SENEGALESE INSTITUTE FOR AGRICULTURAL RESEARCH

Oceanographic Research Center of Dakar - Thiaroye

SCIENTIFIC REPORT

Status of the Ethmalosa fishery in Senegal

COMFISH PLUS PROJECT

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Acronym

CECAF:	Fishery Committee for the Eastern Central Atlantic
CSE:	Ecological Monitoring Center
SRFC:	Sub-Regional Fisheries Commission
CRODT:	Oceanographic Research Center of Dakar - Thiaroye
DPC:	Department of Inland Fisheries
DPM:	Department of Marine Fisheries
FAO:	Food and Agriculture Organization of the United Nations
CFA Franc:	Franc de la Communauté Financière Africaine
EGN:	Encircling gill net
IFAN:	Institut Fondamental d'Afrique Noire/Fundamental Institute of Black Africa:
IUPA:	Institute of Fisheries and Aquaculture
“PENCOO GEJ”:	Collaborative Management for a Sustainable Fisheries Future in Senegal
USAID:	United States Agency for International Development
USAID/COMFISH:	Collaborative Management for a Sustainable Fisheries Future in Senegal
BS:	Beach Seine
PS:	Purse Seine
EEZ:	Exclusive Economic Zone

I. Executive summary

The socio-economic importance of Ethmalosa (*Ethmalosa fimbriata*) fishery accounts for the amount of efforts made to research into this resource. This report is a summary of existing knowledge on Ethmalosa and its fishery.

Juveniles are exclusively zooplanktivore, but as they grow into the adult stage they become phytoplanktivore. They mostly compete with juveniles of flat Sardinella. This species reproduces in lagoons, estuaries and in the sea, mostly during cold seasons. Its size at sexual maturity is equal to or greater than 17cm TL (total length). It has an average size of 25 cm TL, but can grow up to 45 cm TL. It has an average lifespan estimated at 5 to 8 years. The species grows faster during dry seasons than it does during cold seasons, and faster in the sea than in estuaries. As a sedentary clupeid, Ethmalosa is a euryhaline species, relatively eurythermal, found in coastal areas (close to the mouth of major rivers). It is a very mobile species with extreme capacity to adapt to very varying conditions of its living environment. It prefers warm and turbid waters and can tolerate a wide range of salinity. The species gather mostly in shoals close to the surface.

In Senegal, two major trends have been characteristic of Ethmalosa fishery since the 1990s: (I) declining productivity in estuaries and (ii) the emergence of sub-regional export markets, leading to increased demand for processed products. This situation led to the overexploitation of the Senegal-Gambia stock. This notwithstanding, the results of analyses must be considered with caution, given uncertainties over selectivity and the lack of conclusive information to put forward hypotheses on the identity of Ethmalosa stock in the sub-region, and its geographic distribution, coupled with the lack of biological data on various types of fisheries.

This situation of over-exploitation has resulted mainly in dwindling incomes, growing unemployment and poverty, chronic indebtedness of fishermen, migration to other areas and the use of banned fishing gears. In terms of planning, the CECAF Working Group (2017) recommended that fishing effort be reduced to enable the Ethmalosa stock to replenish the stock biomass to the level need to ensure its sustainability.

The economic and social importance of fisheries is mostly measured in terms of their contribution to food security, poverty alleviation, job and wealth creation, and balance of trade equilibrium. However, these general indicators are not the best to monitor the sustainable management of a specific fishery. Lack of understanding the current and potential contributions of each fishery to the national economy has led to the overcapitalization of the means of production, owing largely to incentive schemes available for the development of fisheries (subsidies) and uncontrolled growth in the fisheries industry. This couples with failure to adequately add value to landings, which translates into low industrial value addition.

The greater proportion of the added value generated by the Ethmalosa sub-sector is absorbed by foreign processors / traders. Overall, local populations are unable to fully benefit from Ethmalosa fishery. The added value generated by the local processing segment falls short of contributing to the improvement in the livelihoods of local communities. Indeed, the greater proportion of this added value is harnessed by foreign communities.

II. Introduction

In Senegal, average annual landings of fisheries products stand at 400,000 tons, including 80% from national artisanal fisheries. Fishing helps to provide for 75% of animal proteins needed by the population country wide. This economic and social performance is largely driven by the vibrant artisanal fisheries sub-sector, which accounts for more than 80% of the national production (350,000 tons). With about 70% of small pelagic landings, Ethmalosa and Sardinella fisheries constitute one of the pillars of the Senegalese fishing economy. However, the biomass of these species fluctuates a great deal, owing to environmental changes and the nature of their biological cycle which has a strong correlation with conditions in their marine environment.

Senegal has embarked on a process to put in place an Ethmalosa Management Plan, with support from the SRFC and financial partners as part of a sub-regional strategy for the sustainable management of Ethmalosa. An assessment of Ethmalosa resources and fishery in Senegal was conducted by CRODT with financial support from the USAID/COMFISH Project (Anonymous, 2014). This assessment demonstrates that Ethmalosa landings reported grew from 15,000 tons in 1990 to close to 25,000 tons in 2002 before declining significantly and steadily until 2012. This was followed by an increase from 2013 with declared volumes slightly above 21,000 tons in 2016 (DPM, 2017).

Hence, the project "Collaborative Management for a Sustainable Fisheries Future in Senegal" (PENCOO GEJ) (COMFISH) is funded by the United States Agency for International Development (USAID). The aim of the USAID/COMFISH Project is to support the Senegalese government in its efforts to reform the fisheries sector as contained in the Sectoral Policy Letter on Fisheries and Aquaculture Development by enhancing the conditions needed to improve governance, and by promoting the use of effective management tools and approaches.

The various activities conducted during the early years of the project led to the participatory selection of priority species on which the project has been working to support the development of co-management plans for priority stocks. CRODT was requested to conduct studies on Sardinella and Ethmalosa stocks to support the development of participatory management plans. Therefore, CRODT, in collaboration with the partners of the project, has been working in various focus areas, the third of which is themed "Organizing Scientific Working Groups on Ethmalosa Fisheries", which is the subject of this report.

To implement this focus area on research, CRODT proposes the adoption of a participatory approach comprising two main activities: (I) Exchanging information and data on Ethmalosa fishery and (ii) organizing a national working group to give feedback on workshop results. The end result will be the development of a consultation process to evaluate Ethmalosa stock(s) exploited in Senegal in collaboration with the various stakeholders to support the fisheries management plan.

This report is divided into 3 parts: (I) summary of literature on all essential information provided on the biology, ecology and fishery of Ethmalosa (*Ethmalosa fimbriata*); (ii) description of available data on the species and its fishery and (iii) recommendations and prospects.

III. Summary of existing knowledge on Ethmalosa and its fishery

Ethmalosa *fimbriata* S. (Bowdich, 1825) is an estuarine and coastal clupeid found in abundance from Mauritania to Angola. The socio-economic importance of this species has prompted several studies on its biology and fishery.

In Senegal, the initial biological data available date back to the years 1950-1970 (Blanc, 1951; Boely and Elwertowski, 1970; Scheffers *et al.,* 1972; Scheffers, 1973; Scheffers and Conand, 1976). Recent studies have been conducted on Ethmalosa in the Saloum estuary by Panfili *et al.* (2004), Durant *et al.* (2005) and Ngning (2008), in the Casamance estuary by Labonne *et al.* (2009) and in Saloum and the coastal area by Faye et al. (2013, 2014):

Furthermore, in the sub-region, studies have also been conducted in the Gambia (Scheffers, 1971), Côte d'Ivoire (Albaret and Gerlotto, 1976; Gerlotto 1979, Ngoran, 1991), Sierra-Leone (Anonymous, 1957; Bainbridge, 1961) and Nigeria (Fagade and Olanyan, 1972).

3.1. Bioecology of Ethmalosa

3.1.1. Description of the species

Ethmalosa fimbriata belongs to the phylum Chordata, to the class Actinopterygii, to the order Clupeiformes and to the family Clupeidae. Genus Ethmalosa can be distinguished from other West African clupeidae mainly by their big heads, and among adults, by their comb-shaped fins on the edge of their scales. On the contrary, among young ones, this edge is made up of striae. Genus Ethmalosa are monospecific (Charles Dominique, 1982).

The species has a fairly elongate body, laterally compressed, with very sharp stripped scutes along the belly (Lozano-Rey, 1950). It has very small teeth, and sometimes no teeth at all. Its 8 ray ventral fins are located slightly behind the base of the dorsal fin. It has a V-shaped caudal fin with scaled lobes at each side of the base. This caudal fin is mostly straw yellow, especially among adults. The species also has big adipose eyelids (Charles Dominique, 1982). It has an olive-brown back and light sides with silver glints. It has a round dark spot behind the upper side of the operculum, which is sometimes followed by a series of 2 to 4 other spots (Fig. 1).

The species can be distinguished from other clupeidae by its upper jaw with a distinct median notch into which the tip of lower jaw fits (Whitehead, 1985).

Figure 1. Ethmalosa, Ethmalosa fimbriata (S. Bowdich, 1825) (Source: Modou Thiaw)

3.1.2. Diet of Ethmalosa

Juveniles are exclusively zooplanktivore, but as they grow, they become phytoplanktivore (Bainbridge, 1957; Fagade & Olaniyan, 1972; Nieland, 1980). Studies conducted on the diet of Ethmalosa in the Sine-Saloum estuary in Senegal (Séne, 1994; Diouf, 1996), in the Lagos lagoon in Nigeria (Fagade and Olaniyan, 1973) and in the Ebrié lagoon in Côte d'Ivoire (Nieland, 1980) confirmed the presence of planktonic algae in the stomach contents of the species.

The presence of ostracods, bivalve larvae and gastropods has also been found by Fagade and Olaniyan (1973) in the stomach contents of Ethmalosa. The presence of these preys was also reported among juvenile Ethmalosa in Sine-Saloum (Gning *et al.,* 2008). Its diet may also include mainly big diatoms and some copepoda of a maximum size of 0.6 mm (Bainbridge, 1957). The fact that Ethmalosa is predominantly phytophagous, zooplanktivore or microbenthophagous could rather be attributed to the availability of food in its environment than the size of the species.

3.1.3. Reproduction of Ethmalosa

The reproduction of Ethmalosa as well as its larvae stages were investigated in Senegal (Scheffers *et al.,* 1972; Faye *et al.,* 2013), in the Gambia (Scheffers, 1971), in Sierra Leone (Anonymous, 1957; Bainbridge, 1961), in Nigeria (Fagade & Olanyan, 1972) and in Côte d'Ivoire (Albaret & Gerlotto, 1976; N'goran, 1991). This species reproduces mostly during cold seasons (Table 1).

Ethmalosa reproduces mainly in lagoons and estuaries, but also possibly in the sea (Charles-Dominique, 1982). Its reproduction depends on some environmental parameters such as salinity (Charles-Dominique, 1982) Generally, the sex ratio of Ethmalosa is 50% (Faye et al., 2013). However, there may be far lower proportions of males in some environments (Boëly and Fréon, 1979). This difference in sex ratio may be due to females of bigger size being more vulnerable to some fishing gears made up of some specific meshes (Gerlotto, 1979). However, the hypothesis of a higher natural mortality among the males cannot be ruled out (Caverivière, 1982).

In West African coastal areas, males generally reach sexual maturity earlier than females, (Table 2) but die earlier. On the other hand, females grow faster (Al-Hakim *et al.,* 1980). Individuals may reach sexual maturity at a minimal size of 17 cm TL at one and half years of age. Furthermore, a decrease in size at first sexual maturity has been noted in Saloun, a hyper-saline reversed estuary. In addition, in "open" estuarine environments (Senegal, Gambia, Sierra-Leone) Ethmalosa populations could have a size at first sexual maturity bigger than those found in lagoons (Côte d'Ivoire, Benin, Nigeria) (Albaret and Dominique, 1982).

In Senegal, in the Fleuve region, esggs are laid from March to August, with two surges in May and June in salinities between 3.5 and 35 % and temperatures between 22 and 31 °C. Larvae are more abundant in the waters of the rivers, with salinities between 5 to 10%.

Among a large number of clupeidae, fecundity is difficult to determine, owing to the large number of oocytes and sometimes, to their small size. The weight of the gonads accounts for 4 to 6% of the total weight of the fish during reproduction period. In Senegal, Ethmalosa recorded high fecundity according to a recent study conducted on the reproduction of the species in the Saloun estuary and in the sea (Faye et al., 2013). In the sea, absolute fecundity and relative fecundity are respectively estimated at 50,694 ± 18,160 eggs and 257 ± 81 eggs per gram of female. In estuaries on the other hand, they are estimated at 51,083 ± 17,103 eggs and 317 ± 82 eggs per gram of female. Absolute fecundity both in the sea and in estuaries is almost the same. However, relative fecundity statistically differs for these two environments.

Table 1. Reproduction periods of Ethmalosa fimbriata found in the literature

Study area	Month of the year												Authors
	J	F	M	A	M	J	J	A	S	O	N	D	
Senegal (sea)													Faye et al. (2014)
Senegal (Saloun)													
Saloun and Gambia													Panfili et al. (2004)
Côte d'Ivoire													Ngoran (1991)
Senegal-Gambia													Scheffers et al. (1972)
Gambia													Whitehead (1985)
Côte d'Ivoire													Albaret & Gerlotto (1976)
Sierra Leone													Bainbridge (1961)
Sierra Leone													Salzen et al. (1958)
Nigeria													Marcus (1984)
Nigeria													Fagade & Olanyan (1972)
Ghana													Blay & Eyeson (1982)
Guinea Bissau													Kromer (1994)
Guinea													Bah et al. (1991)

Table 2. Size at first sexual maturity (fork length at 50% mature FL50) determined in some West African zones

Study area		FL50 in cm (males)	FL50 in cm (females)	Authors
Senegal	Sea	17.2	18.7	Faye et al. (2014)
	Estuary (Saloun)	16.2	17.5	
	Estuary (Saloun)	17.3	15.3	Panfili et al. (2004)
	Estuary (Saloun)	17.5	18.0	Diouf (1996)
	Estuary (River Senegal)	16.0	17.0	Scheffers (1972)
Gambia	Estuary (River Gambia)	20.2	19.1	Panfili et al. (2004)
	Estuary (River Gambia)	-	18.5	Scheffers (1972)
Côte d'Ivoire	Estuary (Ebrie Lagoon)	13.0	14.0	Albaret & Gerlotto (1976)
	Biétri Bay	8.1	8.4	Albaret & Charles-Dominique (1982)
Côte d'Ivoire	Aby Lagoon	9.6	9.9	Ngoran (1991)
Nigeria	In the sea	10.0	14	Fagade & Olanyan (1972)
Sierra Leone	In the sea	-	19	Salzen et al. (1958)
Guinea	In the sea	18	19	Bah et al. (1991)

3.1.4. Growth

Growth curves like those of Von Bertalanffy have been drawn by Salzen (1958), Scheffer (1973) and Gerlotto (1976). According to Scheffers (1973), Ethmalosa in River Senegal reaches 12 to 13 cm TL in size at the age of 6-7 months and 16 cm TL after one year. After one and half years, Ethmalosa can reach a minimum reproduction size of 17cm (Scheffers, 1972). Maximum sizes of 47 cm TL and 35 cm FL were noted by Postel (1950) in the Saloun estuary (Senegal). In Senegal, the average lifespan of Ethmalosa is estimated at 5 years (Faye *et al.,* 2014). Gerlotto (1976) observed a differential growth among Ethmalosa species found in the Ebrie lagoon (Côte d'Ivoire) depending on their gender. A significant decrease in growth was noted in hyper-saline environments such as the Saloun estuary (Panfili *et al.,* 2004). The average size of Ethmalosa is 25 cm TL, but it can also grow up to 45 cm TL (CSRP, 2017).

In Senegal, Faye et al. (2014) noted that Ethmalosa grows slower during cold seasons (low temperature) and faster during hot seasons. Indeed, the hot season (June-July) is the period when the temperature of upper layer waters increases from of 23°C to a maximum of 28°C, which is the only period in the year when salinity levels of both surface and deep waters are the highest. This a period favorable for the growth of phytoplankton, when maximum density levels are recorded (Maingy & Doutre, 1958).

Additionally, Ethmalosa grows faster in the sea than in estuaries (Faye *et al.* 2014) This difference could be attributed to the difference in density between the two environments; density is believed to be higher in estuaries. Meanwhile, in high density environments, the decrease in growth rate could be attributed to trophic competition which could have affected food consumption or energy expenditure rate (Jones, 1987; Booth, 1995).

Finally, the demographic structure of Ethmalosa populations in the estuaries in the course of the year is not the same as in the sea (Charles-Dominique & Albaret, 2003). In Senegal, two different cohorts have been observed in estuaries during the cold season: a first cohort of 17 to 20 cm TL in size and a second of 21 to 26 cm TL in size (Faye *et al.,* 2014).

3.1.5. Geographic distribution of Ethmalosa

Ethmalosa is a sedentary clupeid (unstable stocks). It is a euryhaline species found in coastal areas (close to the mouth of major rivers). The species can spend part or all of its life in inland mixosaline waters (rivers, estuaries, deltas, lagoons). It reproduces in waters of variable salinity of 3.5 to 38 % (Dominique, 1982). Spawning and hatching areas are the same as those where adult stocks are distributed (Albaret and Gerlotto, 1976). The species is relatively eurythermal. Therefore, temperature can play a limiting role only if it falls below 22°C (Scheffers et al., 1972).

It is a species of marine origin with a strong affinity with estuaries (Albaret, 1994; Charles-Dominique & Albaret, 2003). It is found only along West African coasts. The highest proportions in the North are recorded in Villa Cisneros (Mauritania, 24°N; Lozano-Rey, 1950) and in the South in Lohito (Angola, 12°S; Poll, 1953). Seasonally, Ethmalosa enters inland areas, notably River Senegal, up to 140 km from the mouth, and the Gambian estuary, up to 380 km from the mouth (Scheffers & Correa, 1971). In the sea, the species remains very close to the coast.

It has been noted from the landings in the regions that the highest concentrations of Ethmalosa occur in Senegal (from Sangomar to Casamance), in the Gambia, in Guinea, Sierra Leone, Nigeria and Cameroon. A high concentration of Ethmalosa has also been observed in Mauritania. In Senegal, three different distribution areas have been noted. Each of them is associated with one or

several estuaries: River Senegal, Sine Saloum, River Gambia and River Casamance. The relationships that may exist between concentrations present in those different areas are unknown, but differences in their biology have been noted.

The distribution of Ethmalosa seems to be fragmented, with juveniles, young adults and adults having preferences for different habitats (Scheffers, 1973; Scheffers & Conand, 1976; Boely & Fréon, 1979; Charles-Dominique & Albaret, 2003; Faye, 2013). Adults have preference for marine environment, and the intermediary group is more adaptable to estuarine environments, with very high plasticity in reproductive features. Juveniles abound more in rivers and in estuaries, while young reproducers (15 to 25 cm TL in size) as well as adults (above 25 cm TL) occur both in estuaries and in the sea, where they remain very close to the coast.

The geographic distribution of Ethmalosa has been investigated by Durand et al. (2013) at sub-regional level through a genetic study. These authors highlighted the existence of three distinct areas of abundance of Ethmalosa: the area from Cote d'Ivoire to Congo (Southern population), the area covering the southern part of Senegal up to Guinea (central population) and the area covering Mauritania and the Northern part of Senegal (Northern Population). Durand et al. (2013) have also observed that Ethmalosa's habitat is closer to the coast than that of Sardinella. It occurs mostly in waters of less than 15 m depth.

Table 3. Growth parameters of Ethmalosa fimbriata obtained from the literature

Study area	Methodology used	L∞ (FL cm)	K (year^{-1})	Φ'	Authors
In the sea (Senegal)	Size frequencies	31.4	0.47	2.67	Faye et al. (2014)
Saloun estuary (Senegal)		29.1	0.36	2.48	
Senegal	Otolites recorded	27.0	0.48	2.54	Panfili et al. (2004)
Côte d'Ivoire (Ebrie lagoon)	Size frequencies	24.5	0.96	2.76	Gerlotto (1976)
Nigeria		26.3	0.43	2.47	Moses (1988)
		29.2	0.36	2.49	Essen (1995)
		31.2	0.9	2.94	Ama-Abasi et al. (2004)
Sierra Leone		40.8	0.25	2.62	Showers (1996)

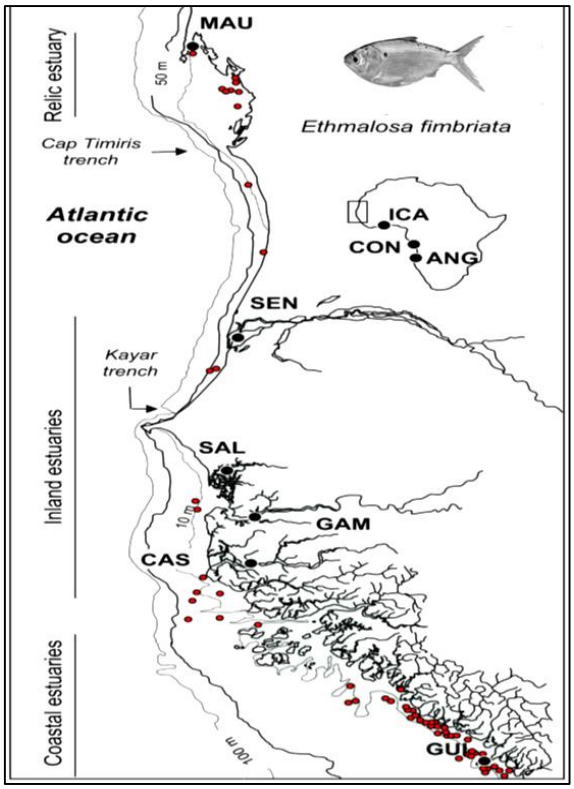

Figure 2. Geographic distribution of Ethmalosa along the West African coast

Geographic distribution of Ethmalosa along the West African coast (Durand et al., 2013).
The grey line along the West African coast represents the area of distribution of Ethmalosa. MAU: Etoile Bay, Mauritania; SEN: River St. Louis, Senegal; SAL: Foudioungne, Saloum, Senegal; GAM: Tendaba, Gambia; CAS: Diogue, Casamance, Senegal; GUI: Conakry, Guinea; ICG: Grand Lahou Lagoon, Ivory Coast; ICE: Ebrié Lagoon, Ivory Coast; ICA: Aby lagoon, Ivory Coast; BEN: Nokoué lagoon, Benin; CAM: Idenau beach, Cameroon; ATM: Libreville Bay, Gabon; CON: Loango Bay, Congo; and ANG: Luanda, Angola. The red dots indicate the sampling stations where Ethmalose has been identified.

3.2. Ethmalosa exploitation

3.2.1. Artisanal fisheries

A large number of fishing gears are used in the fishing of Ethmalosa along West African coasts, the diversity of which reflects the complex nature of artisanal fisheries which accounts for the greater proportion of landings. These can be grouped into several categories: surface drift gill-nets (authorized mesh: 50 mm), encircling gill nets (60 mm), purse seine nets (28 mm) and casting nets (40 mm). The mesh size of artisanal fishing nets is determined by the measurement of the stretched mesh or the length of the mesh.

In most cases, the crafts used are wooden canoes of variable sizes. They tend to be motorized (outboard motor of 10 to 40 CV on average).

The major Ethmalosa fishing zones along the Senegalese coasts are River Senegal and the Saint Louis region, Petite Cote, from Dakar to the Sine-Saloun estuary, the Sine- Saloun region, the River Gambia and the Gambian estuary, River Casamance and the Casamance estuary.

- Trends in Ethmalosa catches

In Senegal, data on Ethmalosa catches are provided by the two available sources of data: The Oceanographic Research Center of Dakar - Thiaroye (CRODT), and the Department of Marine Fisheries (DPM). Data from CRODT cover the period from 1990 to 2015, while those from the DPM cover 1993 to 2017. (Fig. 3) shows that annual catches vary from one year to the other irrespective of the source of the data with a general downward trend since 2009. It has been noted that the catches recorded by the DPM are higher than those recorded by CRODT, with the exception of 2014-2015 when CRODT recorded higher volumes of catches. However, the trends remain more or less the same over the period from 1993 to 2010.

As regards the trends in catches, 3 important phases have been noted in fisheries dynamics: a first phase of fisheries development observed over the period from 1990 to 2001 with the highest volumes of catches in 2001 (25,000 tons), followed by a phase of downward trend between 2002 and 2011 and finally a second phase of upward trend from 2012 onward. Declared landings increased from 15,000 tons in 1990 to close to 25,000 tons in 2002 before declining significantly and steadily until 2008. From 2010, a substantial increase has been noted in landings, which neared 21,000 tons in 2016, exceeding the yield recorded in 2000 (DPM, 2017).

An analysis of CRODT's data on landings per maritime region demonstrates that more than 95% of Ethmalosa landings take place in the Thiès Sud region (Fig. 4). Out of the eight centers covered by CRODT surveys, Joal is the leading landing site for this fishery sub-sector. The rest of the maritime regions recorded on average 350 tons per year from 1990 to 2015. The highest catch volumes (1,150 tons) with these other fishing gears were recorded in 2003.

Ethmalosa catches are carried out mainly by means of encircling gill nets (EGNs) and purse seines (PS). On average, 64% of landings are carried out using EGNs, 38% with PS and 3% with other fishing gears (beach seines, fixed nets, lines) (Fig. 5).

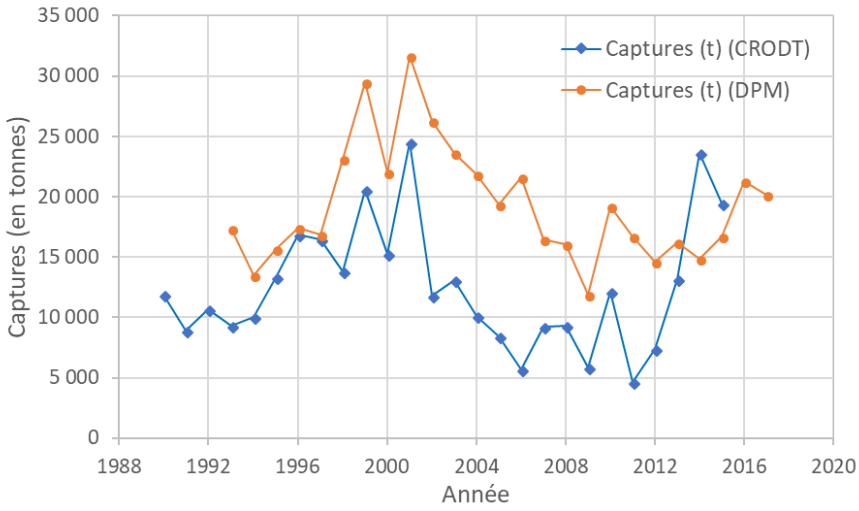

Figure 3. Annual Ethmalosa landings in Senegal between 1990 and 2015, provided by CRODT and the DPM

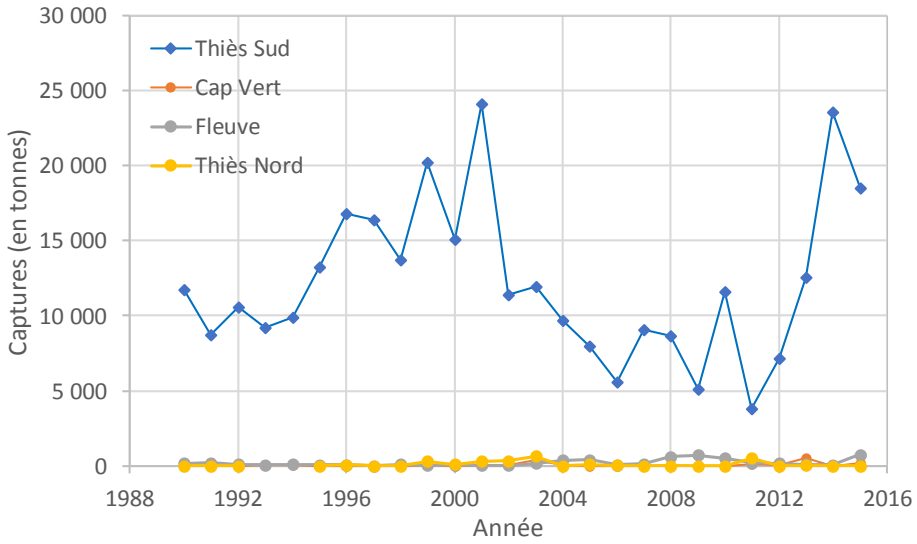

Figure 4. Annual Ethmalosa landings in Senegal between 1990 and 2015, per fishery site

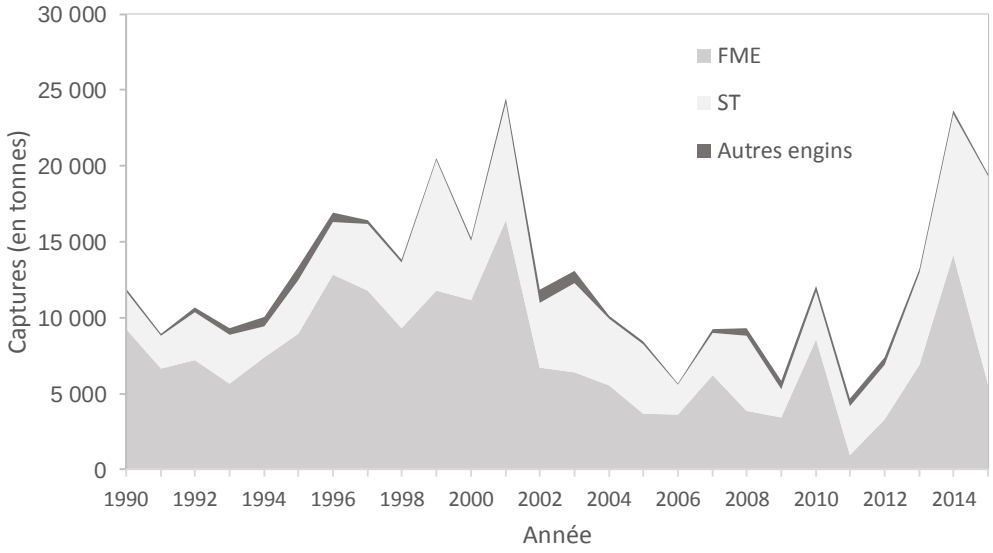

Figure 5. Annual Ethmalosa landings in Senegal between 1990 and 2015, per main fishing gear used

- Trends in fishing effort

Ethmalosa is exploited by canoes of variable dimensions using mostly two fishing gears: purse seines (PS) and encircling gill nets (EGNs). Other artisanal fishing gears can also be used to catch Ethmalosa, but as a secondary activity (beach seine, fixed nets and lines). An analysis of trends in fishing effort using the main artisanal fishing gears targeting Ethmalosa indicates that purse seine fishing effort is by far the highest, almost double the effort for encircling gill nets (Fig. 6). This high purse seine fishing effort is followed by those of encircling gill nets and beach seines.

Overall, from 1990 to 2010, purse seine fishing effort had been relatively stable (on average 59,000 trips per year) with some pronounced fluctuations. Furthermore, from 2004 to 2010, a decline was

recorded in the overall purse seine fishing effort. This decline could be attributed to the issuing of permits (about 300 permits per year) by the government of Mauritania, which led to the transfer of the greater part of purse seines activities based in Saint Louis. However, from 2010, purse seine fishing effort has surged steadily, from 54,000 trips in 2010 to 99,000 trips in 2015.

As for fishing effort by encircling gill nets, it remained stable around 22,000 trips per year over the entire period of 1990-2015, with some pronounced variations at times. These data concern fishing units based in the area covered by the CRODT survey system, notably encircling gill nets operating in the Petite Cote area between Mbour and Joal.

Purse seines are mainly concentrated in the coastal area, from Saint Louis to Djifere, while encircling gill nets targeting Ethmalosa operate in the Southern part, especially in estuaries (Sine-Saloum, Gambia and Casamance). The partial coverage of CRODT surveys tends to strongly minimize the importance and potential fishing effort of the fleet of encircling gill nets. If Sine Saloun had been covered, it would have certainly brought out more significant and dynamic efforts.

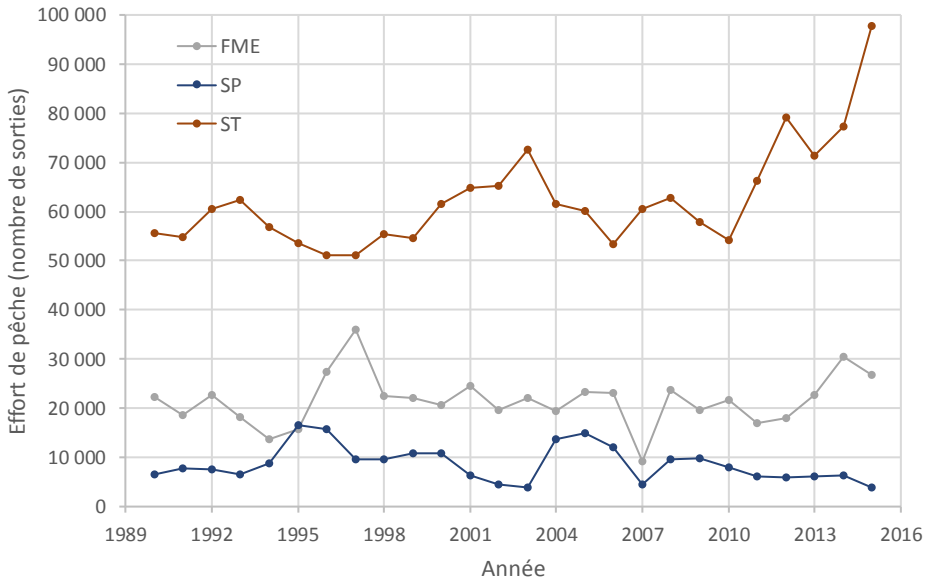

Figure 6. Artisanal fishing effort per fishing gear used to produce Ethmalosa in Senegal between 1990 and 2015

In Senegal, 4,333 units of encircling gill nets were identified in the Fatick region in 2009, out of which 69% are concentrated at only less than ten fishing sites. In Casamance, the fleet of canoes is relatively inadequate with only about 70 units in 2007 according to information provided by fishermen.

3.2.2. Industrial fisheries

In Senegal, industrial vessels do not target ethmalosa, despite the government's efforts to modernize artisanal fishing. As a result, Ethmalosa catches are low, and even non-existent in the industrial databases, especially that of CRODT.

3.3. Ethmalosa fishery value chain

3.3.1. Fishery sub-sectors

In the context of the status of the stocks, the goal needs to shift from producing large quantities to adding the best value of fish landed, hence the need to compute the added value of the Ethmalosa fishery sub-sector. This initiative highlights not only the wealth created, but also its significance in each segment of the value chain, and its distribution among the various factors of production. This tool provides policy-makers with the necessary information to guide them in decision-making.

Added value is defined as the measure of wealth created by an economic activity. In the case of Ethmalosa, the added value generated is the sum of added values of all segments of the species' value chain. Four segments have been identified, having to do with production, wholesale fish trade (fresh fish distribution), artisanal processing and the generation of tax revenue. There is no form of industrial processing of Ethmalosa.

3.3.2. Value addition in 2015

The added value generated by each segment is equal to the difference between the value of the products and that of intermediary consumptions occurring within the process. The production value is computed by multiplying Ethmalosa catches by the prevailing average landed price of the species. Intermediary consumptions are drawn from operating accounts of the various fishing units (purse seines, encircling gill nets) targeting Ethmalosa. The value addition during the marketing of fresh and processed products is the sum of trade margins generated on such products.

In Senegal, the added value generated by Ethmalosa fishery in 2015 is estimated at **7.6 billion CFA Francs,** which is made up of 6.1 billion CFA Francs (Fig. 7) by the production segment, 445 million CFA Francs by wholesale fish trade, 1.05 billion CFA Francs by artisanal processing and 5 million CFA Francs of tax revenue (tableau 4). Value addition from the Ethmalosa value chain accounts for 4.7% of the total value added by the fisheries sector, estimated at 161.6 billion CFA Francs in 2015 (Dème, in press).

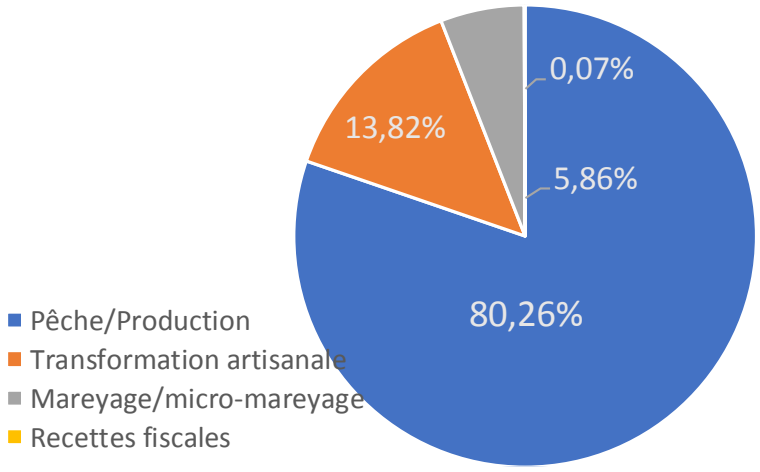

Figure 7. Distribution of the total added value per segment generated by the Ethmalosa sub-sector

This added value highlights two major factors, namely the low taxation of the sector and inadequate domestication of the value added by the artisanal processing segment of Ethmalosa.

The taxation of artisanal fisheries in Senegal is limited to almost fishing permits which cost 25,000 CFA Francs annually for fishing units targeting Ethmalosa. Besides, fishermen enjoy duty-and tax-free purchasing of fishing equipment (nets, engines, spare parts) and subsidies on canoe fuel, as part of measures taken by the Senegalese government to support fisheries production.

The inadequate domestication of the added value generated by the artisanal processing of Ethmalosa is attributable to the control by foreign communities (mainly Guineans) at the end of the value chain, where the greater proportion of this added value is recorded (close to 80%). This situation is the outcome of several factors, including (1) limited financial capacity of local actors to produce adequate quantities and to cope with prolonged times to market, (2) very specialized marketing channels owing to major constraints (loss of products, prolonged delivery times, high cost of transportation, payment difficulties, cumbersome administrative and customs procedures).

Overall, local populations are unable to fully benefit from Ethmalosa fishery. Value addition recorded in the value chain, especially by the artisanal processing segment falls short of contributing to the improvement in the livelihoods of local communities, especially since the greater proportion of this added value is harnessed by foreign communities.

3.4. Status of the stocks

Indirect evaluations of small pelagics in the North-West African zone have been conducted by the CECAF Working Group. Biological reference points adopted by this working group are target reference points ($B_{0.1}$ and $F_{0.1}$) and limit reference points (B_{MSY} and F_{MSY}).

A cohort analysis model based on size frequencies (LCA, Jones, 1984) and yield per recruit model by Thompson and Bell (1934) (in, Sparre and Venema, 1992) have been used to estimate biological reference points. This is because it has not been possible to apply the dynamic production model, owing to lack of adequate data. In addition, acoustic surveys could neither be conducted to estimate the biomass of Ethmalosa, which is an estuarine species that abounds in shallow waters.

Series of size frequencies from artisanal fisheries in Mauritania, Senegal and the Gambia from 2010 to 2016 have been used. Given the ambiguous nature of the data provided by the Gambia, and the longevity of Ethmalosa, the working group decided to try three scenarios (Mauritania, Senegal and Mauritania-Senegal combined) to evaluate the stock for the 2012-2016 period (FAO, 2017). Parameters such as growth, size-weight relationship and natural mortality, used in both models, have been estimated by the working group (Table 4).

Table 4. Parameters used in Ethmalosa stock assessment models (CECAF, 2017)

Growth parameters			Length-weight relationship		M (year^{-1})
TL+∞ (cm)	K (year^{-1})	to (year)	a	b	0.4
40	0.46	-0.483	0.012	3.098	

In 2017, the results for the LCA model for the three scenarios demonstrate that fishing pressure is very high on individuals within the 17 to 34 cm bracket. As for the results from the yield per recruit model by Thomson and Bell, they indicate that the current exploitation level F_{cur} is far higher than the precautionary level $F_{0.1}$ (Table 5). These results demonstrate that the stock of Ethmalosa in the sub-region is overexploited.

Table 5. Values of the reference points of the three scenarios (CECAF, 2017)

Stock/unit area	$F_{cur}/F_{0.1}$	F_{cur}/F_{Max}
Mauritania and Senegal	139%	79%
Senegal	130%	45%
Mauritania	154%	51%

An analysis of the average size composition over a period of five years (2012-2016) using the LCA model shows various types of fishing according to the countries. In Mauritania, it is mainly big size individuals that are fished, while in Senegal, all kinds of sizes are represented in the catches. However, young individuals are predominant in the catches.

In Senegal, two major trends have been characteristic of Ethmalosa fishery since the 1990s (Samba, 2009). The first trend is the substantial decline in productivity in estuarine environments owing to various factors (Hyper-salination of waters, construction of dams, mangrove destruction). These factors led, among other things, to dwindling Ethmalosa production and a decrease in the average size of individuals in River Senegal, in hyper-saline estuaries of Saloun and Casamance. The second observation is the emergence of sub-regional export markets (Guinea, Mali and Burkina Faso) and high demand for processed products, which have intensified fishing pressure in the sub-region, and the shifting of interest in fishing gears (purse seines, encircling gill nets) to Southern regions of Senegal.

This situation led to the overexploitation of the Senegal-Gambia stock. For fishermen, this situation of overfishing has resulted mainly in the decrease of their incomes, growing unemployment and poverty, chronic indebtedness, migration to other areas and the use of banned fishing gear. Therefore, FAO (2017) calls for a reduction in the fishing effort for this stock.

3.5. Fisheries management system

The management of the fisheries sector in Senegal has been centralized for a long time under the authority of the Ministry of Fisheries and Maritime Economies and its decentralized services such as regional services, departmental services and control stations. Those various services at national, regional and local levels work together to create enabling conditions to achieve the main objectives of the fisheries Act in Senegal. It puts high priorities on the conservation of the resources as part of its fisheries strategies. More specifically, these decentralized services are involved in overseeing fishing activities (landings, inspection of fishing gears and the quality of the seafood product). They support actors in terms of organization, implementation of local fisheries resources management initiatives, search for funding, and technical capacity building. Some fishing sites have benefited

from investments from the fisheries ministry through development projects. The most significant are the construction of artisanal fishing harbors and fish processing areas, the restructuring of some sub-sectors and the protection of resources and the environment through the creation of reserves (artificial reefs, establishment of fish concentrations, protected fishing zones). The Ethmalosa sub-sector, like other fisheries sub-sectors, benefits from this institutional framework.

On the legislative front, the Ethmalosa fishery, like any other fisheries sub-sector, is regulated by two fundamental legal texts: Act No 2015-18 of 13 July 2015 instituting the Marine Fisheries Code and its implementing order (Order No 2016-1804 of 22 November 2016).

Article 24 of the Decree on fishing gears and mesh size of artisanal fishing nets defines a minimum stretched mesh size of 60 mm (30 mm of mesh side) for encircling gill nets and 28 mm (14 mm of mesh side) for purse seine nets.

Article 38 of the same Decree on the regulation of species' minimum size and weight bans the catching, transportation, transshipment, detention, sale and purchasing of any Ethmalosa species of eighteen (18) centimeters or less in size. The minimum size used to be fifteen (15) centimeters in the fisheries code of 1998.

Article 57 of the Act requires a valid fishing permit issued by relevant departments of the ministry responsible for maritime fisheries before the conduct of any commercial artisanal fishing operation either on foot or on board of a boat in waters under Senegalese jurisdiction. Its annual cost is 25,000 CFA Francs for fishing units targeting Ethmalosa. Very few fishing units have acquired fishing permits, except over the past two years, in order to benefit from a million CFA Francs subsidy by the President of the Republic for the purchasing of engines.

Article 66 of the same Act bans the use or keeping on board of a fishing craft, gill nets made with nylon monofilament or multi-monofilament materials. Actors fail to comply with this important provision, and majority of fishing units targeting Ethmalosa use monofilament rigs.

Article 68 of the Act also requires the registration of fishing boats.

It should be noted that logistic and human resource constraints facing the fisheries administration (inadequate staffing and means of transportation) as well as the large number of landing sites to be covered along the Senegalese coast hamper the effective and regular monitoring of fishing activities. The commission of offences is widespread, constant and go unpunished.

Given the limitations of the centralized management of fisheries (overcapacity of production means, unsustainable fishing, overexploitation of resources), policy-makers established Local Artisanal Fisheries Councils (CLPAs) for greater involvement of fishermen in the management of fisheries resources at local level. These new local governance institutions have been mandated to give advisory opinions on all issues pertaining to artisanal fishing activities and fish farming, to inform small-scale fishermen and fish farmers about issues concerning them, to organize fishermen in communities so as to curtail and resolve conflicts, to induce them to assist the administration in monitoring and regulating fishing activities.

As regards Ethmalosa, collective fisheries regulation actions have been initiated in estuarine environments, notably in Saloum. Such actions entailed regulating fishing gears close to river mouths to enable fish to migrate to inland waters, instituting one-off closing of some fishing zones, and banning small mesh beach seines in some communities.

Along the coast, USAID/COMFISH played a major leading role to support the Government of Senegal in its strategy on the management of fisheries resources, the project recommended the local

convention as a participatory tool for fisheries management at local level. This local convention is "defined as a formal agreement among users, governing the management of natural resources at local level in compliance with legislative and regulatory provisions signed by the Administrative Authority".

The local convention draws its legality from the powers of the CLPA having jurisdiction over the area. Therefore, the overall objective of the local convention is to ensure sustainable conservation and utilization of fisheries resources to meet the growing, diverse and changing needs of the population, while preserving the productive, ecological and cultural functions of marine and coastal ecosystems for the benefit of the community. More specifically, the local convention aims to (1) promote measures for the management of fisheries resources, (2) to regulate in a consensus manner, access to fisheries resources, (3) to involve the population in the development and implementation of consensual rules for the management of fisheries resources, (4) to encourage the populace to demonstrate civic-mindedness towards rules adopted for the sustainable exploitation of fisheries resources, (5) to promote equity among actors when it comes to accessing fisheries resources and (6) to facilitate conflict prevention and resolution.

In all, 6 local conventions (Yenne, Rufisque-Bargny, Mbour, Sindia, Kayar and Joal) have been finalized.

IV. Data available and collection system

As part of the COMFISH-PLUS Project, the Oceanographic Research Center of Dakar - Thiaroye (CRODT) organized a workshop for the exchange of information and data on Ethmalosa fishery in Senegal. This workshop enabled us to catalogue all relevant information and to describe, among other things, data available on the exploitation of the species.

To gather further information, it was planned during the workshop that CRODT ought to visit partner institutions of the COMFISH PLUS Project for a description of data available on Ethmalosa fishery in Senegal. Subsequently, a mission was organized to collect available data and information from partner institutions of the project. The mission was aimed at providing a platform for consultation and exchange with focal points of partner institutions of the project such as the DPM, the CSE and the SRFC to collect and describe information and data available on Ethmalosa fishery in Senegal. The mission was conducted from 12 to 13 March 2018 to some institutions (DPM, CRODT, SRFC, CSE, DPC, IUPA, IFAN) based in Dakar, Senegal. As a result, the various data available on Ethmalosa fishery were presented and described (Annex 1).

The mission enabled us to have the initial inputs for the preparation of the report on the summary information and the description of available data on Ethmalosa fishery. It was also the first stage of consolidating synergies (contact making, sharing and exchanging information and data) among the various partners of the project. The information gathered during the mission is presented in (Table 6). It pertains to the source, nature, type, format, breakdown and accessibility of the data. It would be necessary to collect further information on the geographic coverage, spatio-temporal coverage, variables associated with the data collected, data update frequency, among others.

Table 6. Description of data available in institutions visited

Source	Nature of data	Type of data	Data format	Breakdown	Access	Comments
CRODT	Experimental fishing and biological sampling	Measurements and meristics	Excel	Per major fishing zone	Accessible	-
	Artisanal fisheries	Landings Fishing efforts	Database / Access and Excel	Per month, fishing gear and home port	Accessible	Data available on scientific format
		Size frequencies	Database / Excel	Per month, fishing gear and home port	Accessible	Data available on a scientific format
		Number of fishing units Engine power of fishing units Migration flows of fishing units Size of crews of fishing units Landed price / market value of catches	Database / Excel	- Per half-year, fishing gear and home port	Accessible	
	Industrial fisheries	Landings Fishing efforts	Database / Access and Excel	Per month, fishing zone	Accessible	Data available on scientific format
DPC	Artisanal fisheries (fisheries statistics in inland environments)	Quantities landed	DPC Database / Excel	Per month and environment	Accessible	-
LABEB-AO/IFAN	Biological sampling (reproduction and growth)	Artisanal fisheries	Database / Excel	Per month and home port	Accessible	-
IUPA/UCAD	Experimental fishing (gear selectivity)	Experimental fishing	Database / Excel	Per month and fishing zone	Accessible	-
CSE:	Distribution	Area of distribution of small pelagics	Maps / Shape files		Accessible	
		Migration flow of Sardinella	Maps / Shape files		Accessible	
		Area of concentration of small pelagics	Maps / Shape files		Accessible	
		Area of distribution of Ethmalosa	Maps / Shape files		Accessible	
		Ethmalosa fishing sites	Maps / Shape files		Accessible	
DPM	Artisanal fisheries	Landing quantities	Reports	Per maritime region / month	Accessible	
		Market value	Reports	Per maritime region / month	Accessible	
	Processing	By-products	Reports	Per maritime region / month	Accessible	
SRFC	Artisanal fisheries	DPM and CRODT compiled	Reports and database		Accessible	Data compilation (DPM and CRODT)

V. Challenges, recommendations and prospects

In Senegal, Ethmalosa fishery is confronted with various problems, including:

- Scarcity of fisheries resources,
- Lack of control over artisanal fishing capacity;
- Non-compliance with the legislation on fishing gears: unsustainable fishing practices by fishermen (juvenile, fishing, use of monofilaments, etc);
- Limited access to inputs (fuel, food for crews ....);
- Limited access to fishing equipment (engines, nets, canoes, light safety equipment, etc);
- Conflicts over space and resources among actors practicing different types of fishing;
- Difficulties associated with the marketing of processed products;
- Lack of basic landing, conservation and transportation infrastructure: lack of conservation infrastructure and suitable equipment;
- Low profitability of fishing activities
- Constraints associated with the development of processing,
- Lack of adequate resources for research,
- Poor governance system: operational shortcomings of governance bodies.

In this context, the government of Senegal, with support from the SRFC, has developed an Ethmalosa fishery development plan to propose measures to promote sustainable exploitation of this resource. However, the effective implementation of these measures requires prior actions to facilitate their implementation. There is also the need to put in place supporting measures to (1) enhance knowledge on resources and fisheries, (2) to ensure adequate protection of the resource, (3) to adjust fishing efforts to the authorized potential, (4) to ensure better processing and value addition of the products and (5) to facilitate their marketing nationwide and throughout the sub-region.

Finally, research avenues were proposed for coming years or for future projects. There was a broad consensus among national research actors during the meeting on:

- The need to pool human and financial resources to carry out research activities, given budgetary constraints hindering in-depth research in some areas,
- The need to share scientific information on Ethmalosa fishery,
- The need to update some information (maps, fisheries statistics),
- The need to harmonize study methodologies for the identification of Ethmalosa stock(s) exploited in the sub-region,
- The need to continue studies on the selectivity of fishing gears for the exploitation of Ethmalosa in Senegal: an initial step would be the provision of scientific support to IUPA/UCAD which is already working in this area.
- The need to conduct studies on the identification of the stock(s) of Ethmalosa exploited in the sub-region: several methodologies or approaches were proposed. These include the conduct of the toponymy of fishing zones, the harmonization of study methodologies i.e.

morphometrics, genetics and microchemistry. Other approaches proposed included the conduct of a comparative study on Ethmalosa's life history traits, size frequency, genetic structure and parasites among the various populations described, to provide more precise information on the subject. As a reminder, some studies have been conducted in this regard, but their results differ according to the methodologies used (Durand et al., 2013).

- A study to estimate the added value of Ethmalosa fishery in Senegal to inform decision-making while laying emphasis on industrial processing (fish meal),
- The need to conduct a study on the value chain of Ethmalosa fishery in Senegal.

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VII. Annexes

Annex 1: Description of Ethmalosa metadata available at the Ecological Monitoring Center (CSE)

Content	Description	Sector or type of content	Data format	Metadata standard	Time frame	Update frequency	Source	Access control	Other comments or observations
Ethmalosa distribution area	Spatial distribution of Ethmalosa. This work was done based on scientific studies on the species and contributions from stakeholders	Species	Shape file (map)	ISO 19115	Current	Where necessary	Internal system	None	Free access
Sardinella migration flow	This is a representation of Sardinella's migration flow along Senegalese coasts	Species	Shape file /(map)	ISO 19115	Current	Where necessary	Third-party supplier	None	Free access
Area of concentration of juvenile pelagics	Cartographic representation of areas of concentration of pelagic species along Juvenile Senegalese coasts	Species	Shape file (map)	ISO 19115	Current	Where necessary	Third-party supplier	None	Free access
Pelagic nursery area	Pelagic species nursery area	Species	Shape file (map)	ISO 19115	Current	Where necessary	Third-party supplier	None	Free access
CLPA	Geographic locations of Local Artisanal Fisheries Councils	Administrative	Shape file (map)	ISO 19115	Current	Where necessary	Internal system	None	Free access

FISHING_ SITE	Geographic locations of fishing sites	Administrative	Shape file (map)	ISO 19115	Current	Other	Third-party supplier	None	Free access
Fishing infrastructure	Map of fishing infrastructure in the COMFISH project area	Administrative	Shape file (map)	ISO 19115	Current	Where necessary	Internal system	None	
Landing sites	Geographic locations of landing sites	Administrative	Shape file (map)	ISO 19115	Current	Where necessary	Internal system	None	
Bathymetry	Bathymetric layer	Elevation	Shape file (map)	ISO 19115	Current	Where necessary	Third-party supplier	None	
Plant communities	Spatial distribution of marine plant communities in Senegal	Marine habitat	Shape file (map)	ISO 19115	Current	Where necessary	Third-party supplier	None	
Sea beds	Geographic layer representing sea bed types in Senegal		Shape file (map)	ISO 19115	Current	Where necessary	Third-party supplier	None	

Annex 2: Description of Ethmalosa metadata available at the Department of Marine Fisheries (DPM)

Data sources/type	Fishery type	Period	Characteristics of unit-level data	Species concerned	Number of registrations	Explanatory variables associated with the data
Commercial fisheries data (DPM)	Artisanal and industrial fisheries	1992.-2017	Ethmalosa landings in tons per artisanal fishing canoe and some industrial fishing trawlers. Monthly data per region available. We also have data on the estimated market value	Ethmalosa	-	Data are received on monthly basis in the form of reports from regional bodies in Dakar, Thiès, Ziguinchor, Fatick, Kaolack, Saint louis and Louga and amateur fishermen in the industrial fishing sector.

Annex 3: Ethmalosa catch data (in tons) on artisanal fisheries and industrial fisheries available at the Department of Maritime Fisheries (PDM).

Année	Pêche artisanale	Pêche industrielle
1993	17 332	
1994	13 503	
1995	15 686	
1996	17 462	
1997	16 462	378
1998	164 933	3
1999	29 454	14
2000	22 031	1
2001	31 675	
2002	26 240	
2003	23 627	3
2004	21 839	
2005	19 370	
2006	21 625	
2007	16 480	
2008	16 075	
2009	11 893	
2010	19 155	
2011	16 711	
2012	14 585	
2013	16 189	
2014	14 860	
2015	16 721	
2016	21 289	
2017	20 139	