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Assessing the vulnerability of Mediterranean demersal stocks and predicting exploitation status of un-assessed stocks

Giacomo Chato Osio[a,*], Alessandro Orio[a,b], Colin P. Millar[a,c]

[a] European Commission Joint Research Centre, Institute for the Protection and Security of the Citizen (IPSC), Via Enrico Fermi 2749, 21027 Ispra, VA, Italy
[b] Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Marine Research, Turistgatan 5, S-453 30 Lysekil, Sweden
[c] Marine Scotland Science, Freshwater Laboratory, Faskally, Pitlochry , Perthshire, PH16 5LB, UK

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ABSTRACT

According to the Common Fisheries Policy, all commercial fish stocks in the Mediterranean and Black Sea should be managed at MSY by 2015–2020. However, currently 95% of assessed stocks are overexploited and 73% of demersal species are not assessed. To explore the risk of overexploitation to un-assessed stocks, vulnerability scores were constructed using Productivity Susceptibility Analysis (PSA) for 151 Mediterranean demersal fish species. Out of 151 species, 58 displayed low vulnerability, 20 medium vulnerability, 25 high vulnerability and 48 were considered of major concern. More than half of stocks showed a risk of being overfished (termed "vulnerability"), greater than that of the stocks currently assessed in the Mediterranean Sea. Most of the cartilagineous fish fell into the high and major concern areas. The quality of data used for the PSA was scored and these scores could be used to improve future collection of data. Vulnerability scores are well correlated with IUCN red list classification. To rank the priority of commercial stocks still to be assessed, vulnerability scores were scaled with landings and mean price per stock. Eight of the top fifteen ranking stocks are currently not assessed. When the vulnerability of cartilaginous fish was tested against rate of decline estimated from trawl survey time-series, no strong correlation was found. The exploitation ratio (F/F_{msy}) of assessed stocks was regressed, using generalized mixed models, against PSA scores and area and a significant relationship was found. Using this result, assessed stocks were used as a training set to predict the exploitation of un-assessed stocks. F/F_{msy} was predicted for 151 species in 14 management areas (GSAs). The results over all areas is that 39 species-area combinations are exploited sustainably, all occurring in area 20 (Greece), while the remaining 2075 are exploited unsustainably with respect to F_{msy} ($F/F_{msy} > 1$). This prediction model, albeit after further refinement with more data and testing, could be used to predict exploitation ratio when no information on stock status is available. We predict that ≈98% of the unassessed demersal fish species are potentially overexploited in the evaluated areas. This makes it clear that strong management action will be required to achieve the targets of the Common Fisheries Policy in the next 1–5 years.

1. Introduction

There has been an increase in effort world-wide to assess the status of living marine resources. Management bodies and Regional Fisheries Management Organizations (RFMOs) focus on determining the exploitation status of important commercial stocks. While progress has been made, still only a fraction of stocks under directed commercial fishing or caught as bycatch are currently assessed. According to Costello et al. (2012), fisheries lacking formal assessment comprise >80% of global catch. Many regional policies mandate that all fish stocks, or fish stocks with economic value, should be managed in a sustainable way (US Magnusson-Stevenson Act; European Community Common Fisheries Policy (CFP) and Maritime Strategy Framework Directive (MSFD); Australia's Fisheries Administration Act 1991), but many countries are far from reaching this target. To address the lack of knowledge on stock status, several efforts aiming at developing new methods for assessing the status of data poor stocks are under development (Rosenberg et al., 2014).

In the Mediterranean and Black Sea the situation is the same. According to the revised CFP, European stocks subject to commercial fishing should be managed at their long term maximum sustainable yield (MSY) by 2015, or at the latest 2020 (EU Regulation No. 1380/2013, https://biobs.jrc.ec.europa.eu/sites/default/files/generated/files/policy/REGULATION%20%28EU%29%20No%201380-2013%20CFP%20Common%20Fisheries%20Policy.pdf). In

* Corresponding author. Tel.: +39 0332785948.
E-mail address: giacomo-chato.osio@jrc.ec.europa.eu (G.C. Osio).

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the Mediterranean, a fish stock is traditionally defined as one species in one GFCM statistical area, under the strong assumption that stock unit and statistical area coincide. In the last five years, out of the 98 stock assessments with analytical results, less than 25 species have been assessed at least once in one of the 27 Mediterranean sub areas (GFCM GSA), while more than 100 species are subject to fishing. Therefore the stock status, at species level, is known for around a fourth of the species subject to commercial fishing. However, at the stock level this fraction is much smaller. Additionally the status of the 25 assessed species is not known uniformly across GSAs.

The Mediterranean demersal stocks have been subject to trawling at least since 1700 (Osio, 2012), one of the longest trawl fishery exploitation in the Western world. A consequence of this is that around 95% of assessed stocks are classed as overexploited based on assessments performed between 2008 and 2012. The few stocks considered to be exploited sustainably are either short-lived small pelagics or crustaceans.

Given that approximately 75% of Mediterranean species are not assessed, there are two main problems: (1) the lack of knowledge on exploitation status of unassessed stocks is of particular concern given the generally high exploitation rate in assessed stocks; (2) in policy terms, it will be impossible to show MSY and fulfill the CFP and MSFD targets in compliance with the timelines set in the CFP. While there are stocks that have landing time series and could be assessed with methods for intermediate data situations as those tested in Rosenberg et al. (2014), many of the un-assessed stocks are effectively data poor, meaning that not even landings time series are available. Understanding which species should be assessed is a clear need, as well as gaining a realistic picture of the vulnerability of the data poor stocks. Hobday et al. (2011) developed in Australia the Ecological Risk Assessment for the Effects of Fishing (ERAEF) where different levels of risk assessment are implemented based on data availability and risk. The novelty of this framework is a hierarchical structure, a precautionary approach to uncertainty and tracking of uncertainty across levels (Hobday et al., 2011).

There are different methodologies for assessing stock vulnerability. Typical approaches are semi-quantitative risk assessments (Patrick, 2010) such as evaluating fishery impact on target and bycatch species (Stobutzki et al., 2001a), evaluating the impacts on ecosystem viability (Astles et al., 2006) or the extinction risk of a determinate species (Mace et al., 2008). Among these is a widely used method known as Productivity and Susceptibility Analysis (PSA), originally devised in Australia (Milton, 2001; Stobutzki et al., 2001b). PSA is based on scoring an array of productivity and susceptibility attributes for each stock, which are then summed to provide a productivity and susceptibility value by stock, often presented graphically. The approach has since been modified to include habitat and community components (Hobday and Smith, 2004) and further revisions have been suggested by Rosenberg et al. (2007).

The PSA methodology has benefits and limitations (Watling et al., 2011).

Benefits:

- It is suitable in data-poor situations where data for traditional stock assessments are lacking (it is based on qualitative data).
- The outputs provide a visual tool for examining the relative vulnerability of a suite of species to a particular fishery.
- The method can be tailored to the data availability and state of knowledge of species and fisheries by carefully selecting productivity and susceptibility attributes.
- The method is rapid and is based on previously developed, tested and published protocols, and has a history of application as a risk assessment method in fishing.
- It is easy to add new information as soon as better data become available.

Limitations:

- The PSA analysis essentially measures potential for risk. A measure of absolute risk requires some direct measure of abundance or mortality rate for the stock in question, and this information is generally lacking (Hobday et al., 2007). In this assessment, species are ranked relative to each other. However, comparing with assessed stocks can give more absolute results.
- The analysis is only what it appears, a vulnerability analysis, and it should be used as a tool to highlight potential management strategies, vulnerable species, and areas where particular attention should be paid.
- This assessment is fishery-specific, as susceptibility rankings are specific to a species' interaction with the fishery in question.
- The results are only as strong as the attributes included. There are many more attributes that increase or decrease a species' susceptibility or recovery potential. Attributes should be added or removed based on the fishery and as more information becomes available.
- The method lacks ecosystem context. It primarily focuses on the individual fish species and not the broader ecosystem.

The goals of this paper are the following:

(1) Calculate vulnerability via scoring susceptibility and productivity for commercially exploited demersal fish in the Mediterranean Sea using the outputs from a PSA analysis.
(2) Produce a ranking of species with high vulnerability, as well as high vulnerability and economic importance, to identify those deserving more attention in terms of stock assessment and management.
(3) Investigate the relationship between PSA scores and (1) exploitation level of assessed stocks, (2) IUCN red list classification and (3) estimated annual rate of change from trawl survey catch per unit of effort for cartilagineous fish.
(4) Predict the potential exploitation status of unassessed stocks from the relationship between vulnerability and exploitation status in assessed stocks.

2. Material and methods

We evaluated 151 demersal and bathydemersal fish species including 40 chondrichthyans (Supplementary materials, file "psa_scores_Med.xlsx") in the Mediterranean Sea. Only species caught (or likely to be caught) by otter-trawl were considered. Species were selected based on their listing in the European Data Collection Framework (DCF) landings database and their presence in the international Mediterranean bottom trawl survey (MEDITS) over the past 19 years—see Bertrand et al. (2000) for a description of the MEDITS database. Discard data is generally poor from commercial landings, thus the use of a comprehensive list of demersal fish caught in the MEDITS survey helped detect species that are captured by trawlers and that might go undetected in discard sampling. Extremely rare species, like sturgeons and angel sharks, were added to the PSA analysis to assess if the PSA could identify a high potential risk, explaining current disappearance and rare sightings. Therefore, the analysis included un-assessed species as well as all the assessed demersal and bathydemersal species (99 stock assessments performed in 16 sub-areas over 5 years (http://www.europarl.europa.eu/document/activities/cont/201312/20131217ATT76355/20131217ATT76355EN.pdf).