AN ASSESSMENT OF MARINE MAMMAL INTERACTIONS
WITH LONGLINE GEAR IN THE NORTH ATLANTIC OCEAN

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SUMMARY

A spatial model was fit to the interactions of the Canadian longline fleet with marine mammals. The model was used to predict the total annual interactions from 1982 to 2017 using the North Atlantic monthly longline effort obtained from ICCAT's Task II catch and effort database. Estimated interactions declined in the past five years to near the low levels of the late 1980s and early 1990s while fishing effort remained relatively constant until the most recent four years when it declined to a 30 year low. The interaction rate has been declining over the last four years.

RÉSUMÉ

Un modèle spatial a été ajusté aux interactions de la flottille palangrière canadienne avec les mammifères marins. Le modèle a été utilisé pour prédire les interactions annuelles totales de 1982 à 2017 en utilisant l'effort palangrier mensuel dans l'Atlantique Nord obtenu à partir de la base de données de prise et d'effort de la tâche II de l'ICCAT. Les interactions estimées ont diminué au cours des cinq dernières années pour se rapprocher des faibles niveaux de la fin des années 1980 et du début des années 1990, tandis que l'effort de pêche est resté relativement constant jusqu'à ces quatre dernières années où il a chuté au niveau le plus bas de ces 30 dernières années. Le taux d'interaction a diminué au cours des quatre dernières années.

RESUMEN

Se ajustó un modelo espacial a las interacciones de la flota de palangre canadiense con los mamíferos marinos. El modelo se utilizó para predecir las interacciones anuales totales desde 1982 a 2017, utilizando el esfuerzo mensual de palangre del Atlántico norte obtenido de la base de datos de captura y esfuerzo de Tarea II de ICCAT. Las interacciones estimadas descendieron en los cinco últimos años hasta casi los bajos niveles de finales de los ochenta y comienzos de los noventa, mientras que el esfuerzo se mantuvo relativamente constante hasta los cuatro años más recientes, cuando descendió hasta el nivel más bajo en treinta años. La tasa de interacción ha estado descendiendo durante los cuatro últimos años.

KEYWORDS

Marine mammal, longline, interactions, North Atlantic, indicator

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1. Introduction

In 2017 the ICCAT Sub-committee on Ecosystems developed a work plan that included a proposal to develop a prototype Ecosystem report card for the ICCAT Commission to review in 2018. The inter-sessional exercise involved groups of the Sub-committee to assess the status of 10 ecosystem components (Assessed Retained Species, Non-Assessed Retained Species, Seabirds, Marine Turtles, Marine Mammals, Non-Retained Sharks, Trophic Relationships, Socio Economic, Fishing Pressure and Habitat). The indicators described in the ten assessment documents will form the basis for a prototype report card and provide information towards implementing ecosystems based fisheries management (EBFM) in ICCAT in accordance with Resolution 15-11.

The work presented here relates to the Marine Mammal component and its objective is to create an indicator of marine mammal status based on total interactions with ICCAT fisheries, total mortality or alternatives.

2. Methods

2.1 Indicators

Very little marine mammal interaction data has been submitted to ICCAT although in many cases this information is collected by CPCs with an onboard observer program (e.g. Passadore *et al*. 2015). Given that the data from the Canadian onboard observer program was available, this source was used to reflect the North Atlantic wide trend in marine mammal interactions. An alternative approach not pursued was to use published mammal bycatch rates (Passadore *et al*. 2015, Read *et al*. 2006) to extrapolate regional interactions to a basin scale domain.

The indicator is the total annual predicted marine mammal interactions in the North Atlantic from 1982 to 2017. Due to a lack of post release mortality data, this could not be factored into the assessed status.

Because mammal interactions are generally rare, dolphins, whales and seals were grouped together.

2.2 Data and Model

The Canadian onboard observer program for the pelagic longline fleet reported marine mammal interactions each year from 1982 to 2017 (**Table 1**). The following model was fit to the set data of undifferentiated mammal encounters.

$$Mammal_{tmi} \sim NB(\mu_{tmi}, \theta)$$
$$E(Mammal_{itm}) = \mu_{tmi}$$
$$var(Mammal_{tmi}) = \mu_i + \mu_{tmi}^2/\theta$$
$$\log(\mu_{tmi}) = \alpha + log_{10}Hooks_{tmi} + f_1(Year_{tmi}) + f_2(Month_{tmi}) + u_{tmi}$$
$$f_1(Year_{tmi}) = 2Year_{tmi-1} - Year_{tmi-2} + v1_{tmi}$$
$$f_2(Month_{tmi}) = Month_{tmi-1} + v2_{tmi}$$
$$u_{tmi} \sim GMRF(0, \sum)$$
$$v1_{tmi} \sim N(0, \sigma_{v1}^2)$$
$$v2_{tmi} \sim N(0, \sigma_{v2}^2)$$

$Mammal_{tmi}$ is the number of mammal interactions in set *i* year *t* and month *m* and it is assumed that it is negative binomial distributed. The long term trend $f_1(Year_{tmi})$ and seasonal trend $f_2(Month_{tmi})$ in interactions were fit using first and second order random walks, respectively. Both $v1_{tmi}$ and $v2_{tmi}$ represent noise in these trends. The u_{tmi} term allows for the spatial dependency of the observations and $log_{10}Hooks_{tmi}$ is an offset for the number of hooks used per set. This model was used to predict interactions for the entire North Atlantic (**Table 2**) using ICCAT's Task II catch effort database (http://iccat.int/Data/t2ce_20171120.zip) which provided monthly longline hook usage by year. Quarterly and yearly reporting of effort was apportioned to a monthly level assuming equal probability.

The effort was restricted to latitudes greater than or equal to 15 degrees N. Consequently, it was assumed that the interaction rate in the Canadian longline fishery was representative of interaction rates for other fisheries operating within this area of the Atlantic Ocean and that the mammal species observed by the Canadian longline fishery also occurred there.

Complementary data was not freely available and requires that a formal request be sent to all CPCs to gain access to it. The data that was used was available on line (Task II) or extracted directly from a DFO server (Canadian observer data). The Canadian observer data is normally only be accessible upon formal request but in this instance the author was a DFO scientist and had free access.

2.3 Regions

Two alternatives have been proposed for partitioning the ICCAT convention area into subareas for reporting (**Figure 1**). The first uses the existing ICCAT stock boundaries and data reporting structure to create 5 regions (Partition A) and the second uses established ecological provinces and ICCAT species occurrence to partition the domain (Partition B) into 6 regions.

A candidate indicator for mammals can be created for regions defined by Partition A provided there is CPC supporting data on mammal interactions within these areas. The current procedure assumes that the observed interactions in one location are representative of the unreported interactions in a much larger domain. Reporting to the regions of Partition B is more problematic because the boundaries do not conform to lines of longitude and latitude.

2.4 Goals and Objectives

Goal: Minimizing the interactions and mortality as practically as possible.

Objective: Determine if the number of interactions is being reduced.

3. Interpretation

Since 2000 the relative number of mammal interactions has remained high, however over the last 5 years the number of interactions has fallen below the lower threshold. This decline coincides with recent declines in longline effort (**Figure 2**). The interaction rate, which is independent of the effort, has been declining over the last 4 years and is within one standard deviation of the mean. The 5-year trend follows the series mean.

References

Cecilia Passadore, Andrés Domingo, Eduardo R. Secchi. 2015. Analysis of marine mammal bycatch in the Uruguayan pelagic longline fishery operating in the Southwestern Atlantic Ocean, ICES Journal of Marine Science, Volume 72, Issue 5, 1 June 2015, Pages 1637–1652, https://doi.org/10.1093/icesjms/fsu250Surname of first author, name or initial(s), Surname of other others, name or initials.

Andrew J. Read, Phebe Drinker and Simon Northridge. 2006. Bycatch of Marine Mammals in U.S. and Global Fisheries. Conservation Biology Volume 20, No. 1, 163–69 https://pdfs.semanticscholar.org/4495/caf38114d477dacd72775dccbe411513c1d0.pdf

Table 1. Mammal interactions by species reported by Canadian observers from 1982 to 2017.

Species Common Name	Observed Interactions
Seals (not specified)	16
Walrus	1
Whales (not specified)	4
Atlantic Pilot Whale	15
Northern Bottlenose Whale	1
Dolphins (not specified)	30
Atl. Bottlenosed Dolphin	2
Atl. White-sided Dolphin	3
Total	**72**

Table 2. The estimated total number of mammal interactions, longline effort and interaction rate (mammals per million hooks) by year in the North Atlantic Ocean north of 15° north latitude.

Year	Interactions	Hooks	Interaction rate
1982	5.8	109600185	0.053
1983	3.4	120600943	0.028
1984	2.3	168888198	0.014
1985		119187196	NA
1986	1.2	184586900	0.007
1987	0.8	113443387	0.007
1988	0.8	128056057	0.006
1989	0.8	116229523	0.007
1990	0.8	106986622	0.007
1991	1	137392654	0.007
1992	1.1	118759287	0.009
1993	1.3	138607715	0.009
1994	1.6	161016676	0.01
1995	2	166201065	0.012
1996	2.5	150103196	0.017
1997	3.4	160290478	0.021
1998	4.6	149459171	0.031
1999	6.3	152285688	0.041
2000	7.9	155178874	0.051
2001	9.3	166016098	0.056
2002	7.9	111797082	0.071
2003	7.3	101953091	0.072
2004	7.3	117555000	0.062
2005	6.8	110156570	0.062
2006	6.6	114669990	0.058
2007	5.8	92689743	0.063
2008	5.8	104470770	0.056
2009	6	131500585	0.046
2010	6.9	197770568	0.035
2011	4.7	82992277	0.057
2012	6.8	214162076	0.032
2013	10.1	810996664	0.012
2014	3.4	66697040	0.051
2015	2.8	65127702	0.043
2016	2.2	63254264	0.035
2017	1.7	63254264	0.027
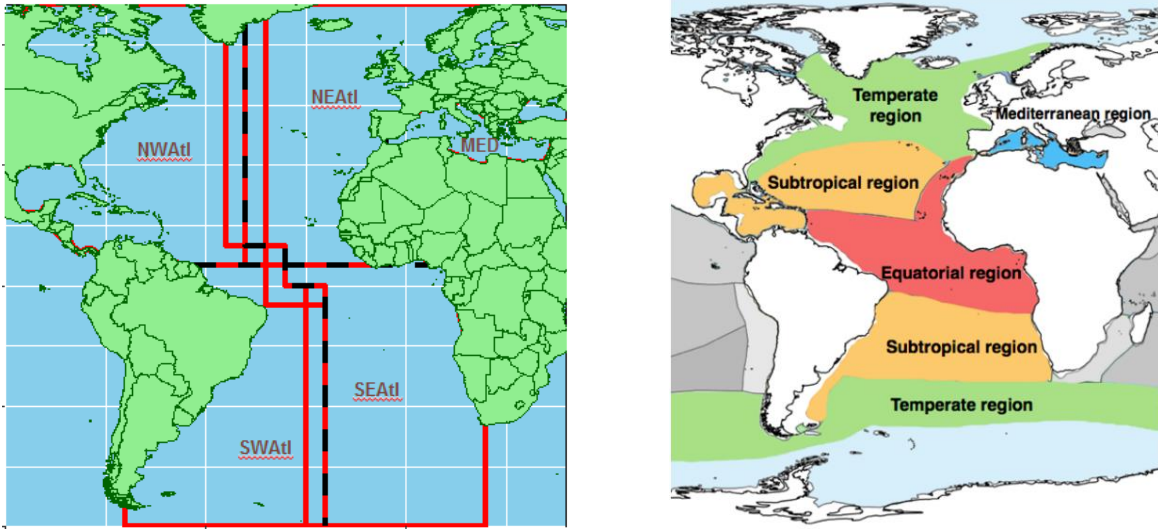
Figure 1. Proposed ecological divisions of the ICCAT convention area. The regions in the left plot are based on existing ICCAT partitions (red and black line) while those on the right are based on ecological provinces and ICCAT species occurrence.
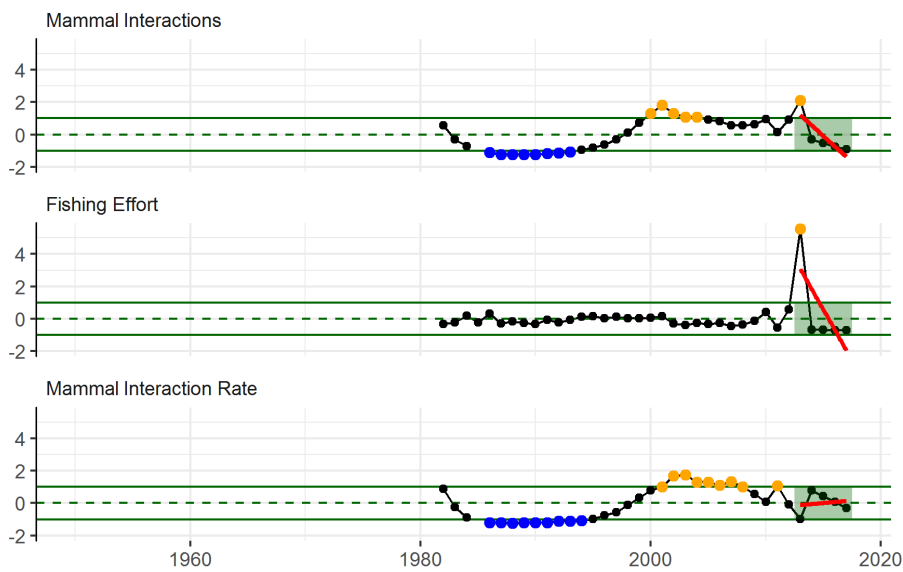
Figure 2. Standardized indicators of mammal interactions, fishing effort and interaction rate for the north Atlantic Ocean north of 15º north latitude. Values >= 1 std are orange. Values <= -1 std are blue. Red trend lines are for the last 5 years and were fit with a linear model.