardic et al., 2021; PNUE, 2004).

While encircling gillnets operate exclusively in the Senegalese EEZ, some of the purse seine units fish in neighbouring coastal countries (Failler et al., 2021b). Of the 1,249 purse seine vessels surveyed in 2020, only 700 operate exclusively in the Senegalese EEZ, 349 units fish in neighbouring coastal countries (Mauritania, Guinea Bissau, Gambia) under fishing agreements and around 200 others are active in Mauritania under chartering contracts concluded with Mauritanian operators for the supply of fishmeal factories in Nouakchott and Nouadhibou (Dème et al., 2021c; Failler et al., 2021a ; Ly et al., 2021; Failler et al., 2020a). Thus, the migratory channels of small pelagics also supply the local Senegalese market (Dème et al., 2021b).

Small pelagic fish are marketed in different forms: fresh distribution (fish trade), artisanal processing, whole freezing and industrial processing into fish meal. Small pelagic fish have a low commercial value compared to demersal species. Thus, its price varies according to its availability, with an annual average of 150 *FCFA XOF* per kilogram.

3. Materials and methods

3.1 Study framework and presentation of resources

With a marine coastline of about 700 km and a continental shelf covering an area of about 27,600 km². The Senegalese coast is divided into five maritime regions, namely the Centre (Cape Verde peninsula) the Petite Côte (from the south of the Cape Verde peninsula to the Sine Saloum region), the Grande Côte (from the north of the Cape Verde peninsula to the Senegal river delta), the Saloum (deltaic region), and finally beyond Gambia, the Casamance (Fig. 1).

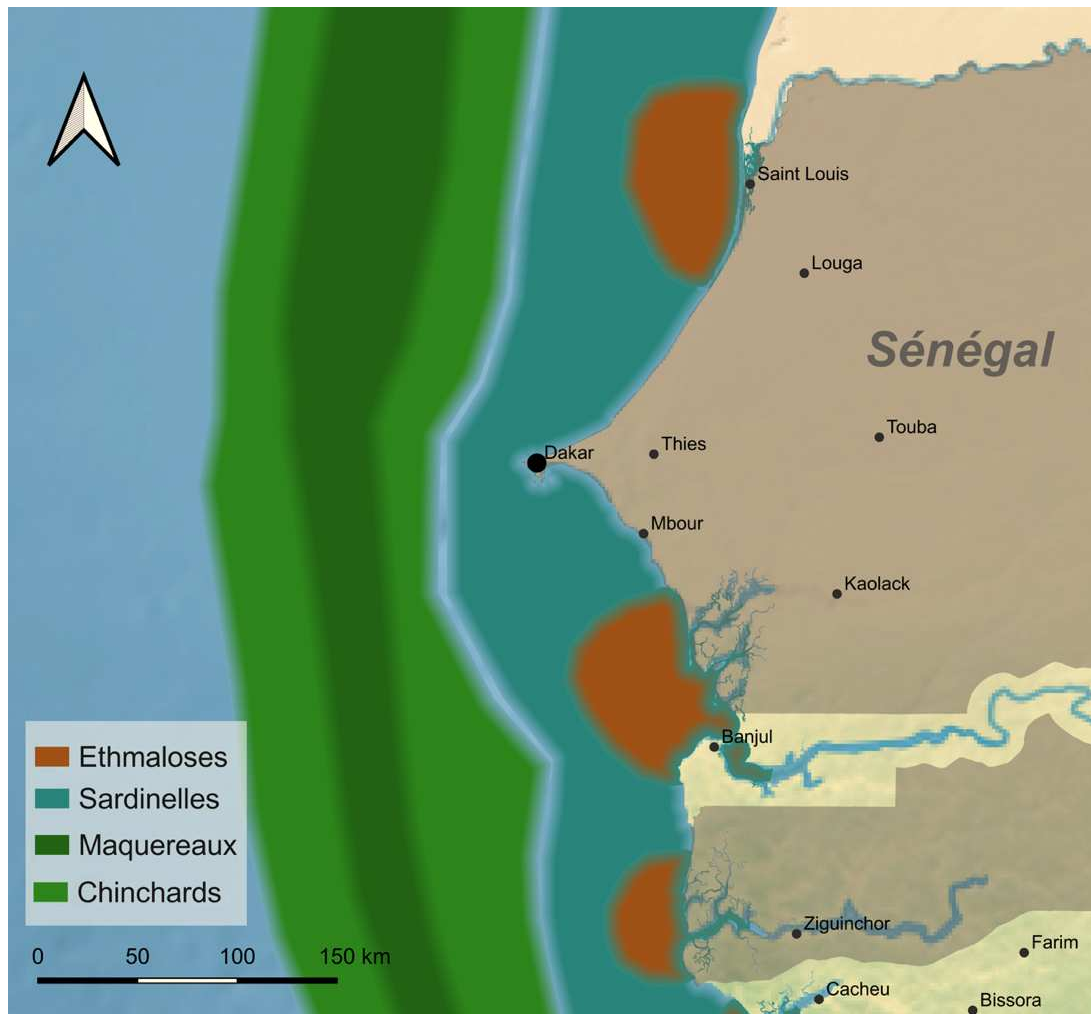


Fig. 1 : Map showing the coastal regions and the distribution of small pelagics on the Senegalese coasts

Source : Touron-Gardic et al., 2021

The main species caught and commonly considered in Senegal in the group of small pelagics are sardinella flat and round (*Sardinella aurita* and *maderensis*), ethmalose (*Ethmalosa spp.*), horse mackerel (black, yellow and white) (*Trachurus trachurus*), and mackerel (*Scomber scombrus*) (Fig. 1) (Fréon et al., 2014). Small pelagics are characterised by a wide and dynamic distribution along the West African coasts in relation to the inter-tropical front, with species seeking optimal conditions of temperature and food availability (Gorez, 2018; Fréon et al., 2014; Laêr et al., 2004; Cury et al., 2000). Figure 1 shows the distribution of these different small pelagic species along the Senegalese coast.

3.2 Data source

3.2.1 Fishery dependent data

Statistics on fisheries landings in Senegal, provided by CRODT, generally do not include catches from migrant fisheries. Thus, the landings of migrant fishermen are assimilated to catches made in the Senegalese EEZ (Failler et al., 2020b; Binet et al., 2015) This leads to

overestimated catch data. Thanks to the financial support of the GREPPAO project, the CRODT has been able to dissociate landings of small pelagic fish from migrant fisheries from those caught in the Senegalese EEZ. Data on annual landings of the five main species of small pelagics landed over the period 2009 - 2018 were considered. These are round and flat sardinella, ethmalose, horse mackerel and mullet. The data on the number of purse seine and gillnet units were taken from the various census campaigns of the Senegalese pirogue fleet conducted by CRODT.

3.2.2 Field activities

Field surveys were carried out in the major fishing centres along the Senegalese coast where small pelagic fish are caught, in order to identify aspects related to the conditions of landing and packaging of the fish, their forms of valorisation and their marketing. Discussions with all stakeholders (public administrations in charge of the sector, professionals in the value chain, development projects, associations and environmental NGOs) also made it possible to identify the strengths and weaknesses of the small pelagic fish value chain and to identify, in a consensual manner, possible economic and sanitary improvement points, the strategies to be adopted and the means necessary for their implementation.

The surveys were conducted over an annual period (June 2019-June 2021) on the Petite Côte (Mbour, Joal), on the Grande Côte (Saint-Louis) and in the Dakar region (Hann, Yoff).

3.2.3 Literature review

A literature review was carried out with a view to identifying the dynamics and changes in the small pelagic coastal fisheries. Scientific publications and study reports from public administrations in charge of fisheries, development projects, and NGOs were used. The important and recent work on small pelagic fisheries in the sub-region commissioned by the PRCM (Regional Partnership for the Conservation of the Coastal and Maritime Zone), of which the authors are stakeholders, was used in this work (Dème et al., 2019a; Dème et al., 2021). Furthermore, the methodology of the European Commission report on the economic and social value of small pelagics in Gambia was adopted in this study. In addition, information on the fisheries opportunities and the status of small pelagic stocks in the sub-region (Guinea Bissau, Gambia, Mauritania and Senegal) was obtained from the reports of different working groups of the Committee for Fisheries of the Eastern Central Atlantic - CECAF. The databases of CRODT and the Maritime Fisheries Department (DPM) were also explored. All this data and information allowed the conceptualisation of Senegalese and West African small pelagic fisheries.

3.3 Data Analysis

The information collected was stored in a database structured around the variables of small pelagic production, imports and exports, domestic consumption and non-food uses (fish meal). To assess the contribution of small pelagics to food security, two indicators were used, namely the apparent availability of fishery products and per capita consumption of halieutic

products. Apparent availability is the quantity of small pelagics available (fresh, frozen, smoked, etc.) after deducting exports from domestic production and adding imports (Berchie et al., 2021; Dème et al., 2020). Per capita consumption is the average amount of fish consumed per inhabitant based on the apparent availability of fish and the resident population of the country (Berchie et al., 2021; Dème et al., 2020). Based on yields, artisanal and industrially processed products are converted to fresh equivalents.

4. Results

4.1 Marketing of small pelagics in Senegal

In Senegal, small pelagics are mainly exploited by national and migrant artisanal fisheries. Of the 278,000 tons landed annually on average over the period 2014-2020, sedentary national artisanal fisheries account for 72% or 200,000 tons. Senegalese migrant artisanal fisheries operating in Gambian, Mauritanian and Guinea Bissau waters within the framework of fishing agreements provide the other 78,000 tons of fish (Fig. 2).

Small pelagics are valorised in different forms: fresh distribution (fishmongering), artisanal processing, whole freezing and industrial processing into fish meal. Small pelagics are sold on both the national and international markets. The national market absorbs most of the production with an average of 233,000 tons in various forms (fresh, artisanal processing) (Fig. 2). Senegalese purse seines supply the local fishmeal industry. Thus, more than 11,000 tons of small pelagic fish are processed into fishmeal each year and sent to European and Asian countries. In addition to fishmeal, Senegal exports an average of 16,000 tons of small pelagics in frozen form, mainly to countries in the sub-region (Fig. 2).

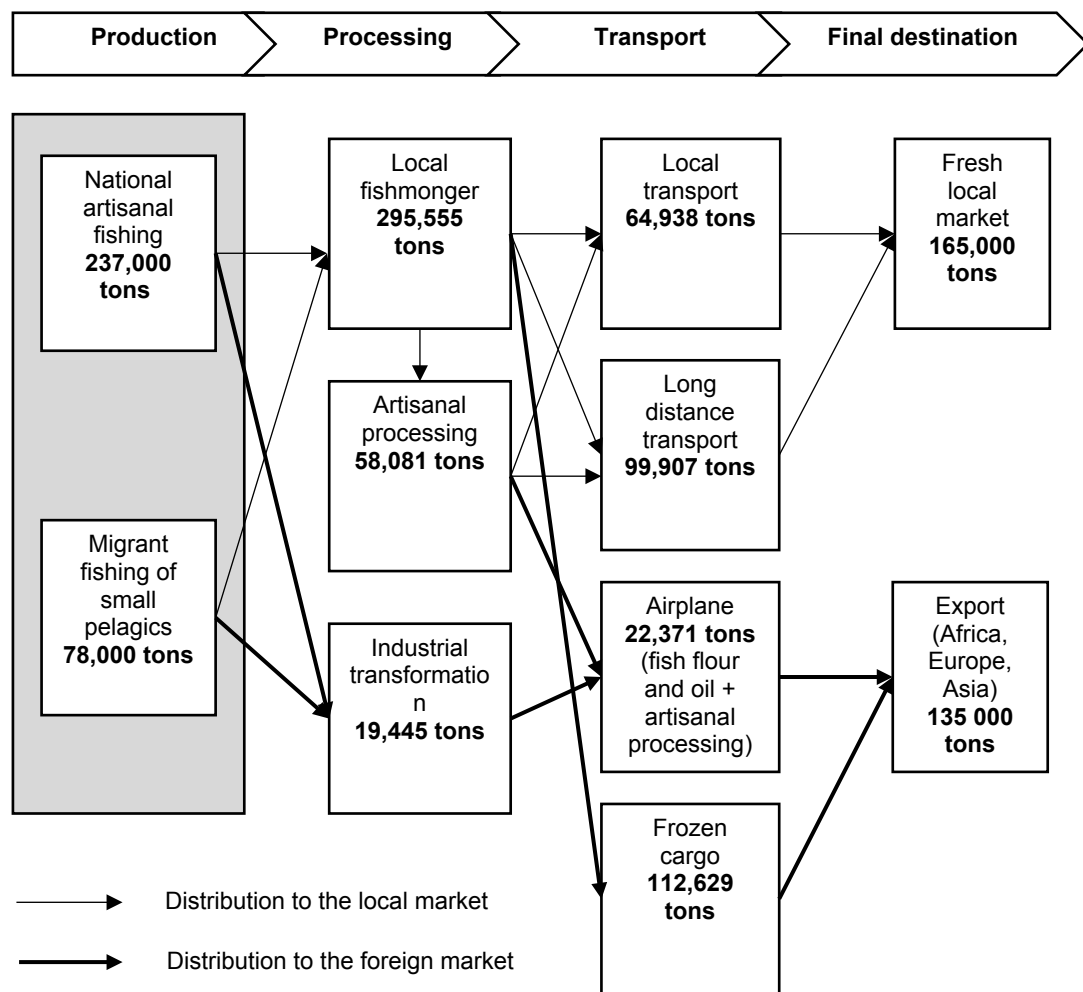


Fig. 2 : Marketing of catches of the small pelagics in Senegal

Source : DPM – CRODT data and field surveys

4.2 Annual landings

Annual fish landings in Senegal average 421,000 tons over the period 2009 - 2018. Fish landings in Senegal are generally on the rise. They reached 461,000 tons in 2018 with an average annual growth of 15,000 tons per year. Small pelagic stocks contributed about 72% of total fish landings over the decade 2009 - 2018. Trends indicate that small pelagic landings are also increasing with an annual average of 315,000 tons. The pattern of small pelagic landings is generally of discontinuous growth with small fluctuations (Fig. 3).

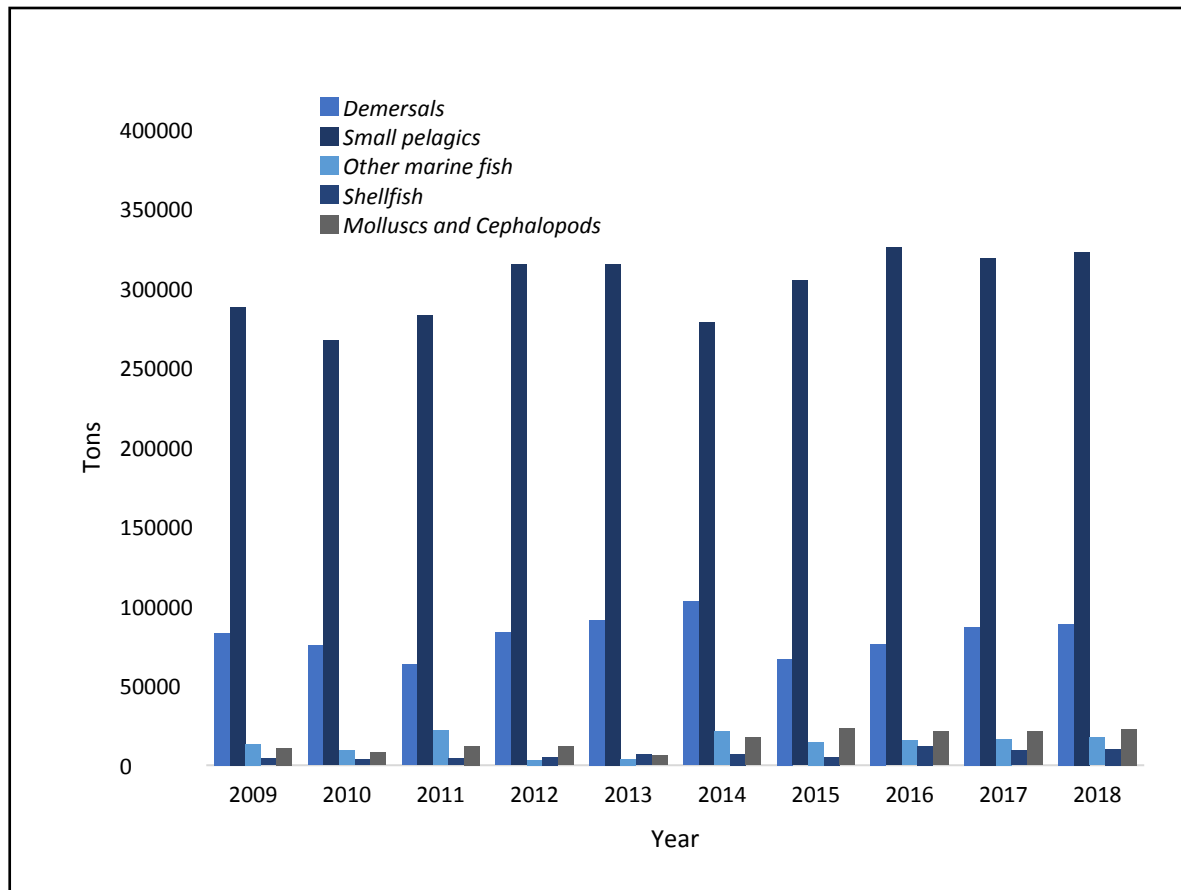


Fig. 3 : Annual landings of all species (2009 - 2018) in Senegal

Source : Crodt and DPM data

Landings of small pelagics in Senegal are largely dominated by two species, namely round sardinella (*Sardinella aurita*) and flat sardinella (*Sardinella maderensis*), which account for an average of 39% and 32% of total landings of small pelagics (Fig. 4). Horse mackerel (*Trachurus*) account for an average of 8% of small pelagic landings (Fig. 4). Landings of ethmalose (*Ethmalosa fimbriata*) and mullet (*Mugilidae*) are relatively small and represent less than 5%. The category "other pelagics" includes all the small pelagic species with very low landings in Senegal (Fig. 4).

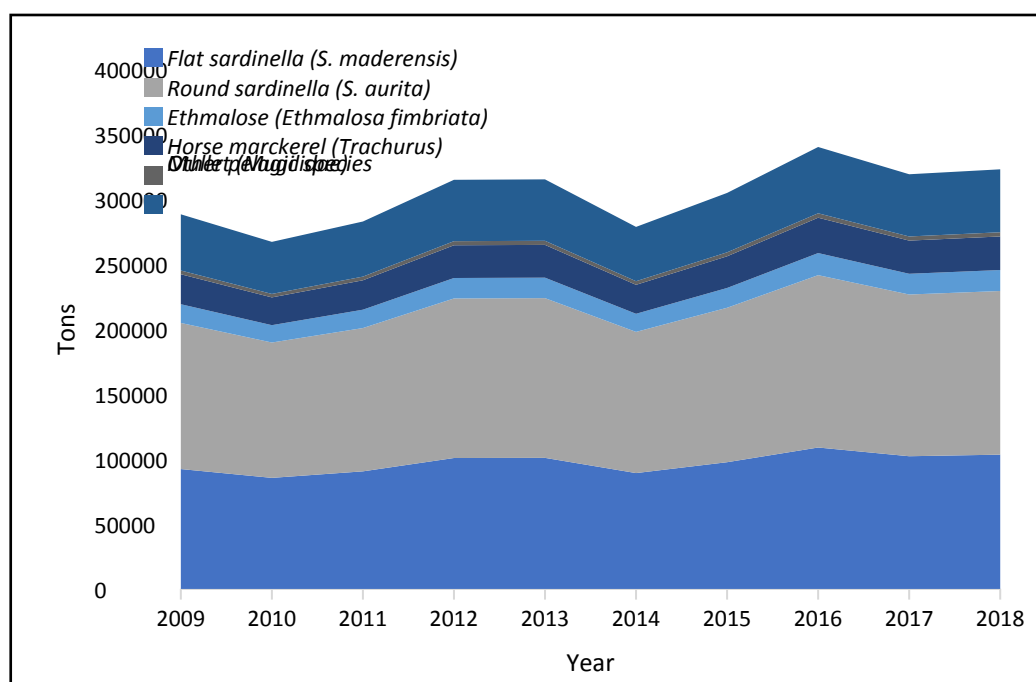


Fig. 4 : Annual landings (2009 - 2018) of small pelagics species in Senegal

Source : Crodt and DPM data

The analysis of small pelagic landings shows that sardinella landings have been increasing with slight fluctuations from year to year. From less than 204,000 tons in 2009, around 230,000 tons of sardinella were landed in 2018 (Figure 4). Over this interval, there was a drop in 2010 and 2014 with less than 189,000 tons and 197,000 tons of sardinella landed respectively (Figure 4). In the other years, landings are above 200,000 tons (Figure 4). The other small pelagic species considered in this study are also experiencing slight fluctuations.

4.3 Small pelagic imports and exports in Senegal

Foreign trade in fishery products is marked throughout the period (2009 - 2018) by a very large trade surplus with exports more than 10 times greater than fish imports. Exports have experienced strong dynamical growth from 2009 to 2018 to the point of doubling in volume. From less than 112,000 tons in 2009, they have risen to more than 200,000 tons in 2019. Small pelagics dominate Senegalese exports of fishery products. They represent around 85% of external sales. Starting from 70,944 tons in 2009, exports of small pelagics are increasing by an average of 8,000 tons per year. Senegalese imports of fishery products are mainly made up of canned products. Although very low, these imports have nevertheless increased from less than 110 tons in 2009 to 22 431 tons in 2018 (Table 1).

Table 1 : Imported and exported quantities of small pelagics in Senegal

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
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Import										
Demersal	126	38	88	45	541	39	227	342	115	84
Small Pelagic	106	6987	15451	9492	9078	10447	18825	17600	20326	22431
Other marine fish	132	110	158	131	51	83	207	354	226	240
Shellfish	206	275	284	392	449	64	178	371	336	353
Molluscs and Cephalopods	1	43	79	219	165	69	96	54	132	142
Total import	571	7453	16060	10279	10284	10702	19533	18721	21135	23250
Export										
Demersal	25400	18143	16943	12613	11005	14325	18312	18358	12664	11638
Small Pelagic	70944	75229	95071	94148	134935	143026	164953	179781	191020	206584
Other marine fish	0	0	0	0	0	0	0	0	0	0
Shellfish	4284	3551	4327	5287	4789	4249	4378	3702	4200	4166
Molluscs and Cephalopods	10758	7942	11926	9477	6663	7372	9072	8842	7781	7514
Total export	111386	104865	128267	121525	157392	168972	196715	210683	215665	229902
Trade surplus	110815	97412	112207	111246	147108	158270	177182	191962	194530	206652

Source : Crodt and DPM data

4.4 Contribution of small pelagics to food security

The following two figures show the local market supply and per capita consumption (Fig. 5) for all species and for small pelagics specifically (Fig. 6). Over the period 2009 - 2018 the net supply of fish fell by almost 40,000 tons from 289,000 tons in 2009 to less than 255,000 tons in 2018. Slight fluctuations and a peak of 307,000 tons in 2017 can be observed over the period. (Fig. 5). The supply of small pelagics has followed the same downward trend and apparent availability has declined by at least a third in ten years (Fig. 5).

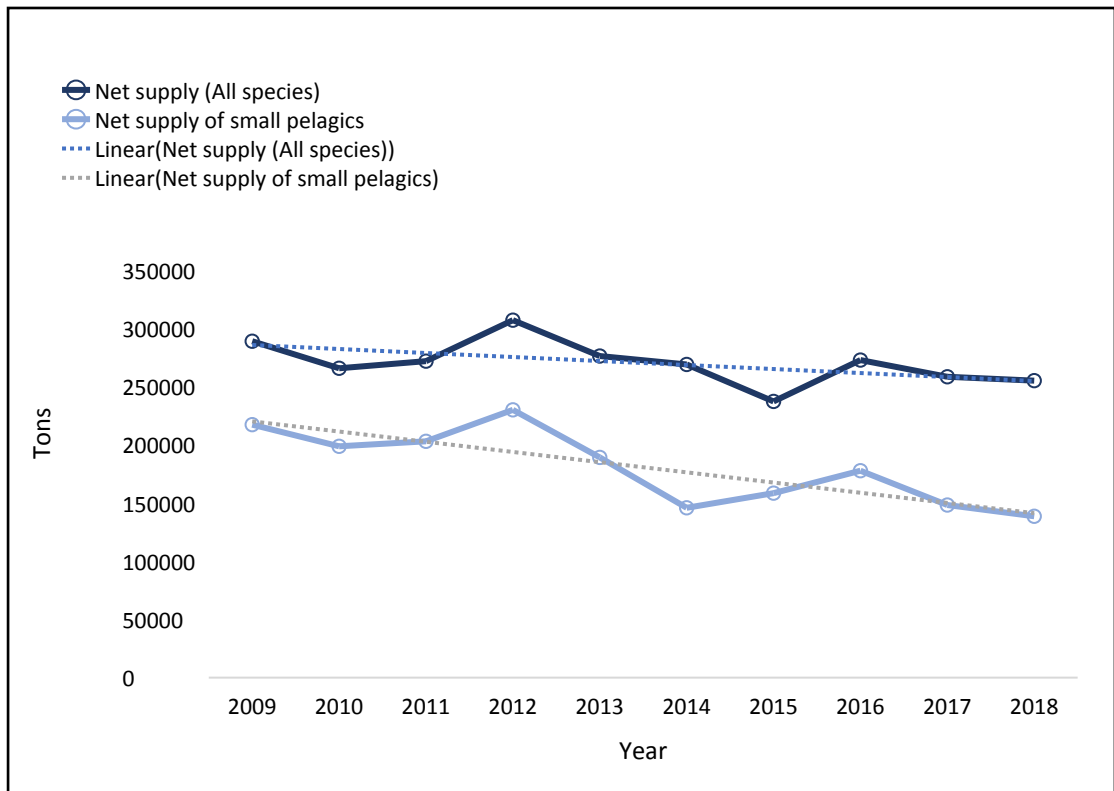


Fig. 5 : Supply of all species / small pelagics on the Senegalese national market

Source : Oceanographic Research Center of Dakar and Directorate of Marine Fisheries data

The continuous growth of the population in Senegal coupled with a declining apparent availability has led to a decrease in per capita consumption from 24 kg in 2009 to 16 kg in 2018 (Fig. 6). This decline in per capita consumption is much more noticeable with small pelagics. From 18 kg of small pelagics in 2009, per capita consumption is only 9 kg in 2018 (Fig. 6).

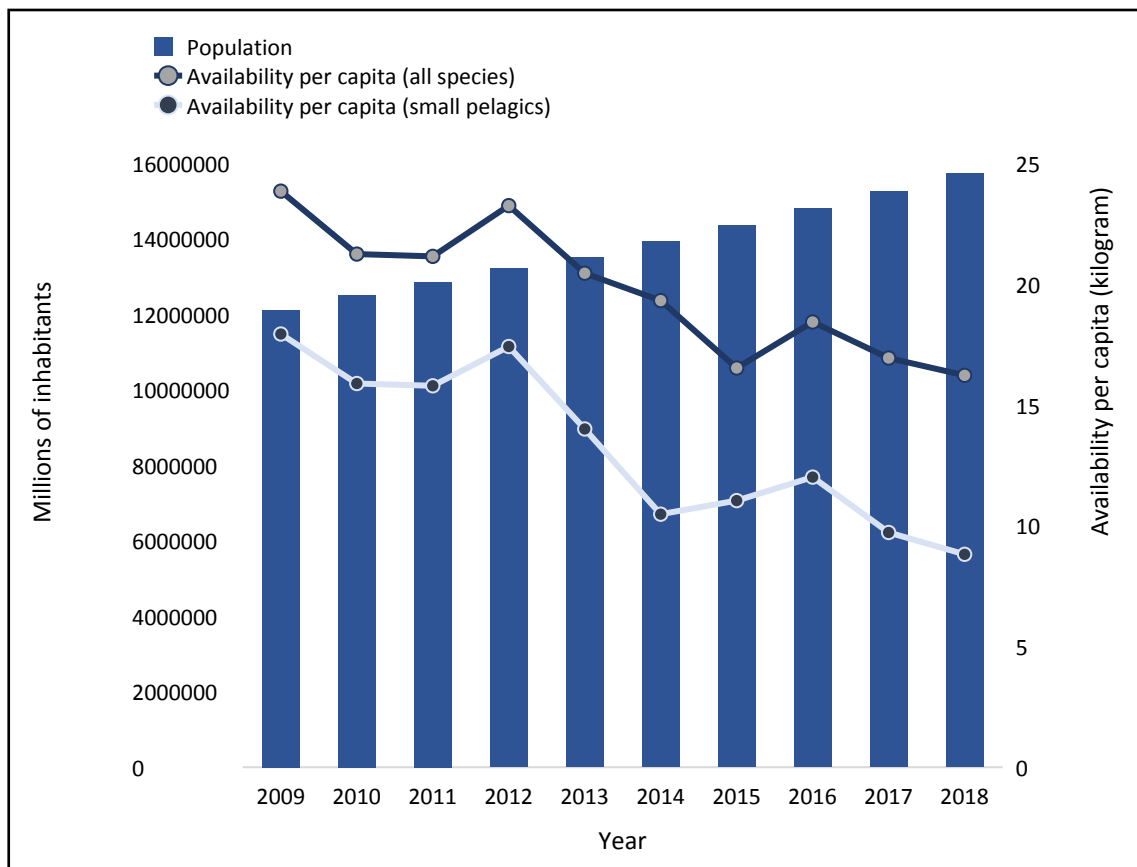


Fig. 6 : Availability per capita (kilogram) all species / small pelagics (kilogram)

Source : Crodt and DMP data

4.5 Small pelagics as sources of raw materials for processing

Small pelagics in Senegal are the raw material for the artisanal processing sector and the fishmeal industry. On average, more than 58,000 tons of small pelagics are processed each year into smoked, braised, salted or dried fish for human consumption. A peak of 65,000 tons was recorded in 2012. Round sardinella and flat sardinella are particularly targeted by artisanal actors.

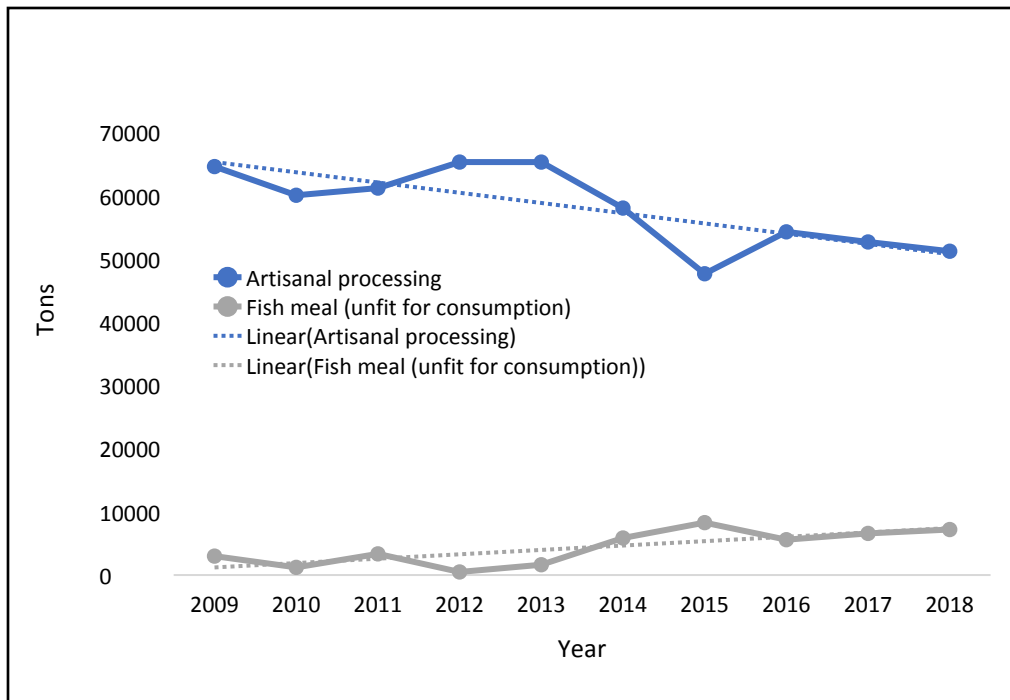


Figure 7 : Quantities of small pelagics processed by traditional means and into fishmeal (tons)

Source : Crodt and DPM data

In contrast to artisanal processing, industrial processing is on the rise (Figure 7). With less than 2,000 tons of fishmeal produced in 2009, this has risen to over 7,000 tons in 2018. This production was particularly high in 2015, with more than 8,000 tons of fishmeal coming out of Senegal's nine factories. If we consider the average annual production of fishmeal to be 4,500 tons over the period 2009 - 2019, and by applying the ratio of fish to fishmeal, we can deduce that more than 20,000 tons of small pelagic fish are processed in the country's fishmeal industries, and are unfit for human consumption.

5. Discussion

Small pelagics are of strategic importance in Senegal because of their major role in creating opportunities and jobs for thousands of individuals along the value chain (Dème et al., 2019b; USAID, 2014). Indeed, because of their ability to provide livelihoods for people without heavy investment or substantial know-how, small pelagic fisheries support a large number of related jobs along the entire value chain, and at the same time play an important role in the fight against poverty in Senegal. Small pelagic fisheries employ 12,000 fishers and generate 34,000 related jobs in the fish trade, and 38,000 in the artisanal fish processing segment (Dème et al., 2019a).

Small pelagics also play a strategic role in the food security of rural and urban populations with low purchasing power by providing protein at affordable prices (Dème, 2018; UNCTAD, 2014). The ease of transporting fish in its fresh state or in its various stabilised forms facilitates its availability in the most remote and isolated areas (Ly et al., 2021). The consumption of chicken, beef and sheep meat often requires a fairly high purchasing power,

which explains why for a large part of the Senegalese population, fish is almost the only source of animal protein (Dème et al., 2021b). For prices per kg of around 150 *FCFA XOF*, small pelagics are available and accessible and are a major component in the national policy for food security and the fight against malnutrition.

For the artisanal and industrial processing sectors, small pelagics are the raw material. They also play a major role in Senegal's fisheries exports. Small pelagics are in demand by countries in the sub-region in frozen and whole form, while Europe and Asia target fish meal derived from these species for fish and livestock feed.

However, this decisive contribution of small pelagics to food security is threatened by the emergence of non-food uses (fishmeal and fish oil) and the large volumes of frozen and whole exports. These new trends pose a threat to the social character of these fisheries. Exports of small pelagics now exceed the volumes placed on the Senegalese market, leading to a drastic reduction in per capita consumption. Average annual per capita consumption of small pelagics has fallen from 18 kg in 2009 to 9 kg in 2018. This is also due to population growth (Failler et al., 2021a; Kassé et al., 2015). This trend for small pelagic exports is likely to become even more pronounced with the high prices prevailing on these external markets and the absence of a quota requirement. Fish exporters speak of financial margins on these markets that are three times higher than on the local market. These high profits are not, however, coupled with significant added value (Tacon, 2018). Inshore pelagics are distributed frozen and unprocessed. This situation is not satisfactory from an environmental point of view, as the export of unprocessed products leads to a preference for volumes over margins. From an economic point of view, the added value generated by this export segment of the value chain remains relatively low and the many jobs linked to small pelagics are threatened. It is no longer a question of producing more but of making the best use of the landings. The approach will be to curb these trends by substituting frozen products for artisanal processed products that create added value and jobs. The public authorities and development partners will have to accompany this process with technological innovations that will enable industrialists to export products adapted to the targeted markets, taking into account consumer preferences. These new dynamics will be accompanied by efforts to diversify the commercial outlets of the industrialists and to widen the distribution area of Senegalese fishery products.

The processing of small pelagic fish into fishmeal and fish oil is one of the major causes of the decline in the apparent availability of fishery products in Senegal (Corten et al., 2021). The fishmeal and fish oil industry in Senegal has 9 operational factories (Belhabib et al., 2015). The high demand for raw materials from these factories, which are supplied exclusively with small pelagics by purse seine units, has a negative impact on the community economy (Baldé et al., 2019). It poses a serious threat to artisanal processing by limiting its supplies of small pelagics. The continuous increase in the volumes of fish processed into fishmeal is accompanied by a decrease in the quantities of pelagic fish processed artisanally. The jobs of thousands of women involved in processing and a source of animal protein accessible to vulnerable populations are therefore threatened. These multiple uses of small pelagics have created strong competition for these products. The obvious consequence is overcapacity in the fisheries and overexploitation of resources (Brochier et al., 2018; Thiaw et al., 2017; Atta et al., 2004)

Today, the question of the sustainability of small pelagic stocks is a critical one, as the resource management policies implemented are insufficient to bring fishing capacity into line with the fisheries potential. In Senegal, the lack of control over the development of fishing capacity has led the country to relocate some of its fleets to neighbouring countries. The threats to resources are further aggravated by their gregarious behaviour (Chouvelon et al., 2015; Bâ et al., 2015) which increases their vulnerability. Formed in schools, the fish are easily detected by fishermen, which can keep yields high despite an overall decline in stock abundance, leading to risks of sudden major collapses (Dème et al., 2019b).

6. Conclusion

Small pelagic fish contribute significantly to the food security of Senegalese populations, to job creation and to the livelihoods of thousands of Senegalese living on the coast. This is due to their preponderance in fish landings in Senegal. Small pelagics are the most available and accessible source of animal protein for Senegalese people. In addition, small pelagics are the raw material for the artisanal and industrial processing sectors. Moreover, they allow Senegal to have a large surplus in the trade of fishery products and are distributed in Africa, particularly in Ivory Coast, Nigeria and Benin, but also in European and Asian countries with the recent emergence of fishmeal processing.

The social character of small pelagics in terms of food security in particular is threatened, as the volumes of fish put on the external market exceed the availability of the local market. The emergence of fishmeal processing not suitable for human consumption is depriving the artisanal processing segment of its raw material. To reverse these trends, it is important to revive local consumption of small pelagics. This will require two mechanisms: limiting fishmeal processing to fishmonger sales and fish factory waste, as is the case in official discourse, and limiting the volumes of small pelagics distributed on the African market. It will also be necessary to replace frozen and whole small pelagics with products processed by craftsmen and which meet the needs of the requesting countries.

In order for all these policy orientations to be implemented, it is essential to move towards an integrated information system generating fisheries, product and market data which is the only way to formulate reliable scientific advice on the basis of good fisheries policies.

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References

Asiedu, B., Okpei, P., Nunoo, F.K.E. & Failler, P. (2021). A fishery in distress: an analysis of the small pelagic fishery of Ghana. *Marine Policy*, 129, 104500.
<https://doi.org/10.1016/j.marpol.2021.104500>

- Allison EH, Ellis F. (2001). The livelihoods approach and management of small-scale fisheries. *Marine Policy* 25 377-388. [https://doi.org/10.1016/S0308-597X\(01\)00023-9](https://doi.org/10.1016/S0308-597X(01)00023-9)
- Atta-Mills J., Alder J., Sumaila U.R. (2004). The decline of a regional fishing nation: the case of Ghana and West Africa, *Nat. Resour. Forum* 28 (2004) 13–21. <https://doi.org/10.1111/j.0165-0203.2004.00068.x>
- Baldé S.B., Fall M., Kantoussan J., Sow F.Ng., Diouf M., Brehmer P. (2019). Fish-length based indicators for improved management of the sardinella fisheries in Senegal. *Regional Studies in Marine Science* Volume 31. <https://doi.org/10.1016/j.rsma.2019.100801>
- Berchie A., Okpei P., Nunoo F. K. E., Failler P., 2021. A fishery in distress: An analysis of the small pelagic fishery of Ghana. *Marine Policy* [Online], vol. 129. DOI: <https://doi.org/10.1016/j.marpol.2021.104500>
- Brochier, T., Auger, P. Thiao, D. Bah, A. Ly, S. Nguyen-Huu, T. Brehmer, P. (2018). Can overexploited fisheries recover by self-organization? Reallocation of fishing effort as an emergent form of governance, *Marine Policy* 95, 46-5. <https://doi.org/10.1016/j.marpol.2018.06.009>
- Belhabib D, Sumaila UR, Lam VWY, Zeller D, Le Billon P, Kane EA, Pauly D. (2015). Euros vs. Yuan: Comparing European and Chinese fishing access in West Africa. *PLoS One* 10: 3. <https://doi.org/10.1371/journal.pone.0118351>.
- Binet T, Failler P, Thorpe A. (2015). Migration of Senegalese fishers: a case for regional approach to management». *Maritime Studies* vol. 11, Issue 1, pp. 1-14. <https://doi.org/10.1186/2212-9790-11-1>
- Corten A., Braham C.B., Sadegh A.S. (2017). The development of a fishmeal industry in Mauritania and its impact on the regional stocks of sardinella and other small pelagics in Northwest Africa. *Fish. Res.* 186, 328–336. <https://doi.org/10.1016/j.fishres.2016.10.009>
- Chouvelon T., Violamer L., Dessier A., Bustamante P., Mornet F., Pignon- Mussaud C., Dupuy C. (2015). Small pelagic fish feeding patterns in relation to food resource variability: an isotopic investigation for *Sardina pilchardus* and *Engraulis encrasicolus* from the Bay of Biscay (north-east Atlantic). *Marine Biology* 162, pp.15–37. DOI : [10.1007/s00227-014-2577-5](https://doi.org/10.1007/s00227-014-2577-5)
- Cury P., Bakun A., Crawford RJM., Jarre A., Quinones RAA., Shannon LJ., Verheye HM. (2000). Small pelagics in upwelling systems: patterns of interaction and structural changes. *ICES Journal of Marine Science* 57 pp.603–618. <https://doi.org/10.1006/jmsc.2000.0712>.
- Dème B., M. Deme, M. Sidibeh and P.F. (2021a), The exploitation of small pelagics fish in Gambia: What valorization policies? *International Journal of Fisheries and Aquatic Studies* 2021; Vol. 9, Issue 4, pp 297-305. <https://doi.org/10.22271/fish.2021.v9.i4d.2547>
- Dème, E., Brehmer, P., Bâ, A. & Failler, P. (2021b). Résilience et réactivité des pêcheurs artisans sénégalais : la crise écologique comme moteur d’innovations [1]. *Mondes en développement*, 193, 109-127. <https://doi.org/10.3917/med.193.0113>
- Dème B., Failler P. and Deme M. (2021c), Migration of Senegalese artisanal fishermen in

- West Africa: patterns and impacts, *African Identities*, Vol. 19, Issue 3, pp. 253-265.
<https://doi.org/10.1080/14725843.2021.1937049>
- Dème El. B., Ricard D. et P. Brehmer. (2019a). Dynamiques et mutations dans la gestion des pêcheries artisanales sénégalaises : de la gestion centralisée des ressources aux dynamiques participatives et durables. *Noroi* [En ligne], 252 | 2019, consulté le 20 décembre 2019. URL : <http://journals.openedition.org/noroi/9354>
- Dème M., Inejih C., Baldé B. (2019b). Étude sur l'importance économique, sociale et écologique des petits pélagiques au Sénégal, en Mauritanie et en Guinée Bissau. Rapport technique du PRCM, septembre 2019. 62 pages.
- Dème El. B. (2018). Cogestion et dynamiques participatives durables des pêcheries artisanales sénégalaises : potentialités et limites en contexte de crise du secteur halieutique sénégalais. Thèse de géographie. Université Clermont Auvergne. 327 p.
- Dème M., Thiao D., Sow F.Ng., Sarre A., Diadhiou H.D., 2012.- Dynamiques des populations de sardinelles en Afrique du Nord-Ouest : Contraintes environnementales, biologiques et socio-économiques, Rapport technique COMFISH, 123 pages.
- Diankha O., Ba A., Brehmer P., Brochier T., Sow B.A., Thiaw M., Gaye A.T., Ngom F., Demarcq H. (2018). Contrasted optimal environmental windows for both sardinella species in Senegalese waters, *Fisheries Oceanography*, 4, p. 351-365.
<https://doi.org/10.1111/fog.12257>
- Failler P., Touron-Gardic G., Hansen J.A., Rodriguez A., Doblado A., Hermansen Ø. (2021a) Report on potential return on investments – Cost-benefit analysis of EU fleet investments in selected Case Studies, Report Responsive Results-Based Management and capacity building for EU sustainable Fisheries Partnership Agreement-and international waters (FarFish). [Rapport d'étude]. European Commission, 55p.
- Failler P., Ferraro G. (2021b). Fishermen migration in Africa: a historical perspective and some introductory notes. *African Identities* vol. 19 Issue 3 pp. 245-252.
<https://doi.org/10.1080/14725843.2021.1937053>
- Failler P. (2020a) Fisheries of the Canary Current Large Marine Ecosystem: From capture to trade with a consideration of migratory fisheries. *Environmental Development* vol. 36, n°. 100573 pp. 1-17. Doi : [10.1016/j.envdev.2020.100573](https://doi.org/10.1016/j.envdev.2020.100573)
- Failler, P., Binet, T., Dème, E. B., & Dème, M. (2020b). Importance de la pêche migrante ouest-africaine au début du XXIe siècle. *Revue Africaine Des Migrations Internationales*, 1(1), 1–15. mise en ligne le 14 Juin 2020, consulté le 15 Juin 2020
<https://revues.imist.ma/?journal=RAMI,SSN:2509-176X>.
- Failler P., Beyens Y., Asiedu B. (2014a). Value chain analysis of the fishery sector in Ghana with focus on quality, environmental, social, sustainable, food safety, organic requirements and its compliance infrastructure, Trade Capacity, Build. Program. Ghana 1–98, <https://doi.org/10.13140/RG.2.1.2421.5201>.

- Failler P. (2014b). Climate variability and Food Security in Africa : The case of Small Pelagic Fish in West Africa. *Journal of Fisheries & Livestock Production* 2:2.
<http://dx.doi.org/10.4172/2332-2608.1000122>
- Failler P. (2014c). Nutritional security, healthy marine ecosystems and value added priorities for developing coastal countries. *Editorial Journal of Fisheries & Livestock Production* pp.1-2. <http://dx.doi.org/10.4172/2332-2608.1000e107>.
- Fréon P., Avadí A., Marin Soto W., Negrón R. (2014). Environmentally extended comparison table of large- versus small- and medium-scale fisheries: the case of the Peruvian anchoveta fleet. *Can. J. Fish. Aquat. Sci.* 71, 1459–1474. <https://doi.org/10.1139/cjfas-2013-0542>
- Gorez B. (2018). West Africa: fishmeal, mealy deal, Samudra Report. ICSF International Collective in Support of Fishworkers.
- Greenpeace. (2019). A Waste of Fish – Food security under threat from the fishmeal and fish oil industry in West Africa..
- Kassé M. (2015). L'économie du Sénégal : les 5 défis d'un demi-siècle de croissance atone. L'Hamattan 271p. <http://digital.casalini.it/9782336376240>
- Laë R., Ecoutin J.-M., Mendy A., Raffray J., Weigel J.-Y., Sadio O., Djobe O. (2004). Effects of a targeted shrimp (*Penaeus notialis*) exploitation on fish catches in the Gambia estuary. *Aquat. Living Resour.* 17, 75–85. <https://doi.org/10.1051/alr:2004010>
- Ly D, David G. The migration of fishers as a driver of change in local fishers identity. The case of Imraguen fishermen in Mauritania. (2021). *African Identities* 19:3 266-283
<https://doi.org/10.1080/14725843.2021.1937045>
- Mahfoudh O. T., Souleimane O., Bâ S.A., 2012, Etude comparative de la réglementation des pêches des petits pélagiques dans la zone de la Commission Sous régionale des Pêches et le Royaume du Maroc. Rapport technique du projet « Pêche durable des petits pélagiques en Afrique Nord Ouest », 30 pages.
- Mangin T, Costello C, Anderson J, Arnason R, Elliott M, Gaines SD. (2018). Are fishery management upgrades worth the cost? *PLoS ONE* 13(9): e0204258.
<https://doi.org/10.1371/journal.pone.0204258>
- PNUE. 2004. Mise en œuvre des mesures de conservation et gestion durable des ressources halieutiques : le cas du Sénégal, Sénégal, Nations Unies, 101 p.
- Saraux C., Van Beveren E., Brosset P., Queiros Q., Bourdeix J.H., Dutto G., Gasset E., Jac C., Bonhommeau S., Fromentin J.M. (2019). Small pelagic fish dynamics: A review of mechanisms in the Gulf of Lions, Deep. Res. Part II 159 52–61.
<https://doi.org/10.1016/j.dsr2.2018.02.010>.
- Tacon AGJ, Metian M. (2018) Food Matters: Fish, Income, and Food Supply-A Comparative Analysis. *Reviews in Fisheries Science & Aquaculture* 26 pp.15–28.
<https://doi.org/10.1080/23308249.2017.1328659>

- Thiaw M., Auger P.A., Ngom F., Brochier Th., Faye S., Diankha O., Brehmer P. (2017).
Effect of environmental conditions on the seasonal and inter-annual variability of
small pelagic fish abundance off North-West Africa : The case of both Senegalese
sardinella. Fisheries Oceanography, Volume 26, Issue 5.
<https://doi.org/10.1111/fog.12218>
- Touron-Gardic, G., E. H. B Dème, M. Thiaw, D. Domingos Da Costa, R. Teeuw, A.
Argyriou, A et P. Failler, 2021, Etude sur la valeur écosystémique de 6 AMP du
RAMPAO présentant des sites critiques pour les petits pélagiques, RAMPAO (Réseau
des aires marines protégées d'Afrique de l'ouest), 131 p.
- USAID, 2014, Gambia-Senegal Sustainable Fisheries Project. Final Report, BaNafaa Project.
United States Agency for International Development / West Africa and Department of
Fisheries, Ministry of Fisheries and Water Resources, The Gambia..