

OBSERVED LIVE RELEASES AND DEAD DISCARDS OF SHORTFIN MAKO SHARK (*ISURUS OXYRINCHUS*) FROM CANADIAN FISHERIES

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SUMMARY

Information on the magnitude and condition (alive, dead) of discards of shortfin mako shark (Isurus oxyrinchus) from Canadian fisheries has not been previously reported. Here, we have compiled observer records from 1987 – 2016 as a first summary of the magnitude of by-catch in Canadian fisheries operating within and outside of Canada's Exclusive Economic Zone. Years in which these data are not complete or are influenced by inaccurate species identification or non-reporting are identified. Totals are split into live releases and dead discards based on gear-specific mortality rate estimates. No attempt has been made to scale up observed discards to fleet-wide totals, which remains an ongoing research area.

RÉSUMÉ

Les informations sur l'ampleur et l'état (vivant/mort) des rejets de requin-taupe bleu (Isurus oxyrinchus) des pêcheries canadiennes n'ont pas été déclarées auparavant. Le présent document rassemble des registres d'observateurs de 1987 à 2016 au titre de premier résumé de l'ampleur de la prise accessoire dans les pêcheries canadiennes opérant à l'intérieur et à l'extérieur de la zone économique exclusive du Canada. Les années pour lesquelles ces données ne sont pas complètes ou sont influencées par une identification erronée des espèces ou par une non-déclaration sont identifiées. Les totaux sont divisés en rejets vivants et en rejets morts en fonction des estimations du taux de mortalité spécifique aux engins. Rien n'a été tenté pour extrapoler les rejets observés aux totaux de l'ensemble de la flottille, un domaine qui fait actuellement l'objet de recherche.

RESUMEN

La información sobre la magnitud y la condición (vivos o muertos) de los descartes de marrajo dientuso (Isurus oxyrinchus) de las pesquerías canadienses no había sido presentada anteriormente. En este documento, se han compilado registros de observadores de 1987 a 2016 como un primer resumen de la magnitud de la captura fortuita que se produce en las pesquerías canadienses que operan dentro y fuera de la zona económica exclusiva de Canadá. Se han identificado los años en los que estos datos no están completos o están influidos por una identificación de especies inadecuada o por la falta de comunicación. Los totales se han separado entre liberaciones de ejemplares vivos y descartes de ejemplares muertos en base a estimaciones de la tasa de mortalidad específica de cada arte. No se ha intentado escalar los descartes observados a totales de toda la flota, dado que esta investigación sigue en curso.

KEYWORDS

Fishing mortality, shark fisheries, long lining, gillnets, trawling

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1. Introduction

As requested by the ICCAT shark species group, this paper provides Shortfin Mako shark (*Isurus oxyrinchus*) discards (alive and dead) from Canadian fisheries in the Northwest Atlantic Ocean. Official data on discards from Canada has not traditionally been available for this species, even though an observer program has been in place since the late 1980s. Here we have included records from all fisheries within the Canadian EEZ (both national and ICCAT managed) that capture Shortfin Mako, with the expectation that this may be more informative for population assessment relative to reporting discards from ICCAT-managed fisheries only. The available data is partitioned into live releases and dead discards for use in assessment, as in Task 1 catch data submissions to ICCAT. Only at-vessel mortality was considered when partitioning totals, post-release mortality estimates were not used to adjust for probable mortality of sharks released alive. We recognize that this is an interim document in that further work may be done to scale up observed discard values to fishery-level totals. However, further analyses and the regional data to support them were not available in time for the 2017 data inputs meeting for Shortfin Mako shark.

2. Observed Discards

We have compiled data from two at-sea observer programs: one from the Maritimes region and the other from the Newfoundland and Labrador region (hereafter called the Newfoundland region), including all records available from 1987 until 2016 (**Table 1**). Although there may be additional discards of Shortfin Mako from the Gulf and Quebec regions, these are expected to be relatively small compared to the overall total. The longline and gillnet fisheries in these two regions report Shortfin Mako landings that are two orders of magnitude smaller than those from the Maritimes region, considering 1993 to present. If discarding is similarly different in magnitude, excluding data from the Gulf and Quebec will have minimal effect on annual totals. However, we will attempt to incorporate these data into future assessments.

There are several characteristics of the historical observer data that become problematic when trying to understand shark discards. Until the early 1990s, some observers correctly identified each shark to species, while others reported both shortfin and porbeagle as “Mackerel shark” or did not report sharks at all. Thus totals from observed trips during 1987 until approximately 1994 are biased low. Much more attention has been paid to sharks by observers since 2002 due to the introduction of a specific protocol for recording shark by-catches, leading to more detailed information. Thus, we expect that data from 2002 until present will be the most complete and representative. However, observer coverage of domestic commercial fisheries has been relatively low throughout the time series and sporadic at times among fleets and regions. For example, observer coverage of the pelagic longline fleet averaged around 5% since 2004 in the Maritimes region (Campana *et al.* 2015a) yet random deployment of observers among trips has only occurred in recent years. Coverage in many fisheries in the Newfoundland region has been less than 5% annually, with some years having no trips observed in a particular fishery. Therefore, the totals we report represent a minimum number of discards from Canada (**Table 1**).

For more recent data, values for 2016 should be considered preliminary as further validation and error correction will take place this year. There is also some uncertainty with data from the Newfoundland region from 2013 onwards. The way that data are being archived and made available to DFO Science is currently changing in the Newfoundland region. Although all available information has been incorporated, it is only current to 2012. We will update these data as they become available.

2.1 Estimating live releases and dead discards

Prior to 1994, most shark by-catch in Canadian pelagic longline fisheries was killed by finning. After finning was banned in 1994, a proportion of discarded sharks were released alive (Campana *et al.* 2015a, Campana *et al.* 2009). Having observers report the condition (alive, dead) of discarded sharks (as opposed to landed sharks) is a relatively new addition to at-sea protocols, implemented only in 2010 (Campana *et al.* 2015b). For the pelagic longline fishery, the percentage dead ranged from 12% to 32% with a mean of 20% between 2010 and 2016 (**Table 2**). Although the condition of landings has been reported since 1992, these data may not be representative of the condition of discards if fishermen have any tendency to preferentially retain dead sharks.

There are very few observations of shark condition when animals are discarded in other fisheries and all data comes from the Maritimes region. For example, only 10 individual animals were categorized from the groundfish otter trawl fishery between 2010 and 2016, 2 of which were dead and 8 released alive. More informative data exists for porbeagle shark from the groundfish otter trawl fishery (N=235), where an average of 7% were dead when discarded (Campana *et al.* 2015c). Here, we have assumed 7% mortality for Shortfin Mako in otter and mid-water trawls. Further, we have assumed that this percentage is representative of Newfoundland fisheries using these gears. For gillnets, several at-sea observers and multiple participants in groundfish fisheries have reported that by-catch mortality of large pelagic shark species is 100%, due to the shark drowning after entanglement with the gear. Therefore, all observed discards of Shortfin Mako from gillnet fisheries (both regions) were assumed to be dead (Campana *et al.* 2011; Campana *et al.* 2015c). Similarly, 100% mortality was assumed for all by-catch in groundfish longline fisheries and purse seine (Campana *et al.* 2011; Campana *et al.* 2015c). We will revisit these assumptions in the future if new data becomes available.

In summary, discards were partitioned into live and dead components assuming 100% mortality from 1987-1994, 20% mortality from 1995-2009, and observed annual mortality rates from 2010-2016 for the pelagic longline fishery. Only 7% of discards from groundfish otter and mid-water trawls (both regions and all years) were considered dead. All other discards were assumed to be dead. This suggests that the majority of Shortfin mako were alive at release, given that discarding is most commonly observed from the pelagic longline and groundfish otter trawl fleets in Canada (**Table 3**). Total observed discards have been relatively low, peaking at 10.8 t in 2007.

3. Future Research and Conclusions

No attempt has been made to scale up observed discards to fishery-wide totals, although there would be the possibility to apply a ratio method similar to Campana *et al.* 2011. In brief, this involves calculating the ratio between total Shortfin mako discards and target species' catch by fishing quarter (1 = Jan-Mar, 2 = Apr-Jun, 3 = Jul-Sept, 4 = Oct-Dec). Then, annual ratios are summarized as 5-year averages (e.g. 1990-1994, 1995-1999 etc.), which are multiplied by total commercial catches of target species in each fishing quarter and year (e.g., Campana *et al.* 2015c). Summing over fisheries and quarters for each year would give estimates of total Canadian discards of Shortfin Mako. Then, the mortality rates described in this document would be applied to partition the time series into live releases and dead discards.

Scaling up observed discards to fishery-wide totals will not be possible for all fisheries and regions included in this document. It is most likely that any extrapolation would be specific to ICCAT managed fisheries (e.g. Swordfish/Tunas). However, other Canadian fisheries affecting the Shortfin mako shark population were identified in this document in order to be able to compare relative magnitudes of discards among fleets, and to summarize what is known about at-vessel or capture mortality. For the Maritimes region, fisheries that are expected to lead to high mortality rates (e.g. groundfish gillnet) are a relatively small component of observed discards, while those where capture mortality is low are a much larger component. Excluding the Maritimes region otter trawl fishery from any extrapolation of discards would cause the total and the live component to be more substantially underestimated than dead discards. This is somewhat different in the Newfoundland region, where the majority of Shortfin Mako discards have been observed in groundfish gillnet fisheries. Unfortunately, there are insufficient observations by fishing quarter to support extrapolation using the method proposed by Campana *et al.* 2011. This remains an ongoing research area with the hope that more representative data can be provided in advance of the Shortfin Mako assessment by ICCAT.

References

- Campana, S.E., Joyce W., and Manning M.J. 2009. Bycatch and discard mortality in commercially caught blue sharks *Prionace glauca* assessed using archival satellite pop-up tags. *Marine Ecology Progress Series* 387:241-253.
- Campana, S.E., Brading J., and Joyce W. 2011. Estimation of pelagic shark by-catch and associated mortality in Canadian Atlantic Fisheries. DFO Canadian Science Advisory Secretariat Research Document 2011/067.
- Campana, S.E., Fowler M., Houlihan D., Joyce W., Showell M., Miri C. and Simpson M. 2015a. Current status and threats to the North Atlantic blue shark (*Prionace glauca*) population in Atlantic Canada. DFO Canadian Science Advisory Secretariat Research Document 2015/026.
- Campana, S.E., Joyce W., Fowler M., and Showell M. 2015b. Discards, hooking, and post-release mortality of porbeagle (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*), and blue shark (*Prionace glauca*) in the Canadian pelagic longline fishery. *ICES Journal of Marine Science*. Doi:10.1093/icesjms/fsv234.
- Campana, S.E., Fowler M., Houlihan D., Joyce W., Showell M., Simpson M., Miri C., and Eagles M. 2015c. Recovery Potential Assessment for porbeagle (*Lamna nasus*) in Atlantic Canada. DFO Canadian Science Advisory Secretariat Research Document 2015/041.

Table 1. Observed discards of Shortfin mako in Canadian fisheries (metric tonnes) from 1987 to 2016, grouped by fishing gear type and region. Although zeros are included in all years where no discards were observed, these are not considered true zeros (reflecting the absence of Shortfin mako discards in the fishery) because of low and potentially sporadic observer coverage.

Year	Maritimes Region						Newfoundland and Labrador Region					TOTAL
	Otter Trawl	Midwater Trawl	Purse Seine	Groundfish Gillnet	Pelagic Longline	Groundfish Longline	Otter Trawl	Midwater Trawl	Groundfish Gillnet	Pelagic Longline	Groundfish Longline	
1987	0.015	0	0	0	3.766	0	0	0	0	0	0	3.78
1988	1.29	0	0	0	3.351	0	0	0	0	0	0	4.74
1989	1.881	0	0	0	4.537	0	0	0	0	0.015	0	6.54
1990	1.89	1.875	0	0	1.818	0	0	0	0	0.007	0	5.74
1991	2.179	0.1	0	0	0.634	0	0	0	0	0	0	3.05
1992	2.288	0.075	0	0	1.383	0	0	0	0	0	0	3.71
1993	0.147	0.075	0	0	1.121	0	0.35	0.1	1.725	0.3	0	4.72
1994	0.27	0	0	0	1.995	0	0.097	0.418	0.025	0.118	0	3.12
1995	0.07	0	0	0	0.282	0	0	0.658	0	0	0	1.09
1996	0.85	0	0	0	0.599	0	0	0	0	0	0	1.22
1997	0	0	0	0	0.165	0	0	0.32	0	0	0	0.49
1998	0	0	0	0	1.42	0	0	0	0.175	0	0	1.72
1999	0.5	0	0	0	4.686	0	0	0	0.068	0	0	5.35
2000	0.02	0	0.206	0	0.520	0.009	0	0	0.612	0.21	0	1.98
2001	0.25	0	0.05	0	1.313	0	0.2	0	0.672	0	0	2.96
2002	0.568	0	0	0	0.854	0.009	0	0	0.209	0	0	2.70
2003	0	0	0	0	0.702	0.046	0.876	0	2.978	0	0	4.59
2004	0.025	0	0.35	0	0.518	0.017	0.284	0	0.036	0	0	1.61
2005	0.363	0	0	0.573	0.801	0	0.3	0	0.896	0	0	3.35
2006	1.393	0	0	0	1.036	0.01	0	0	0.185	0	0	3.47
2007	7.959	0	0	0	1.073	0	0	0	0.929	0	0.125	10.80
2008	0.45	0	0	0	0.856	0	0.135	0	0.34	0	0	1.87
2009	0.689	0	0	0	1.251	1.05	0.075	0	1.47	0	0	4.54
2010	0.948	0	0	0	1.749	0.011	0.715	0	0.375	0	0.07	3.81

Year	Maritimes Region						Newfoundland and Labrador Region					TOTAL
	Otter Trawl	Midwater Trawl	Purse Seine	Groundfish Gillnet	Pelagic Longline	Groundfish Longline	Otter Trawl	Midwater Trawl	Groundfish Gillnet	Pelagic Longline	Groundfish Longline	
2011	0.612	0	0.09	0.135	1.266	0.35	0.135	0	1.118	0	0	3.52
2012	1.391	0	0	0	3.009	0.134	0	0	0.76	0	0.15	6.41
2013	0.49	0	0	0	0.768	0.056						1.31
2014	0.495	0	0	0	0.886	0.014						1.29
2015	0.818	0	0	0	0.971	0.338						1.81
2016 ²	0.726	0	0.2	0	1.278	0.351						2.33

² Data from 2016 are considered preliminary

Table 2. Summary of the condition of Shortfin Mako discards at the time of release as compared to the condition of Shortfin Mako landings at the time of capture, as recorded by fisheries observers in the Maritimes Region.

Type	Year	Unknown	Alive	Dead	Total	% Dead
discarded	2010	5	77	19	101	19
discarded	2011	1	58	17	76	22
discarded	2012	2	189	90	281	32
discarded	2013	0	36	5	41	12
discarded	2014	0	41	13	54	24
discarded	2015	3	67	16	86	19
discarded	2016 ³	0	57	8	65	12

³ Data from 2016 are considered preliminary

Table 3. Time series of live releases (DL) and dead discards (DD) in metric tonnes for Shortfin Mako sharks from Canada. The total represents the sum of all discards recorded in the at-sea observer programs in the Maritimes and Newfoundland regions. Values are not scaled up to represent entire fisheries and are conditional on observer coverage within each fishery and region; as such, they represent a minimum number of discards. The mortality rates used to partition the catches from **Table 1** into live and dead components are given in Section 2.1.

Year	DL	DD	Total
1987	0.01	3.77	3.78
1988	1.20	3.44	4.64
1989	1.75	4.68	6.43
1990	3.50	2.09	5.59
1991	2.12	0.79	2.91
1992	2.20	1.55	3.75
1993	1.90	1.91	3.82
1994	0.66	2.26	2.92
1995	0.90	0.11	1.01
1996	1.27	0.18	1.45
1997	0.43	0.06	0.49
1998	1.30	0.30	1.60
1999	4.28	0.98	5.25
2000	1.17	0.41	1.58
2001	1.91	0.58	2.49
2002	1.41	0.23	1.64
2003	3.33	1.27	4.60
2004	0.47	0.76	1.23
2005	1.81	1.12	2.93
2006	2.30	0.33	2.62
2007	9.12	0.96	10.09
2008	1.42	0.36	1.78
2009	3.01	1.53	4.54
2010	2.65	1.22	3.87
2011	2.59	1.11	3.71
2012	4.05	1.40	5.44
2013 ⁴	1.13	0.18	1.31
2014	1.13	0.26	1.40
2015	1.55	0.58	2.13
2016	1.80	0.76	2.56

⁴ Data from 2013 onwards are incomplete