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Evaluation of status of commercial fish stocks in European marine subareas using mean trophic levels of fish landings and spawning stock biomass

R.P. Prabath K. Jayasinghe [a, b, c, *], Upali S. Amarasinghe [d], Alice Newton [c, e]

[a] Marine Biological Resources Division, National Aquatic Resources Research and Development Agency, Crow Island, Colombo 15, Sri Lanka
[b] Fundación Universidad Empresa de la provincia de Cádiz (FUECA), University of Cádiz, 11003 Cádiz, Spain
[c] CIMA, Gambelas Campus, University of Algarve, Faro 8005-139, Portugal
[d] Department of Zoology and Environmental Management, University of Kelaniya, Kelaniya, Sri Lanka
[e] NILU-IMPEC, Box 100, 2027 Kjeller, Norway

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ABSTRACT

Most of the fish stocks in the world, including European fish stocks, are threatened by overfishing and/or degraded environmental conditions. Although the Common Fisheries Policy (CFP) is the main policy instrument managing fish stocks in Europe, there is continued concern as to whether commercial fish stocks will achieve Good Environmental Status (GEnS) in 2020 in accordance with the Marine Strategy Framework Directive (MSFD). In this context, the evaluation of the status of fish stocks in the subareas of FAO fishing area 27 was carried out using mean trophic levels (*MTL*) in fish landings and spawning stock biomass (*SSB*). Comparisons were made before and after 2008 to establish whether the trend is positive or negative. The main data sources for landings and *SSB* were the International Council for the Exploration of the Sea (ICES) advisory reports. *MTL*s in landing and *SSB* were determined for each subarea and the subareas were categorized into four groups, according to *MTL*s after 2008. The first group (subareas I + II, V) had higher *MTL* in landings and higher *MTL* in *SSB* after 2008. Therefore, fisheries in these subareas appear sustainable. The second group was subareas VIII + IX, for which the fish stocks have higher *MTL* in landings but low *MTL* in *SSB*, indicating that *SSB* was being overfished. The third was subarea (VI), where fish stocks have lower *MTL* in landings than those in *SSB* after 2008, which may indicate that fish stocks are recovering. Fish stocks in the fourth group (subareas III, IV and VII) had low *MTL* in landings and the *MTL* in *SSB* was lower than that of landings before 2008. This may be due to heavy fishing. In addition, we estimated the harvest rate (*HR*) of the fish stocks before and after 2008. The results showed that most of the fish stocks have lower *HR* after 2008, indicating that the status has improved, perhaps due to improvements in the implementation of CFP. However, some fish stocks showed high *HR* even after 2008, so that new management options are still needed. Other factors such as eutrophication, seafloor disturbances, marine pollution, invasive species etc., influence *SSB* ecosystem health options and should also be incorporated in the management criteria. Most of these environmental pressures are of high priority in the MSFD, and therefore the findings of this study will be useful for both CFP and MSFD.

1. Introduction

The Common Fisheries Policy (CFP) is the main policy document to manage European fisheries resources. It was adopted in 1983 and has since been revised every 10 years (Aanesen et al., 2012). The latest version was approved by the European Parliament in 2013 (Pastoors, 2014). The main *modus operandi* of the CFP for managing fisheries is to decrease the fishing capacity (Villasante, 2010; Gascuel et al., 2011). However, the very high fishing pressure exerted by EU fishing fleets has been insufficiently reduced by the CFP to achieve healthy stocks and maximum sustainable yield

* Corresponding author. Marine Biological Resources Division, National Aquatic Resources Research and Development Agency, Crow Island, Colombo 15, Sri Lanka.
E-mail addresses: prabath_jayasinghe@yahoo.com (R.P.P.K. Jayasinghe), zoousa@kln.ac.lk (U.S. Amarasinghe), anewton.ualg@gmail.com (A. Newton).

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(MSY) (Villasante, 2010). Furthermore, the EU has a legal responsibility under the United Nations Convention on the Law of the Sea (UNCLOS) to restore fish stocks by maintaining fishing mortality at a level of producing MSY that reached a critical milestone in 2015 (Froese and Proelß, 2010). As a further governance response, the European Marine Strategic Framework Directive (MSFD) was established in 2008 by European nations with coastal boarders (EU, 2008). The main objective of MSFD is to achieve good environmental status (GEnS) by 2020 through 11 qualitative descriptors (Borja et al., 2010; Foley, 2013). Descriptor number three (D3) addresses populations of commercially exploited fish/shellfish emphasizing that these should be within safe biological limits, while exhibiting population age and size distribution pertaining to healthy stocks (EU, 2008). Furthermore, Member States are responsible to conserve, improve and restore the marine ecosystems, including fish populations, to achieve the UNCLOS milestone in conjunction with the CFP and MSFD.

Both the CFP (EU, 2013; Prellezo and Curtin, 2015) and MSFD (EU, 2008) use ecosystem-based management approaches. Garcia et al. (2003), Browman and Stergiou (2004) and Pauly et al. (2002) have shown the importance of ecosystem-based fisheries management (EBM) to obtain a sustainable harvest from marine fish stocks. Additionally, Brodziak and Link (2002) stated that maintaining a healthy trophic structure (food web) is one of the main objectives of EBM. Furthermore, trophic level based indicators are useful to understand complex interactions between fisheries and marine ecosystems (Pauly and Watson, 2005).

Pitcher et al. (2001) suggested that reinventing fisheries management where and when the fisheries are in a crisis, such as the current situation in European Regional Seas. The contention is that EBM directed towards fisheries sustainability should rebuild fish communities, whereas the conventional fisheries management approaches do not reverse the depleted fisheries because of the over-exploitation of species of higher trophic levels (Pitcher et al., 2001). Thus, a fish community trophic level approach, in accordance with the EBM, would better fulfil the objectives of both the CFP and MSFD.

The present study was focused on how trophic level based indicators of fisheries can be used to assess and manage EU fish stocks in marine subareas of FAO area 27, through the evaluation of the status of some commercially exploited fish stocks. The main objective of the study was to determine whether the adoption of new policy instruments (MSFD and CFP) are successfully reversing the negative trend of fisheries. One difficulty is to set the threshold date for comparison of "before" and "after" effective implementation of policy instruments. Any date is arbitrary since the adoption of a policy is not the same as its effective implementation. However, we opted to compare pre and post 2008 data for the purposes of this study. After adoption of the MSFD, member states were mandated to draw up cost-effective plans by 2015, prior to the full implementation of the MSFD (Long, 2011). Additionally, the latest version CFP is effective from 1st January 2014, and hence we used data until 2013, to show the status of fish stocks prior to the new version of the CFP. The findings of the present study may thus be useful to monitor the progress due to both the CFP and MSFD implementation.

The present study addresses the following research questions:

(i) Is there a change in fishing pressure over trophic levels in the context of the implementation of the policy instruments?
(ii) Are fish stocks showing signs of recovery since 2008?

2. Materials and Methods

2.1. Area, fish stocks and data sources

2.1.1. Study area

Sub areas of FAO fishing area 27 (Baltic and NE Atlantic) were selected for the present analysis (Fig. 1). Table 1 describes the marine subareas considered in this analysis.

2.1.2. Selection of fish stocks and data sources

Commercially important fish stocks that are listed in the International Council for the Exploration of the Sea (ICES) advisory reports were selected for the present analysis. The species evaluated were cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), saithe (*Pollachius virens*), herring (*Clupea harengus*), sole (*Solea solea*), plaice (*Pleuronectes platessa*), whiting (*Merlangius merlangius*), hake (*Merluccius merluccius*) and sprat (*Sprattus sprattus*). These stocks represent about 25% of the fish stocks in the European region. They are considered as the most important in European commercial fisheries and these data are considered to be rich and reliable by ICES (Cardinale et al., 2013).

Data on fish landings and spawning stock biomass (*SSB*) of concerned fish stocks from the ICES scientific advisory reports for 2014 (http://www.ices.dk/community/advisory-process/Pages/Latest-advice.aspx) were accessed on 20.10.2014 and used in the study. In these reports, catch data were available up to and including 2013.

2.2. Data analysis

2.2.1. Mean trophic levels in SSB and fish landings in different subareas

Mean trophic levels (TL_i) of fish communities were calculated based on the feeding habits of constituent species and according to Equation (1) (Pauly and Palomares, 2005), which are reported in www.fishbase.org (Froese and Pauly, 2014).

$$TL_i = 1 + \sum_j (TL_j \cdot DC_{ij}) \quad (1)$$

where TL_j is trophic level of the prey j and DC_{ij} is the fraction of j in the diet of i. For the present analysis, TL_i values for the spawning stock biomass and landings of constituent species in the fishing areas (Table 1) were extracted from the www.fishbase.org (Froese and Pauly, 2014). Accordingly, TL_i values used in the analysis were 4.29 for cod, 3.56 for haddock, 3.61 for saithe, 3.29 for herring, 3.30 for sole, 3.23 for plaice, 3.57 for whiting, 3.84 for horse mackerel, 4.30 for hake and 3.01 for sprat (Jayasinghe et al., 2015).

Seven subareas (I + II, III, IV, V, VI, VII, VIII + IX) were considered, based on the availability of ICES advisory reports. For each area, the Mean trophic level for year y (MTL_y) was computed from 2009 to 2013 to observe whether there are any trends before and after the 2008. The fish stocks that were considered for each subarea for *MTL* analysis are given in Table 2. The data availability of each fish stock was inconsistent, and therefore, the analysis was performed for the periods when data were available for all fish stocks in several consecutive years before and after 2008. Accordingly, the analysis was for the periods commencing in 1960, 1991, 1990, 1987, 1992, 1987, and 1992 for the I + II, III, IV, V, VI, VII and VIII + IX subareas respectively, and until 2013. The formulae are given below.

$$MTL_y = \sum_i (TL_i \cdot Y_{iy}) \Big/ \sum_i Y_{iy} \quad (2)$$