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Using Bayesian belief networks to disclose interactions between small-scale fisheries and offshore aquaculture developments off south-east Portugal

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Summary
In southern Portugal the recently enacted delimited area with restricted access for offshore aquaculture production purposes has created some friction between small-scale fishermen and offshore aquaculture/ranching firms. The former claim their were the ones who previously used the area to go fishing which is now partially barred, whereas the latter by their turn claim that offshore aquaculture is the best way to keep fish resources and jobs sustainable in the long run by bringing additional resilience into the system. By using Bayesian belief networks (BBN) based on evidence from socioeconomic indicators such as: reported landings, fishing patterns, and registered fishermen; it is investigated the impacts (either negative or positive) offshore aquaculture developments under different scenarios have on local fishing communities. The results/inferences are explored under the development of different conditions, assumptions and scenarios. The results also show which variable combinations rise conflicts and which ones allow a more pacific coexistence between stakeholders. It is believed that the output of this case-study can be of great utility to inform policy and scientific advice for fisheries and ecosystem management not only at local level, but also at a larger scale.

Introduction
Kidd & Shaw (2014) refer that the existing knowledge from terrestrial planning is transferable to marine spatial planning (MSP). The integration of different coastal activities into marine planning using BBN tools have already been approached (Stelzenmüller et al., 2010; Levontin et al., 2011). The point is to find out a compromise between coastal activities and facilitate synergies. This issue apparently is a priority on the Portuguese decision makers' agenda. Offshore aquaculture (OSA) is a relatively new concept in Portugal and appears to be one of such priorities (Figure 1). Simultaneously keeping small-scale fisheries (SSF) seems of high importance too. The enactment of legislation for coastal areas restricted use (e.g. OSA production), has raised some opposing voices, namely small-scale fishermen (SSF), as it can be found in the reported news.

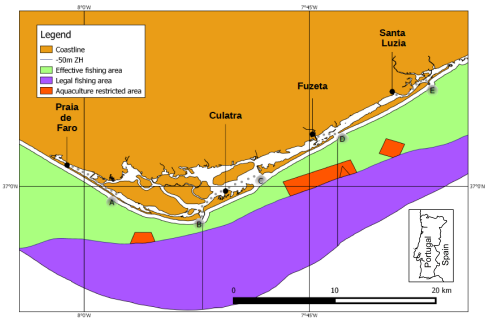

Figure 1 – Southeast Portugal: offshore aquaculture areas (in orange) and small-scale fishing areas (light green and purple).

There are considerable differences between SSF and OSA (expressed by random variables). Considering the biological resources along time, species biodiversity found in SSF catch is high and constant, whereas OSA presents few species but with an increasing trend. In terms of effort, SSF have a declining trend but the EU gives monetary incentives to keep fleets active as a way to enhance fishing communities social role; by its turn OSA presents increasing number of vessels related to the rising ranching production. In terms of catch, SSF is random and fishers' income is completely dependent on them; whereas for the OSA case, production is usually known, as well as its market price, leading to a better revenue certainty.

SSF is usually composed by self-employed people (each fishing vessel has most of the times 1-2 men on-board), whereas OSA have been set-up by firms that are able to hire employees. SSF usually sell their catches at a local market, but eventually can sell to broader markets if they are enrolled in producers organizations; whereas OSA entered into larger markets by filling the gap of supply and because are able to present economies of scale demanded by retailers.
The objective of the present study is to use a BBN approach to integrate variables characterizing both SSF and OSA, and to investigate the access restriction to a coastal area by both viewpoints. It is intended to find out the differences in production (yield) and determine the effectiveness of the decision.

Methodological Approach

By constructing Bayesian Belief Networks (BBN), it is attempted to find out the probability of success (effectiveness) of the management of a coastal area off southeast Portugal through the inclusion of two activities that interact and may compete for space (Figure 2).

BBN model random variables were fed through the evidence provided by socioeconomic indicators such as: reported landings, fishing patterns and registered fishermen. Public policies on aspects such as the management of the area used may affect one activity in detriment of another. By its turn, the production achieved (both through fishing yield and aquaculture production), may have influence on the effectiveness of the whole system. Conditional probability tables were used throughout the process of data testing. The BBN work is still ongoing.

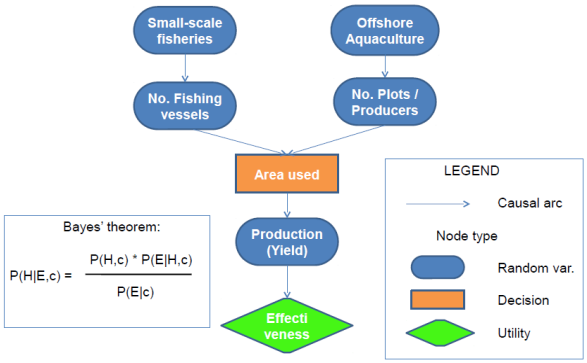

Figure 2 – Bayesian Belief Network model for the interaction between small-scale fisheries and offshore aquaculture off southeast Portugal.

Results and Discussion

As shown by Schmitt and Brugere (2013), BBN can be used to support complex decision making on coastal aquaculture and fisheries issues. The model needs to be fed on the most reliable data available, and sometimes we face data poor situations (e.g. SSF haven't VMS to track fishing vessels and their activities).
The big issue seemed to be related to jobs creation and attraction when activities are compared. Evidence showed that older fishermen were more averse to change livelihoods and kept on fishing by using their empirical experience, whereas by their turn younger people were more attracted to enter into an OSA activity. OSA appeared to be more prone to provide job and wage sustainability.

References

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