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Size composition of the California Driftnet Fishery, 1981-Present

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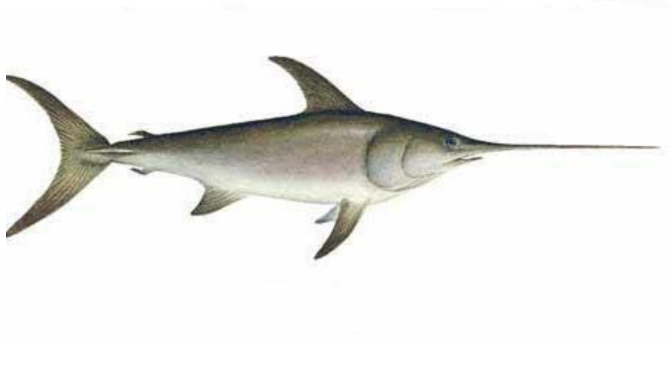

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Abstract

Drift gill net fisheries have operated off the west coast of the United States as early as the 1970's but began targeting swordfish in 1981. With the development of the fishery the state of California and US government implemented programs to monitor catches. Information onf the size composition of the fishery is available from 2 sources. Port samplers from California's Department of Fish and Wildlife collected size data from 1981-1990 and the National Oceanic and Atmospheric Administrations observers collected size data from 1990-2007. Both data sources show very similar size composition and can probably be considered as consistent data source. No long term trend is seen in the mean size, but within decadal may indicate the progression of relatively strong year-classes. An equation to convert cleithrum to fork length to eye to fork length is developed and presented based upon the observer data.

Introduction

Overview of gillnet fisheries

Gillnet operations off the coast of California (USA) are comprised of both set-net and drift-net (drift-net) fisheries. Set-nets typically take demersal species in inshore waters while drift-net fisheries capture pelagic species from farther offshore. The drift-net fishery has historically targeted sharks (thresher and mako) and swordfish, but have included other larger species such as opahs and tunas. The fishing vessels typically range in size from 30-75 feet with an increasing trend in size which may be associated with shift in fishing patterns to more offshore banks. Fishing trips have varied in duration from one night to more than a month (Diamond et al. 1986). Market factors, fish holding facilities and weather conditions all impact the duration of fishing activity. The majority of drift-net fishing has taken place in southern and central California; however there has been an expansion of fishing effort as far as the Canadian border.

California Department of Fish and Game (CDF&G) began collection size data from state ports of landing (Childers and Halko 1994) in 1981. Beginning in 1991 the National Marine Fisheries Service (NOAA Fisheries) placed observers on board driftnet vessels to monitor bycatch of protected species (Carretta and Enriquez 2006; (Carretta et al. 2005)). Observers collected additional information on the size composition of target fisheries catch. Because these observations were taken onboard the vessel and their records of the length distribution of the catch represent actual mortality (not just landings) these size samples may be more representative of the actual fishing mortality.

Objectives

The objectives of this paper were to create a quarterly time series of proportion-at-size data that characterize the drift-net fishery for potential use in stock assessment. The size composition data are presented in a common unit of eye to fork length distance.

Estimates of the number of individual net sets or other metric of effort were also estimated as a measure of the independent number of size samples that were collected.

Materials and Methods

Data source

Data for this project has come from both port sampling by California Department of Fish and Game (CDF&G) and observers from the National Marine Fisheries Service (NOAA). Seasons were defined as 1- Jan-Mar, 2-Apr-Jun, 3-July-Sepy, and 4-Oct-Dec. All measurements are given to the nearest 1cm with rounding occurring at each 0.5cm interval.

Conversion of size measurements

Because CDF&G sampled fish landed fish and pre-processing of swordfish occurs onboard the vessel, a conversion to eye to fork length (EFL) was necessary. Landed swordfish are typically headed and gutted prior to arrival at the port of landing; therefore samplers measured distance from the cleithrum to the fork in tail (CLFL). In this paper, we created a conversion of CLFL to EFL using paired observations in the observer data set (1991-present). Observers accessed fish at catch and were able to measure size samples prior to processing. Multiple size measurements were recorded on most samples including CLFL and EFL. A simple linear model was fit predicting ELFL from CLFL:

$$\mathrm{EFL}=a\mathrm{CLFL}+b \qquad \text{Equation 1.}$$

Where a is the slope and b is the intercept of the linear model. Equation 1. was used to predict EFL for all samples where missing but a record of CLFL was present.

Size composition 1981-1990

CDF&G port samples used were to create the size composition of the catch. Equation 1 was used to convert all CLFL measurements into EFL. The number of fish within each 1cm bin was aggregated for each season with years 1981-1990. The number of sets for each trip was not available in this database. Thus the number of trip days was used as a proxy and calculated for each season/year.

Size composition 1990-2007

NOAA observer samples were used to create the size composition of the catch. Equation 1 was used to convert any observation were EFL was missing but CLFL was measured (<5% of obs). The number of fish within each 1cm bin was aggregated for each season for the years 1991-2007. The number of sets within each season/year was calculated.

Results and Discussion

Data characteristics

A total of 23,712 swordfish were measured from 1989 trip days and used to create the size composition 1981-1990 (Table 1). A total of 15,171 swordfish were measured from 8037 sets and used to create the size composition 1990-2007 (Table 1). In the linear model used to convert CLFL to EFL *a*= 1.1056 and *b*=8.0521 and the relation explained the majority of the variability (r^2=0.9615, n=10,984). Figure 1 presents the relationship of EFL to CLFL and this relation was subsequently used to convert data where necessary.

General discussion

The driftnet fishery takes fairly large fish between 100-250 cm EFL. The mean size in the fishery catch has remained fairly stable from the onset of the fishery until present at around 168 cm EFL. This agrees well with the results presented by Hanan et al. (1993) presented in CLFL. There are some multi-year patterns of either increasing and decreasing size (Figures 2 and 3) that may be indicative of relatively strong year classes. It is interesting to note that the average size of the fish is largest in the middle of the year and decline subsequently (Figure 4). It is unclear if this is an effect of the loss of larger fish or the addition of smaller fish.

In Figure (5) it is evident that the conversion of CLFL to EFL resulted in an artifact of specific length bins not containing fish. This can occur when converting from a smaller measurement to a larger one when both units are measured to the same precision (1cm). It is unclear how this will affect model fitting, but it may be preferable to use the data in >1cm bins if this artifact affects the multinomial error assumption. However is also clear that both the port and observer samples are quite similar in distribution and there appears to be no clear bias in sizes measured between the two data bases. It also appears that there was not noticeable discarding of small fish as both observer and port sample data show similar proportion of <100cm fish.

No statistical weighting was used to produce the size composition. Given the relatively large fraction of fish sampled versus caught in the fishery, the relatively small spatial extent of the fishery (relative to stock boundary) and homogenous sizes inside the spatial bounds it is unlikely that weighting schemes would greatly affect the resulting size compositions. However this is an area of investigation that should be explored for subsequent stock assessments. We also note that the unit of effort (sets versus trip days) is different between the port sample data and observer data. We generally felt that a set may be an appropriate measure of the independent effort useful to gauge the effective sample size for the multinomial error assumption in stock synthesis. However, we could not generate the number of sets in port sample data. Thus trip days (days fished) were an intermediate statistic between number of trips and number of sets. It may be possible that with some further investigation (matching to landings tickets etc) that the calculation of the number of sets may be possible. Further work here is also warranted. Furthermore, for the observer data the number of sets in some season/years exceeds the number of fish sampled and this is due to not all sets observed caught at least one swordfish. In these instances the best measure of sample size is likely the number of fish. Finally, we also note that additional port sample length data is available from 1991-1995. However, it is unknown if these are the same fish that were measured by the observers. Because the observers measured catch, with all measurement occurring prior to processing we chose to present the observer data in lieu of port samples when both occurred. With additional work it may be possible to determine which (if any) fish occurred in both data sets and then the sources could be combined.

Literature cited

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Table 1. General statistics of the CPUE data used in this work.

source	year	season	fish	sets or trips	source	year	season	fish	sets or trips
CDF&G	1981	2	1	1	NOAA	1994	3	224	199
CDF&G	1981	3	34	6	NOAA	1994	4	707	443
CDF&G	1981	4	242	25	NOAA	1995	1	24	20
CDF&G	1982	1	0	0	NOAA	1995	2	0	5
CDF&G	1982	2	1	1	NOAA	1995	3	263	158
CDF&G	1982	3	422	85	NOAA	1995	4	858	389
CDF&G	1982	4	440	61	NOAA	1996	1	25	35
CDF&G	1983	1	8	2	NOAA	1996	2	0	15
CDF&G	1983	2	4	2	NOAA	1996	3	73	92
CDF&G	1983	3	375	70	NOAA	1996	4	612	279
CDF&G	1983	4	1778	168	NOAA	1997	1	76	81
CDF&G	1984	1	428	34	NOAA	1997	2	0	0
CDF&G	1984	2	21	9	NOAA	1997	3	99	138
CDF&G	1984	3	597	99	NOAA	1997	4	1276	473
CDF&G	1984	4	2028	147	NOAA	1998	1	308	137
CDF&G	1985	1	199	17	NOAA	1998	2	0	0
CDF&G	1985	2	12	6	NOAA	1998	3	122	99
CDF&G	1985	3	1280	85	NOAA	1998	4	876	351
CDF&G	1985	4	1805	94	NOAA	1999	1	32	49
CDF&G	1986	1	14	3	NOAA	1999	2	0	0
CDF&G	1986	2	11	8	NOAA	1999	3	50	56
CDF&G	1986	3	1215	137	NOAA	1999	4	915	421
CDF&G	1986	4	3800	218	NOAA	2000	1	68	51
CDF&G	1987	1	401	29	NOAA	2000	2	0	15
CDF&G	1987	2	14	7	NOAA	2000	3	86	64
CDF&G	1987	3	309	49	NOAA	2000	4	797	314
CDF&G	1987	4	1462	109	NOAA	2001	1	48	51
CDF&G	1988	1	38	6	NOAA	2001	2	0	5
CDF&G	1988	2	13	4	NOAA	2001	3	12	52
CDF&G	1988	3	773	76	NOAA	2001	4	311	231
CDF&G	1988	4	2381	139	NOAA	2002	1	11	35
CDF&G	1989	1	121	5	NOAA	2002	2	0	15
CDF&G	1989	2	0	0	NOAA	2002	3	11	36
CDF&G	1989	3	543	66	NOAA	2002	4	468	274
CDF&G	1989	4	1912	152	NOAA	2003	1	31	48
CDF&G	1990	1	354	26	NOAA	2003	2	0	0
CDF&G	1990	2	36	2	NOAA	2003	3	25	40
CDF&G	1990	3	184	17	NOAA	2003	4	258	210
CDF&G	1990	4	456	24	NOAA	2004	1	6	45
NOAA	1990	3	43	50	NOAA	2004	2	0	0
NOAA	1990	4	338	128	NOAA	2004	3	1	13
NOAA	1991	1	2	17	NOAA	2004	4	469	165
NOAA	1991	2	0	10	NOAA	2005	1	24	28
NOAA	1991	3	67	187	NOAA	2005	2	0	0
NOAA	1991	4	465	256	NOAA	2005	3	2	10
NOAA	1992	1	13	24	NOAA	2005	4	399	187
NOAA	1992	2	2	30	NOAA	2006	1	31	31
NOAA	1992	3	375	191	NOAA	2006	2	0	0
NOAA	1992	4	1059	351	NOAA	2006	3	38	31
NOAA	1993	1	86	88	NOAA	2006	4	806	204
NOAA	1993	2	0	8	NOAA	2007	1	133	49
NOAA	1993	3	337	164	NOAA	2007	2	0	0
NOAA	1993	4	1164	468	NOAA	2007	3	8	13
NOAA	1994	1	129	117	NOAA	2007	4	508	142
NOAA	1994	2	0	0					

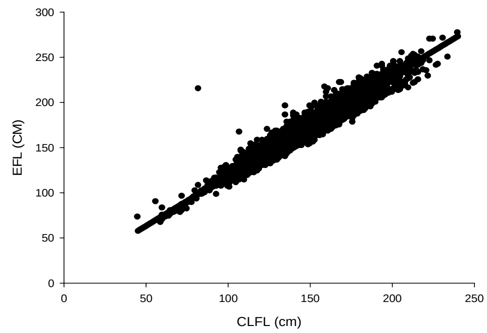

Figure 1. A plot of Eye fork length measurements against Cleithrum to fork length (●) and the fitted linear model (**solid line**) used to create the equation.

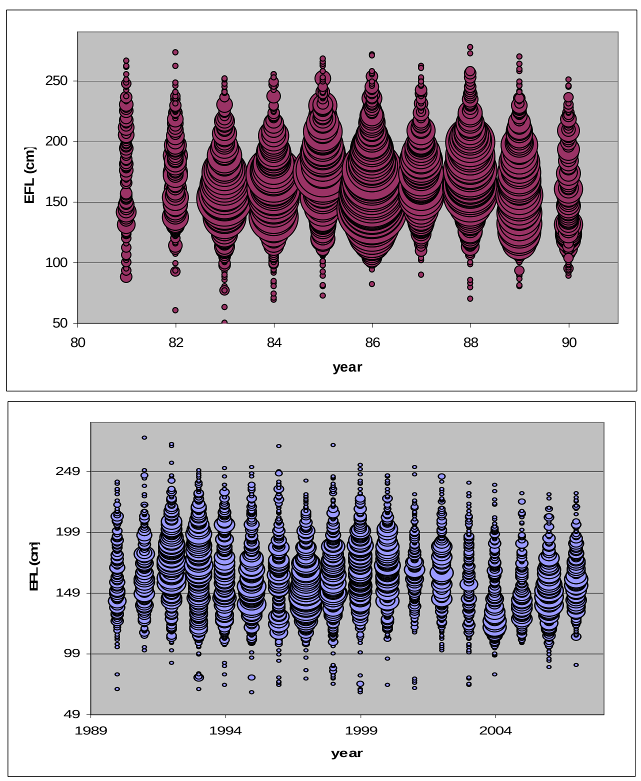

Figure 2. Bubble plot of the number fish within each 1cm bin by annual year (seasons aggregated for space). The upper plot depicts 1981-1990 from CDF&G port samples. The lower plot depicts 1990-2007 from NOAA observer data. Area of the bubble is proportional to the number of fish.

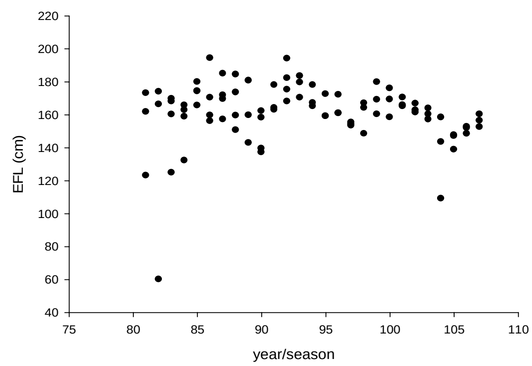

Figure 3. Plot of the mean swordfish size by year and season.

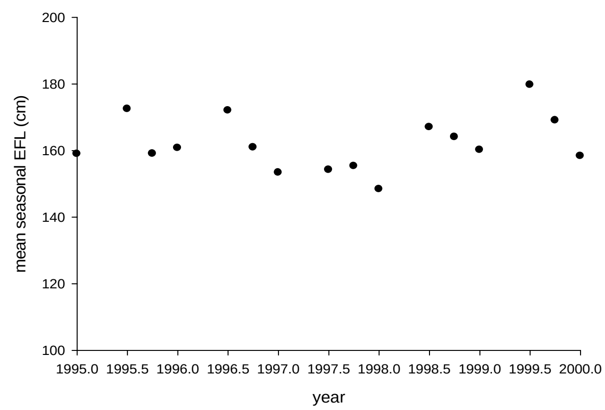

Figure 4. Plot of the quarterly mean size from 1995-2000. A subset the years are displayed to better illustrate seasonal changes in mean size.

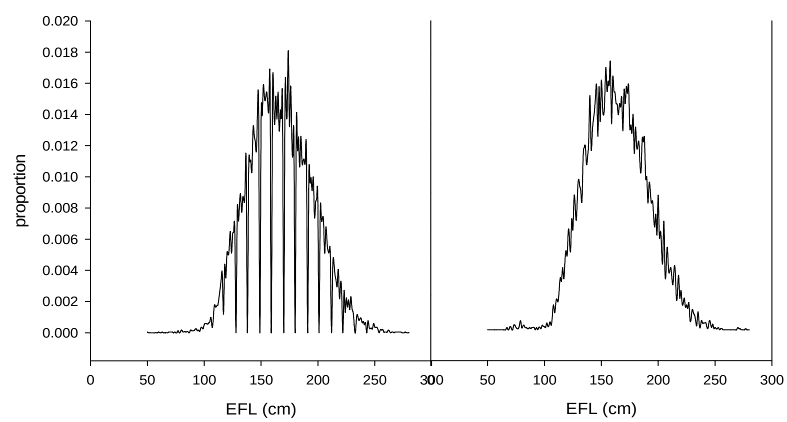

Figure 5. Plot of the size distribution of swordfish taken in the driftnet fishery. The left plot is from CDF&G port sampler data and the right is from NOAA observer data. In both plots all measured fish have been aggregated across time (1981-1990 and 1990-2007, respectively). The missing values in the port sampled data are due to an artifact of converting CLFL to EFL.