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Multidimensional analysis of marine fishery resources of Maharashtra, India

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A B S T R A C T

The performance of 18 marine fishery resources of the state of Maharashtra in the western region of India was studied using modified and validated RAPFISH methodology (RAPFISH-India), with 45 identified attributes distributed among five evaluation fields: ecology, economic, social, technology and management. The technique relies upon ordination of scored attributes using multi-dimensional scaling. An interdisciplinary approach was carried by analyzing fisheries within each discipline by using all the attributes. Leverage analysis is used to determine the influence of attributes on the ordination. Group wise fishery sustainability scores of all five dimensions were averaged and results indicate that about 60% of fisheries studied fall under 'Quite Sustainable' category. The low leverage values indicate the multivariate nature of the ordinations and that the results are not dominated by any one attribute. Fishery specific and dimension specific RAPFISH results are to be considered as very important and shall form the basis for developing fisheries management plans in Maharashtra state.

1. Introduction

In the present Indian context effective fisheries management is important for the sustainability of marine fisheries. Many methodological tools have been used to assess the status of marine fisheries performance and management. They are carried out with the objective of helping the States (resource managers) in planning and policy formulation for more appropriate and effective management measure to sustain marine fisheries and livelihoods in the long run. Historically, stock assessment models were the choice method for biologists to understand the health of the particular fishery in a given point of time. These approaches, however, require substantial information, independent surveys and complex models to estimate past and present reference points representing management objectives for fisheries. Besides, the inherent uncertainty in fisheries limits the ability of these complex models to estimate the sustainability with a high degree of certainty (Walters, 1998). The requirement for reliable data, complex models and widely educated resource managers further limits their use in developing countries like India from assessing fisheries with precision or accuracy. More importantly, these methods are increasingly questioned for their ability to focus only on the biological (sometimes ecological) outcomes for single species, whereas fisheries are primarily a *multidisciplinary human endeavour* that has social, economic, technological and ethical implications as well (McGoodwin, 1994).

As the marine fisheries have shown signs of stagnation and decline since late 1990s, the fisheries management imperatives have changed from maximizing production and economic returns to management and sustainability of resources. Though the notion of sustainability is hotly debated and there is no single agreed definition of what sustainability means, there is some common ground in its meaning in that it is a multidisciplinary concept and therefore must include social and economic dimensions in addition to ecological dimension (Buckingham-Hatfield and Evans, 1996). This debate is also founded in fisheries management as evidenced from the recent focus on Ecosystem Approach to Fisheries Management and the multidisciplinary aspect of the FAO's Code of Conduct for Responsible Fisheries (FAO, 1995). *The conventional*

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methods do not, address adequately the question of sustainability (Alder et al., 2000). Hence, in the present scenario, it is necessary to evaluate the sustainability of fisheries in its multiple dimensions in order to realistic and effective decision making. The challenge for fisheries managers is to assess the sustainability of fisheries using *multidisciplinary approaches* that integrate diverse aspects. RAPFISH is one such new multidisciplinary technique based on multivariate statistics to assess the sustainability of fisheries.

So far no such comprehensive assessments consisting of ecological, technological, social, economic, policy and governance aspects using a unified methodological tool has been attempted in India. In this regard, RAPFISH methodology has been chosen to assess the fisheries management performance in Indian states. This has been chosen as it offers several advantages over the other methods. It uses simple, easily scored attributes from a range of disciplines to provide a rapid and cost effective appraisal of the sustainability of fisheries (Pitcher et al., 1998) and compliance with the FAO Code of Conduct. The technique also provides managers with a considerable flexibility in defining fisheries, from a broadly defined geographically based fishery to a fishery defined by its geographic range, target species, vessel type, and gear. Also, the inherent flexibility of the technique allows sets of fisheries or individual fisheries to be compared, or the trends of individual fisheries through time may be analyzed (Pitcher, 1999). RAPFISH approach has been used to assess the sustainability status of several fisheries around the world (Preikshot et al., 1998; Alder et al., 2000; Baeta et al., 2005; Tesfamichael and Pitcher, 2006; Murillas et al., 2008). Nevertheless, to our knowledge, this is the first study providing a comparative analysis of Maharashtra's fishery under multiple dimensions. The paper discusses the status of 18 marine fishery resources of the state of Maharashtra using Rapfish-India.

2. Materials and methods

2.1. Selection of Rapfish

For assessing the sustainability of Maharashtra's marine fisheries, the modified and validated Rapfish technique RAPFISH-India (Adiga et al., 2015) is adopted here. The technique simultaneously evaluates the status of fisheries under different evaluation fields by considering ecological, technological, economic, social and management dimensions. Under each evaluation field 6–12 attributes are scored on a simple semi-quantitative scale. The standard method (Pitcher et al., 2013) scores are assigned on a scale of 0–10. Scoring is normative, expressing how close the current state of the fishery lies in the best or worst possible status. Utility can be linear or non-linear, depending on how scoring is performed in relation to the guidelines for each attribute (Pitcher et al., 2013).

2.2. Definition of fisheries to be evaluated

The important fishery resources in Maharashtra were identified based on peer-reviewed literature by Central Marine Fisheries Research Institute (CMFRI). The top ten fisheries during different decades were identified based on the marine fish production data from CMFRI mainly to eliminate the fluctuation in data. Triennial average production for the years 1979, 1989, 1999 and 2009 representing the respective decades for each of the top ten fisheries were calculated. The decade wise top ten fisheries were compared and the common and uncommon fisheries were identified. Eighteen unique fisheries were identified and chosen for the detailed further study (Table 1).

2.3. Attributes scoring

An attribute is a characteristic of the fishery, which reflects certain feature/aspects of the sustainability within each dimension (Pitcher and Preikshot, 2001). Total 45 attributes corresponding to 5 dimensions were scored using an interview schedule for assessing the sustainability of Maharashtra's marine fishery resources. Scores for each fishery were determined from secondary literature, and correspondence with experts and fishers. Expert scoring was taken from the staff of Central Marine Fisheries Research Institute (CMFRI) Research Centre, Mumbai and College of Fisheries, Ratnagiri. Meanwhile 2 fisheries cooperatives, each of five coastal districts of Maharashtra were selected to score the attributes from fishers' perspective. In total, 10 fishermen cooperative societies were selected from five coastal districts. Out of 45 attributes, eight attributes such as exploitation level, recruitment variability, growth rate, trophic level and life span of fishes, vulnerability under ecological dimension and price and landings under economical dimension were scored based on data sourced from secondary literature. The source for scoring these attributes are given below.

Exploitation level: Status of fish stock is classified into five categories, namely abundant, less abundant, declining, depleted and collapsed based on the methodology by Mohamed et al. (2010).[1]

Recruitment variability: Recruitment of particular fishery can be measured in terms of landing variation. The coefficient of variation in landings during the recent decade (2001–2010) was calculated for each fishery and used for scoring the attribute.

Growth rate: Compound Growth Rate (CGR) was calculated for each fishery during last two decades (1990–2000 and 2001 to 2010) to see the changes in the growth rate of the particular fishery over last two decades. The results are used for scoring the attribute.

Trophic level: Trophic levels of fishes of Maharashtra were identified based on the literature (Vivekanandan et al., 2009).

Life span: This was identified by using the formula $t_{max} = 3/K$ (Froese and Binohlan, 2000), where t_{max} is the life span of fish and K is growth coefficient and Fishbase (www.fishbase.org) source. An excel spreadsheet is available for download on Fishbase website which is useful for estimation of the life history parameters of fishes.

Vulnerability: Vulnerability/susceptibility of the particular fishery in its environment was identified based on information available in Fishbase.

Price: Variations in average price of fish over a period of time was calculated by taking the average price of fish during the year 2000, 2005 and 2010 and comparing with the recent (2010) year (Sathiadhas et al., 2012).

Landings: Recent annual landing of the target fishery was compared with last five year average landings to score the attribute. Landing data were taken from the annual reports of CMFRI.

2.4. Rapfish analysis

RAPFISH analysis was performed in Microsoft's Excel 2003 version using a specially written formula/code with the help of its add-in functionality (Kavanagh and Pitcher, 2004). This 'add-in' was downloaded from the RAPFISH official website (www.rapfish.org). Scoring obtained from experts' assessment, secondary literature and fishers' were combined for RAPFISH analysis. The technique of RAPFISH is thoroughly described in Pitcher (1999), Pitcher and Preikshot (2001) and Alder et al. (2000), Kavanagh and Pitcher (2004) described its statistical basis. RAPFISH uses a statistical

[1] Abundant: recent average catches >70% of the historical maximum; less abundant (50–69%); declining (11–49%); depleted (6–10%) and collapsed (<5%).