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Short communication

Is fishing-down trophic web a generalized phenomenon? The case of Mexican fisheries

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Abstract

There is a consensus that fisheries around the world have reached their maximum levels of capture, and, in many cases, overexploitation is apparent. On the basis of FAO data, it has been found that overexploitation can be detected as a decrease in the trophic levels of the fisheries due to the greater energetic cost that maintaining high trophic levels implies. After analyzing data from Mexican fisheries on both littorals, no decrease in the trophic level was observed even though catches have reached stable levels since the 1980s. This result is probably due to the multi-species fishery characteristic of the area and the low technological level, rather than to a healthy fishery. Mexican fisheries, being tropical, are mainly multi-specific, implying the capture of several trophic levels at the same time and avoiding, in this way, a single trophic level decrease typical of temperate and mono-specific fisheries.

Keywords: Overexploitation; Trophic web; Artisanal fishery; Biodiversity

1. Introduction

The consensus that worldwide fisheries are over-fished is based on a steady volume of capture, a decrease in capture per unit of effort, and the economic bankruptcy of some fisheries (Stone, 1997; Caddy et al., 1998; INP, 2000). According to FAO data (FAO, 2003) and the Mexican National Fishery Commission (CONAPESCA, 2003), captures in Mexico have been stable since 1980 with values ranging between 1.2 and 1.5 million tonnes year^{-1}, even though the number of vessels employed showed a continuous increase up to 1997 (CONAPESCA, 2003).

In general, fisheries tend to extract organisms that are at the top of the food pyramid, those with the highest energetic cost according to the way matter is distributed within the trophic web. Once primary producers fix carbon, just a small portion of it is incorporated into their consumers' tissues, which in turn will pass a small portion to their predators, and so on. Each predator–prey step is known as a trophic level. According to Christensen and Pauly (1993), the amount of energy needed to produce a certain amount of biomass from one trophic level to the next increases by a factor close to 10. Furthermore, the transference efficiency at higher trophic levels tends to be low (Iverson, 1990). With this great loss of energy in the trophic web, it is clear that the amount of organisms extracted from the upper trophic levels cannot be high, and their maintenance is difficult. Moreover, top predators tend to be large, long-living individuals with a low production/biomass ratio, and a slow response to environmental changes (Jennings et al., 2001).

Loss of biomass from one trophic level to the next and a low response rate to environmental changes would make it easy for fishing to affect populations, provoking additional mortality to the natural populations. Pauly et al. (1998) analyzed fisheries around the world using historical data from FAO from 1950 to 1994, observing a decrease in the mean trophic level of the catches. On the other hand, Caddy et al. (1998) suggested that local studies would test the Pauly et al. work. Considering the above, the aim of this work was to assess Pauly et al.'s (1998) proposal by applying the same methodology to Mexican fisheries and using two data sets: the FAO captures record (FAO, 2003) and the official Mexican statistics (CONAPESCA, 2003).

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2. Materials and methods

Capture statistics from FAO (FAO, 2003) for Mexico from 1950 to 2001 and the statistics from the National Commission for Fisheries of Mexico (CONAPESCA, 2003) from 1940 to 2001 were analyzed. The FAO data were separated according to Mexican littorals, the Pacific and the Atlantic Oceans; the latter was named the Gulf and Caribbean littoral by FAO. Fish trophic levels were taken from the FishBase data (Froese and Pauly, 2004), while the trophic level of invertebrates was estimated using TrophicLab software (Pauly et al., 2000). In both cases, primary producers and detritus were assigned trophic level one. The average weigh of the preys consumed is added to one to estimate the trophic level of each consumer (Christensen et al., 2004). Eq. (1) describes how the trophic level was estimated:

$$TL_j = 1 + \sum_{i=1}^{n} (PP_{ij}\, TL_i) \qquad (1)$$

where TL_j is the trophic level of consumer j, PP_{ij} the proportion of prey i in the diet of consumer j, and TL_i is the trophic level of prey i.

Once the capture volumes and the trophic level were estimated for each species, the whole fishery trophic level was estimated for each year by multiplying the trophic level of each species by its annual capture proportion. The analysis was done for each of the Mexican states on both littorals. The data series for the Atlantic was shorter, running from 1989 to 2001.

In order to determine a relationship between the capture volume and the trophic level, plots of these two variables were drawn for each data set. Finally, from the Mexican Statistics Compendium, the historical number of vessels employed by the main fisheries was recorded. This datum served as a rough indicator of the fishing effort so that any change observed in the trophic level could not be considered due to a change in the number of fishing boats.

3. Results

For both Mexican littorals, the FAO data set reports 108 species, whereas the Mexican National Commission of Fisheries reports only 51 groups of species. The capture level for both littorals becomes stable at around 1 200 000 tonnes (Fig. 1), both data sets presenting a similar trend since 1980. The Pacific littoral presents a higher extraction value, contributing to the overall fishery variations by almost 4:1 compared to the Atlantic.

According to the CONAPESCA data, the trophic level trend before 1963 was toward a decrease, increasing from that year on. On the other hand, the FAO data showed a slow but steady trend toward an increase of the trophic level of the catches for the whole series (Fig. 2).

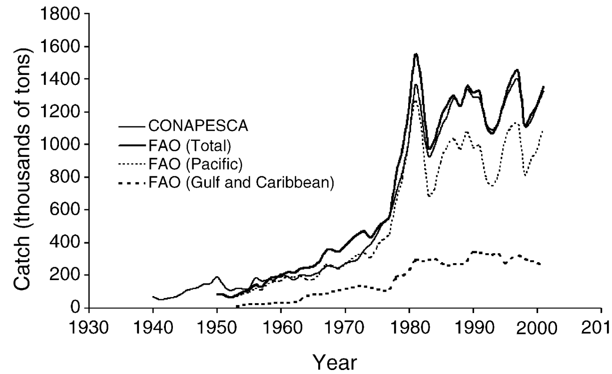

Fig. 1. Volume of capture of Mexican fishery.

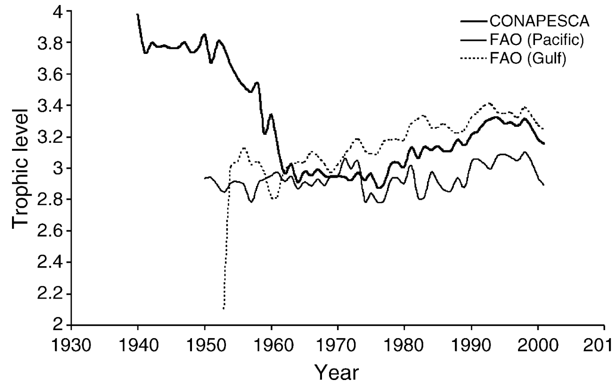

Fig. 2. Average trophic level of Mexican fishery according to FAO and CONAPESCA data.

No clear relationship was observed between the trophic levels and the capture values (Fig. 3). CONAPESCA data (Fig. 3A) showed a decrease in the trophic level for capture volumes of less than 200 000 tonnes, with no changes in the trophic level for higher capture volumes. A similar pattern occurred after analyzing both littorals independently with the FAO data (Fig. 3B and C).

4. Discussion

Fish production depends mostly on primary production, the length of trophic chains, and the transfer efficiency of matter between trophic levels (Jennings et al., 2001). At the initial phase of a tropical fishery, large fish are captured, decreasing in size as the extraction continues (Jennings et al., 2001), with a concomitant decrease of the trophic level in the fishery (Pauly et al., 1998).

Mexico is close to reaching its maximum capture levels (Fig. 1), as is the rest of the world, even with an increase in the number of vessels. However, contrary to what Pauly et al. (1998) reported, the trophic level in Mexican fisheries has increased in the last 40 years. This finding is opposed to the supposition that, after reaching the maximum level of extraction, a decrease in the trophic level of the fisheries should occur due to the energetic cost that this represents for