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STANDARDIZED CATCH RATES OF SWORDFISH FROM THE U.S. DEALER LANDING SYSTEM WITH A PRELIMINARY CONSIDERATION OF A COMBINED U.S.-CANADA PELAGIC LONGLINE FLEET DATASET

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SUMMARY

*Trip summary catch and effort data from the U.S. and Canadian Pelagic longline fleets operating in the Western North Atlantic were used to obtain a suite of CPUE indices for swordfish (*Xiphias gladius*). Seven indices were constructed for fish greater than 33lbs to avoid contamination with undersized fish prior to the imposition of size limits in 1991. Eight indices are presented for consideration: 1.USCPUEW1986-2011, 2. USCPUEW 1996-2011, indices in number 3 USCPUEN1986-2011 and 4.Strict update (1982-2011) of the 2009 index using the fraction of SWO/total catch as a categorical factor and a preliminary exploration of the potential to develop a joint US Canada index. The time series split was done as it was possible to assign gear characteristics regarding targeting to the trips for 1996 forward. For the full time series index 1986-2011 a categorical variable constructed from the catch rates of key negative correlates with SWO was developed. For index 4. Strict update of 2009, uses a variable defined from the fraction of SWO/total catch for targeting. The short time series model (2) use gear characteristics to account for targeting. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution. The combined index may allow for estimation of the reduction in CPUE due to regulation to use circle hooks in the U.S. and Canadian fisheries.*

RÉSUMÉ

Des données de prise et d'effort récapitulant les sorties des flottilles palangrières pélagiques des États-Unis et du Canada qui opèrent dans l'Atlantique Nord Ouest ont été utilisées pour obtenir une série d'indices de CPUE pour l'espadon (Xiphias gladius). Sept indices ont été élaborés pour des poissons pesant plus de 15 kg afin d'éviter la contamination avec des poissons sous-taille avant l'imposition des limite de taille en 1991. Huit indices sont présentés à des fins d'examen : 1.USCPUEW1986-2011, 2. USCPUEW 1996-2011, indices en nombre 3. USCPUEN1986-2011 et 4. Actualisation stricte (1982-2011) de l'indice de 2009 utilisant la fraction de la prise d'espadon/totale comme facteur catégorique et une exploration préliminaire du potentiel à développer un indice conjoint États-Unis-Canada. La division de la série temporelle a été réalisée étant donné qu'il a été possible d'assigner les caractéristiques des engins en ce qui concerne le ciblage aux sorties de 1996 et au-delà. Pour l'indice de série temporelle complète 1986-2011, on a élaboré une variable catégorique construite à partir des taux de capture des corrélations négatives avec l'espadon. Pour l'indice 4. Actualisation stricte de 2009, on utilise une variable définie d'après la fraction de la prise d'espadon/prise totale pour le ciblage. Le modèle de la courte série temporelle (2) utilise les caractéristiques des engins pour tenir compte du ciblage. Les taux de capture standardisés ont été estimés en utilisant une approche de modèle linéaire généralisé mixte postulant une distribution d'erreur delta lognormale. L'indice combiné pourrait permettre d'estimer la réduction de la CPUE en raison de la réglementation à l'effet d'utiliser les hameçons circulaires dans les pêcheries des États-Unis et du Canada.

RESUMEN

Se utilizaron los datos de captura y esfuerzo resumidos de las flotas de palangre pelágico estadounidense y canadiense que operan en el Atlántico norte occidental para obtener un conjunto de índices de CPUE para el pez espada (Xiphias gladius). *Se elaboraron siete índices para peces de más de 15 kg con el fin de evitar la contaminación con peces de talla inferior a la*

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regulada antes de la imposición de límites de talla en 1991. Se presentan ocho índices para su consideración: 1.USCPUEW1986-2011, 2. USCPUEW 1996-2011, índices en número, 3 USCPUEN1986-2011 y 4 actualización estricta (1982-2011) del índice de 2009 utilizando la fracción de SWO/captura total como factor categórico y una exploración preliminar del potencial para desarrollar un índice conjunto de Canadá y Estados Unidos. Se realizó una separación de la serie temporal ya que fue posible asignar características del arte respecto a la especie objetivo en las mareas desde 1996 en adelante. Para el índice de la serie temporal completa, 1986-2011, se desarrolló una variable categórica construida a partir de las tasas de captura de correlaciones negativas claves con SWO. Para el índice 4, una actualización estricta de 2009, se utiliza una variable definida a partir de la fracción de SWO/captura total para la especie objetivo. El modelo de la corta serie temporal (2) usa las características del arte para tener en cuenta la especie objetivo. Se estimaron las tasas de captura estandarizadas mediante modelos lineales generalizados mixtos asumiendo una distribución de error delta-lognormal. El índice combinado podría permitir la estimación de la reducción en la CPUE debido a la reglamentación para el uso de anzuelos circulares en las pesquerías de Estados Unidos y Canadá.

KEYWORDS

Catch/effort, Abundance, Longline, Pelagic fisheries, Swordfish

1. Introduction

The paper presents standardized indices of abundance for swordfish from the U.S. and a preliminary exploration of combined U.S. and Canadian longline fishery dataset. This paper updates previous CPUE indices obtained from the U.S. Dealer Landings System (DLS), provides revised indices based upon a new method of defining targeting strategy and combines U.S. and Canadian data. Combining Canadian and U.S. data on a common scale may be useful for evaluating the effects of circle hooks as the fleets changed hook types in different years and may be valuable in evaluating similarities in the trends in the different fisheries.

Previous swordfish stock assessments have used the indices of abundance estimated for the U.S. pelagic longline fishery obtained from DLS trip reports which record the landed weights of individual fish from pelagic longline fishing trips. These indices (Ortiz 2009) were constructed for fish >33 lbs to account for the absence landings of fish after a minimum size of 125 cm LJFL with a 15% tolerance was implemented in mid 1991. Standardized catch rates were estimated using the Generalized Linear Mixed Model (GLMM) approach. A similar approach is used in this paper. A key contribution of this work is to provide a longer time series of CPUE for the U.S. fishery and, potentially, a joint U.S.- Canada index.

2. Materials and methods

The U.S. pelagic longline fishery has three different sources of catch and effort information:

Dealer Landings System: this is the longest time series of information but with the most limited amount of information on factors related to gear or targeting. This data consists of information collected at the time of landing of the fish. Vessels are required to submit weigh-out sheets for each trip, which include individual carcass weights for swordfish and other pelagic species landed and marketed in the U.S. This data system is called the Dealer Landings System (DLS). The DLS database contains information from the early 1960's (limited data) to the present. Prior to 1986, effort (hooks, days fished, number of sets) information was recorded from personal vessel logbooks voluntarily submitted by vessel captains/owners. Beginning in 1986, all pelagic longline vessels that actively fished were required to submit daily logbook set records for each trip. Based upon this information, fishing effort is determined and, subsequently, added to the longline database.

Pelagic logbook: This database spans 1986-the present and consists of set by set catch and effort data with substantial ancillary variables. An index with this dataset was originally considered by the authors, but due to under-reporting of discards after the 1991 size limits were adopted, the index showed substantial and uncorrectable biases related to under reporting of small fish. Reporting areas for the US pelagic longline are shown in **Figure 1**.

Pelagic observer program. The Pelagic longline fleet has also an observer program, established in 1992 that monitored the fishing activities of the fleet, recording detailed information on fishing operations, gear characteristics and deployment, environmental related conditions and biological information from all longline catch (Lee and Brown 1998).This database spans 1992-the present and has the most comprehensive recording of catch, effort and ancillary information but the smallest sample sizes and represents only a subsample of the fleet effort. A separate index from this dataset (Lauretta *et al*. 2013) has been constructed for the current assessment.

Canadian longline data comes from catch and effort data for the Canadian swordfish longline fishery were obtained from mandatory logbook submissions beginning in 1994; with voluntary submissions prior to 1994. The database provides information about each species caught, such as total weight3, number of fish caught, type and size of hook used, type of bait, surface temperature and effort (number of hooks) for each set but were aggregated to trip level. For further details of the processing of trips see Andrushenko *et al.* 2013.

For the Canadian dataset hook type was available for many of the trips and the gradual phase in of circle hooks provides contrast to estimate a hook type effect when combined with the U.S. pelagic longline fishery. Bait type data was available for 88.3% of set-level data and 93.4% of trip-level data from 2002 to 2012, and 100% of the data from 1988 to 2001.Data on the number of swordfish caught was available for 98.9% of the trip-level data. A large proportion of the missing data (56 of the 82 missing trips) occurred in 2003. Swordfish weight data is provided by dockside

Spatial overlap of the US and Canadian longline fleets over all years (**Figure 2**) and by year (**Figure 3**) indicate the spatial and temporal distribution of fishing effort by the two fleets. Nominal CPUE in the areas of overlap (NED, NEC and MAB) provide some comparison of the relative catch rates of the two fleets and of the trends in nominal CPUE in overlapping areas (Figure 4). Plots of nominal CPUE in weight (**Figure 5**), proportion positive (**Figure 6**) and number (**Figure 7**) by year and area show trends for the combined datasets by area.

Regulatory and other impacts

Implementation of U.S. regulations, in conformity with the ICCAT recommendations and other domestic requirements, limit the allowable landings of swordfish by U.S. fishers, resulting in changes in both the type of data obtained and in the protocols in which the data are used for analysis. Regulatory norms that affect the present analysis include: a) the implementation(s) of the minimum size of 125 cm LJFL with a 15% tolerance in mid 1991, subsequently modified to 119 cm LJFL with 0% tolerance in mid 1996; b) the implementation of a total annual allowable catch (TAC) since 1995; and c) time-area closures that were in effect since late 1999 due to management regulations related to swordfish and or other species. These time-area restrictions include two permanent closures to pelagic longline; the Desoto Canyon in the Gulf of Mexico (effective since November 1st 2000) and the Florida east coast (effective since March 1st 2001) (**Figure 1**). There are also three time-area closures for longline in the U.S. Atlantic coast: the Charleston Bump that is closed from February 1st to April 30th, effective in 2001, the Bluefin tuna protection area that is closed from June 1st to June 30th, effective in 1999, and the Grand Banks that was closed from July 17th 2001 to January 9th 2002, as a result of an emergency rule implementation (Cramer 2002). The use of circle hooks became mandatory in 2004 and hooks with a weaker bending strength were made mandatory in the Gulf of Mexico in 2011. However, experiments conducted with both hook types have found non-significant changes in swordfish catch rates with the weak hooks (Foster 2012).

Canadian Regulations allowing only landings of fish above 125 cm with 15% tolerance was introduced in May of 1994. The following minimum sizes were in effect:

1994 - assumed to be same as 1995 to conform with Regulations (125cm with 15%)
1995 - 125 cm total length (79 cm dressed length allowed) with 15% tolerance
1996 - 1999: the size limit was varied through licence conditions to the 119 cm total length (73 cm dressed length) with no tolerance option (could not confirm 1998 but with 97 and 99 same it appears to be a reasonable assumption).
2000 - 2003: the 119 cm with no tolerance option was in licence conditions but also added a 33lb dressed weight so some tolerance was included.
2004 - present: the 125cm total length (or 79cm dressed length) with 15% tolerance but a 38lb dressed weight was also included

But as the Canadian fleet lands few undersized swordfish their catch rates are likely comparable to the U.S. landings of fish greater than 33 lbs.

Dependent variables: The dependent variables considered were the catch per 1000 hooks of swordfish greater than 33lbs from the U.S. fishery in number and weight and the catch per 1000 hooks of all swordfish from the Canadian fleet as they rarely land small fish. The dependent variable applies only to *landed* fish summed at the level of a trip divided by total hooks set on the trip.

As per recommendation of the SCRS, a swordfish biomass index was estimated using the Dealer Landings system. This biomass index was restricted to fish ≥ 13 kg (due to size-weight restrictions implemented in 1991) and estimated as total pounds landed per thousand hooks.

Data exclusions

Exclusions. Data exclusions for the U.S. DLS dataset matched decisions made for Ortiz (2009). They included:

1. Incomplete data records,
2. Records where the total weight on a trip was missing or zero
3. Vessel op codes 1 and 3 which have very few vessels
4. Records with no area location
5. Records for which the source could not be verified (SRC=N,T,R, or T)
6. Trips that occurred in closed areas prior to the closures

Due to implementation of time-area closures on pelagic longline fishing within U.S. EEZ waters, trips that occurred in closed areas prior to the closures were removed from the dataset to create a continuous time series. However, only trips after 1996 could be excluded so the pre-1996 U.S. dataset could be contaminated by trips in areas such as the Florida Straits or Desoto canyons, traditional areas where smaller swordfish were captured. The removal of trips from closed areas before and after resulted in a substantial number of trips being excluded. One exception to this rule was for the NED area where observations were kept in the models.

Model factors

Year- categorical factor 1962-2011, or subsets thereof.

Area- The longline fishing grounds of the U.S. fleet extend from the Grand Banks in the North Atlantic to 5°-10° latitude south, off the South America coast, including the Caribbean and the Gulf of Mexico. Eight geographical areas have been defined for spatial classification of this fishery (**Figure 1**). These include: the Caribbean (CAR, area 1), Gulf of Mexico (GOM, area 2), Florida East coast (FEC, area 3), South-Atlantic Bight (SAB, area 4), Mid-Atlantic Bight (MAB, area 5), New England coastal (NEC, area 6), Northeast Distant waters (NED, area 7) and the Southern offshore (OFS, area 8). Trimesters were used to account for seasonal fishery distribution through the year (Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Dec). Canadian data was assigned to either the MAB, NEC or NED depending upon where the observations came from.

Quarter- seasonal category (Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec)

Operations code- The U.S. longline pelagic fleet has changed in terms of gear technology and fishery operations, Hoey *et al.* (1988) characterized the swordfish fleet into nine different vessel-groups based on boat size-power and fishing operations. This classificatory factor (OP) has shown to be an important explanatory variable of several species catch rates including swordfish (Ortiz and Cramer 2000). Vessels which missing an ops code were given a value of 0. This is an increasing fraction of the fleet as newer vessels have not been classified.

Targeting- Swordfish one of the main target species of the U.S. pelagic longline fleet; this fleet also targets tunas (yellowfin, and bigeye tuna) and to a lesser extends other pelagic species including sharks. In the 2009 paper a proxy (*TargSWO*) for targeted species was defined based on the proportion of swordfish catch to total catch per trip and grouped into categories, corresponding to the quartiles 0-25%, 25-50%, 50-75%, and 75-100%. This target variable was assumed to control for effects on swordfish catch rates associated with the diverse species targeted by the fleet.

In this paper we explore an alternative to using a function of swordfish catch to define targeting by using a categorical variable obtained from the summed catch rates of other key species that are generally negatively associated with swordfish (*TargKey*). The variable is obtained by calculating:

Catch rate of key species= $\left[1000 * \frac{sum(yft+bet+bft)}{hooks}\right]$
and then determining partitions of this catch rate that clearly separate catch rates of swordfish. These partitions then represent categories of the catch rate of other key species. The process is illustrated in Results section. It is analogous to the process of splitting the *TargSWO* into quartiles, but the difference is that the quantiles are not arbitrary partitions of the data but are informed based upon partitions that result in relatively homogenous catch rates of swordfish.

Gear characteristics (only available for the DLS records from 1996-forward) Hooks between floats, light sticks, temperature. Other factors included in the analyses of catch rates included; the use and number of light-sticks (lightc) expressed as a categorical variable obtained from the ratio of light-sticks per hook (0,0.4,0.7,1), hooks between floats (HBFL2) expressed as a categorical variable obtained from the hooks/floats with four categories [0,2] (2,3] (3,5] (5,10] (10,100] or the numbers of hooks between floats which alters the depth of the hooks, modeled as a categorical factor.

Fishing effort is reported as total number of hooks per trip. Prior to 1986, effort (hooks, days fished, number of sets) information was recorded from personal vessel logbooks voluntarily submitted by vessel captains/owners. Beginning in 1986, all pelagic longline vessels that actively fished were required to submit daily logbook set records for each trip. Based upon this information, fishing effort is determined and, subsequently, added to the Dealer Landing System database. Nominal catch rates were calculated as numbers or weight of swordfish caught per 1000 hooks. Starting in 1996, individual DLS records could be linked automatically to logbook reports which allowed for more precise determination of other gear factors that might affect catchability commonly used such as hooks between floats, light sticks and surface water temperature. For this reason we have split the indices prior to 1996 so that the 1996-2012 account for targeting factors averaged for all sets within a trip.

Modeling and model fitting

A stepwise approach was used to quantify the relative importance of the main factors explaining the variance in catch rates. That is, first the Null model was run, in which no factors were entered in the model (intercept only model). These results reflect the distribution of the nominal data. Each potential factor was then tested iteratively. The results were ranked from greatest to least reduction in deviance per degree of freedom when compared to the Null model. The factor which resulted in the greatest reduction in deviance per degree of freedom was then incorporated into the model, provided two conditions were met: 1) the effect of the factor was determined to be significant at the 5% probability based upon a Chi-Square test, and 2) the deviance per degree of freedom was reduced by at least 1% from the less complex model. This process was repeated, adding factors one at a time at each step, until no factor met the criteria for incorporation into the final model or the model demonstrated a lack of convergence. Note that models with two-way factor interactions demonstrated a lack of convergence.

Relative indices of abundance were estimated by Generalized Linear Modeling approach assuming a delta lognormal model distribution. The standardization protocols assumed a delta lognormal model with a binomial error distribution for modeling the proportion of positive sets, and a lognormal error distribution for modeling the mean catch rate of successful (i.e. positive swordfish catch) sets. Parameterization of the models used the GLM structure; for the proportion of successful sets per stratum is assume to follow a binomial distribution where the estimated probability is a linear function of fixed factors and interactions. The logit function was used as a link between the linear factor component and the binomial error. For successful sets, estimated CPUE rates assumed a lognormal distribution of a linear function of fixed and random effect interactions when the *year* term was in the interaction. All models were run in SAS.

A step-wise regression procedure was used to determine the set of systematic factors and interactions that explained the observed variability. Variables were allowed to enter the model in a stepwise manner and the one reducing the greatest amount of deviance per degree of freedom was retained until no remaining factor reduced the deviance by more than 1%. Once the suite of single effect factors was chosen a set of two-way interactions were determined in the same manner. All interactions were modeled as random effects. LSmeans estimates were weighted proportional to observed margins in the input data, and, for the lognormal estimates, a log-back transformed bias corrections was applied (Lo *et al.* 1992).

Indices

Four indices were constructed for consideration:

1. USCPUEW1986-2011 – This index uses DLS data from 1986, starting at a time when the DLS logbook reporting became mandatory and when DLS began recording all trips and all species rather than just swordfish.
2. USCPUEW 1996-2011 This model is split to a time period with complete reporting of effort and the ability to link DLS data with logbook data to use gear targeting variables.
3. USCPUEN1986-2011. This is to obtain an index in number, it uses that same binomial component as INDEX
4. USCPUEW from DLS 1982-2011: Strict update of the 2009 index using the fraction of SWO/total catch- this index uses the same model with updated data as Ortiz (2009)

3. Results

Nominal catch rates by area and fleet

Visual description of nominal CPUE and proportion positive show some coherence between the U.S. and Canadian CPUE (**Figure 4**). Furthermore, plots of nominal CPUE in wt (**Figure 5**), proportion positive sets (**Figure 6** and CPUE in number (**Figure 7**) show the appearance of some effects due to regulatory measures (plotted as vertical lines on the graphs) and some divergent trends between areas with generally increasing trends in northern areas (NEC, NED) and decreasing in other, southern areas. Furthermore the nominal CPUE indicate very high catch rates in the early time periods for which reporting for both the Canadian and U.S. fisheries was voluntary. Where the two fleets overlap the absolute levels of the catch rates are quite similar.

Development of the TargKey as a factor

Figure 8 shows the development of the categorical variable using the catch rate of key species. To evaluate the use of TargKey as a model factor we compared an index derived from the US PLOP observer data using TargKey as a model factor (blue line in **Figure 9**) and an index calculated using targeting based on gear and fishing characteristics (red line in **Figure 9**). Note that this is not exactly the same observer CPUE index as presented in Lauretta et al (2013) but is used here for illustrative purposes. The correlation between the two index constructions was high indicating that the key species CPUE might serve as a fairly effective proxy for swordfish targeting, when gear characteristics are not available. We then applied the same analytical process to the dealer landing system datasets. There was a negative correlation between swordfish and yellowfin and between swordfish and non-mako sharks (shw) and other species (dolphin, wahoo, blackfin, skipjack and bonito). Based upon visual observation of the different bins we proposed using the 4 bins shown in **Figure 8**.

Models and indices

Index 1 (**Figure 10**):
SUCCESS ~ YEAR OP TARGKEY AREA QTR *YEAR*AREA YEAR*OP AREA*QTR*
LGCPUEW ~ YEAR OP TARGKEY AREA QTR *YEAR*AREA YEAR*OP YEAR*TARGKEY AREA*QTR*
Index 1 did not converge with interactions and ultimately had to be reduced to:
SUCCESS ~ YEAR OP
LGCPUEW ~ YEAR OP TARGKEY AREA QTR *YEAR*AREA YEAR*OP YEAR*TARGKEY AREA*QTR*

This index has fairly well-behaved diagnostics (**Figure 11**) and appears to diverge from the nominal in both the early and late time period.

Index 2 (**Figure 12**):
SUCCESS ~ YEAR lghtc HBFLcut ;
LGCPUEW ~ YEAR LGHTC HBFLcut area qtr op year *YEAR*AREA YEAR*OP year*LGHTC*
This index also has fairly well-behaved diagnostics (**Figure 13**)
Index 5: LGCPUEW ~ YEAR area target hooktype

Index 3 Same model factors used as for the index in weight (**index 2**, **Figure 14**)
SUCCESS ~ YEAR lghtc HBFLcut ;
LGCPUEN ~ YEAR LGHTC HBFLcut area qtr op year *YEAR*AREA YEAR*OP year*LGHTC*
This index also has fairly well-behaved diagnostics (**Figure 15**)

Index 4 (**Figure 16**: Model factors not refit from Ortiz 2009 paper.
Model diagnostics indicate a rather poor q-q plot (**Figure 17**) and that the model estimated proportion positive does not reflect the observed. The index is very similar to the Ortiz 2009 index in the overlapping years but it differs in the more recent years as we have added the trips from the NED areas.

US DLS indices

The U.S. DLS indices show a steep decline starting in either 1982 (Index 4) or 1986 (Index 1) which is slightly moderated from the nominal by the standardization but nonetheless may be due, in part, to the biases in the early part of the DLS towards only recording swordfish trips and then an incomplete recording of effort in the early years. In the recent years the indices show a slight increase in divergence from the nominal indicating a slight population increase not seen with the nominal indices likely indicative of lack of targeting by the longline fleet. When combined and plotted on the same relative scale (**Figure 17**), the indices all show a steep decline from the earliest years, with the relatively low and stable values for the 1996-2006 time period, at least relative to the earlier high values. All index construction show low values in 2010 but not as low as the observer indices from Lauretta *et al.* (2013) which may be due to declines in catches of smaller fish.

When comparing the Model 1 using catch rate of key species versus model 2 which uses the actual gear characteristics (**Figure 18**), over the same time period, the correlation was 0.67 and they both have similar trends. In contrast the correlation for the index based on SWO/total catch (index 4) had a correlation of only 0.27 with index 2 indicating that, at least for this time period of overlap (1996-2011) it did not correlate well with the more preferred method of dealing with targeting based on gear characteristics (index 2).

Discussion

The combined U.S.-Canada index was not completed for the meeting. The results of the combined US-Canada index are promising and may be useful for further analyses, particularly for estimating a circle hook effect which may be very useful for standardizing the US observer indices. Examination of the nominal trends are quite informative, however. There is a clear latitudinal differentiation in the catch rates with a general pattern of increasing CPUE in the north. Taken in conjunction with the direction of several known biases (circle hooks, which tend to decrease CPUE when used with squid bait, Foster et al 2012) and the trend of the standardized indices for Canada increasing faster than the nominal (Andrushenko *et al.* 2013) we can interpret these trends as likely to be steeper increases than observed in the nominal plots. The general coherence between the US and the Canadian indices in the NED (where both fleets can generally overlap in fishing) and the NEC (where the slight divergence may be due to the fact that the US is excluded from productive Canadian waters indicate that divergence in trends between the overall US and Canadian indices may have a latitudinal pattern indicative of potential movement of the fish.

The US DLS index was not chosen for inclusion in the models over the Observer index (Lauretta *et al.* 2013) as neither method of dealing with targeting appeared entirely satisfactory. Further research is needed to determine the best proxy for dealing with targeting which might recover an unbiased time series for the DLS dataset. It is also recommended that the operations code be updated for all current vessels in the fishery and perhaps also in the Canadian fishery.

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Table 1. Observations by year and fleet.

	USA			Canada		
YEAR	N trips	CPUE wt (lbs/1000 hooks) USA	Prop Pos	N trips	CPUE wt lbs/1000 hooks CAN	Prop Pos
1962	1	2513.6	100%	11	5940.6	100%
1963	2	7154.1	100%	104	7564.9	100%
1964	5	1387.2	100%	252	2666.3	100%
1970	11	1735.0	100%	197	1681.8	100%
1979	744	3951.1	99%	201	1680.7	100%
1980	1071	2456.1	100%	214	2103.2	100%
1981	72	4317.9	99%	296	1446.1	100%
1982	98	3657.0	100%	270	1354.3	100%
1983	142	2108.0	99%	182	1629.8	100%
1984	166	1833.0	99%	39	2774.4	100%
1985	185	1997.4	99%	75	2482.6	100%
1986	347	1499.4	94%	36	1997.0	100%
1987	833	1217.4	95%	34	1762.8	100%
1988	1139	1217.2	91%	30	1602.0	100%
1989	883	1112.1	93%	33	978.8	100%
1990	915	1006.1	91%	34	1372.3	100%
1991	1376	830.1	87%	30	2387.7	100%
1992	1894	693.3	90%	35	1244.2	100%
1993	2195	636.7	86%	36	1173.3	100%
1994	2325	629.4	81%	44	1252.7	100%
1995	2482	600.4	81%	45	2016.7	100%
1996	1965	491.5	78%	117	1407.8	100%
1997	2080	564.4	81%	117	1380.5	100%
1998	1687	629.2	87%	218	1101.0	100%
1999	1640	592.5	84%	427	901.2	100%
2000	1672	505.3	83%	405	977.7	100%
2001	1731	452.6	83%	330	572.8	100%
2002	1653	575.0	83%	272	833.3	100%
2003	1615	631.2	83%	210	1196.5	100%
2004	1675	608.2	81%	202	1493.6	100%
2005	1354	579.7	84%	187	1105.8	100%
2006	1305	559.3	85%	234	1694.3	100%
2007	1561	546.0	85%	217	1981.0	100%
2008	1408	513.2	88%	195	1789.5	100%
2009	1430	572.7	89%	239	1583.5	99%
2010	1315	541.5	89%	239	1959.9	100%
2011	1307	572.5	91%	258	1810.1	100%
2007	1271	401.1	83%	209	1601.6	100%
2008	1084	385.2	86%	165	2148.5	100%
2009	1169	469.2	87%	153	2830.1	100%
2010	964	498.5	88%	178	3022.8	100%
2011	1017	491.0	90%	178	2724.6	99%

Table 2. Table of sample sizes and percent positive by area and year, Canada and U.S. combined

	Sample size								Percent positive							
	CAR	FEC	GOM	MAB	NEC	NED	SAB	SAR	CAR	FEC	GOM	MAB	NEC	NED	SAB	SAR
1962	NA	NA	NA	NA	1	11	NA	NA	NA	NA	NA	NA	100%	100%	NA	NA
1963	NA	NA	NA	12	46	48	NA	NA	NA	NA	NA	100%	100%	100%	NA	NA
1964	NA	NA	NA	22	120	67	NA	NA	NA	NA	NA	100%	100%	100%	NA	NA
1965	NA	NA	NA	32	110	51	1	NA	NA	NA	NA	100%	100%	100%	100%	NA
1966	NA	NA	NA	7	125	69	NA	NA	NA	NA	NA	100%	100%	100%	NA	NA
1967	NA	NA	NA	17	96	99	2	NA	NA	NA	NA	100%	100%	100%	100%	NA
1968	NA	NA	NA	48	179	69	NA	NA	NA	NA	NA	100%	100%	100%	NA	NA
1969	NA	NA	NA	28	180	62	NA	NA	NA	NA	NA	100%	100%	100%	NA	NA
1970	NA	NA	11	22	79	81	NA	NA	NA	NA	100%	100%	100%	100%	NA	NA
1979	NA	743	NA	NA	NA	1	NA	NA	NA	99%	NA	NA	NA	100%	NA	NA
1980	NA	1070	NA	1	NA	NA	NA	NA	NA	100%	NA	100%	NA	NA	NA	NA
1981	NA	53	NA	16	NA	NA	3	NA	NA	98%	NA	100%	NA	NA	100%	NA
1982	NA	29	1	53	3	NA	12	NA	NA	100%	100%	100%	100%	NA	100%	NA
1983	NA	26	6	81	9	3	18	NA	NA	100%	100%	98%	100%	100%	100%	NA
1984	NA	76	5	52	14	11	8	NA	NA	97%	100%	100%	100%	100%	100%	NA
1985	11	60	48	33	13	16	4	NA	100%	100%	98%	100%	100%	100%	100%	NA
1986	42	119	56	77	16	18	19	NA	100%	98%	79%	94%	94%	100%	100%	NA
1987	136	350	116	136	35	27	33	NA	97%	99%	74%	96%	100%	100%	100%	NA
1988	190	452	246	110	9	57	75	NA	100%	99%	62%	99%	100%	100%	100%	NA
1989	85	332	217	111	21	66	51	NA	98%	99%	76%	98%	100%	100%	100%	NA
1990	63	281	243	160	30	46	92	NA	100%	99%	73%	96%	100%	100%	95%	NA
1991	72	393	489	279	43	49	51	NA	99%	99%	69%	93%	95%	100%	96%	NA
1992	96	536	628	296	161	67	110	NA	99%	99%	76%	91%	94%	100%	99%	NA
1993	160	518	671	374	400	106	171	NA	98%	100%	71%	78%	94%	100%	99%	NA
1994	179	560	659	555	416	152	210	NA	99%	99%	60%	73%	96%	100%	97%	NA
1995	217	516	703	540	531	138	240	NA	94%	97%	73%	66%	95%	100%	85%	NA
1996	150	117	683	307	289	115	75	106	100%	95%	73%	58%	93%	100%	65%	98%
1997	144	221	716	324	306	46	62	112	100%	98%	77%	63%	98%	100%	55%	97%
1998	80	186	599	274	205	55	49	60	100%	100%	77%	87%	99%	100%	80%	98%
1999	45	111	643	285	191	61	25	40	100%	99%	81%	75%	98%	100%	80%	100%
2000	46	151	693	312	165	61	27	19	100%	100%	80%	67%	99%	100%	74%	100%
2001	40	145	681	343	245	68	50	33	100%	97%	78%	70%	100%	100%	80%	94%
2002	48	155	714	293	265	32	52	37	100%	99%	77%	75%	99%	100%	75%	100%
2003	31	148	787	209	218	35	60	36	100%	99%	78%	72%	99%	100%	65%	100%
2004	43	110	869	259	263	36	53	25	100%	100%	74%	77%	99%	100%	79%	100%
2005	23	106	581	267	233	50	47	39	100%	100%	80%	75%	100%	100%	79%	56%
2006	12	111	445	358	273	37	43	48	100%	99%	85%	77%	100%	100%	74%	71%
2007	8	133	564	424	205	42	63	41	88%	97%	83%	85%	98%	100%	57%	34%
2008	13	195	389	312	210	24	65	41	100%	98%	86%	81%	98%	100%	80%	56%
2009	7	229	455	298	178	31	82	42	100%	99%	91%	78%	100%	100%	83%	43%
2010	13	306	187	253	226	14	94	48	92%	99%	88%	78%	99%	100%	91%	50%
2011	2	303	227	274	215	20	98	52	100%	100%	87%	85%	100%	95%	95%	50%

Table 3. Canada and United States pelagic longline number of trips per region and year.

	CANADA					*UNITED STATES*							
Year	***MAB***	***NEC***	***NED***	***SAB***	***UNK***	***CAR***	***FEC***	***GOM***	***MAB***	***NEC***	***NED***	***SAB***	***SAR***
1962			11							1			
1963	12	44	48							2			
1964	22	115	67		48					5			
1965	32	110	51	1	3								
1966	7	125	69										
1967	17	96	99	2									
1968	48	179	69										
1969	28	180	62										
1970	22	79	81					11					
1979					39		743				1		
1980					75		1070		1				
1981					36		53		16			3	
1982					34		29	1	53	3		12	
1983		1			29		26	6	81	8	3	18	
1984					33		76	5	52	14	11	8	
1985					34	11	60	48	33	13	16	4	
1986					30	42	119	56	77	16	18	19	
1987					35	136	350	116	136	35	27	33	
1988					36	190	452	246	110	9	57	75	
1989					44	85	332	217	111	21	66	51	
1990					45	63	281	243	160	30	46	92	
1991					117	72	393	489	279	43	49	51	
1992					117	96	536	628	296	161	67	110	
1993		166	39		13	160	518	671	374	234	67	171	
1994		310	96		21	179	560	659	555	106	56	210	
1995		313	90		2	217	516	703	540	218	48	240	
1996		213	114		3	150	137	683	385	145	46	313	106
1997		226	45		1	144	238	718	409	163	46	248	114
1998		148	55		7	80	202	600	355	131	37	222	60
1999		139	61		2	45	132	645	429	112	30	206	41
2000		125	61		1	46	172	698	410	110	40	177	19
2001		164	65		5	40	170	681	436	144	31	194	35
2002		187	30			48	166	714	376	106	34	172	37
2003		160	34		1	31	163	787	277	86	40	195	36
2004		197	34		8	43	116	869	307	83	36	196	25
2005		190	48		1	23	116	582	317	73	36	168	39
2006		226	32			12	111	445	431	74	30	154	48
2007		168	41			8	143	564	487	64	25	229	41
2008		141	24			13	214	389	428	97	21	205	41
2009		125	28			7	235	455	392	81	26	191	43
2010		164	13		1	13	316	187	390	109	21	230	49
2011		154	20		4	2	308	237	368	95	19	226	52

Table 4. Canada and United States pelagic longline trips per season and year within the Northeast Coastal and Northeast Distant Waters, 1993 to 2011.

	CAN				*USA*			
Year	***Jan-Mar***	***Apr-Jun***	***Jul-Sep***	***Oct-Dec***	***Jan-Mar***	***Apr-Jun***	***Jul-Sep***	***Oct-Dec***
1993	0	26	151	28	0	36	182	83
1994	0	26	313	67	0	20	90	52
1995	0	20	322	61	1	17	146	102
1996	0	15	281	31	0	10	129	52
1997	0	26	233	12	3	10	137	59
1998	0	20	167	16	0	9	109	50
1999	0	39	161	0	0	9	93	40
2000	0	32	154	0	1	13	101	35
2001	0	44	185	0	2	20	109	44
2002	0	40	157	20	4	18	87	31
2003	0	15	140	39	0	13	73	40
2004	0	10	177	44	0	6	77	36
2005	0	15	188	35	0	11	66	32
2006	0	27	195	36	0	10	62	32
2007	0	23	158	28	0	5	66	18
2008	0	18	133	14	0	12	66	40
2009	0	21	115	17	0	12	58	37
2010	0	19	129	29	0	15	92	23
2011	0	19	129	26	0	19	75	20

Table 5 a) Generalized linear model selection criteria for the proportion positive observations of CPUE in weight for index 1 U.S. Pelagic longline DLS 1986-2011. Significant factors are in yellow. The final model did not converge with any interactions or with area or quarter so these were removed from the binomial component. The same model structure is used for INDEX 6, calculated in weight.

Proportion positive
There are no explanatory factors in the base model.

FACTOR	*DEGF*	*DEVIANCE*	*DEV/DF*	*% REDUCTION*	*LOGLIKE*	*CHISQ*	*PROBCHISQ*	
BASE	34551	4578	0.1325	-14108.9				
OP	34544	4201.3	0.1216	8.21	-12625.5	2966.79	0	
AREA	34512	4062.9	0.1177	1.73	-12046.7	611.64	0	DNC
QTR	34509	4008.1	0.1161	1.34	-11812.2	468.98	0	DNC
TARGKEY	34508	4036.1	0.117	0.65	-11932.3	228.7	0	
YEAR*AREA	34349	3849.6	0.1121	3.51	-11115.2	1393.99	0	DNC
YEAR*OP	34176	3775.6	0.1105	1.43	-10779.6	671.13	0	DNC
AREA*QTR	34155	3722.3	0.109	1.35	-10534.3	490.66	0	DNC
YEAR*QTR	34101	3749.3	0.1099	0.48	-10659.2	240.93	0	

b) Generalized linear model selection criteria for the positive catch observations of CPUE in weight for index 1 U.S. Pelagic longline DLS 1986-2011. Significant factors are in yellow.

Lognormal

The explanatory factors in the base model are: YEAR

FACTOR	*DEGF*	*DEVIANCE*	*DEV/DF*	*%REDUCTION*	*LOGLIKE*	*CHISQ*	*PROBCHISQ*
BASE	29094	55885.1	1.9208		-50810.7		
OP	29087	41136.2	1.4142	26.37	-46349.4	8922.65	0
TARGKEY	29084	37983.4	1.306	7.65	-45188.4	2321.99	0
AREA	29077	35820	1.2319	5.67	-44334.6	1707.71	0
QTR	29074	34945.9	1.202	2.43	-43974.9	719.42	0
YEAR*AREA	28914	32835.7	1.1356	5.52	-43068	1813.74	0
YEAR*OP	28741	31837.6	1.1077	2.46	-42618.6	898.85	0
YEAR*TARGKEY	28666	31198.3	1.0883	1.75	-42323.2	590.71	0
AREA*QTR	28645	30725.7	1.0726	1.44	-42101	444.47	0
YEAR*QTR	28570	30363.1	1.0628	0.92	-41928.1	345.65	0

c) Table of parameter estimates for binomial component.

Solution for Fixed Effects

Effect	***op***	***year***	***Estimate***	***Standard Error***	***DF***	***t Value***	***Pr > |t|***	***Alpha***	***Lower***	***Upper***
Intercept			4.2563	0.2093	6126	20.34	<.0001	0.05	3.8461	4.6665
year		1986	-0.282	0.3856	6126	-0.73	0.4647	0.05	-1.038	0.474
year		1987	0.00782	0.2853	6126	0.03	0.9781	0.05	-0.5515	0.5672
year		1988	-0.5332	0.2262	6126	-2.36	0.0185	0.05	-0.9767	-0.0897
year		1989	-0.1277	0.2583	6126	-0.49	0.621	0.05	-0.6342	0.3787
year		1990	-0.5176	0.2401	6126	-2.16	0.0312	0.05	-0.9883	-0.0468
year		1991	-0.9197	0.2009	6126	-4.58	<.0001	0.05	-1.3136	-0.5258
year		1992	-0.6798	0.1968	6126	-3.45	0.0006	0.05	-1.0655	-0.2941
year		1993	-1.0186	0.1856	6126	-5.49	<.0001	0.05	-1.3824	-0.6547
year		1994	-1.405	0.1798	6126	-7.81	<.0001	0.05	-1.7575	-1.0526
year		1995	-1.3305	0.1784	6126	-7.46	<.0001	0.05	-1.6802	-0.9808
year		1996	-1.5432	0.185	6126	-8.34	<.0001	0.05	-1.9059	-1.1805
year		1997	-1.3209	0.1862	6126	-7.09	<.0001	0.05	-1.6859	-0.956
year		1998	-0.8038	0.1993	6126	-4.03	<.0001	0.05	-1.1945	-0.4131
year		1999	-0.8865	0.1976	6126	-4.49	<.0001	0.05	-1.2739	-0.4991
year		2000	-0.9807	0.1921	6126	-5.1	<.0001	0.05	-1.3573	-0.604
year		2001	-1.0022	0.1894	6126	-5.29	<.0001	0.05	-1.3735	-0.6309
year		2002	-0.9102	0.1899	6126	-4.79	<.0001	0.05	-1.2825	-0.5378
year		2003	-0.8884	0.1899	6126	-4.68	<.0001	0.05	-1.2607	-0.5162
year		2004	-0.9834	0.1861	6126	-5.28	<.0001	0.05	-1.3483	-0.6186
year		2005	-0.7985	0.196	6126	-4.07	<.0001	0.05	-1.1827	-0.4143
year		2006	-0.5538	0.2002	6126	-2.77	0.0057	0.05	-0.9463	-0.1613
year		2007	-0.5373	0.1922	6126	-2.8	0.0052	0.05	-0.914	-0.1606
year		2008	-0.4054	0.2055	6126	-1.97	0.0486	0.05	-0.8083	-0.0025
year		2009	-0.2691	0.2048	6126	-1.31	0.1889	0.05	-0.6706	0.1324
year		2010	-0.3078	0.2163	6126	-1.42	0.1547	0.05	-0.7317	0.1161
year		2011	0	.	.	.	.	.	.	.
op	0		-2.6358	0.1443	6126	-18.26	<.0001	0.05	-2.9188	-2.3528
op	2		0.6063	0.2798	6126	2.17	0.0303	0.05	0.05777	1.1548
op	4		-1.5092	0.1475	6126	-10.23	<.0001	0.05	-1.7983	-1.22
op	5		-1.2211	0.1592	6126	-7.67	<.0001	0.05	-1.5332	-0.9091
op	6		0.1615	0.1823	6126	0.89	0.3756	0.05	-0.1958	0.5188
op	7		-2.4087	0.1588	6126	-15.17	<.0001	0.05	-2.7201	-2.0974
op	8		-2.1697	0.1446	6126	-15.01	<.0001	0.05	-2.453	-1.8863

d) Table of parameter estimates for lognormal component.

Solution for Fixed Effects

Effect	*area*	*TargKey*	*op*	*year*	*qtr*	*Estimate*	*Standard Error*	*DF*	*t Value*	*Pr > |t|*	*Alpha*	*Lower*	*Upper*
Intercept						6.5759	0.2731	21	24.08	<.0001	0.05	6.008	7.1439
area	CAR					0.3186	0.2094	21	1.52	0.1431	0.05	-0.117	0.7542
area	FEC					-0.086	0.2064	21	-0.42	0.6823	0.05	-0.515	0.3436
area	GOM					-0.826	0.2064	21	-4	0.0006	0.05	-1.256	-0.397
area	MAB					-0.551	0.2064	21	-2.67	0.0144	0.05	-0.98	-0.121
area	NEC					-0.258	0.2142	21	-1.2	0.242	0.05	-0.703	0.1876
area	NED					0.7631	0.2417	21	3.16	0.0048	0.05	0.2604	1.2658
area	SAB					-0.345	0.208	21	-1.66	0.112	0.05	-0.778	0.0875
area	SAR					0	.	.	.	.	.	.	.
year				1986		0.6168	0.2976	75	2.07	0.0417	0.05	0.0239	1.2097
year				1987		0.4316	0.2921	75	1.48	0.1437	0.05	-0.15	1.0134
year				1988		0.4799	0.2913	75	1.65	0.1036	0.05	-0.1	1.0601
year				1989		0.3908	0.2906	75	1.34	0.1828	0.05	-0.188	0.9698
year				1990		0.2573	0.2907	75	0.89	0.379	0.05	-0.322	0.8364
year				1991		0.0886	0.2895	75	0.31	0.7603	0.05	-0.488	0.6653
year				1992		-0.044	0.2877	75	-0.15	0.8781	0.05	-0.618	0.5289
year				1993		-0.248	0.2873	75	-0.86	0.3903	0.05	-0.821	0.3241
year				1994		-0.389	0.2875	75	-1.35	0.1805	0.05	-0.961	0.1841
year				1995		-0.423	0.2874	75	-1.47	0.1455	0.05	-0.995	0.1497
year				1996		-0.584	0.2872	75	-2.03	0.0457	0.05	-1.156	-0.012
year				1997		-0.381	0.2873	75	-1.33	0.1886	0.05	-0.953	0.1912
year				1998		-0.231	0.2881	75	-0.8	0.4255	0.05	-0.805	0.3431
year				1999		0.0266	0.2908	75	0.09	0.9273	0.05	-0.553	0.6059
year				2000		-0.009	0.2915	75	-0.03	0.9761	0.05	-0.589	0.5719
year				2001		-0.208	0.2877	75	-0.72	0.4715	0.05	-0.781	0.3649
year				2002		-0.055	0.2879	75	-0.19	0.8497	0.05	-0.628	0.5188
year				2003		0.0607	0.2889	75	0.21	0.8341	0.05	-0.515	0.6362
year				2004		-0.255	0.289	75	-0.88	0.3797	0.05	-0.831	0.3203
year				2005		-0.131	0.2903	75	-0.45	0.6527	0.05	-0.71	0.4472
year				2006		-0.295	0.291	75	-1.01	0.3138	0.05	-0.875	0.2846
year				2007		0.0557	0.2942	75	0.19	0.8504	0.05	-0.53	0.6417
year				2008		-0.229	0.2918	75	-0.79	0.4343	0.05	-0.811	0.3519
year				2009		-0.004	0.2911	75	-0.01	0.9894	0.05	-0.584	0.576
year				2010		-0.17	0.2905	75	-0.58	0.5605	0.05	-0.749	0.4089
year				2011		0	.	.	.	.	.	.	.
qtr					1	0.029	0.1171	21	0.25	0.8068	0.05	-0.215	0.2725
qtr					2	-0.204	0.1104	21	-1.85	0.0785	0.05	-0.434	0.0254
qtr					3	-0.283	0.1099	21	-2.58	0.0176	0.05	-0.512	-0.055
qtr					4	0	.	.	.	.	.	.	.
TargKey		1				0.7158	0.0556	75	12.87	<.0001	0.05	0.605	0.8266
TargKey		2				0.5045	0.057	75	8.86	<.0001	0.05	0.3911	0.618
TargKey		3				0.2656	0.054	75	4.92	<.0001	0.05	0.158	0.3732
TargKey		4				0	.	.	.	.	.	.	.
op			0			-0.701	0.0732	173	-9.57	<.0001	0.05	-0.845	-0.556
op			2			-0.372	0.0767	173	-4.85	<.0001	0.05	-0.523	-0.22
op			4			-0.441	0.0737	173	-5.99	<.0001	0.05	-0.587	-0.296
op			5			-0.264	0.0735	173	-3.59	0.0004	0.05	-0.409	-0.119
op			6			-0.017	0.0731	173	-0.24	0.8135	0.05	-0.162	0.127
op			7			-1.285	0.0812	173	-15.82	<.0001	0.05	-1.445	-1.124
op			8			-0.858	0.0771	173	-11.12	<.0001	0.05	-1.01	-0.705
op			9			0	.	.	.	.	.	.	.

Table 6 a) Generalized linear model selection criteria for the proportion positive observations of CPUE in weight for index 2. U.S. Pelagic longline DLS 1996-2011. Significant factors are in yellow. The same model is applied to index 7 which is the same index calculated in number.

Factor	*Degf*	*Deviance*	*Dev/df*	*%reduction*	*Loglike*	*Chisq*	*Probchisq*
BASE	20162	2919.8	0.1448		-9129.2		
LGHTC	20159	2353.6	0.1168	19.38	-6955.9	4346.58	0
HBFLCUT	20154	2327	0.1155	1.11	-6841.3	229.1	0
AREA	20147	2308.2	0.1146	0.77	-6759.5	163.65	0
OP	20147	2310.4	0.1147	0.68	-6769.2	144.27	0
QTR	20151	2311.6	0.1147	0.65	-6774.4	133.79	0
YEAR	20139	2313.8	0.1149	0.49	-6783.9	114.79	0
YEAR*QTR	20152	2321.1	0.1152	0.19	-6815.9	40.1	0
AREA*QTR	20152	2321.1	0.1152	0.19	-6815.9	.	.
YEAR*HBFLCUT	20148	2321.7	0.1152	0.15	-6818.3	35.17	0
YEAR*LGHTC	20150	2325	0.1154	0.02	-6832.9	6.06	0.10862
YEAR*AREA	20153	2325.7	0.1154	0	-6835.9	.	.
YEAR*OP	20153	2325.7	0.1154	0	-6835.9	.	.

b) Generalized linear model selection criteria for the positive catch observations of CPUE in weight for index 2. U.S. Pelagic longline DLS 1996-2011.

Factor	*Degf*	*Deviance*	*Dev/df*	*%reduction*	*Loglike*	*Chisq*	*Prob chisq*
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BASE	16620	33870.4	2.0379	-29500.2			
LGHTC	16617	22467.9	1.3521	33.65	-26089.1	6822.15	0
HBFLCUT	16612	20568.7	1.2382	8.43	-25355.2	1467.93	0
AREA	16605	18918.4	1.1393	7.98	-24660.1	1390.12	0
QTR	16602	18362.4	1.106	2.92	-24412.2	495.84	0
OP	16595	18076.3	1.0893	1.52	-24281.7	260.99	0
YEAR	16587	18242.6	1.0998	0.56	-24357.8	108.73	0
YEAR*AREA	16480	17308.1	1.0502	3.01	-23920.8	.	.
YEAR*OP	16375	16866.7	1.03	1.93	-23706.1	.	.
YEAR*LGHTC	16330	16607.8	1.017	1.26	-23577.6	.	.
AREA*QTR	16310	16428.5	1.0073	0.96	-23487.4	180.36	0
YEAR*HBFLCUT	16260	16382.4	1.0075	0.93	-23464	.	.
YEAR*QTR	16285	16469.7	1.0113	0.56	-23508.2	.	.

c) Table of parameter estimates for binomial component for model 2.

Solution for Fixed Effects

Effect	***lghtc***	***HBFLcut***	***year***	***Estimate***	***Standard Error***	***DF***	***t Value***	***Pr > |t|***	***Alpha***	***Lower***	***Upper***
Intercept				6.066	0.241	5618	25.16	<.0001	0.05	5.5931	6.5382
year			1996	-0.834	0.1543	5618	-5.4	<.0001	0.05	-1.136	-0.531
year			1997	-0.532	0.154	5618	-3.45	0.0006	0.05	-0.834	-0.23
year			1998	-0.020	0.1654	5618	-0.12	0.9032	0.05	-0.344	0.3042
year			1999	-0.247	0.1614	5618	-1.53	0.1267	0.05	-0.563	0.0699
year			2000	-0.530	0.1604	5618	-3.31	0.001	0.05	-0.845	-0.216
year			2001	-0.615	0.16	5618	-3.85	0.0001	0.05	-0.929	-0.302
year			2002	-0.573	0.1618	5618	-3.54	0.0004	0.05	-0.891	-0.256
year			2003	-0.613	0.1625	5618	-3.77	0.0002	0.05	-0.932	-0.294
year			2004	-0.668	0.1598	5618	-4.18	<.0001	0.05	-0.982	-0.355
year			2005	-0.617	0.1688	5618	-3.65	0.0003	0.05	-0.948	-0.286
year			2006	-0.327	0.1711	5618	-1.91	0.0559	0.05	-0.663	0.0083
year			2007	-0.335	0.1644	5618	-2.04	0.0418	0.05	-0.657	-0.012
year			2008	-0.196	0.1753	5618	-1.12	0.2634	0.05	-0.54	0.1476
year			2009	-0.134	0.1762	5618	-0.76	0.4468	0.05	-0.48	0.2114
year			2010	-0.293	0.1804	5618	-1.63	0.1039	0.05	-0.647	0.0602
year			2011	0.000	.	.	.	.	.	.	.
lghtc	0			-4.325	0.1627	5618	-26.59	<.0001	0.05	-4.644	-4.006
lghtc	1			-2.381	0.168	5618	-14.17	<.0001	0.05	-2.71	-2.052
lghtc	2			-1.232	0.2001	5618	-6.16	<.0001	0.05	-1.624	-0.84
lghtc	3			0.000	.	.	.	.	.	.	.
HBFL cut		1		-1.717	0.3732	5618	-4.6	<.0001	0.05	-2.449	-0.985
HBFL cut		2		-0.714	0.1784	5618	-4	<.0001	0.05	-1.063	-0.364
HBFL cut		3		-0.972	0.1257	5618	-7.73	<.0001	0.05	-1.219	-0.726
HBFL cut		4		-0.916	0.1354	5618	-6.77	<.0001	0.05	-1.181	-0.651
HBFL cut		5		-1.932	0.2382	5618	-8.11	<.0001	0.05	-2.399	-1.465
HBFL cut		NA		0.000	.	.	.	.	.	.	.

d) Table of parameter estimates for lognormal component for model 2.

Effect	*lghtc*	*HBF Lcut*	*area*	*op*	*year*	*qtr*	*Estimate*	*Standard Error*	*DF*	*t Value*	*Pr > |t|*	*Alpha*	*Lower*	*Upper*
Intercept							8.739	0.181	45	48.35	<.0001	0.05	8.375	9.103
year					1996		-0.479	0.198	45	-2.42	0.020	0.05	-0.877	-0.080
year					1997		-0.304	0.198	45	-1.54	0.131	0.05	-0.703	0.094
year					1998		-0.069	0.198	45	-0.35	0.728	0.05	-0.469	0.330
year					1999		0.003	0.200	45	0.01	0.989	0.05	-0.399	0.405
year					2000		-0.094	0.200	45	-0.47	0.639	0.05	-0.497	0.308
year					2001		-0.354	0.199	45	-1.77	0.083	0.05	-0.756	0.048
year					2002		-0.169	0.200	45	-0.84	0.403	0.05	-0.571	0.234
year					2003		-0.281	0.200	45	-1.4	0.167	0.05	-0.685	0.122
year					2004		-0.398	0.201	45	-1.98	0.053	0.05	-0.803	0.006
year					2005		-0.193	0.202	45	-0.96	0.344	0.05	-0.600	0.214
year					2006		-0.156	0.203	45	-0.77	0.447	0.05	-0.564	0.253
year					2007		-0.115	0.204	45	-0.56	0.576	0.05	-0.525	0.295
year					2008		-0.216	0.203	45	-1.07	0.293	0.05	-0.623	0.192

year					2009		-0.064	0.203	45	-0.31	0.755	0.05	-0.473	0.346
year					2010		-0.248	0.202	45	-1.23	0.226	0.05	-0.654	0.159
year					2011		0.000	.	.	.	.	.	.	.
lghtc	0						-2.047	0.060	45	-34.07	<.0001	0.05	-2.168	-1.926
lghtc	1						-1.238	0.059	45	-20.88	<.0001	0.05	-1.357	-1.119
lghtc	2						-0.560	0.059	45	-9.49	<.0001	0.05	-0.679	-0.441
lghtc	3						0.000	.	.	.	.	.	.	.
HBFLcut		1					-1.285	0.091	2.1E+4	-14.11	<.0001	0.05	-1.463	-1.106
HBFLcut		2					-1.386	0.057	2.1E+4	-24.25	<.0001	0.05	-1.498	-1.274
HBFLcut		3					-1.682	0.051	2.1E+4	-33.18	<.0001	0.05	-1.781	-1.583
HBFLcut		4					-1.695	0.054	2.1E+4	-31.5	<.0001	0.05	-1.800	-1.589
HBFLcut		5					-2.036	0.100	2.1E+4	-20.39	<.0001	0.05	-2.231	-1.840
HBFLcut		NA					0.000	.	.	.	.	.	.	.
area			CAR				0.358	0.113	105	3.16	0.002	0.05	0.133	0.582
area			FEC				-0.278	0.105	105	-2.65	0.009	0.05	-0.487	-0.070
area			GOM				-0.317	0.105	105	-3.02	0.003	0.05	-0.525	-0.109
area			MAB				0.187	0.105	105	1.79	0.077	0.05	-0.021	0.395
area			NEC				0.346	0.106	105	3.26	0.002	0.05	0.135	0.557
area			NED				1.439	0.110	105	13.14	<.0001	0.05	1.222	1.656
area			SAB				0.495	0.105	105	4.73	<.0001	0.05	0.287	0.702
area			SAR				0.000	.	.	.	.	.	.	.
qtr						1	0.159	0.022	2.1E+4	7.25	<.0001	0.05	0.116	0.202
qtr						2	-0.211	0.020	2.1E+4	-10.41	<.0001	0.05	-0.250	-0.171
qtr						3	-0.329	0.019	2.1E+4	-16.95	<.0001	0.05	-0.367	-0.291
qtr						4	0.000	.	.	.	.	.	.	.
op				0			-0.237	0.067	105	-3.51	0.001	0.05	-0.370	-0.103
op				2			-0.603	0.071	105	-8.45	<.0001	0.05	-0.745	-0.462
op				4			-0.150	0.067	105	-2.25	0.027	0.05	-0.282	-0.018
op				5			-0.154	0.069	105	-2.25	0.027	0.05	-0.290	-0.018
op				6			0.004	0.067	105	0.06	0.951	0.05	-0.129	0.137
op				7			-0.518	0.083	105	-6.21	<.0001	0.05	-0.683	-0.353
op				8			-0.423	0.070	105	-6.04	<.0001	0.05	-0.562	-0.284
op				9			0.000	.	.	.	.	.	.	.

Table 7. Table of indices with observed CPUE, observed proportion positive, number of observations, estimated CPUE, standard error, cv and relative CPUE and confidence intervals.

Index 1 with key species CPUE as a targeting characteristic

year	obcpue	Obp pos	nobs	new std	stderr	cv_i	STD CPUE	LCI	UCI
1986	1499.39	0.94	347	1090.311	225.162	0.207	1.804	1.199	2.715
1987	1217.36	0.95	833	929.016	184.775	0.199	1.537	1.037	2.279
1988	1217.16	0.91	1139	939.164	185.563	0.198	1.554	1.051	2.298
1989	1112.10	0.93	883	889.943	175.309	0.197	1.472	0.997	2.175
1990	1006.12	0.91	915	765.627	151.057	0.197	1.267	0.857	1.873
1991	830.13	0.87	1376	640.178	125.335	0.196	1.059	0.719	1.561
1992	693.30	0.90	1894	557.439	107.764	0.193	0.922	0.629	1.353
1993	636.65	0.86	2195	442.603	85.339	0.193	0.732	0.500	1.073
1994	629.43	0.81	2325	364.567	70.449	0.193	0.603	0.411	0.885
1995	600.40	0.81	2482	362.486	69.958	0.193	0.600	0.409	0.879
1996	491.47	0.78	1965	335.727	63.664	0.190	0.555	0.381	0.809
1997	564.43	0.81	2080	404.754	76.629	0.189	0.670	0.460	0.975
1998	629.19	0.87	1687	540.934	102.528	0.190	0.895	0.615	1.303
1999	592.48	0.84	1640	587.636	112.493	0.191	0.972	0.665	1.421
2000	505.32	0.83	1671	611.459	117.034	0.191	1.012	0.692	1.478
2001	452.56	0.83	1731	465.082	88.818	0.191	0.770	0.527	1.124
2002	575.04	0.83	1653	622.538	118.751	0.191	1.030	0.706	1.503
2003	631.22	0.83	1615	554.178	106.028	0.191	0.917	0.628	1.340
2004	608.16	0.81	1675	485.608	93.378	0.192	0.803	0.549	1.176
2005	579.70	0.84	1354	544.229	105.284	0.193	0.900	0.614	1.321
2006	559.28	0.85	1305	563.839	109.858	0.195	0.933	0.634	1.372
2007	546.00	0.85	1561	641.670	125.650	0.196	1.062	0.720	1.565
2008	513.23	0.88	1408	546.042	106.173	0.194	0.903	0.615	1.328
2009	572.66	0.89	1430	687.227	134.023	0.195	1.137	0.773	1.673
2010	541.52	0.89	1315	479.710	92.998	0.194	0.794	0.541	1.165
2011	572.52	0.91	1307	661.975	130.094	0.197	1.095	0.742	1.617

Index 2 with Gear targeting

year	obcpue	obppos	nobs	estcpue	stderr	cv_i	STD CPUE	LCI	UCI
1996	491.47	0.78	1965	332.347	55.056	0.166	0.722	0.519	1.003
1997	564.43	0.81	2080	406.098	67.168	0.165	0.882	0.635	1.225
1998	629.19	0.87	1687	529.625	87.706	0.166	1.150	0.828	1.598
1999	592.48	0.84	1640	562.362	93.942	0.167	1.221	0.876	1.702
2000	505.32	0.83	1671	500.798	83.901	0.168	1.088	0.780	1.517
2001	452.56	0.83	1731	383.783	64.129	0.167	0.833	0.598	1.161
2002	575.04	0.83	1653	463.469	77.618	0.167	1.006	0.722	1.404
2003	631.22	0.83	1615	412.682	69.395	0.168	0.896	0.642	1.252
2004	608.16	0.81	1675	365.453	61.553	0.168	0.794	0.568	1.109
2005	579.70	0.84	1354	450.518	76.528	0.170	0.978	0.698	1.371
2006	559.28	0.85	1305	477.452	81.430	0.171	1.037	0.739	1.455
2007	546.00	0.85	1561	497.048	85.181	0.171	1.079	0.768	1.517
2008	513.23	0.88	1408	453.090	77.139	0.170	0.984	0.702	1.380

2009	572.66	0.89	1430	529.084	90.522	0.171	1.149	0.818	1.614
2010	541.52	0.89	1315	436.384	74.089	0.170	0.948	0.676	1.328
2011	572.52	0.91	1307	567.530	97.480	0.172	1.232	0.876	1.733

Index 3 CPUE in weight using model from index 1

year	obcpue	obppos	nobs	estcpue	stderr	cv_i	STD CPUE	LCI	UCI
1986	18.89	0.94	347	13.691	2.875	0.210	1.806	1.192	2.736
1987	15.85	0.95	833	11.848	2.403	0.203	1.563	1.046	2.335
1988	16.29	0.91	1139	12.246	2.467	0.201	1.615	1.084	2.407
1989	14.19	0.93	883	11.558	2.321	0.201	1.524	1.024	2.269
1990	13.30	0.91	915	9.864	1.984	0.201	1.301	0.874	1.937
1991	10.28	0.87	1376	7.754	1.548	0.200	1.023	0.689	1.519
1992	8.99	0.90	1894	6.754	1.333	0.197	0.891	0.603	1.317
1993	8.15	0.86	2195	5.369	1.057	0.197	0.708	0.479	1.046
1994	8.61	0.81	2325	4.592	0.906	0.197	0.606	0.410	0.895
1995	7.87	0.81	2482	4.564	0.899	0.197	0.602	0.407	0.889
1996	6.76	0.78	1965	4.355	0.841	0.193	0.574	0.392	0.842
1997	7.80	0.81	2080	5.298	1.022	0.193	0.699	0.477	1.024
1998	9.51	0.87	1687	7.589	1.465	0.193	1.001	0.683	1.467
1999	8.19	0.84	1640	7.924	1.544	0.195	1.045	0.710	1.538
2000	6.80	0.83	1672	7.935	1.546	0.195	1.046	0.711	1.539
2001	6.01	0.83	1731	5.899	1.147	0.194	0.778	0.529	1.144
2002	7.88	0.83	1653	7.953	1.544	0.194	1.049	0.714	1.541
2003	9.18	0.83	1615	7.018	1.366	0.195	0.926	0.629	1.361
2004	8.41	0.81	1675	5.995	1.173	0.196	0.791	0.537	1.165
2005	7.85	0.84	1354	6.852	1.348	0.197	0.904	0.612	1.335
2006	7.93	0.85	1305	7.422	1.471	0.198	0.979	0.661	1.450
2007	7.37	0.85	1561	8.070	1.608	0.199	1.064	0.717	1.579
2008	6.75	0.88	1408	6.645	1.315	0.198	0.876	0.592	1.297
2009	6.77	0.89	1430	8.001	1.588	0.198	1.055	0.712	1.563
2010	5.80	0.89	1315	5.091	1.004	0.197	0.671	0.454	0.992
2011	6.27	0.91	1307	6.846	1.370	0.200	0.903	0.607	1.342

Index 4 with swo/total. Strict update of 2009 index

year	obcpue	obppos	nobs	estcpue	stderr	cv_i	STDCPUE	LCI	UCI
1982	3657.04	1.00	98	1379.569	249.009	0.180	2.321	1.622	3.321
1983	2107.97	0.99	142	984.616	151.773	0.154	1.657	1.219	2.251
1984	1832.96	0.99	166	902.076	134.481	0.149	1.518	1.128	2.042
1985	1997.44	0.99	185	875.229	118.305	0.135	1.473	1.125	1.927
1986	1499.39	0.94	347	821.238	103.190	0.126	1.382	1.076	1.775
1987	1217.36	0.95	833	659.102	78.739	0.119	1.109	0.874	1.407
1988	1217.16	0.91	1139	686.168	81.234	0.118	1.154	0.912	1.462
1989	1112.10	0.93	883	613.378	72.490	0.118	1.032	0.815	1.306
1990	1006.12	0.91	915	639.294	75.530	0.118	1.076	0.850	1.361
1991	830.13	0.87	1376	614.319	71.771	0.117	1.034	0.819	1.305
1992	693.30	0.90	1894	557.351	63.831	0.115	0.938	0.746	1.178

1993	636.65	0.86	2195	498.125	56.737	0.114	0.838	0.668	1.052
1994	629.43	0.81	2325	457.357	52.276	0.114	0.769	0.613	0.966
1995	600.40	0.81	2482	498.273	56.741	0.114	0.838	0.668	1.052
1996	491.47	0.78	1965	408.530	46.422	0.114	0.687	0.548	0.862
1997	564.43	0.81	2080	450.059	50.929	0.113	0.757	0.604	0.949
1998	629.19	0.87	1687	482.461	55.164	0.114	0.812	0.646	1.020
1999	592.48	0.84	1640	598.495	69.455	0.116	1.007	0.799	1.269
2000	505.02	0.83	1672	512.335	59.806	0.117	0.862	0.683	1.088
2001	452.56	0.83	1731	477.673	55.257	0.116	0.804	0.638	1.012
2002	575.04	0.83	1653	533.208	61.582	0.115	0.897	0.713	1.129
2003	631.22	0.83	1615	492.785	57.491	0.117	0.829	0.657	1.046
2004	608.16	0.81	1675	462.807	54.229	0.117	0.779	0.616	0.984
2005	579.70	0.84	1354	506.908	60.315	0.119	0.853	0.673	1.081
2006	559.28	0.85	1305	451.048	53.965	0.120	0.759	0.598	0.963
2007	546.00	0.85	1561	523.386	63.383	0.121	0.881	0.692	1.121
2008	513.23	0.88	1408	378.035	45.040	0.119	0.636	0.502	0.806
2009	572.66	0.89	1430	487.154	56.940	0.117	0.820	0.649	1.035
2010	541.52	0.89	1315	400.380	46.414	0.116	0.674	0.535	0.849
2011	572.52	0.91	1307	479.585	56.622	0.118	0.807	0.638	1.021

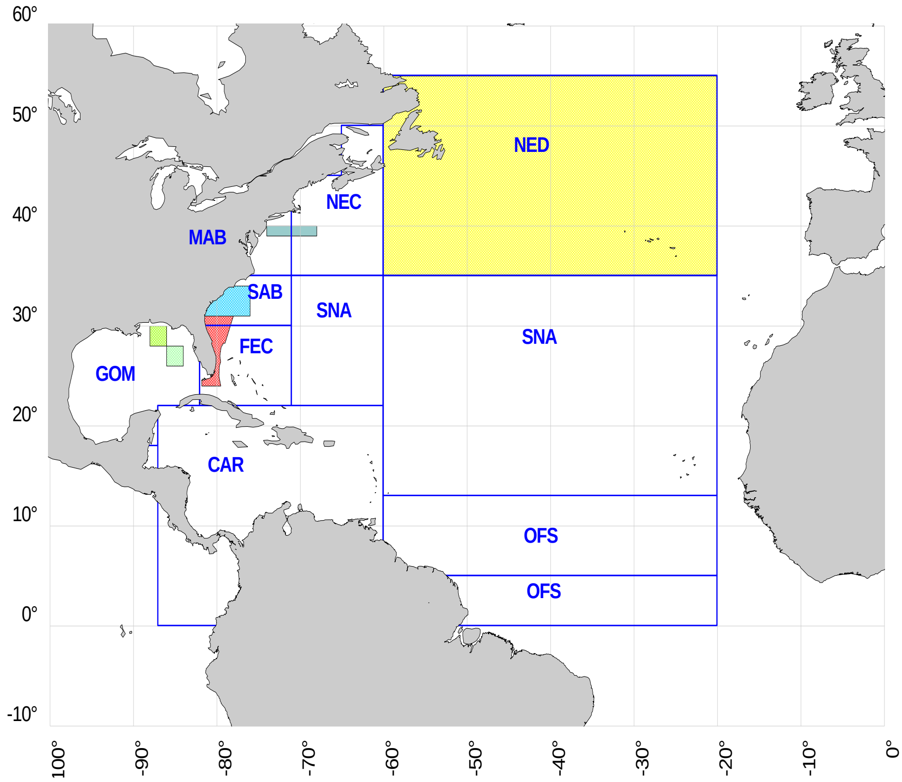

Figure 1. Geographic area classification for the U.S. Pelagic longline fishery: CAR Caribbean, GOM Gulf of Mexico, FEC Florida east coast, SAB south Atlantic bight, MAB mid Atlantic bight, NEC north east coastal, NED north east distant waters, SNA Sargasso area, and OFS offshore waters. Shaded areas represent the current time-area closures affecting the pelagic longline fisheries. Permanent closures: the DeSoto area in the Gulf of Mexico, and the Florida east coast area. Time-area closures: the Charleston Bump in the SAB area closed Feb-Apr, the Bluefin tuna protected area in the MAB and NEC areas closed Jun, and the Grand Banks in the NED area closed from October 10/00 to April 9/01.

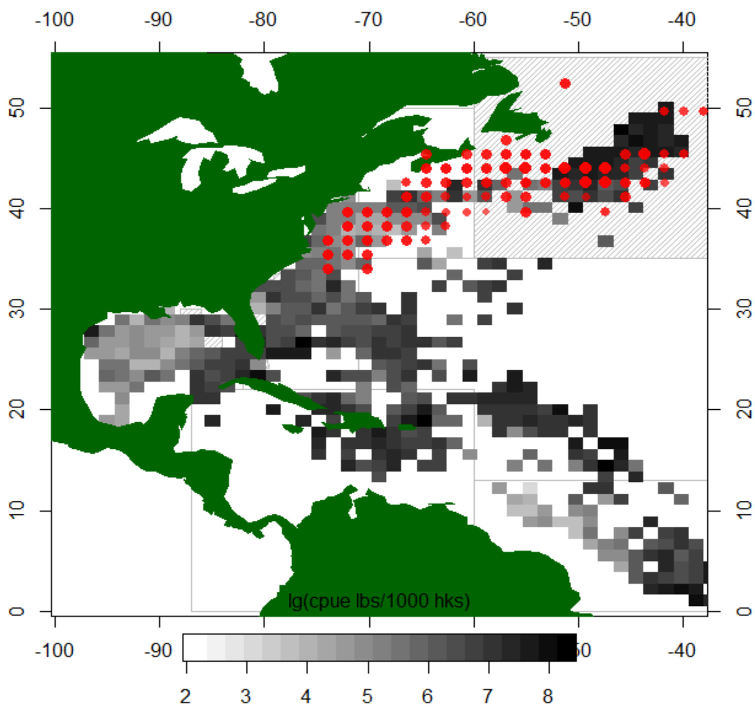

Figure 2. Canada and U.S. fleet overlap. All observations are averaged over a coarse grid. Any overlap into closed areas, land or territorial waters of other nations is caused averaging over the grid and any implied locations are only approximations. Density or size of character represent relative effort.

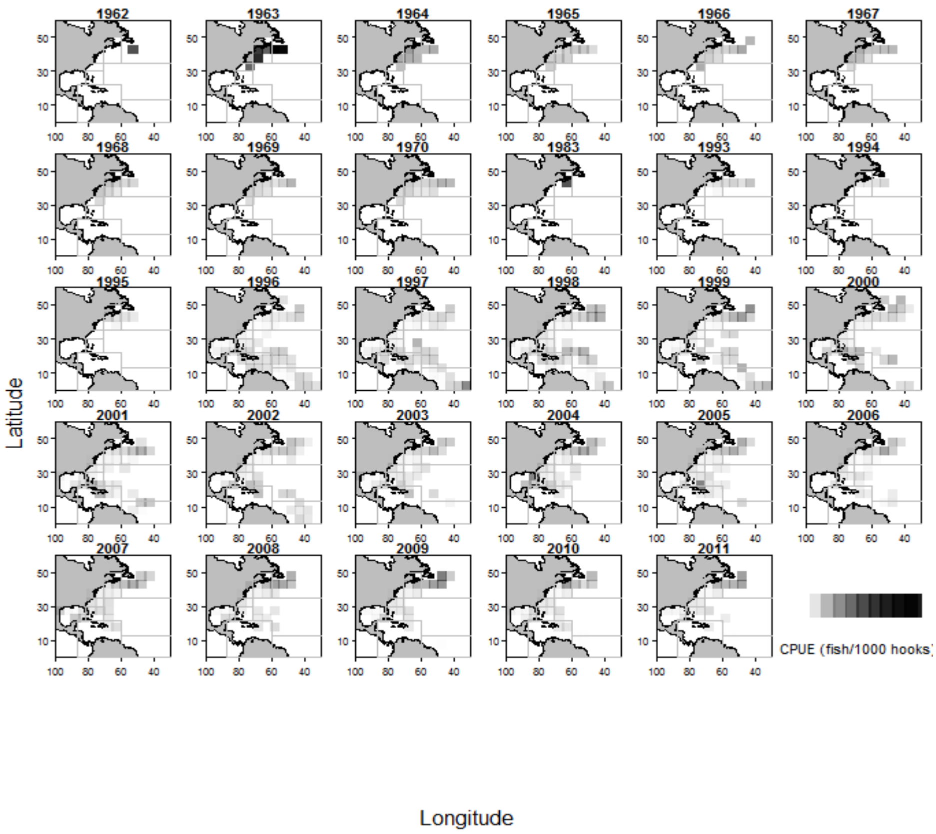

Figure 3. CPUE (swordfish lbs round wt /1000 hooks) for the combined CAN-US dataset.

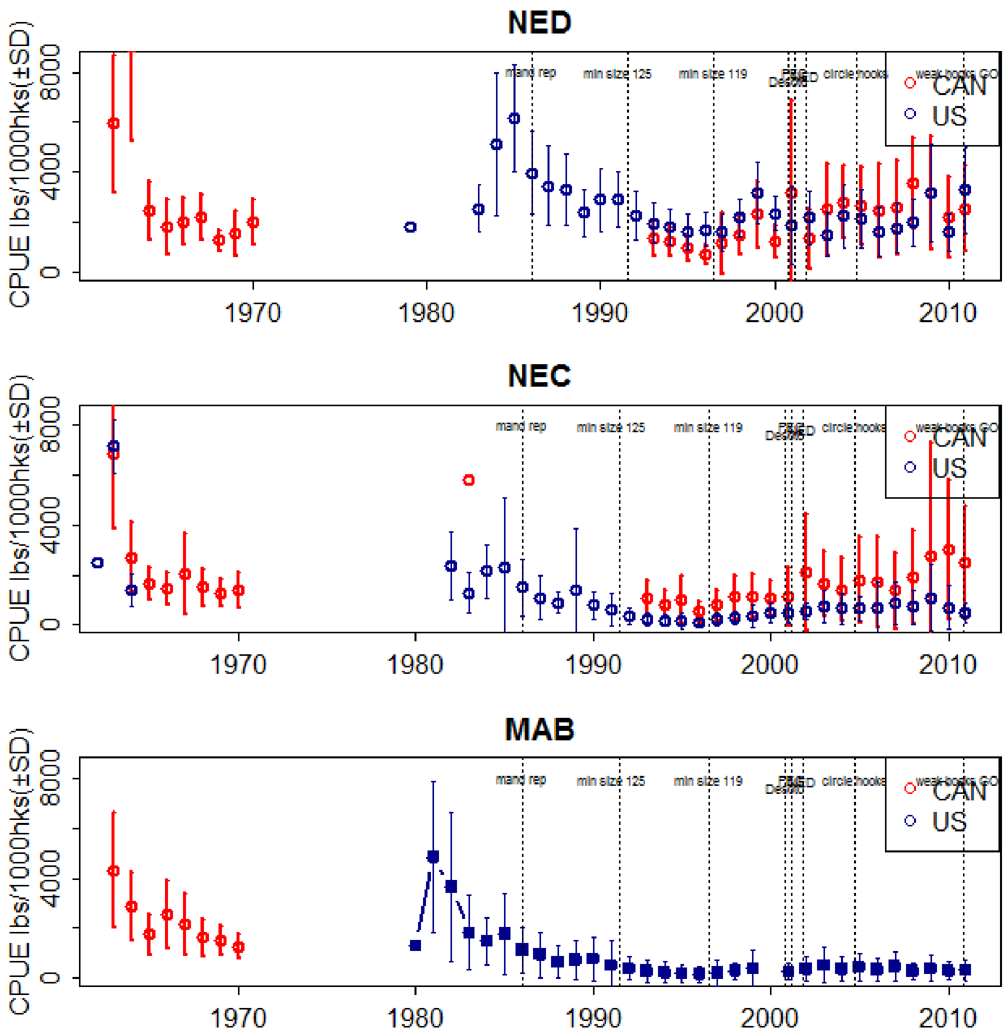

Figure 4. Nominal catch rates for U.S. and Canadian fleets in adjacent areas. Note that some observations for the US may come from experiment conducted onboard vessels.

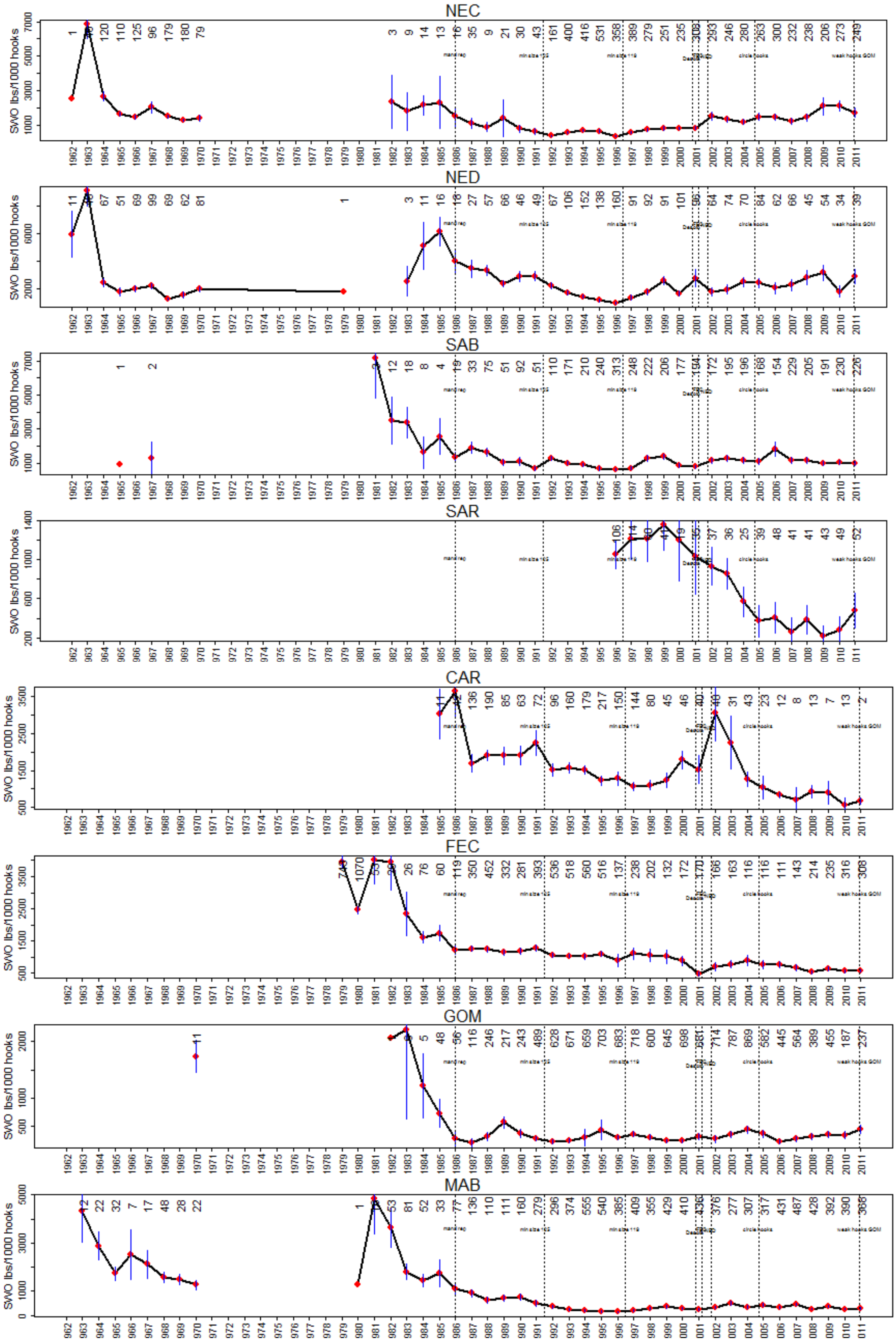

Figure 5. Plots of nominal large swordfish CPUE in weight by area and year with sample sizes (Trips) as text. Canada and US data combined with 95% confidence intervals.

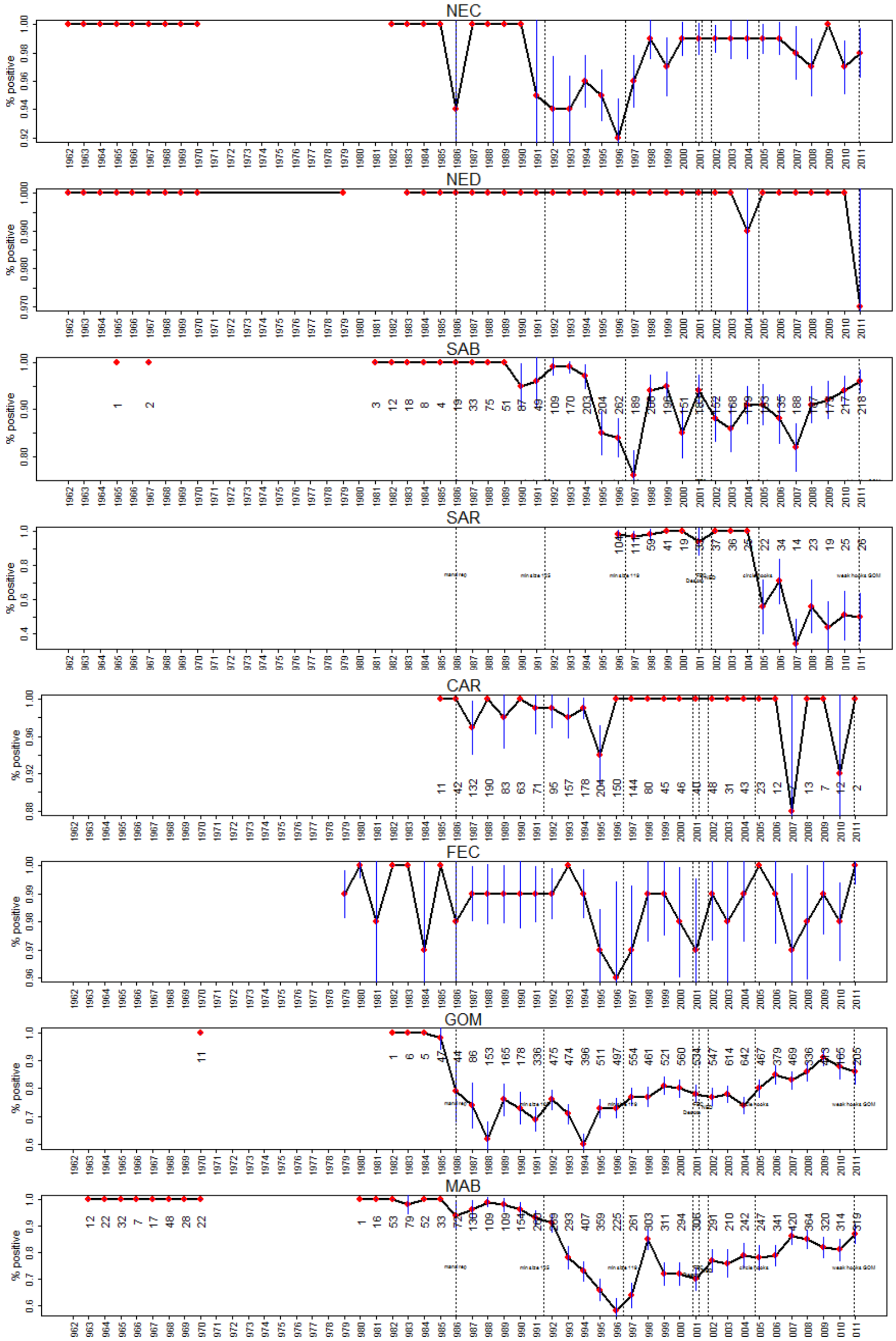

Figure 6. Plots of nominal % positive trips for large swordfish CPUE in number by area and year with sample sizes (Trips) as text. Canada and US data combined 95% confidence intervals.

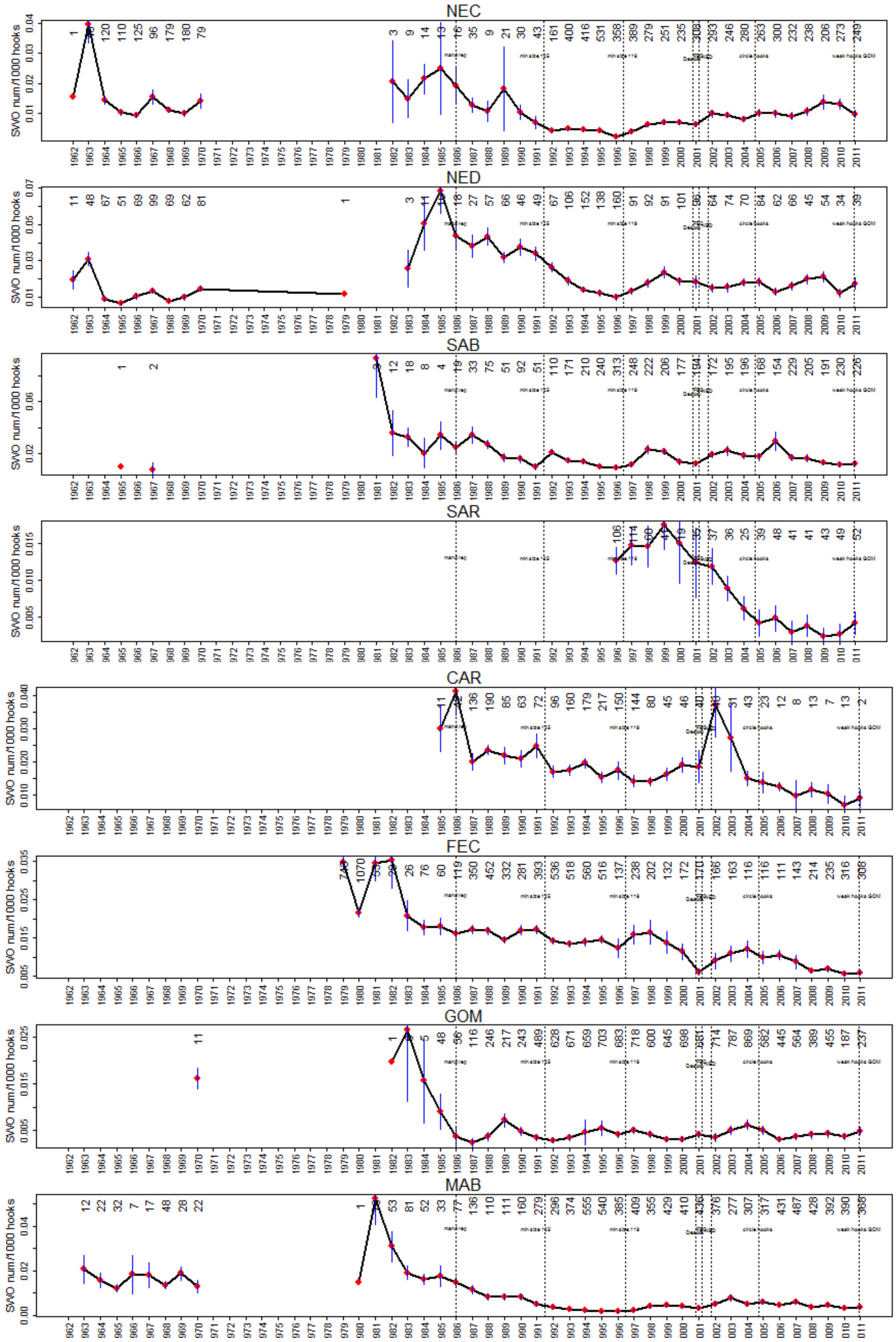

Figure 7. Plots of nominal large swordfish CPUE in number by area and year with sample sizes (Trips) as text. Canada and US data combined 95% confidence intervals.

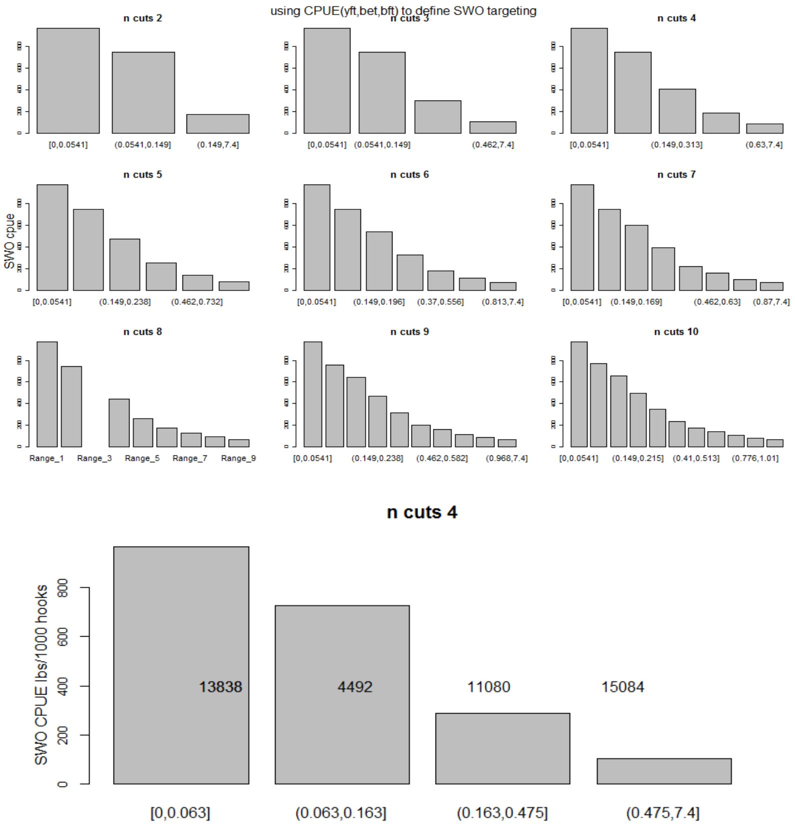

Figure 8. Partitions of the proposed targeting variable CPUE in weight (yellowfin, bigeye, bluefin) to use to define sword targeting trips. The y axis is the CPUE of swordfish and the x axis is different quantiles of the targeting factor. The concept is to look for clean breaks that define swordfish targeting.

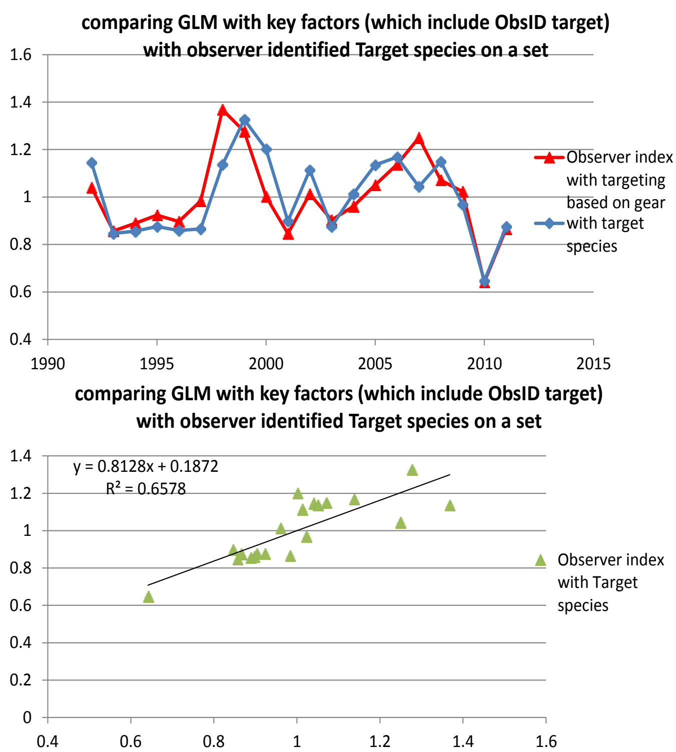

Figure 9. Test of proposed targeting classification with observer dataset to determine whether it works well compared to using gear characteristics to identify targeting.