Targeting bigger schools can reduce ecosystem impacts of fisheries

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Targeting bigger schools can reduce ecosystem impacts of fisheries

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Abstract: Sustainability of living resource exploitation relies on an ecosystem management approach. Within tropical tuna purse seine fisheries using fish aggregating devices (FADs), such an approach incorporates the reduction of bycatch, in particular vulnerable species such as elasmobranchs. The levels of total bycatch (in mass) from fishing operations using FADs is known to be five times higher than when tuna are caught in free-swimming schools. We intend to find practical solutions to reduce bycatch in FAD sets through the investigation of the relationships between the ratio of bycatch to target catch across different set size classes in all oceans. Ratios were always highest when catches were small, with the smallest class of catches responsible for the highest total portion of bycatch (23%–43%) while only contributing negligibly to the total target catch (3%–10%). Reducing the number of fishing sets (a part of the total effort) while maintaining the same total yield could contribute to a substantial reduction in the impacts of human activities.

Résumé : L'exploitation durable des ressources biologiques dépend d'une approche de gestion écosystémique. En ce qui concerne la pêche au thon tropical à la senne coulissante faisant appel à des dispositifs de concentration de poissons (DCP), ce genre d'approche comprend la réduction des prises accessoires, particulièrement d'espèces vulnérables comme les elasmobranches. Il est établi que les prises accessoires totales (en masse) d'activités de pêche faisant appel à des DCP sont cinq fois plus importantes que pour la pêche au thon nageant en banc libre. Nous proposons de trouver des solutions pratiques visant à réduire les prises accessoires dans les calées de pêche à DCP en étudiant les liens entre le rapport entre les prises accessoires et les prises cibles pour différentes classes de tailles de calées dans tous les océans. Ces rapports étaient toujours plus élevés quand les prises étaient petites, la plus petite classe de prises représentant la plus grande proportion des prises accessoires totales (23 %–43 %), mais ne contribuant que de manière négligeable aux prises cibles totales (3 %–10 %). La réduction du nombre de calées (dans l'effort total) jumelée au maintien du même rendement total pourrait permettre une réduction importante des impacts des activités humaines.

[Traduit par la Rédaction]

Introduction

One of the primary goals of ecosystem-based fisheries management is to reduce excessive levels of bycatch. As such, bycatch reduction has been a major priority in many industrial fisheries globally (Hall 1996; Hall et al. 2000; Hall and Mainprize 2005). Several approaches have been proposed to facilitate such reductions (see Hall 1996; Hall and Mainprize 2005), and these typically fall into two categories. To reduce the bycatch per unit of fishing effort, either a technical or a management approach could be adopted. The challenge lies in finding the most ecologically sound method (or

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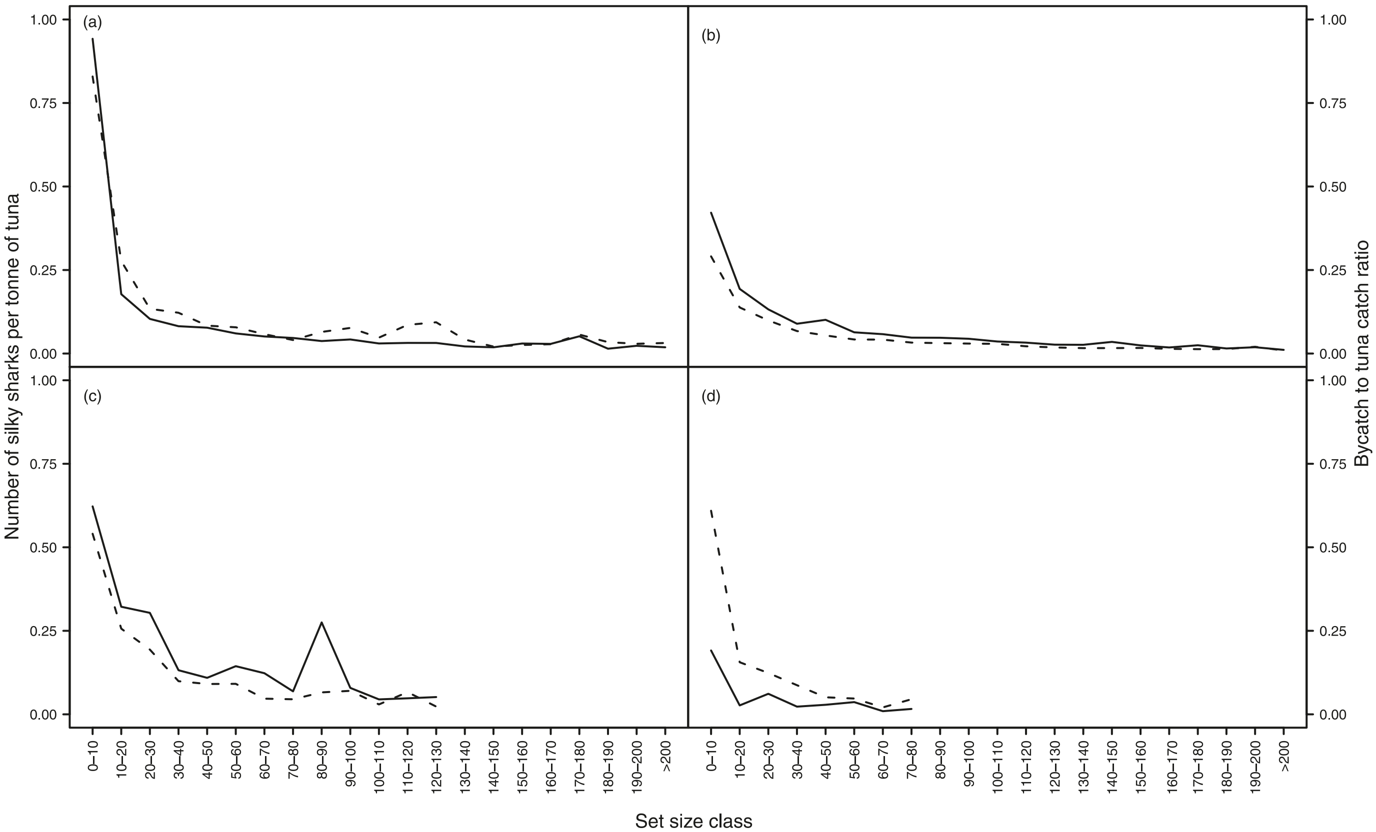
Fig. 1. Ratios of bycatch to target catch (dotted line) and silky sharks to target catch (solid line) per set size class (tonnes) from the tropical tuna purse seine fishery in the western and central Pacific, eastern Pacific, Indian, and Atlantic oceans.

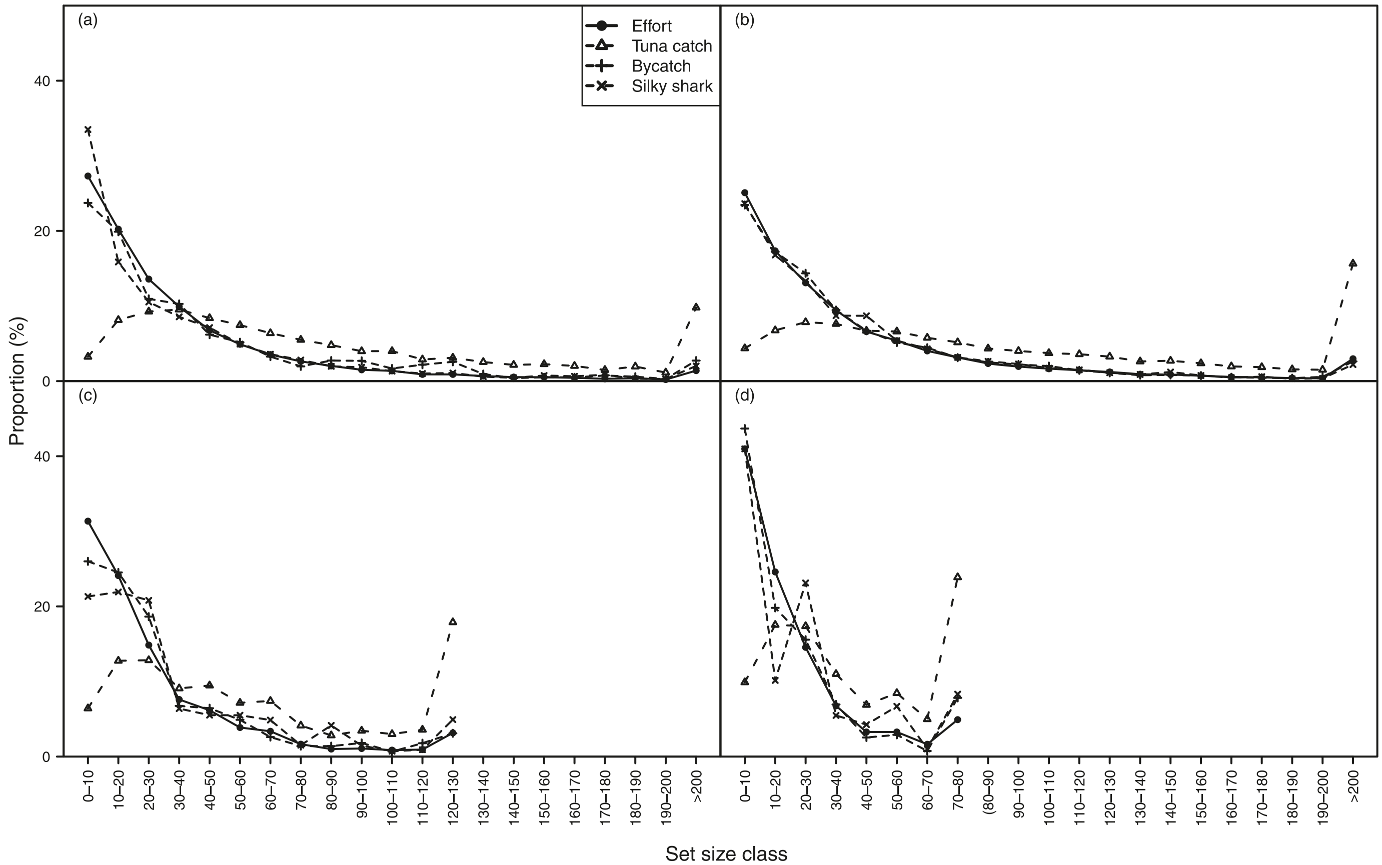


combination of methods) that will be readily adopted in the fishery and that can be effectively monitored.

The large majority of canned tuna (1.7 million tonnes (t) of canned tuna in 2006; Miyake et al. 2010) originates from the tropical tuna purse seine fisheries, which contribute approximately 60% to the world's tuna catch (roughly 2.5–3 million t annually, primarily consisting of skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares)*, and bigeye tuna (*Thunnus obesus*)) (Miyake et al. 2010). Tropical tuna purse seiners are typically large vessels, which use surrounding nets to catch schools of tuna. The impacts that this global fishery has on the ecosystem have recently received much attention, mainly because of the increased use of fish aggregating devices (FADs). During the past two decades, more than half of the total tropical tuna catch from purse seine vessels came from tunas associated with floating objects (Miyake et al. 2010), highlighting the efficiency of this fishing method. The majority of the remaining tuna catch comes from sets on free-swimming schools. These two fishing modes generate varying amounts of bycatch; fishing on FADs generate approximately five times more total bycatch (in mass) than fishing on free-swimming schools (Romanov 2002; Amandè et al. 2010). Unwanted catches incurred during FAD sets comprise teleosts, which represent the primary component by mass (Romanov 2002; Amandè et al. 2010), usually followed by elasmobranchs, with the silky shark (*Carcharhinus falciformis*) forming the principal component (Gilman 2011). To date, the most common management approaches for purse seiners have included the regulation of fishing effort or the restriction of capacity through fishery closures (eastern Pacific Ocean), area closures (western and central Pacific Ocean, eastern Pacific Ocean, Indian Ocean), moratoria on fishing with floating objects (Atlantic Ocean and western and central Pacific Ocean), and full retention of the tuna catch (western and central Pacific ocean). The effects of these measures on bycatch reduction, however, are yet to be demonstrated (Dagorn et al. 2012). As such, there exists an urgent need to investigate other potential measures, especially those targeting specific vulnerable taxonomic groups, such as elasmobranchs.

The ecological impact of a fishery is often characterized by the ratio of bycatch to target catch, which allows for comparisons between various fishing techniques (Hall 1996). Within the tropical tuna purse seine fishery, this ratio has been used by some environmental groups to justify a ban on FAD fishing. However, such a measure would severely impact the production of the fishery and result in a major shortage of canned tuna, a major source of animal protein, because alternative methods of extraction are not as efficient. Nonetheless, the method of discriminating between certain fishing practices based on their bycatch to catch ratio may still be of potential use within this fishery. A more realistic approach could be to explore the possibility of substantially reducing this ratio for the FAD component of this fishery. The lower the bycatch to catch ratio, the lower the ecological impacts of the fisheries. Here we explore the possibility of

Fig. 2. Contribution of each set size class (tonnes) to the total target catch, total bycatch, total number of silky sharks, and total number of fishing sets from the tropical tuna purse seine fishery in the western and central Pacific, eastern Pacific, Indian, and Atlantic oceans.



using the relationship between the bycatch to catch ratio across a range of catch sizes in FAD sets to develop a simple technical measure to reduce the total bycatch incurred.

Materials and methods

Data collected by scientific observers onboard purse seine vessels in the Indian Ocean (IO, 2003–2009), Atlantic Ocean (AO, 2003–2009), eastern Pacific Ocean (EPO, 2001–2010), and central and western Pacific Ocean (WCPO, 2000–2011) were used for this analysis. These data provide estimates of the captures of all species (target and bycatch species). For the purpose of this study, we extracted the following information to the set level: landed catch (in mass) of target species (tunas), total bycatch — nontarget species (in mass), and catch of silky sharks (in numbers). Considering the life history traits and abundance of silky sharks, the number of individuals was preferred to the mass for a more accurate assessment of the impact of the fishery on their populations. Sets where no catch was taken (i.e., the tuna school was missed) were excluded from the analysis. Data were then aggregated into set size classes of 10 t increments. In each ocean, the number of samples per class decreased as set size increased. Set size classes were grouped when individual classes had less than 10 samples.

Following this, the bycatch ratio for each set size class was calculated by dividing the total amount of bycatch by the total tuna catch taken in the class. Similarly, the silky shark bycatch ratio was calculated by dividing the sum of all silky sharks taken by the total tuna catch in each set size class. This allowed for the investigation of the effect of set size on these ratios. After identifying the set sizes that produce the highest ratios, the contribution of each set size class to the total catch of tuna, total bycatch, and total numbers of silky sharks caught by the fishery was computed. Furthermore, the contribution of each set size class to the overall strategy of the fishery was reported, through the calculation of the number of fishing sets in each class in relation to the total number of sets made.

Results

In all four oceans (Fig. 1), both ratios (bycatch to tuna catch, silky shark bycatch to tuna catch) were observed to generally decrease as set size increased. However, the most rapid decrease was consistently observed between the first (<10 t) and the second (11–20 t) set size classes. The first set size class had the highest bycatch ratios (IO: 108 t/1000 t; EPO: 58 t/1000 t; WCPO: 166 t/1000 t; AO: 121 t/1000 t). By the fourth size class (31–40 t), these ratios had dropped to less than 25 t/1000 t for all oceans. The same trend was observed for the ratio of number of silky sharks to tuna catch (in tonnes; Fig. 1).

A very large percentage of fishing sets (31% IO, 25% EPO, 27% WCPO, 41% AO) resulted in tuna catches of less than 10 t (Fig. 2). However, these large numbers of small sets had a small overall contribution to the total tuna tonnage (6% IO, 4% EPO, 3% WCPO, 10% AO). In contrast, these sets contributed substantially to the total bycatch that occurred in the fishery (26% IO, 23% EPO, 23% WCPO, 43% AO; Fig. 2). Similarly, these small sets resulted in a very high percentage of the total number of silky sharks taken (21% IO, 23% EPO, 33% WCPO, 41% AO).

Discussion

The smallest set size class (0–10 t) always showed the highest bycatch and silky shark ratios. Between 25% and 41% (depending on the ocean) of the number of sets made by the fishery resulted in tuna catches less than 10 t. While the total catch from these sets appears minor (approximately 3%–10%), they contribute to a large portion of both the total bycatch (e.g., nontarget species; 23%–43%) and the total number of silky sharks caught (21%–41%). Higher ratios were observed in the AO, which is likely a result of the local market for bycatch (called “faux-poisson”) that could represent an incentive for fishers to set more often on FADs that have little or no tuna (Dagorn et al. 2012).

Through the avoidance of sets on small schools, the fishery would improve its efficiency both through reductions in the ratio of bycatch to catch, as well as through an increase in the average set size. It is, however, surprising that the fishery has not yet naturally adopted this strategy. One explanation could be that the skippers want to keep the crew occupied (which could have positive impacts on their moral) during periods when medium- to large-sized schools are rarely encountered. It could also be that avoiding bycatch has not yet become an integral concern for the fishers. The method proposed in this study is relatively simple and does not require the development of new technology or some complex and difficult fishing practice. Fishers throughout the global tropical tuna purse seine fishery could easily utilize this strategy, as all skippers estimate the school size prior to setting on a floating object. Such preset estimates are made through the combination of information from sonars and echo sounders, visual information from fish at the surface, and information from previous catches in the area. Despite this range of information sources, these preset estimates are not always accurate because they rely largely on the fishers’ skills, local conditions, and the size of the school. Data collected by observers onboard French purse seine vessels in the Indian and Atlantic oceans revealed that of the 320 preset estimates of schools less than 10 t, 73% resulted in catches less than 10 t (P. Chavance, unpublished data). Additionally, of the 673 preset estimates superior to 10 t, 25% led to catches inferior to this threshold (P. Chavance, unpublished data). These data suggest rather good estimation methods; nonetheless, further improvements to these methods would help in identifying small schools. Recently, the use of echo sounder buoys has increased considerably throughout the fishery, allowing for the remote estimation of the size of aggregations around floating objects (Dagorn et al. 2012). Further improvements in the quality of the information received from such buoys would considerably aid fishers in the selection of large schools before they reach a floating object.

The implementation of a regulation that would prohibit sets on small schools, with a minimum size limit, does not appear to be a realistic solution, considering that it will be difficult for fishers to discriminate between an 8 or 12 t school, if the limit were set at 10 t. Rather, the development of a system that utilizes incentives to reward fishing vessels with low bycatch to catch ratios may be more effective. For instance, if observers or electronic monitoring systems were in place, incentives could be structured in such a way that the price of the target catch is directly dependent upon the vessel’s bycatch ratio. Alternatively a bycatch tax (Finkelstein et al. 2008) directly proportional to the amount of bycatch taken by the vessel could be developed. Such a tax could be used to support research on bycatch species, which are often poorly studied.

Although a single technical practice led to a drastic reduction in dolphin bycatch in the EPO (Francis et al. 1992), it is more likely that reductions in purse seine-related shark bycatch will be facilitated through the combination of multiple approaches. Such a combination could include (*i*) the selection of large schools, (*ii*) the avoidance of areas where sharks are known to be abundant (see Watson et al. 2009), and (*iii*) the immediate release of live sharks as soon as they are brought on deck.

Every fisher, be they recreational, artisanal, or industrial, is constantly driven by the motivation of making a big catch. Here we have shown that the promotion of this inherent desire could lead to a major reduction of total bycatch in the tropical tuna purse seine fishery using FADs. The ability to control the fishing mortality of various components of fisheries (i.e., target and bycatch species) through rather simple methods is essential for achieving the objectives of ecosystem-based fisheries management and in particular to move from the paradigm of single species management with zero bycatch to the management of all species removed from an ecosystem (Garcia et al. 2012). Reducing the numbers of sets (a portion of the total fishing effort) while maintaining the same total yield could contribute to a reduction in the impacts of human activities.

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