Marine Policy 39 (2013) 283–288

Contents lists available at SciVerse ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Extent and implications of IUU catch in Mexico's marine fisheries

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ARTICLE INFO

Article history:
Received 9 October 2012
Received in revised form
4 December 2012
Accepted 5 December 2012

Keywords:
IUU
Fisheries
Mexico
Resource management
Food security

ABSTRACT

It is well recognized that not all fisheries catches are reported or recorded properly by either government or non-government agencies. These unreported catches can be illegal, of unregulated species, or simply not monitored due to logistical barriers. In Mexico, these barriers are an extensive and often not easily accessible coastline, mostly *de facto* open access fisheries, poor administrative practices and generalized corruption in the fishing sector as a whole. These conditions were likely promoted early in the last century through the government's largely successful policies to increase fisheries catches and stimulate employment and economic growth. Many years later and amid declines in fish stocks and subsequent economic benefits, most notably at local scales, it is evidently time for a fundamental change in strategy away from expansion of fishing effort and toward ecological and economic sustainability. An important step in this endeavor is to provide a quantitative *pre-mortem* analysis of Mexico's total marine fisheries catches during the last half-century. Results suggest that from 1950 to 2010, total catches were nearly twice as high as the official reports, with an average annual catch of 1.5 million tonnes (t) compared to 796 thousand t in official statistics. In the last year of available data, 2010, official and total estimated catches were 1.5 million and 2.2 million t, respectively. While these results may be perceived as a criticism of the *status quo* and *ante*, this study actually does not single out a responsible party, but is, rather, a call to the many sectors of society who contribute to a lack of control, to help overcome these conditions, and increase and sustain the benefits from Mexico's marine fisheries.

1. Introduction

The most important lesson learned after a century of modern fishing is that the world's oceans are not inexhaustible, as previously held both in popular and academic circles e.g., [1,2]. Since this (opportune) realization, the main endeavor of the fisheries science community has been to develop quantitative methods by which fish stocks can be monitored and assessed in order to gauge their status with respect to given management reference points e.g., [3–7]. The single most important component of these status indicators is some metric of the catch of a given stock, and it thus has received the most attention in terms of data gathering both at the local and global scale, with a global database of catches since 1950 maintained by the FAO [8]. Though the potential and limitations of catch as a stand-alone indicator of fishery status has been extensively discussed e.g., [9–12], there is no debating that it is the foundation for nearly all other assessment methods, and the only information freely collected by fishing fleets. The current sub-optimal state of most marine fish stocks [13] has prompted organizations at the international, regional and national level to confront fisheries issues with management decisions, with the reliability of catch statistics being of particular concern.

Fisheries in Mexico, reflecting the overarching political system, have historically been characterized by constant shifts in objectives and management schemes [14]. They have thus evolved from an overlooked sector, to a primary source of food and job creation, to a casualty of neo-liberal reform and now to the object of an apparent tug-of-war between laissez-faire management on the one hand and ecological conservation priories on the other [15]. The participation and influence of scientists, academics and conservation organizations in fisheries management has also evolved towards a more holistic understanding of the social, political and ecological context of Mexican fisheries, with an increase in training in and application of novel quantitative methods to assess national fisheries' status [16]. Unfortunately, a lack of effective fisheries governance in general, and catch monitoring in particular, has resulted in highly uncertain fishery statistics, which often lack the quality to be informatively used within quantitative assessments that reflect reality.

Illegal, unreported and unregulated (IUU) fishing is a significant issue all over the world, and can seriously misrepresent fish production at any level [17,18]. In Mexico, a large fishing sector (> 300,000 fishers), versatile boats and gear, an extensive coastline, corruption and a limited capacity for monitoring and enforcement result in significant IUU catch [19]. Even in the case

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http://dx.doi.org/10.1016/j.marpol.2012.12.003

of legal fishers, official statistics rely on the compulsory but unenforced submission of catch logs by fishers or buyers to the local fisheries office. In both cases, there is no further validation of catch, and catch logs are often filled in on the spot (and often for a fee) by fishery officers based on the fishers' memory of past catch [20]. A survey of Mexican fishery experts including scientists, officials, fishers and others, found that in some fisheries, "irregular" fishing (unreported and illegal) currently represents 40%–60% of reported catch [21]. This estimate does not account for discards in shrimp trawls, which historically have had a 1:10 shrimp to bycatch ratio and are widely regarded as the single most important source of unreported bycatch [22].

In light of the apparent disconnect between the recognized importance of catch statistics for management and the state of data monitoring in Mexico, alternative methods must be used in order to provide better estimates. Catch reconstructions have been employed extensively to address this issue e.g., [23,24], under the fundamental thesis that "unknown catch" does not equal "zero catch" [25]. Although this is a simple and logical observation, attaching numbers to qualitative knowledge is powerful in conveying the seriousness of the issue and the need for action; this is indeed the main objective of the present study. Following this principle, we provide the first comprehensive estimate of unreported fisheries catches in Mexico, from 1950 to 2010.

2. Methods

The philosophical core of the reconstruction method is that, when it is recognized that catch in official statistics is incomplete but the magnitude of missing catch unknown, a well-informed estimate should replace a zero value [25]. Information can come from a variety of sources, including peer-reviewed literature, gray literature and expert knowledge, but every attempt is made to employ it in a conservative manner [26]. The main difference between the methods used for this reconstruction with respect to those used in the past is that the focus is on reconstructing catch series by particular species, rather than by a fishery sector. The reconstruction of Mexico's marine fisheries catch was thus undertaken within a structured database as explained below. Specific estimation methods for each fishery are presented in Appendix A (supplementary online material).

Statistics for marine fisheries catch by Mexico within its EEZ from 1950 to 2010 were extracted from the FAO database (〈http://www.fao.org/fishery/statistics/software/fishstat/en〉), where catch is specified by FAO area. Due to significant inconsistencies identified in data available directly from the national fisheries agency (see Section 4), these FAO catch series formed the basis for subsequent estimations.

Mexico's subset of the FAO database consisted of 192 individual catch series (96 each for the Pacific and Atlantic Oceans) of varying taxonomical precision, with catch reported by year from 1950 to 2010. A series of descriptive categories were assigned to each catch series, and to every reconstructed series, and included

a. FAO Name: the name for the species or species group as it appears in the FAO data.
b. Taxon: scientific name for the group, as precise as possible.
c. Group: elasmobranchs (e.g., sharks, rays), large pelagic fish (e.g., tunas, jacks), small pelagic fish (e.g., anchovies, sardines), benthopelagic fish (e.g., snappers, triggerfish), benthic fish (e.g., flounders), cephalopods (e.g., octopus, squids), gastropods (e.g., abalone, snails), bivalves (e.g., clams, mussels), echinoderm (e.g., sea cucumbers, sea urchins), other (e.g., seaweeds).
d. Target: main target of fishery (e.g., the "tuna" or "shrimp" fisheries use specific gears but catch many species other than shrimps and tunas, both targeted and as bycatch).
e. Sector: artisanal (open deck, outboard or no engine), industrial (covered deck, inboard engine), recreational (food or sale are *not* the main motive for fishing), subsistence (catch kept for consumption in the household).
f. Type: reported (FAO statistics), unreported legal (non-quantified catch by fishers operating legally), unreported illegal (non-quantified catch by domestic fishers operating illegally in any way), unreported discard (non-quantified discarded catch).
g. Area: Pacific, Atlantic.
h. Individual reference: a binary variable denoting whether specific information related to unreported catch was found for a given fishery.
i. Interpolated: a binary variable denoting whether a time series of catch was interpolated to fill data gaps.

Once the initial database was compiled as outlined above, the reconstruction was undertaken within its framework. For each catch series in the FAO data, the first step was to seek all available information related to the fishery, including gear types employed, observed bycatch (and discard) rates and species, and governance characteristics. Two initial sources of information were invaluable in this respect. The Mexican National Fisheries Charts [27–29] are official documents that list all species recognized as fished, and include a brief summary on every major commercial fishery by area; the assessment and management "Red Book" [30] contains reports on all currently assessed species. If no information was found to justify clear gaps in a catch series, these were linearly interpolated. This included missing data in the first years of recorded catch. For example, if the first four years of a catch series were missing and the fifth was 500 t, the first year was assigned half the value of the fifth (thus assuming the fishery had not grown from zero catch in 1950) and the other years linearly interpolated. Or, if catch records were missing from, say, 1960–1965, these were linearly interpolated from reported catch in 1959 and 1966. Interpolated catch was designated as unreported and used as the new baseline for subsequent estimations of unreported catch.

Whatever specific information was found for a given catch series was used to estimate the magnitude of unreported catch, expressed as a ratio relative to reported catch and then converted into (metric) tonnes (t) per year and entered as new catch series in the database (including the appropriate descriptors). According to an extensive survey of fishery experts in Mexico, on average (over several fisheries) unreported ("irregular") fishing contributes a further 45% of catch (90% of which is illegal) relative to reported landings [21]. Around half of illegal catch is subsequently bought by processors and reported with legal catches (second author's pers. obs.), so these would appear in FAO statistics. A conservative ratio (relative to reported catch) of 15% for unreported legal catch and 22% for unreported illegal catch were added to current reported catches when no other information was available for a specific fishery, or in the case of the broadly defined finfish (*escama*) fishery. According to fishers and buyers, legal unreported catches have decreased during the last decades due to improvements in monitoring, while unreported illegal catch has increased due to a growing number of fishers and the addition of fishery regulations. Therefore, the ratio of unreported legal and illegal catch from 1950–2010 were assumed to vary linearly, from 40% to 15% and from 10% to 22%, respectively. Due to a general lack of data, we were not able to apply sensitivity analyses directly; however, we calculated and report confidence intervals of $+/-15\%$ applied to resulting aggregate catch estimates (based on variance of expert opinions reported in [21]).

A major component of unreported catches in Mexico is bycatch in the shrimp fishery, particularly by industrial bottom trawlers. The high economic value of shrimp results in discarding of bycatch species, which are high due to the tropical environments