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Overexploitation of round sardinella may lead to the collapse of flat sardinella: What lessons can be drawn for shared stocks

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Abstract

This paper describes the fisheries and presents quantitative stock assessments for two stocks of *Sardinella* in the waters of NW Africa. More robust stock assessments are now possible because of improved sampling in Mauritania and Senegal. Round sardinella (*S. aurita*), which has a wider distribution than flat sardinella (*S. maderensis*), is the most important species targeted by the different artisanal and industrial fleets. The industrial fleet is located beyond 13 miles from the coast, taking mainly adults. The average size in the offshore fishery, although it has decreased, remains above 26cm. The species is also exploited by an artisanal fleet using small purse seiners. Two types of assessment model were applied: a production model and size-based model. The abundance indices were consistent, and showed a continuous decline, increasing in rate in recent years. The Just Another Bayesian Biomass Assessment (JABBA) model (applied for the first time) appeared to be appropriate for the abundance indices (Root Mean Squared Error (RMSE) 18.3–19.2 % for the two models). The results of the two models are consistent in showing increasing fishing mortality and declining biomass for both stocks over the time series. According to the JABBA model, the situation for the round sardinella stock is now critical (biomass at approximately 5 % of unexploited biomass (B₀) and 10 % of biomass capable of producing maximum sustainable yields (B_{msy}), with fishing mortality 2.5 times above F_{msy}), and the flat sardinella is also overfished and suffering massive overfishing (B estimated at 18 %B₀ and 25 %B_{msy}, with fishing mortality more than 11 times above F_{msy}). The results of the Length-based Bayesian Biomass (LBB) model are much more optimistic. It still concludes that both stocks are suffering overfishing (round sardinella F at ~1.4 times F_{msy} proxy, flat sardinella ~2.2 times F_{msy} proxy), but estimates that only the flat sardinella is overfished (B 28%B₀ and 80 %B_{msy}), while the round sardinella stock is not overfished (B 40 %B₀ and 120 %B_{msy}). However, these results are not consistent with the abundance index from acoustic surveys (used in the JABBA model) and overall are thought to be less robust. Signs of heavy exploitation have been observed for round sardinella for several years. This situation has been exacerbated since the arrival in late 2016 in the Mauritanian zone of efficient semi-industrial purse seiners targeting small pelagics. The various indirect assessment models used show a difficult stock situation for the round sardinella, on which many fishing communities in the area depend. Abundance indices from acoustic survey confirm the state of overexploitation of this resource. This situation has directed effort towards the flat sardinella, which is characterized by a more coastal distribution and limited migration. This species has been showing signs of overexploitation since 2019. We highlight this result for flat sardinella, which was previously not thought to be overexploited, and propose that managers should also consider how the estimated maximum sustainable catch and fishing mortality can be appropriately distributed between the different fleets in different countries, to ensure that future industry planning in the countries of the region is compatible with the sustainability of these critical stocks. This is a very complex task, as it involves not only discussions between neighboring countries, but also difficult decisions within countries about the economic and socio-economic importance of different fisheries sectors. It is essential that these reflections start immediately.

Introduction

The EEZ of the Islamic Republic of Mauritania is the epicentre of an area of very high productivity and biodiversity, thanks to a set of hydro-physical, climatic and morphological conditions generating upwelling, as well as the thermal front between the Guinea and Canary currents (Braham et al., 2014, Modou et al., 2017). These conditions produce a wealth of fisheries that present a great opportunity to Mauritania both for its

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economic development and for the food security of its populations. The sectoral policies adopted by the different governments have set objectives for sustainable management of the resources and a better integration of the sector into the national economy (MPEM, 2022).

The small pelagic stocks in Mauritania are shared by other countries in the region; Morocco in the north and Senegal and the Gambia in the south. Within the total range of this distribution area, the species are exploited by artisanal, coastal and industrial fleets, both national and foreign. They are the most important species in terms of landings (tonnage and significance for the local economy) (Braham and Corten, 2015, Ba et al., 2016, FAO, 2021). These species are gregarious, relatively short-lived and have high natural mortality. They undergo trophic and reproductive migrations linked to variations in marine environmental conditions (Modou et al., 2017, Diankha et al., 2018).

The increased demand for these species in recent years has created a critical situation for the main pelagic stocks, including the two sardinella species (round sardinella and flat sardinella). The situation raises several questions about the management and development of the fisheries, such as how the allocation of catches should be arranged, and how fishing effort can be reduced Fig. 1.

The sardinella caught in the Mauritanian zone are composed of two species, namely the round sardinella (*Sardinella aurita*) and the flat sardinella (*Sardinella maderensis*). Acoustic surveys show that these two species are distributed over a vast area ranging from the southern part of Morocco to the south of Senegal. The two sardinella species show the most direct need for sub-regional management. The transboundary nature of the stocks has led to a scramble in which each coastal state tries to extract the maximum amount of sardinella when the fish are in their area.

The pressure on these stocks has further increased not only because of the emergence of fish meal and oil factories in some countries but also because of the arrival of semi-industrial purse seiners and pelagic trawlers. For this reason, the FAO Working Group on Small Pelagics in Northwest Africa has repeatedly sounded the alarm that the round sardinella resources of the sub-region are overexploited (e.g. FAO, 2016, Baldé et al., 2022). If the current trend continues or worsens further, coastal nations engaged in fishing will be deprived of a vital source of food, income, and employment .

The objective of this paper is to carry out a diagnosis of the status of the stocks of the two sardinella species (round sardinella and flat sardinella) focusing on the Mauritanian area, which is main feeding and reproduction area in the region (Braham et al., 2014; Timothée Brochier). In addition, the work analyzes the consequences of the overexploitation of the round sardinella and its impact on the closely related flat sardinella; the distribution of which partly overlaps with that of the round sardnella.

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Characteristics of the two sardinella species

Both sardinella species are similar in size and appearance; the main distinguishing feature is the black spot on the operculum of the round sardinella. On the flat sardinella, the black spot is not on the operculum but rather just behind.

Round sardinella are generally found further offshore than flat sardinella but may also concentrate along the coast when food production declines in the offshore area (Corten et al., 2012). Round sardinella make extensive seasonal migrations (north/south) ...

Data

The analysis was based on combined commercial catch data for the period 1995–2021. We use size-frequency data collected by observers on board vessels and by data collectors at landing sites and freezing and fishmeal plants. The collection of landing and biological sampling data is carried out by investigators and observers from research institutes in the countries of the sub-region (Fig. 3 B):

- National Institute for Fisheries Research (INRH) in Morocco ...
- Mauritanian Institute of Oceanographic ...

...

Trends in catch and acoustic biomass of two species

The trend of catches of the two species in the northwest African area shows a dominance of round sardinella over flat sardinella during the whole period, except for the last three years in which flat sardinella has become the dominant species. A continuous decline in the catch of round sardinella is observed since 2014 with sharp declines since 2018 (Fig. 4). This last year corresponds to the arrival of the efficient semi-industrial purse seiners, working especially in the coastal zone.

The ...

Discussion

For several years, the Fishery Committee for the Eastern Central Atlantic (CECAF) working group has been unable to assess the sardinella stocks due to lack of data. In the last three years, however, thanks to increased sampling carried out in Mauritania and Senegal, we have been able to apply two approaches for the assessment of the round sardinella stock.

The summary of the results of the different models applied to these two stocks can be summarized in the following table (Table 4):

The two ...

CRedit authorship contribution statement

Cheikh Baye Braham: designed and planned the study. **Cheikh Baye Braham, Mohamed Ahmed Jeyid, Jilali Bensbai, Jo Gascoigne:** drafted the manuscript. **Cheikh Baye Braham, Mohamed Ahmed Jeyid, Jilali Bensbai, Jo Gascoigne:** analysed the data. **Cheikh Baye Braham and Jo Gascoigne** field work. All authors contributed to the article and approved the submitted version. ...

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. ...

Acknowledgements

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...A potential issue is that the organisations providing external review of FIPs (in this case
FisheryProgress and MarinTrust) only give 'credit' for activities which are directly linked to their
own MarinTrust or MSC-based workplan – however in general terms we have found that these
objectives very much align. Mauritania is the steward of an incredibly productive marine
ecosystem, supporting a very large fishery which is important to their economy and population,
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