Occurrence of small coastal sharks and standardized catch rates of Atlantic sharpnose sharks in the VIMS Longline Survey: 1974-2005

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Summary

The Virginia Institute of Marine Science has conducted a fishery-independent longline survey during summer months since 1974. Data for Atlantic sharpnose sharks captured in the survey between 1974 and 2005 are presented. In most years, abundance and catch rates of Atlantic sharpnose sharks are second only to sandbar sharks in Virginia coastal waters. Length frequency data indicate that nearly all sharpnose sharks caught in Virginia are mature and most are males. Nominal and standardized catch rates are presented. In general, CPUE increased between 1986 and 1999, declined through 2002, and again increased through 2005.

Materials and Methods

Sampling

The VIMS longline survey is a depth-stratified station-oriented field survey of the Chesapeake Bay and coastal waters from Cape Hatteras, NC to Cape Henlopen, DE with most effort taking place in Virginia waters (Figure 1). The gear used was the standard for the commercial longline industry at the beginning of the VIMS program in 1974. Gear characteristics have remained constant throughout. We used commercial-style longlines consisting of 4.8-mm tarred, nylon mainline that was anchored at each end and marked by buoys equipped with radar reflectors. Three-meter gangions were spaced approximately 18 m apart along the mainline and a large inflatable buoy was attached to the mainline following every 20^{th} gangion. Standard gangions were composed of a stainless-steel tuna clip (quick snap) attached to a 2-m section of 3.2-mm tarred nylon trawl line, the end of which was attached to an 8/0 barrel swivel. We crimped one end of a 1-m section of 1.6-mm stainless-steel aircraft cable to the swivel and the other end to a Mustad-9/0, J-hook. All coastal stations are in water depths between five and 30 meters, therefore nearly all gangions rest on the bottom during a set. Bait consisted of various coastal teleosts including Atlantic menhaden (*Brevoortia tyrranus*) until 1995. Only Atlantic menhaden and Atlantic mackerel (*Scomber scombrus*) were used from 1995 to 2005. A standard set consisted of 100 hooks and was approximately 2 km in length. Standard soak times were four hours long.

Data recorded for each set included 1) location, 2) start and finish times for setting and hauling, 3) maximum and minimum water depth, 4) surface and bottom water temperature (to 30 meters maximum), 5) number of hooks and hook type, 6) bait species. Beginning in 1996, temperature, dissolved oxygen, and salinity were recorded from surface to the bottom at two-meter intervals. Animals that were lost once brought to the side of the vessel were counted as catch, but broken gangions and "bite-offs" were not included in catch. All species captured were recorded and measured. Pre-caudal length, fork length, and stretch total length were measured for all sharks.

Data Analyses

We calculated length frequencies and plotted males and females separately for all sharpnose sharks caught within the survey. This included all gear and all stations. Catch per unit of effort (CPUE) was calculated for each set as the number of sharks per 100 standard hooks fished. Only the five standard coastal stations and standard gear (steel leader with 9/0 J-hook) were used in catch analyses. Monthly mean CPUE was calculated from standard stations and standard gear from all months.

The nominal CPUE for each year was calculated as mean CPUE for all standard stations fished from June to September in a given year. CPUE data were standardized following the Lo method (Lo et al. 1992). Generalized linear models were fitted to the data using the GENMOD procedure in SAS (Version 9.1 of the SAS, SAS Institute Inc. Cary, NC, USA). Probabilities of positive catches were fit to the data assuming a binomial error distribution using the logit link function. CPUE for positive catches was estimated using the GENMOD procedure assuming a normal error distribution with the log link function being used. Factors (station, year, month, surface temperature, year) were individually fit to the data to assess which factor provided the greatest decrease in deviance per degree freedom compared to the nominal model and which factors were significant via the Chi-square statistic of the Type three likelihood ratio test at the 0.05 level. If a factor met these criteria it was included in the model and the remaining factors were tested again with the new model. The product of the yearly mean standardized proportion of positive catches and mean standardized positive catch rates were used to produce the catch index.

Results and Discussion

Species Present

Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) are by far the most common species of small coastal shark in Virginia waters. Between 1974 and 2005, 1,199 Atlantic sharpnose sharks were captured in the VIMS survey. These were dominated by males (84%). The large majority of sharpnose sharks (83.7%; N=1,004) were captured at the five standard stations in coastal waters (Figure 2). The Chesapeake Light Tower (C) and Smith Island Shoal (L) stations accounted for 40.1% and 18.0% of the total sharpnose catch respectively. Both of these stations are located between the 10-meter and 20-meter isobaths. Triangle Wrecks (T), at a depth of ~30-35 meters, accounted for 14.9% while the two standard coastal stations inshore of the 10-meter isobath, Sandbridge (V) and Sandshoal Inlet (W) accounted only for 8.9% and 1.8% of the total respectively. Only two Atlantic sharpnoses sharks have been captured by the survey inside Chesapeake Bay. Seventeen were captured in tidal creeks along Virginia's Eastern Shore between 2000 and 2005. None were captured in these areas prior to 2000.

Other small coastal species are rare in Virginia waters. Five blacknose sharks (*Carcharhinus acronotus*) were captured in the history of the survey: one in 1980, two in 1995, one in 1999, and one in 2002. Four were adult males and one was an adult female. No finetooth sharks (*Carcharhinus isodon*) or bonnethead sharks (*Spyrna tiburo*) have been captured in the VIMS standard longline survey. A single bonnethead was captured in an ancillary survey using small circle hooks to target juvenile sandbar sharks.

Length Frequencies

Length data were available for 183 female and 982 Atlantic sharpnose sharks (Figure 3). Average total length of male sharpnose sharks was 95.49 (S.D. = 4.67) cm and average total length of female sharpnose sharks was 98.37 (S. D. = 5.57) cm. Using samples from Virginia to the east coast of Florida, Loeffer and Sedberry (2002) reported that all male Atlantic sharpnose above 61.5 cm PCL (81.6 cm TL) and all females above 61.1 cm PCL (81.1 cmTL) were mature. Based on this 99.2% of males and 99.5% of females captured in the VIMS longline survey were mature animals.

CPUE Trends

Atlantic sharpnose sharks are migratory summer residents in Virginia coastal waters (Figure 4). None were caught in the VIMS survey during May. Highest CPUE was observed in July, August and September indicating immigration to the region occurs in late June and emigration occurs in late September and early October.

No definitive long-term trends were apparent in the Nominal CPUE data (Figure 5). The highest nominal catch rates occurred in 1977 and 1999, and no Atlantic sharpnose sharks were captured at standard stations in 1974, 1978, 1979, 1984, and 1986. For the standardized catch rates, the final models for proportion of positive catches (PPT) and CPUE of positive catches were:

PPT= Month + Station
CPUE= Station +Surftemp + Year + Surftemp*Month

The nominal and standardized catch rates are shown in Figure 6. The standardized catch rates were slightly lower than the nominal catch rates after 1986. Model fits are shown in Tables 1 and 2. Though no definitive trends are apparent, catch rates generally increased from 1986 to 1999, decreased between 1999 and 2002, and again increased through 2005.

References

Lo, N.C., L.D. Jackson, J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

Figure 1: Distribution of longline sets made by the VIMS Shark Ecology Program 1974-2006.

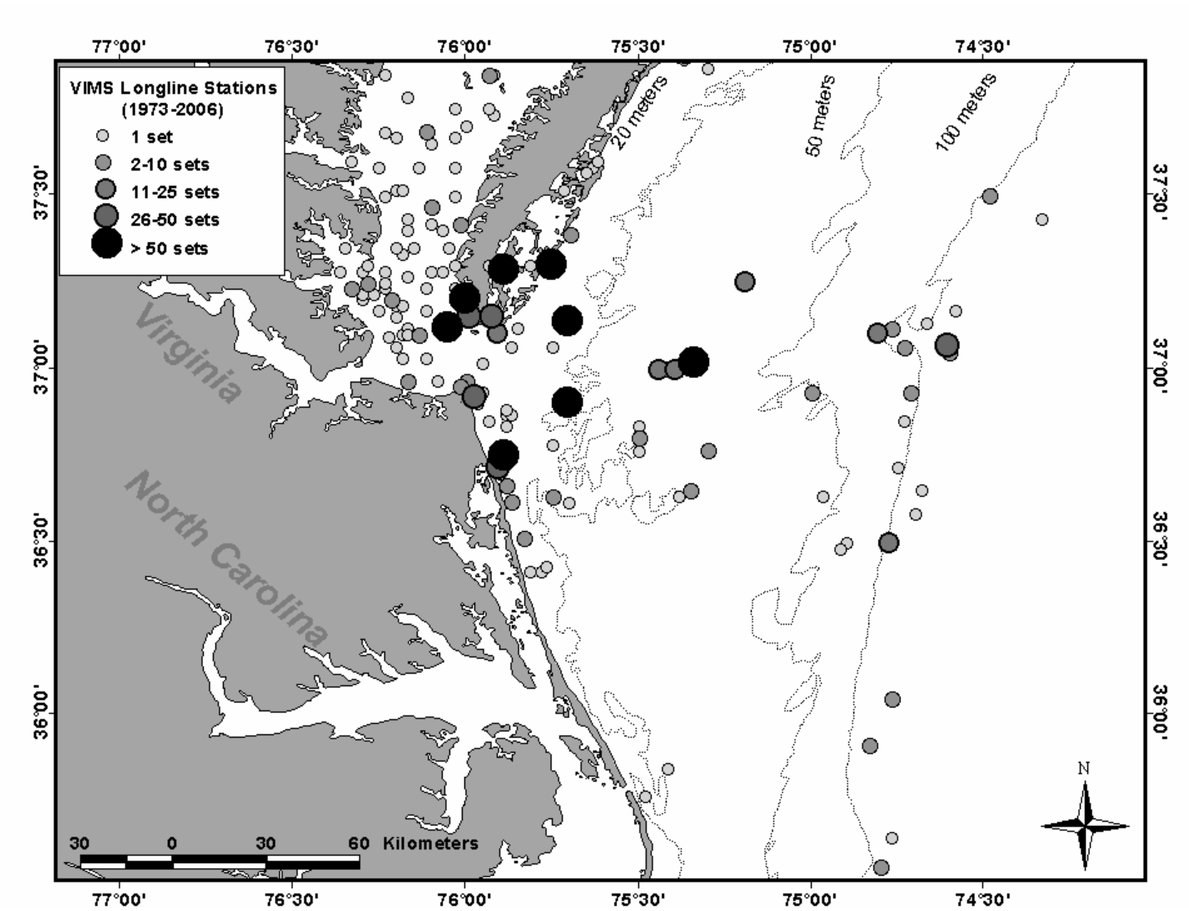


Figure 2: Standard stations fished by the VIMS longline survey.

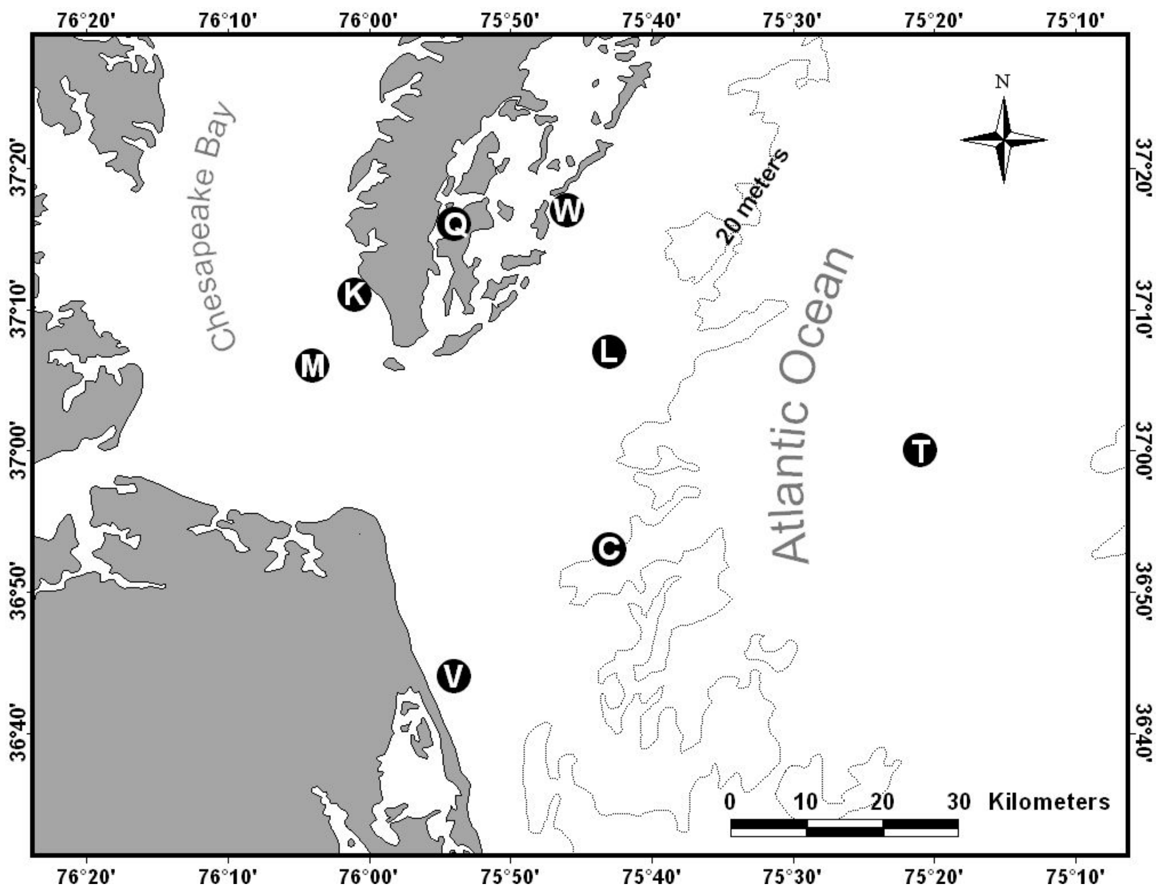


Figure 3. Length frequencies for male and female sharpnose sharks for all years, all stations, and all hooks.

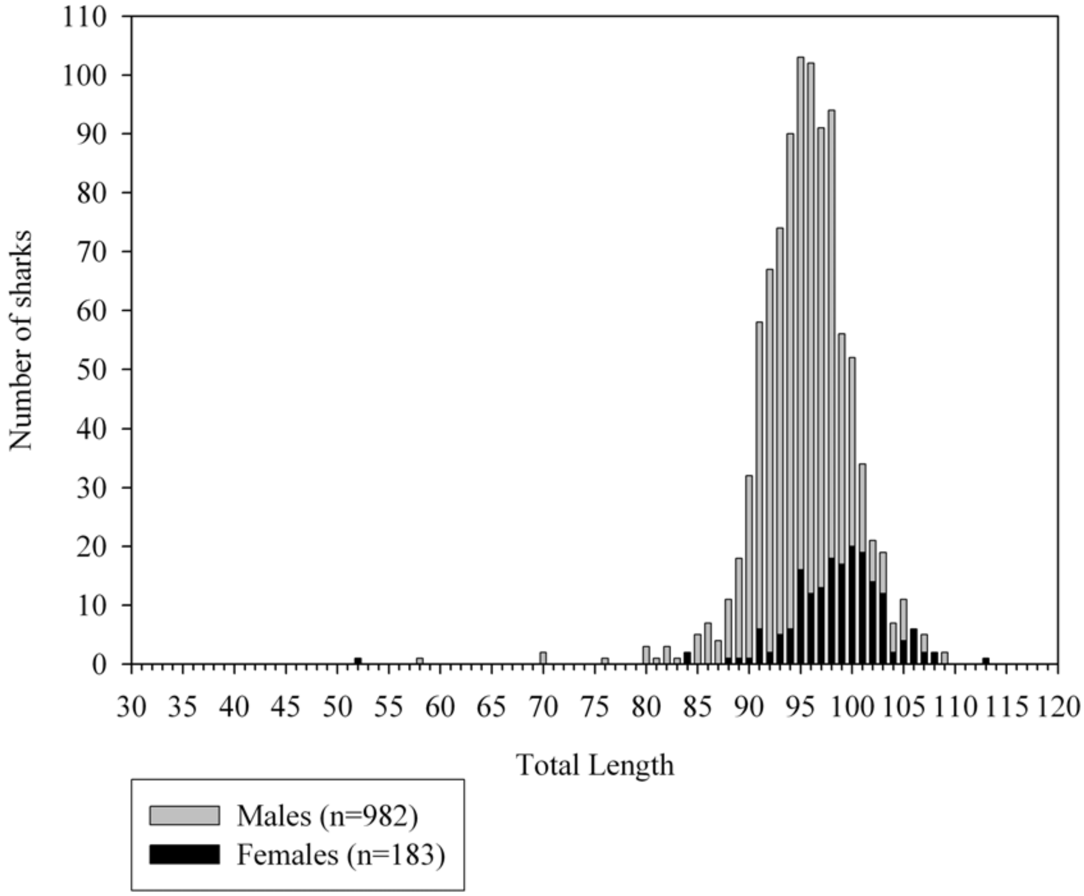


Figure 4. Average monthly CPUE (Average number of sharks/100 hooks).

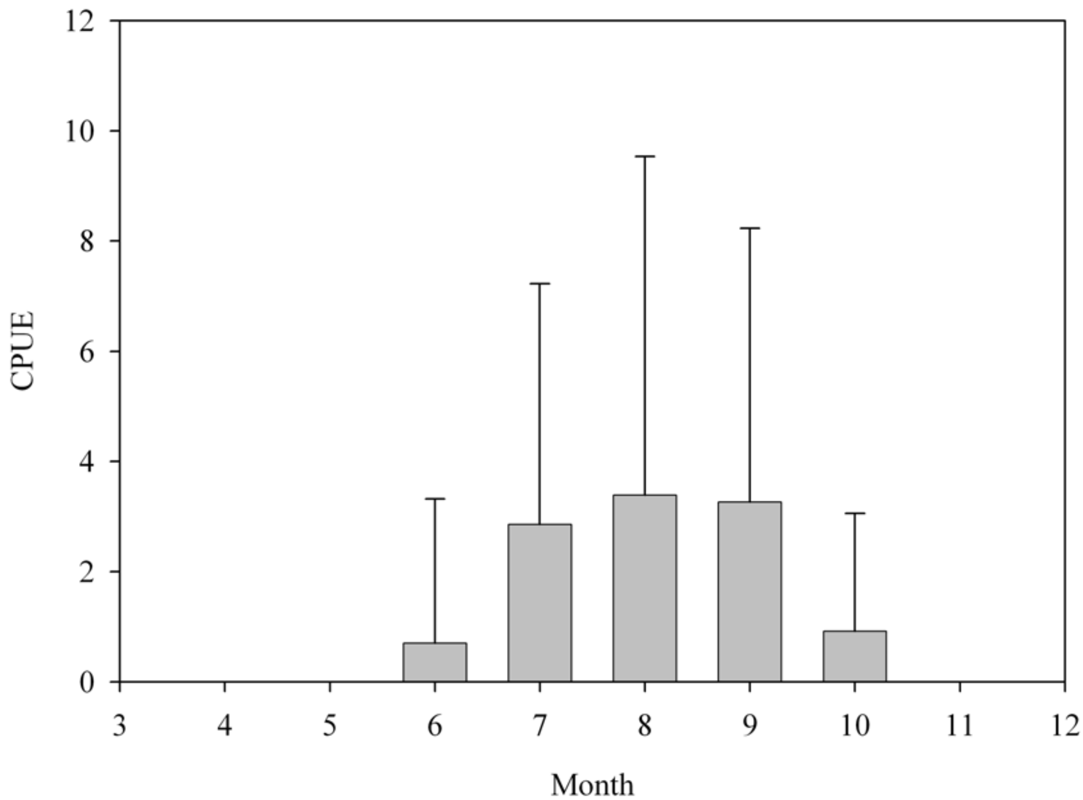


Figure 5. Nominal CPUE (Annual average of sharks /100hooks/set) for June through September, standard coastal staions, and standard gangions.

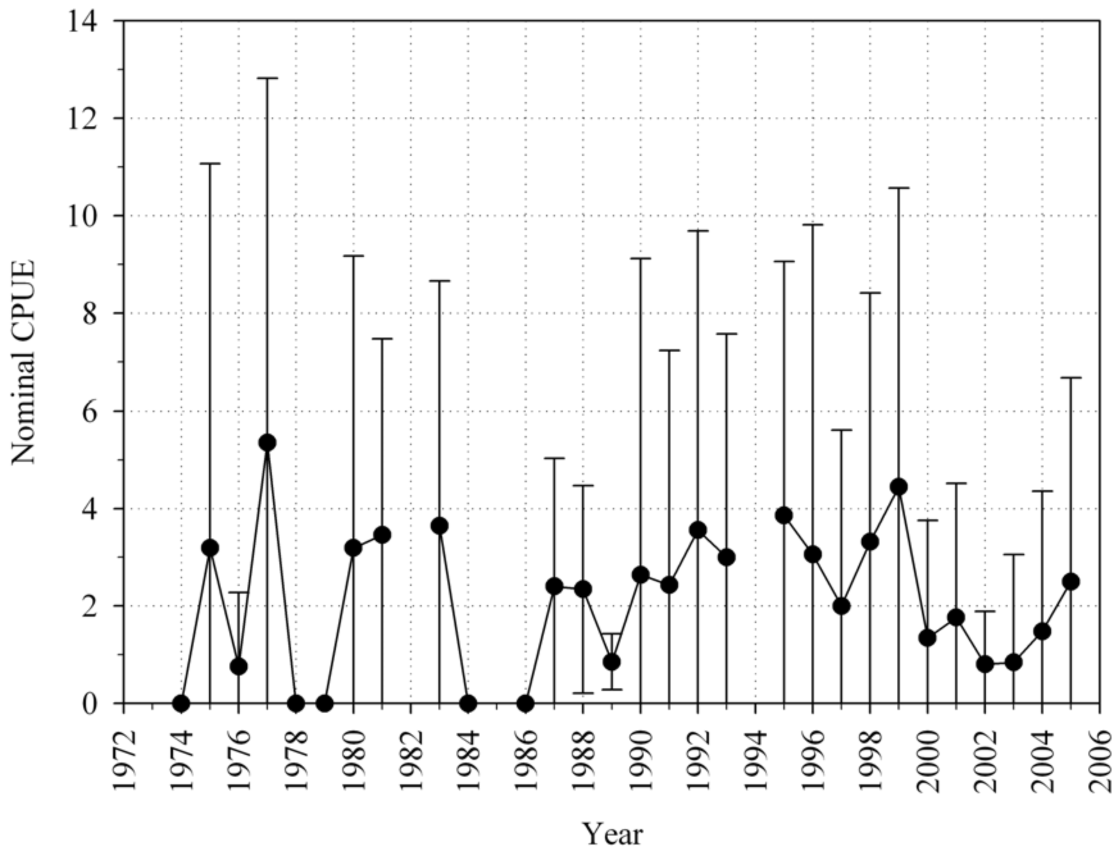


Figure 6. Nominal and Lo transmformed CPUE.

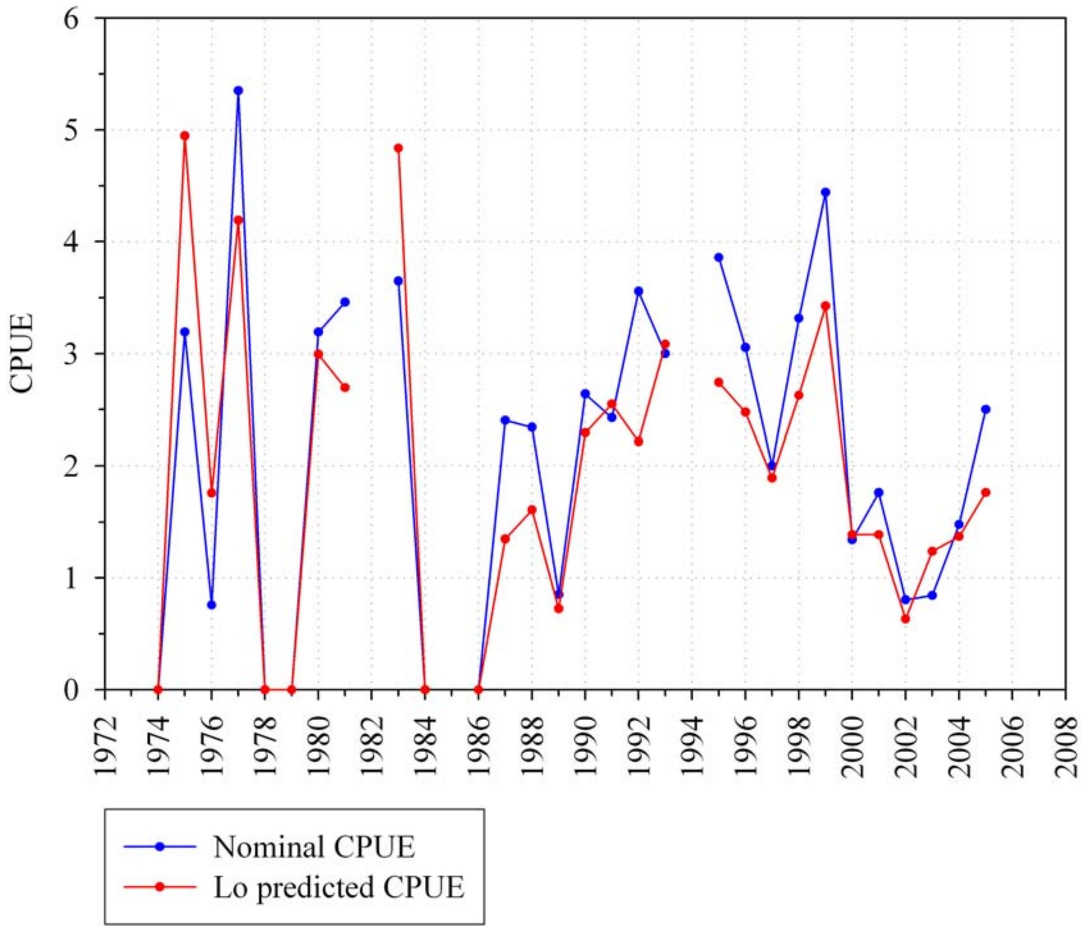


Table 1: Model fits for percent positive catches.

PPT								
	df	deviance	dev/df	%red dev/df	% Difference	Loglikelihood	Chi-square	Pr
Null	381	523.52	1.37			-261.52		
month	378	487.20	1.29	6.20	6.20	-243.60	36.32	<.0001
year	352	488.79	1.39	-1.06		-244.40	Neg. of hessian not positive definitive	
surftemp	303	404.17	1.33	2.93		-202.09	Neg. of hessian not positive definitive	
station	370	436.48	1.18	14.15		-218.24	Neg. of hessian not positive definitive	
julday	272	345.92	1.27	7.44		-172.96	Neg. of hessian not positive definitive	
month+								
year							Neg. of hessian not positive definitive	
surftemp							Neg. of hessian not positive definitive	
station	367	394.86	1.08	21.70	15.50	-197.43	92.34	<.0001
julday							Neg. of hessian not positive definitive	
month+station								
year							Neg. of hessian not positive definitive	
surftemp	335	365.3525	1.0906	20.6316862		-182.6762	0.03	0.8554
julday							Neg. of hessian not positive definitive	
month+station								
month*station							Neg. of hessian not positive definitive	
month*year							Neg. of hessian not positive definitive	
month*surftemp							Neg. of hessian not positive definitive	

Table 2: Model fits for positive catch CPUE.

Positive catches								
	df	deviance	dev/df	%red dev/df	% Difference	Loglikelihood	Chi-square	Pr
null	166	94.409	0.5687			-189.3379		
station	159	79.3345	0.499	12.2560225	12.2560225	-174.8119	29.05	0.0001
surftemp	131	67.2476	0.5133	9.74151574		-155.7194	34.7	0.0731
year	143	80.2492	0.5612	1.31879726		-175.7691	27.14	0.2502
month	163	90.6653	0.5562	2.19799543		-185.9593	6.76	0.0801
julday	95	61.5154	0.6475	-13.856163		-153.5708	20.81	1
station+								
surftemp	125	52.1457	0.4172	26.6397046	14.3836821	-135.8809	47.09	0.0022
year	136	61.2463	0.4503	20.8194127		-153.2047	43.21	0.0065
month	156	73.8401	0.4733	16.7751011		-168.8191	11.99	0.0074
julday	88	43.5755	0.4952	12.9242131		-124.7807	100.06	0.0131
station+surftemp								
year	104	36.7885	0.3537	37.8055214	11.1658168	-108.67	54.42	<.0001
julday	58	23.0559	0.3975	30.1037454		-72.2234	127.32	<.0001
month	122	49.6938	0.4073	28.380517		-132.1242	7.51	0.0572
station+surftemp+year								
surftemp*month	85	26.5555	0.3124	45.0676983	7.26217689	-83.246	50.85	<.0001
month	101	35.2477	0.349	38.6319676	0.82644628	-105.3328	6.67	0.083
julday	38	13.5074	0.3555	37.48901		-30.5184	156.3	<.0001

Table 2. Nominal annual sharpnose CPUE (sharks/100 hks). N= number of sets.

YEAR	n	AVG	CV
1974	3	0.00	
1975	8	3.19	2.467226
1976	4	0.76	2
1977	8	5.35	1.3952691
1978	4	0.00	
1979	2	0.00	
1980	21	3.19	1.8743678
1981	24	3.46	1.1597
1982	1		
1983	5	3.65	1.3743358
1984	3	0.00	
1985	0		
1986	2	0.00	
1987	3	2.40	1.0934944
1988	3	2.34	0.9100606
1989	4	0.85	0.6756457
1990	25	2.64	2.4545338
1991	22	2.43	1.9807226
1992	18	3.56	1.7235728
1993	15	3.00	1.5223207
1994	0		
1995	21	3.86	1.3478632
1996	25	3.05	2.2128964
1997	21	2.00	1.8027756
1998	21	3.31	1.536861
1999	17	4.44	1.3787842
2000	22	1.34	1.8026077
2001	23	1.76	1.5643535
2002	15	0.80	1.3479694
2003	10	0.84	2.6214324
2004	20	1.48	1.9519656
2005	12	2.50	1.6667879

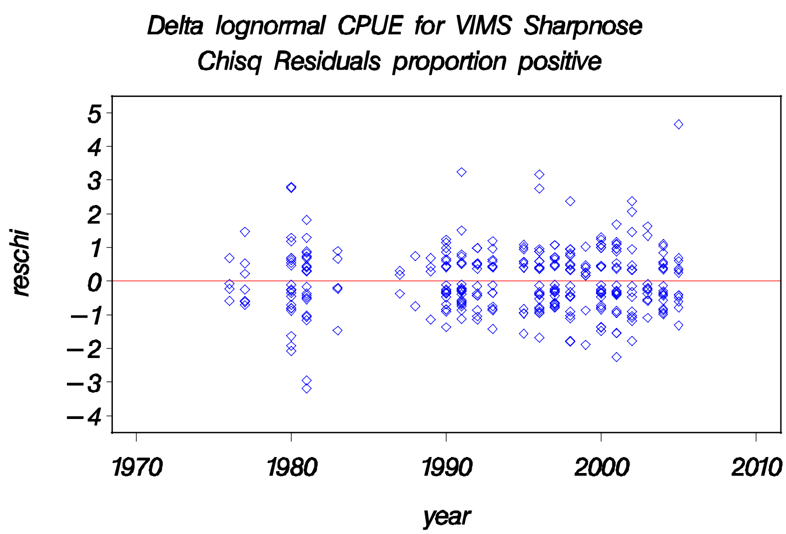
Addendum to SEDAR 13-DW-19. G. Walter Ingram, Jr.

The Indices Working Group were concerned that the values of CV did not correspond to those of the LCL and UCL. Therefore, I developed the indices again using the Lo methodology and a backward selection procedure as described in SEDAR 13-DW-22. The following tables and figures summarize the submodel and final index results.

Binomial Submodel Results

Type 3 Tests of Fixed Effects

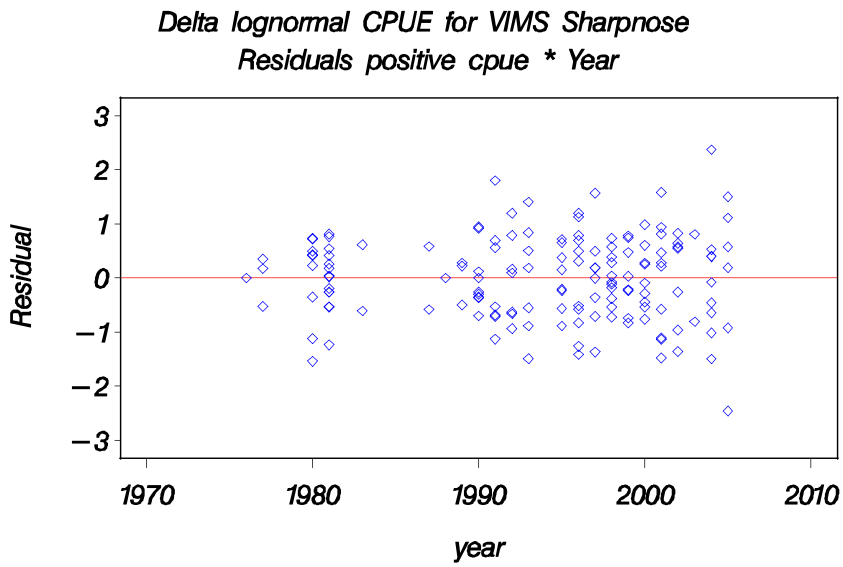
Effect	Num DF	Den DF	Chi-Square	F Value	Pr > ChiSq	Pr > F
year	22	300	13.23	0.60	0.9265	0.9222
station	6	300	49.38	8.23	<.0001	<.0001
month	3	300	27.51	9.17	<.0001	<.0001

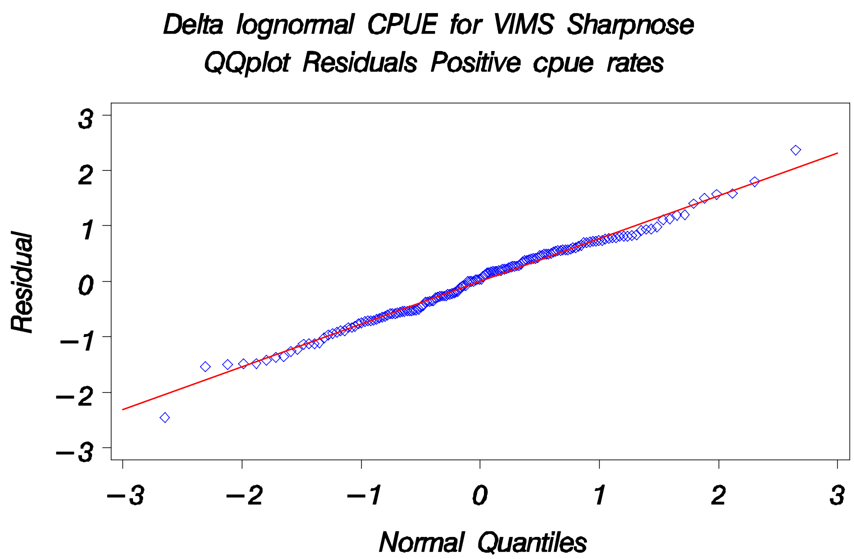


Lognormal Submodel Results

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
year	22	122	2.16	0.0044
month	3	122	6.18	0.0006
station	6	122	10.27	<.0001


Delta lognormal CPUE for VIMS Sharpnose
Residuals positive cpue * Year
Residual
3
2
1
0
−1
−2
−3
1970
1980
1990
2000
2010
year


Delta lognormal CPUE for VIMS Sharpnose
QQplot Residuals Positive cpue rates
Residual
3
2
1
0
−1
−2
−3
−3
−2
−1
0
1
2
3
Normal Quantiles

Index Results

Survey Year	Nominal Frequency	N	Index (CPUE units)	Scaled Index (to a mean of one)	CV	LCL	UCL
1976	0.25000	4	0.03626	0.01286	1.89333	0.00109	0.15176
1977	0.42857	7	1.12546	0.39926	0.72814	0.10833	1.47154
1980	0.42857	21	3.46071	1.22771	0.44368	0.52589	2.86614
1981	0.58333	24	3.70324	1.31375	0.26079	0.78651	2.19441
1983	0.40000	5	3.11430	1.10482	1.04863	0.19734	6.18538
1987	0.66667	3	5.10317	1.81038	0.58737	0.60938	5.37840
1988	0.50000	2	1.76480	0.62607	1.22348	0.09242	4.24136
1989	0.75000	4	0.94609	0.33563	0.53289	0.12348	0.91227
1990	0.39130	23	2.70620	0.96004	0.37980	0.46073	2.00046
1991	0.33333	21	3.14704	1.11643	0.54713	0.40119	3.10679
1992	0.50000	14	2.47821	0.87916	0.43352	0.38336	2.01617
1993	0.50000	14	3.15370	1.11880	0.53154	0.41254	3.03415
1995	0.61538	13	2.71512	0.96321	0.39182	0.45234	2.05103
1996	0.45833	24	3.20118	1.13564	0.40198	0.52369	2.46269
1997	0.38095	21	2.04815	0.72660	0.47098	0.29684	1.77856
1998	0.52381	21	3.24704	1.15191	0.28819	0.65475	2.02656
1999	0.80000	10	6.05703	2.14877	0.27367	1.25534	3.67805
2000	0.40909	22	1.15642	0.41025	0.38203	0.19609	0.85830
2001	0.43478	23	2.55030	0.90474	0.43032	0.39674	2.06317
2002	0.46667	15	1.85002	0.65631	0.44411	0.28092	1.53331
2003	0.20000	10	1.55653	0.55219	0.93911	0.11257	2.70872
2004	0.47368	19	1.83297	0.65026	0.46891	0.26660	1.58605
2005	0.50000	12	7.87920	2.79520	0.61584	0.89925	8.68851

Delta lognormal CPUE for VIMS Sharpnose
Observed and Standardized CPUE (95% CI)