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Life history traits and fishery patterns of teleosts caught by the tuna longline fishery in the South Atlantic and Indian Oceans

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ABSTRACT

The identification and mitigation of adverse effects of the bycatch of tuna longline fishery have been mainly developed and implemented for seabirds, sharks and turtles and, the knowledge on teleost bycatch for this fishery, remains very poor. This paper contributes to a comprehensive assessment of life history traits and fishery attributes of target and bycatch species caught by the tuna longline fishery in the South Atlantic and Indian Oceans. Data was compiled on seven life history traits and three fishery attributes for 33 and 27 teleost stocks caught by longliners in South Atlantic and Indian Oceans, respectively. In addition, each species was assigned into four categories describing the fate of the catch: target species for commercial use, bycatch species kept for consumption, bycatch species kept for commercial use and discarded bycatch. Life history traits and fishery attributes did not differ between oceans. However, non-target but commercialized species were smaller in the Atlantic Ocean. Teleosts caught by the tuna longline fishery was segregated into three main groups: (1) the fast growing species represented mainly by dolphinfishes (*Coryphaena hippurus* and *C. equisellis*), skipjack tuna (*Katsuwonus pelamis*), kawakawa (*Euthynnus affinis*), bullet tuna (*Auxis rochei*), snoek (*Thyrsites atun*) and blackfin tuna (*Thunnus atlanticus*); (2) target tunas and most other bycatch species which were part of an intermediate group and (3) billfishes including swordfish representing the large and slow growing species with moderate to high market values and unknown or highly uncertain stock status. Investment in some key life history traits (such as growth coefficient) and the development of quantitative or semi-quantitative approaches (stock assessment and Ecological Risk Assessment) should be priorized as precautionary management measures for these species.

1. Introduction

Information on the life history traits of individual species and stocks is valuable since it fuels many the ecological models (Thorson et al., 2014). For instance, parameters based on life history traits have helped to predict the effects of climate change (Cheung et al., 2009; Dalgleish et al., 2010), investigate habitat degradation (Ockinger et al., 2010) and to assess the vulnerability of species to collapse (Cortés et al., 2009; Patrick et al., 2010; Hobday et al., 2011) or to extinct (Olden et al., 2008). Life history traits have also been used to evaluate the trade-offs between exploitation and conservation of commercial species (Juan-Jordá et al., 2013a; Le Quesne and Jennings, 2011) and to classify marine fishes analogous to the classic r and K strategy theory developed for terrestrial animals (Kawasaki, 1980, 1983; King and McFarlane, 2003).

In fishery biology, the importance of comparative studies based on life history traits has long been recognized (Holt, 1962; Cushing, 1971; Alverson and Carney, 1975; Adams, 1980). Such researches are largely used to help our understanding of how species respond to human exploitation (e.g., Jennings et al., 1998). For instance, Fromentin and Fonteneau (2001) analysed the relation between the life history of tuna and tuna-like species (target and main bycatch) and the effect of fishing in the Atlantic. Other studies have investigated fishing impacts on demersal fish in the Celtic Sea (Le

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Quesne and Jennings, 2012) and the resilience of elasmobranchs to exploitation (Hoenig and Gruber, 1990).

The knowledge of the aspects of life histories of targeted and bycatch species may also provide guidance for Ecosystem Based Fisheries Management (EBFM) frameworks, by considering individual species' vulnerability to exploitation based on life history characteristics and susceptibility to fishing (Zhou et al., 2012; Gilman et al., 2014). The term bycatch used hereafter is as defined by Gilman et al. (2014), i.e. the retained catch of non-targeted but commercially valuable species, or species consumed by crew, used for bait, or rejected at port or at sea.

Current management practices for targeted species mainly involve individual stock assessments based on detailed biological information and fishery statistics (King and McFarlane, 2003). Responsible fisheries management, therefore, requires information on all sources of fishing mortality, i.e. for both targeted and bycatch species (Gilman et al., 2014). In the case of susceptible bycatch species, however, such as sea turtles, seabirds, marine mammals and many elasmobranchs, due to the overall lack of data, management measures are more based on the risk of irreparable harm or extinction. However, the majority of the teleosteans species has barely been investigated concerning its life history traits and its relation with the fishery, considering also the fate of the catch.

For commercially exploited species, it is often argued that economic extinction of exploited populations will occur before biological extinction, but this is not the case for bycatch species caught in multispecies fisheries (Dulvy et al., 2003, 2004). For those species, it may be still economically viable to continue catching even very rare bycatch species, as long as the target species is still abundant. In this case, the point of economic extinction may be much closer to the point of biological extinction or simply does not exist (Sadovy and Vincent, 2002). These catches may easily lead to adverse impacts on entire populations and ecosystems, may reduce the sustainability of fishery resources, and induce severe bias in stock assessments and population models, which do not account for unobservable fishing mortality (Broadhurst et al., 2006). Quantifying the impacts of fisheries on bycatch species is thus an important challenge particularly to build the necessary stakeholder support for changing fishing practices (Moore et al., 2013).

The tuna longline fishery is one of the main large-scale fishing activities in the world oceans, targeting large pelagic species, mainly tuna and swordfish. Tuna catches by industrial longliners accounted for 13% of the world tuna catch in 2013 (ISSF, 2013). Despite the lower fish production compared with purse seiners, longline catches of the targeted species have high commercial value. Bycatch is an increasingly important management issue for the longline fishing fleets and a growing concern for Regional Fisheries Management Organizations (RFMOs). The impact of the tuna longline fishery on sea birds and turtles has been relatively well described (e.g., Tuck et al., 2003; Lewison et al., 2004; Bugoni et al., 2008; Brothers et al., 2010; Sales et al., 2010). For elasmobranchs, some studies have connected life history parameters and the impact of fishery (see Hoeing and Gruber, 1990; Frisk et al., 2001; Cortés et al., 2009), but very few studies have assessed the impact of longline fishery on bycatch teleosts. In the South Atlantic and Indian Oceans, most of the bycatch of teleost species in the tuna fisheries has never been studied, partly due to the limited data available since a large part of their catches are not recorded. Consequently, stock status and life history characteristics for the majority of these teleosts are largely unknown.

The Pacific Ocean provides 64% of the world's annual tuna catch, while the catches of tuna from the Indian and Atlantic Oceans have averaged about 20% and 14% of the world production of tuna respectively (FAO, 2003). In the Indian Ocean, at least forty species, including tuna, billfishes, sharks, other teleosts, seabirds and sea turtles are regularly caught by this fishery (Huang and Liu, 2010). In the South Atlantic, a total of 19 species of fish, at least 21 seabird species, 16 elasmobranchs and 3 species of turtles have been identified in the catches of the tuna longline fishery (Marín et al., 1998; Bugoni et al., 2008; Pacheco et al., 2011). With the exception of some tunas, billfishes and sharks, only a minor part of the bycatch species caught by the tuna longline fishery in these oceans are actually assessed and managed (Collette et al., 2011a). Growing concerns over the impact of the tuna longline fishery on bycatch species (King and McFarlane, 2003) have therefore led RFMOs to develop holistic approaches to the assessment and management of all exploited species.

This study aims to partially fill the gap in knowledge of teleosts caught by the tuna longline fishery in the South Atlantic and Indian Oceans. The main species caught were identified and their life history traits were then compiled from published literature and available resources including gray literature. Fishery attributes related to the exploitation by the longliners were also estimated for each species and in both oceans, and we assessed the fate of the catch according to four categories (target species, bycatch species kept for consumption onboard, bycatch species kept for commercial use and discarded bycatch). The relationships between life history traits and fishery attributes were then evaluated among species, oceans and categories of catch fate. This approach is rarely considered in fishery management, especially for bycatch species. The information provided will help improve the overall sustainability of all species caught in tuna longline fisheries in these oceans and help move the management and conservation strategies closer to one based on ecosystem based fisheries management. The information will also help managing these stocks, which are also often locally important in artisanal fisheries.

2. Material and methods

2.1. Data collection

2.1.1. Catch composition of the tuna longline fishery in the South Atlantic and Indian Oceans

The list of teleosts caught by the tuna longline fishery in both the South Atlantic and the Indian Oceans was compiled from a variety of sources. An initial list of species was extracted from the RFMOs ICCAT (International Commission for the Conservation of Atlantic Tunas) and IOTC (Indian Ocean Tuna Commission) datasets. The list was complemented based on published documents (Bach et al., 2008, 2009; Marín et al., 1998; Huang and Liu, 2010; Pacheco et al., 2011) and national databases such as the Brazilian On-board Observer Program database (South Atlantic Ocean) and the national database for observer data on-board pelagic longliners based in La Reunion (Indian Ocean) hosted by IRD (Institut de Recherche pour le Développement) (Bach et al., 2008, 2013).

2.1.2. Life history traits

Initially, life history traits relevant to predict and rank the resilience of species to exploitation was compiled from a variety sources, mainly (Musick, 1999; Frisk et al., 2001; Fromentin and Fontenau, 2001; Juan-Jordá et al., 2013a). Extinction risk assessments which use life history traits as productivity attributes were also taken into account (Milton, 2001; Cortés, 2002; Stobutzki et al., 2001; Hobday et al., 2007, 2011; Astles et al., 2006, 2009; Patrick et al., 2010; Arrizabalaga et al., 2011). Considering data availability and the importance of the different life history traits in discriminating groups and for the understanding of how species respond to human exploitation (e.g Fromentin and Fontenau, 2001; King and Mcfarlane, 2003; Hutchings et al., 2012; Juan-Jordá et al., 2013a), seven life history traits were selected for each species and stock by ocean (Table 1).