INDEXES OF ABUNDANCE FOR SMALL COASTAL SHARKS FROM THE SEAMAP TRAWL SURVEYS

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Summary

Simple abundance indexes ('Base Indexes') are reported for four of the time series in the Resource Surveys / SEAMAP trawl surveys database, for Atlantic sharpnose, bonnethead, and blacknose. Finetooth appeared in the surveys only twice, so no meaningful indexes could be calculated for that species. Extended indexes for fall and summer ('Bayesian Indexes') were calculated for sharpnose and bonnethead based on the Bayesian calibration procedures used in SEDAR7 and SEDAR9. An extended sharpnose index for fall is viable for 1972-2006, and for summer 1982-2006. An extended bonnethead index is viable for fall 1972-2006. The summer index for bonnethead may be a bit less useful, but one is available for 1982-2006. Blacknose was too rare to be a candidate for the extended index analysis. Indexes for the 4 small coastal species combined are also reported. Size frequency histograms are submitted in an accompanying file, so the DW can evaluate whether developing additional indexes for specific sizes or sized-based ages are worth attempting.

Introduction

The SEAMAP trawl surveys, and their predecessors in the SEFSC Resources Surveys program, have data potentially relevant to small coastal sharks back to 1972. As identified in SEDAR7-DW-1, there are 6 separate 'time series' to be considered: the fall time series Fall Groundfish (FG) 1972-1986, First Fall (FF) 1987, Fall SEAMAP (FS) 1988-2006; and the summer time series Summer SEAMAP (SS) 1987-2006, Early SEAMAP (ES) 1982-1986, and Texas Closure (TC) 1981.

One analytical treatment calculates simple indexes for each time series, termed 'Base Indexes' in SEDAR7-DW-1 and SEDAR9-DW-27. Details about the Base Index calculations are covered at length in SEDAR7-DW-1; but in brief, all Base Indexes are weighted arithmetic means of catches per hour from stratified random designs, with the weights being the geographic areas of the strata. There are no adjustments for missing strata in the Base Indexes. Even without adjusting for possible effect of missing stations, a constant 'q' within each time series was considered a reasonable assumption. Each index could stand alone as an assessment tuning index, and it is a reasonable option to use them all that way. However, because the areas sampled, and some additional strategic details, are not the same among the surveys, there is no reason to assume the same or even similar q's apply across the several time series.

SEDAR7-DW-2 derived a method to link the series together within each season, producing two much longer series where a constant q would be a reasonable assumption. This linking is done with a Bayesian model, which also accounted for missing observations. Not all species are candidates for this Bayesian analysis – if abundance is too low, the estimation is futile. For the species successfully considered so far, the Base Indexes and the Bayesian Indexes (within individual time series) have been very similar in central tendency. The error structures are different (normal for the Base Indexes; lognormal for the Bayesian), but even so, the spreads of the 95% confidence intervals have been similar within the individual time series. The effects of missing stations have been found to be minimal. The real value of the Bayesian formulation came in revealing the true cost of covering less than the full range in the earliest surveys, and for some species, the cost was quite extreme. For example, the analysis connects Fall SEAMAP with a recalibrated Fall Groundfish series. Although Fall Groundfish confidence interval within the limited area surveyed are often quite respectable, confidence intervals about the calculations required to make SEAMAP-wide inferences from the Fall Groundfish surveys are often not. (However, the magnitude of this effect can be quite variable among species.) Estimated fractions of the stock present in the smaller geographic area covered by the FG and TC surveys were often highly variable across years in the FS and SS surveys. Similarly, day: night differences imply a different q between the SS and the night-only TC and ES series. The Bayesian model takes those variabilities into account in calculating confidence intervals for the extended time series.

In previous SEDARs, analysis of trawl survey data continued between the DW and AW with estimation of age composition from size compostion (SEDAR7-AW-15; SEDAR9-AW-1). The preliminaries for such analyses are presented here, but as in SEDAR9, getting input from experts on recruitment patterns and age and growth at the Data Workshop is necessary before continuing. Shark abundances are so low, and the size compositions are so broad, that it may not be feasible to derive age-specific indexes. In any case, size data are available for 1987 forward.

There are some limitations or caveats to consider prior to analysis. Survey coverage has deteriorated in the most recent years, due to maintenance problems with the primary vessel (Oregon II). Hurricane Katrina also damaged the Oregon II in 2005, so much of that survey was switched to the Gordon Gunter, and some of the state SEAMAP partners were not able to participate. Recovery from the hurricane has caused an interruption in our pipeline bringing newly data into the data management system. The 2006 survey results should still be considered preliminary, although none of the anomalies seen so far affect the analyses here. Vessel calibration analyses conducted so far show little or no detectable catch rate differences among vessels in comparative trawls, although no analysis addressing statistical power of such tests have been completed. The SEAMAP trawling is limited to the area west of Mobile Bay to the Mexican border, 5-50 fm. For some species, this covers much of the range of the stock, but is not as satisfactory for species abundant in Florida or in inshore waters. High taxonomic resolution for rare species of sharks may be a relatively recent addition to our surveys. However, the most abundant small coastals were probably well identified throughout the survey history. One probable exception is the singleton TC survey in 1981. A single Atlantic sharpnose was the only shark recorded. This is so anomalous that I suspect sharks were not worked up for some reason on that particular cruise, and I ignored that cruise in the analyses that follow.

Methods

A detailed description of the data base and methods for calculating the 'Base Indexes' are available in
SEDAR7-DW-1. The analyses used to link separate time series via a Bayesian analysis are the same as those described in SEDAR7-DW-2. For SEDAR9 and SEDAR13, I have used only the recommended model from the red snapper work, which was model 2 in SEDAR7-DW-2. Only catch in numbers are considered here. If someone wished to work with weight indexes, they could be made available, but given the size range for sharks, it would probably be safer to take the number indexes and multiply by average weights. However, weight indexes have rarely been used in recent assessments when CPUE's in number were available.

There have been no changes of any substance to the analytical procedures since SEDAR7-DW-1 & 2. The Bayesian analysis uses the freely available software BUGS, and the program listings for model 2, appended to SEDAR7-DW-2 are still applicable. There probably have been some substitutions of output variables over the last few years for various purposes, but not to the core of the calculations. I have over time dropped some of the secondary diagnostic procedures, having never found any issues not already discussed in SEDAR7-DW-2, and have shortened the analyses to a 16k iteration standard to save time. I have also reduced the number of figures presented here compared to previous Index papers, partly because of the longer list of species to consider, and mainly because given the previous SEDAR experiences, there were no surprises in what is not included here. However, most anything available in previous papers is either already available, or could be calculated, for the asking.

The quantiles reported by BUGS (basically, histograms of MCMC simulation results) are not directly transferable to the stock assessment models generally used. The BUGS results are put in a parameterized form to capture the central tendencies and uncertainties revealed in the Bayesian analyses. For the Bayesian Indexes, parameters are reported for a normal distribution on natural log scale. The median of the BUGS analysis is taken as the central tendency. The standard error is estimated as (interquartile range)/1.34898. (BUGS also reports a mean and standard error that are usually very similar to the median and interquartile-derived values for the trawl index analyses, but in the bycatch analyses using similar methods (e.g. SEDAR7-DW-3), a lognormal did not always approximate the distribution extremes very closely. Generally, the extremes were discounted, and a lognormal approximation preferred. Hence, the statistics were based on median and interquartile range. This convention was carried over to the Index analyses in SEDAR7, and is continued here.) For the Base Indexes, the arithmetic scale mean and standard error are reported. The Base Indexes could probably be used in the stock assessment models in that form, but I believe the extended Bayesian Indexes have been the choice for previous SEDAR species. Species too rare for the Bayesian Index analysis usually were lacking other data required for individual species assessment, anyway.

There are some distributional descriptions reported in the results section, but these are used only for a qualitative picture. These descriptions were developed with simple SAS programs largely centered on Proc Univariate procedures with By statements, and have not included details of those here.

As in all trawl index analyses to date, the FF index results were combined with FS without further adjustment, and are referred to simply as FS in what follows (per the discussion in SEDAR7-DW-2). As noted in the introduction, the TC survey has been dropped from consideration here.

Size frequency data are available for all cruises since 1987. Simple size frequency histograms, i.e. with no weighting for subsampling (which probably did not occur) or for stratum size, are collected in the file UPSCLF.LST submitted to the DW. This file is a SAS output file, most easily read by loading it into the SAS editor, but any text program should work. A text file, UPSCLF.TXT is also available. I ask those at the DW addressing age, growth, and seasonality of recruitment to examine the plots, and decide if calculating indexes for separate size groups is warranted, and if so, what the size boundaries should be. If deemed warranted, I have some standard programs to provide size (age) – specific indexes to the Assessment workshop. This was the procedure we followed in SEDAR9.

Considerable details on the survey designs and database variables are available in SEDAR7-DW-1. Those wanting more information on field procedures will find them in the SEAMAP Field Operations Manual, available from the Pascagoula Lab. Similar field manuals apparently do not exist for the pre-SEAMAP work, but procedures then were very similar to the procedures adopted by SEAMAP.

Because of the disruption from Katrina, the data available for 2004-2006 has not yet been ingested into the full Oracle database described in SEDAR7-DW-1. Data were assembled directly from the shipboard data entry system, ingested into an earlier version of the SEAMAP data management software, and the standard SEAMAP station data were transferred to SAS files suitable for these analyses. These SAS files can be made available if wanted. There are unlikely to be any issues with the standard SEAMAP station records due to this shortcut. The differences would be that non-SEAMAP work piggybacked on any of the cruises has not yet been documented, or included in the available data.

Results

Table 1 lists the cruise dates for each year in each time series, and the number of stations or strata covered.

Atlantic sharpnose are broadly distributed throughout the SEAMAP survey area. Abundances are similar both summer and fall, roughly 1 fish for every 4 hours of trawling. Sharpnose occur in about 10% of the samples both seasons, which is usually enough for reasonably precise indexes. Alongshore, higher abundances occur in the central Gulf in the fall, declining into south Texas. Summer abundances are shifted a bit to the west and south. In depth, about half the population occurs between 20 and 35 fm in the fall, but the distribution is broad. In summer, the largest catches occur in shallow water, with over half the population inside 10 fm. The shallowest (5-6 fm) catch rates are among the highest in summer, suggesting that a substantial portion of the stock may be inside the 5 fm limit of the survey area. Daytime catch rates exceed nighttime rates; by a factor of about 3x in the summer, and over 10x in the fall. Research vessel data from Florida are too sporadic to compare with the SEAMAP survey data, but shrimp bycatch observer data suggest catch rates in Florida run less than 1/5 the rates in the SEAMAP survey area. Average weights per fish run about 1 kg in the fall, without much pattern to variation alongshore or in depth. In the summer, average weights suggest that ~1 kg fish dominate outside 15 fm, but average weights inside 10 fm are nearer 0.1 kg.

Bonnethead occur in about 5% of the fall stations, which is usually enough for a useful if not terribly precise index, and in about 1% of the summer stations, which is marginal for index work. Bonnethead appeared in 13 of the 20 years of the SS time series, which is again marginal. Overall, bonnethead catch rates average about 0.1 fish per hour in the FS survey, but only about 0.01 per hour in the SS. In the fall, they are distributed broadly inside 25 fm, but are sparse outside that. The summer distribution is shallower, with about 60% of the survey-area population inside 10 fm. In the SEAMAP surveys, bonnethead are most frequent in the western Gulf both seasons, and very sparse in the central Gulf. However, they were reasonably abundant, particularly in the early years, in the FG time series, which was restricted to surveying the 88 to 91 30 longitude area. Day catch rates exceed night by about a factor of 8x in the summer, and about 2x in the fall. Average weights appear to run about 2 kg overall, with considerable scatter when calculated over geographic subsets. This scatter probably reflects both the broad size range of the fish, and the small numbers within any subset. Bycatch observer data have Florida catch rates about 3x the rates in the SEAMAP area, suggesting that a sizeable proportion of the Gulf population may be outside the SEAMAP survey area.

Blacknose sharks average about 0.02 per hour in both the FS and SS surveys, and occur in less than 1% of the stations in both seasons. They are at least present most years in the full SEAMAP surveys, but absent most years in the FG survey (central Gulf). All FS occurrences were between 10 and 40 fm; for SS, 5 – 30 fm. In fall, blacknose are distributed reasonably continuously alongshore, with the exception of low rates near the Mississippi river. In the summer, catch rates tend to be higher in the western Gulf. Day catch rates exceed night by about 15x in the fall, but were nearly equal in the summer. However, blacknose were not present at all in the data from the ES survey, which was night only. Bycatch observer data show comparable catch rates between Florida and the SEAMAP area east of the river, but lower catch rates west of the river, so a sizeable portion of the Gulf population may exist east of the survey area. Average weights per fish run 2-3 kg, with no obvious patterns.

Finetooth were not reported at all in any of the summer surveys, and recorded in only 2 years in the fall. No further analyses were made for this species.

As a direct consequence of the relative abundances of the species, patterns for small coastals summed together will match sharpnose in the summer, and combine the features of bonnethead and sharpnose in the fall, dominated by sharpnose.

Base indexes were calculated for each of the 3 small coastal species with sufficient abundance, and for the 4 species summed at each station (Figs 1-15). [The solid bars are interquartile ranges. The thin vertical lines are 95 CI's. Connecting lines join the means.] As noted above, the TC series (singleton year, 1981) is not reported, as only 1 shark was recorded in the entire survey – one Atlantic sharpnose.

Extended Bayesian Indexes were developed for sharpnose, bonnethead, and combined small coastals. Figures 16-18 plot the fractions of the population in the FG survey area each year during the FS surveys. (The calibration is actually ln(FS area CPUE) - ln(FG area CPUE), but the 'fractions of the stock' values seem more intuitive to me, so I plot them instead. Either statistic can be calculated from the other.) Figures 19-21 plot the calibration distribution for converting the FG surveys into FS units. The extended Fall Indexes resulting from applying the calibration appear in figs. 22-27, with paired figures showing the results on arithmetic and log scales. [The solid bars are interquartile ranges. The thin vertical lines are 95 CI's. Connecting lines join the medians, the preferred statistic of central tendency.] Figures 28-29 plot the day:night factor (put more precisely, ln[day and night CPUE]-lnInight CPUE]) from each year in the SS series for sharpnose and bonnethead The resulting calibration distributions are shown in figs. 30-31. Combined small coastal results are so similar to sharpnose that I omitted these plots for them. The extended Summer Indexes, included the combined small coastals are shown in figs. 32-37, again pairing arithmetic and natural log scale results in successive figures.

Parameters approximating the statistical distributions for each index point are collected in the Excel file 'Trawl Indexes.xls' submitted for transmitting to the Assessment Workshop. The Base Index parameters are means and standard errors on an arithmetic scale, with the intention that a normal distribution would be assumed. The Bayesian Index parameters are intended as means and standard errors of a lognormal distribution, and are both in natural log units.

Discussion

The sharpnose Fall Index (fig. 22) suggests a downward trend to the eye, but note the broad confidence intervals from the FG years, and the 2 low points for 1972 and 1973. The reversed-direction, incomplete survey from 1987 produced an anomalously large variance (and a higher central tendency), but there is little indication of any continuing trend after 1988. Figure 17 does not suggest any trend over years in the fraction of the population in the FG survey area during the FS years, which lends some confidence to the estimates from the FG years translated into FS units. Turning to the summer, the sharpnose day:night graph (fig. 28) shows a large variation, probably caused mainly by how low the night catch rates are. This variability causes the very large confidence intervals in figs. 32 and 33, effectively dwarfing the confidence intervals for the SS years when all are plotted on the arithmetic scale. The wider bars in fig 32 might suggest some downward trend to the eye, but the log plot (fig. 33) is more instructive: with the skew removed by the log, the overall trend is quite flat.

For bonnethead, the FG Base Index (fig. 5) suggests an extended drop in the FG survey area. The FS Base Index hints at an upward trend over the last decade. The percent of the population in the FG area during the SEAMAP years is highly variable, again resulting in dwarfing of the FS-years' confidence intervals in figure 24 relative to the FG years. However, fig. 18 suggests no time trend for the fraction of the population in the FG area, which is encouraging for using its content to calibrate the FG years into FS units. After calibration, the trends suggested in the Base Indexes hold. The trend is downward prior to 1990, and the upward since. The extended series suggests that the magnitude of the early downward trend exceeds the magnitude of the later upward trend (fig. 25), which could not be decided by the Base Indexes alone. The day:night factor for bonnethed shows minimal interannual variation, but a large uncertainty within each survey year. This pattern results in much larger confidence intervals for the calibrated ES years compared to the SS years. No extended trends are evident in fig. 35.

The analysis procedures for the 4 small coastals combined were the same as for the individual species cases. Not surprisingly, summer results look very much like the sharpnose results, and the fall results are not greatly different than the sharpnose results.

The general performance seen in these analyses did not contain anything not already seen with species from previous SEDARs. The data appear plausible, and the models appear to be handling the data in a plausible manner. One must always be concerned that extrapolating estimates from smaller surveys to the SEAMAP areas will be in error beyond what the confidence bands suggest, if spatial distributions were substantially different prior to the FS and SS surveys, but the only suggestion of problems from within would be termporal trends in the calibration factors, which are not evident for these species. Doubters would have the option of using the Base Indexes separately, at the cost of having much shorter index segments, and having to estimate separate q's for each in the assessment models. Here, I recommend that the extended Fall Indexes for both sharpnose and bonnethead be used. The extended Summer Index for sharpnose is also recommended. There is probably nothing wrong with the extended Summer Index for bonnethead, and I thus recommend it too, but the high within-year variability coupled with lack of obvious trend, suggests it may have little impact in any stock assessment model.

High taxonomic resolution tends to be the norm in Pascagoula and SEAMAP surveys, but I have some concerns for sharks based on the anomalous results for the TC cruise, the absence of blacknose in the ES series, and by comments from old hands that sharks were not always identified to species in the early years. There is no rigorous way to check from the data alone. No documentation exists regarding taxonomic resolution, and I am not sure what such documentation would look like, anyway. Any concern for small coastals specifically would really depend on how difficult these particular species are to identify to the species level. I will leave that evaluation to the experts at the Data Workshop. I can only comment that I did not see any abnormal fluctuations that might signal variability in taxonomic resolution.

In worrying about any mechanism that might cause fishery independent indexes to be misleading, my biggest concern always centers on any mismatch between the range of any stock and the area covered by the surveys. We usually write off the northern Mexico and its southward narrowing shelf for any species abundant throughout the northwestern Gulf. Extension of a stock to the east is more problematic. The shelf area off Florida is large, and if catch rates there comparable to those in the survey area, a large fraction a stock may not covered. Within the Texas-Alabama range of the SEAMAP trawl surveys, catch rates that peak in the shallowest depths are a warning that a substantial fraction of the population might be beyond the survey area, in inshore waters. One of the biggest lessons from the Bayesian calibrations to date has been the cost of incomplete coverage on inferring stock abundance, shown by the enormous confidence bands for some species when FG surveys are used to infer FS-range abundances. The FG to FS cost can be quantified; the cost of SEAMAP range to larger stock range uncertainty cannot. Nevertheless, the SEAMAP surveys do cover a large spatial area in a consistent manner, and are often the best available sources for abundances indexes.

Citation Notes

All references are to previous SEDAR documents, posted on the SEFSC website: www.sefsc.noaa.gov/sedar

BUGS software is available (free) at www.mrc-bsu.cam.ac.uk/bugs

Tables and Figures

Table 1. List of cruise dates and numbers of stations for each year's surveys.

Fall Groundfish (FG)

YR	NHAULS	MIN	MAX	
1972	319	27-Sep-72	30-Nov-72	
1973	671	13-Nov-73	9-Dec-73	
1974	681	5-Nov-74	27-Nov-74	
1975	589	28-Oct-75	17-Nov-75	
1976	664	2-Nov-76	23-Nov-76	
1977	672	5-Oct-77	23-Oct-77	
1978	684	10-Oct-78	1-Nov-78	
1979	733	25-Oct-79	19-Nov-79	
1980	557	29-Oct-80	24-Nov-80	
1981	614	14-Oct-81	15-Nov-81	
1982	739	12-Oct-82	21-Nov-82	
1983	423	20-Oct-83	14-Nov-83	
1984	614	9-Oct-84	9-Nov-84	
1985	116	15-Oct-85	7-Nov-85	
1986	41	29-Oct-86	9-Nov-86	(reduced density to extend coverage)

Fall SEAMAP (FF & FS)

YR	NSTRAT	MIN	MAX	(Full coverage is NSTRAT~220)
1987	157	23-Oct-87	22-Nov-87	
1988	209	20-Oct-88	21-Nov-88	
1989	209	20-Oct-89	20-Nov-89	
1990	209	16-Oct-90	18-Nov-90	
1991	216	14-Oct-91	18-Nov-91	
1992	201	18-Oct-92	19-Nov-92	
1993	213	15-Oct-93	18-Nov-93	
1994	214	14-Oct-94	20-Nov-94	
1995	216	16-Oct-95	4-Dec-95	
1996	216	11-Oct-96	22-Nov-96	
1997	214	11-Oct-97	20-Nov-97	
1998	213	14-Oct-98	18-Nov-98	
1999	216	16-Oct-99	20-Nov-99	
2000	213	14-Oct-00	19-Nov-00	
2001	218	15-Oct-01	15-Nov-01	
2002	203	12-Oct-02	17-Nov-02	
2003	214	10-Oct-03	18-Nov-03	
2004	191	15-Oct-04	18-Nov-04	
2005	214	11-Oct-05	15-Nov-05	
2006	199	5-Oct-06	20-Nov-06	

Early SEAMAP (ES) (Full coverage is NSTRAT~110)

YR	NSTRAT	MIN	MAX
1982	112	1-Jun-82	12-Jul-82
1983	118	1-Jun-83	14-Jul-83
1984	96	6-Jun-84	3-Jul-84
1985	93	10-Jun-85	5-Jul-85
1986	104	10-Jun-86	6-Jul-86

Summer SEAMAP (SS) (Full coverage is NSTRAT~220)

YR	NSTRAT	MIN	MAX
1987	226	11-Jun-87	15-Jul-87
1988	200	11-Jun-88	14-Jul-88
1989	174	7-Jun-89	16-Jul-89
1990	199	7-Jun-90	13-Jul-90
1991	217	3-Jun-91	13-Jul-91
1992	216	4-Jun-92	13-Jul-92
1993	212	3-Jun-93	18-Jul-93
1994	214	2-Jun-94	18-Jul-94
1995	211	6-Jun-95	19-Jul-95
1996	209	5-Jun-96	17-Jul-96
1997	205	4-Jun-97	16-Jul-97
1998	201	2-Jun-98	16-Jul-98
1999	213	3-Jun-99	20-Jul-99
2000	203	5-Jun-00	20-Jul-00
2001	149	8-Jun-01	22-Jul-01
2002	214	3-Jun-02	17-Jul-02
2003	183	10-Jun-03	28-Jul-03
2004	209	3-Jun-04	16-Jul-04
2005	174	2-Jun-05	31-Jul-05
2006	194	1-Jun-06	16-Jul-06

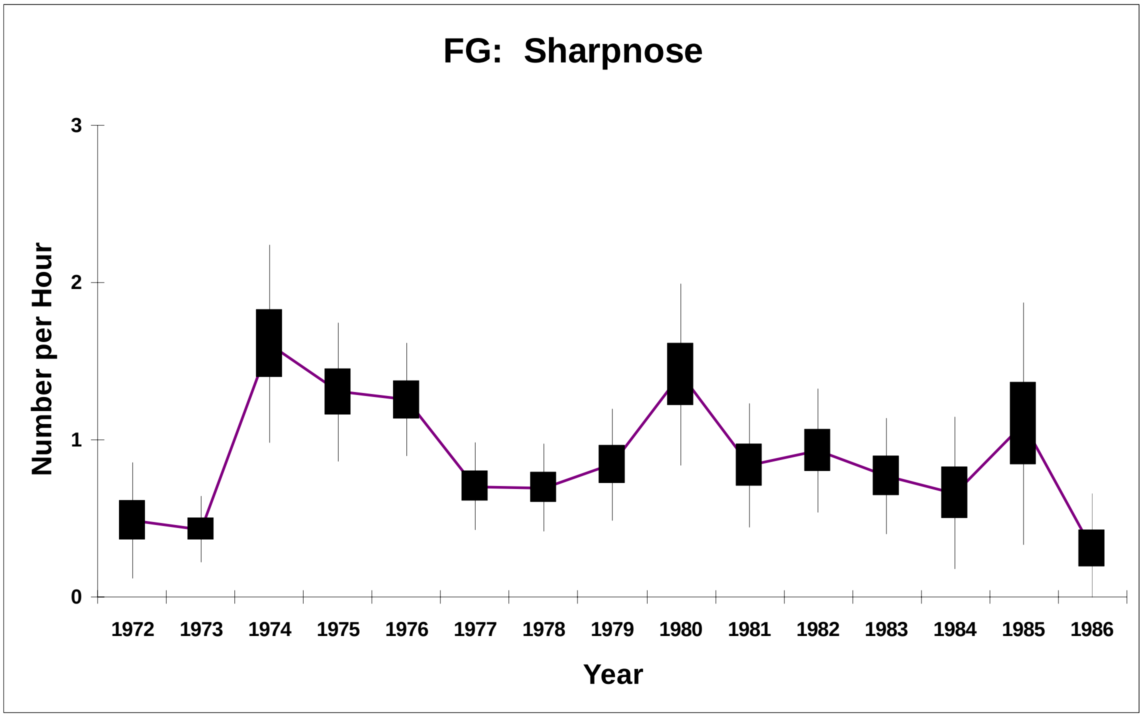

Figure 1. Atlantic sharpnose in the Fall Groundish (FG) time series.

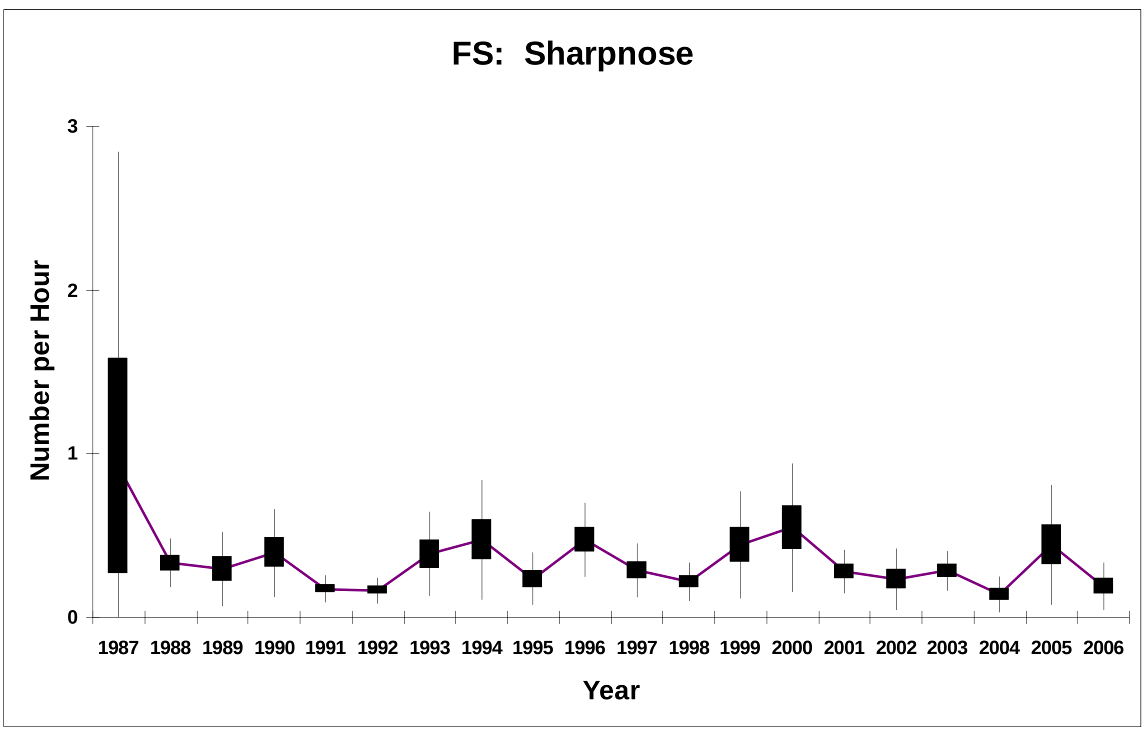

Figure 2. Atlantic Sharpnose in the Fall SEAMAP (FS) time series.

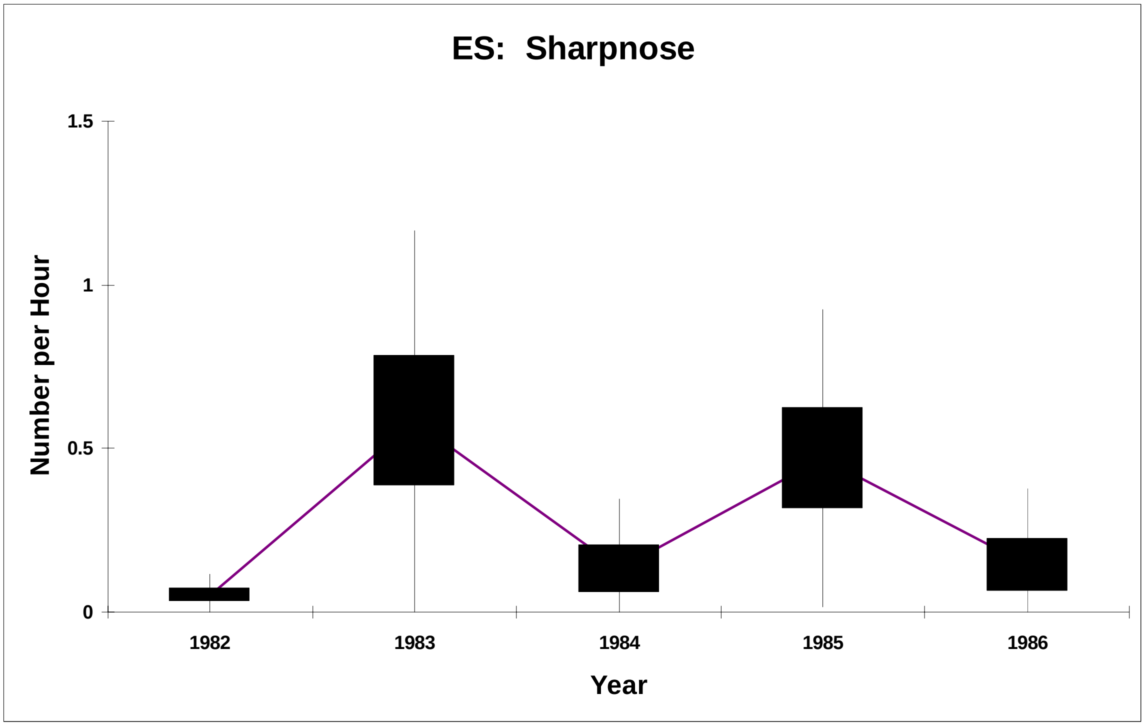

Figure 3. Atlantic Sharpnose in the Early SEAMAP (ES) time series.

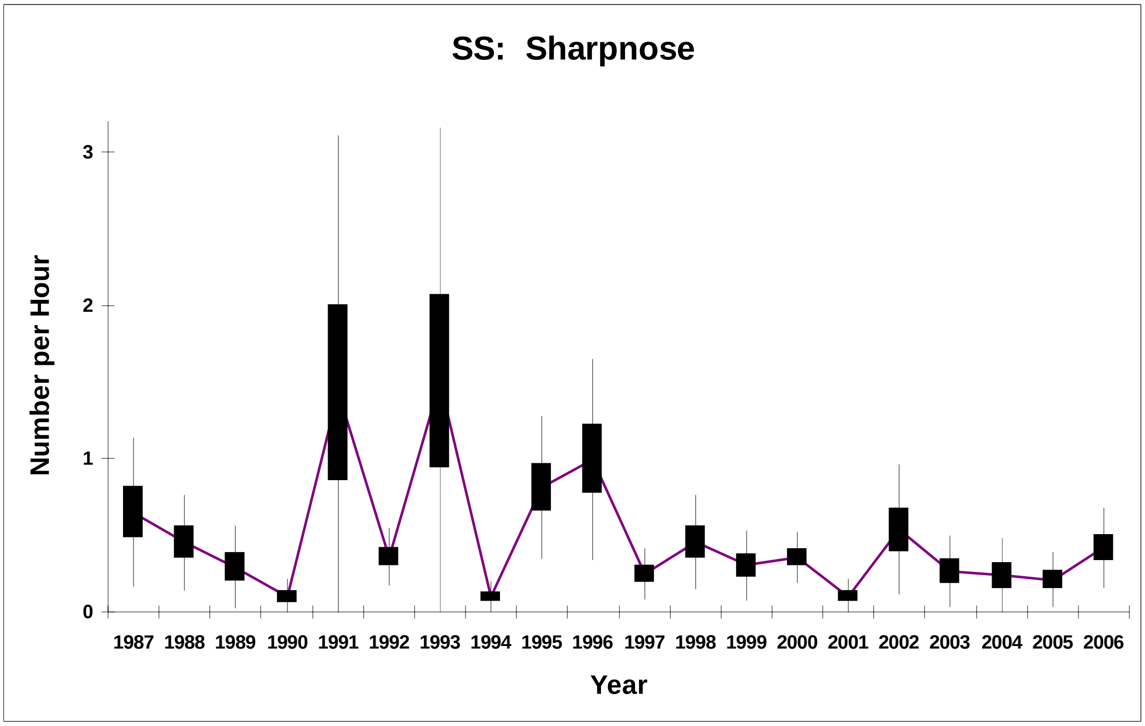

Figure 4. Atlantic Sharpnose in the Summer SEAMAP (SS) time series.

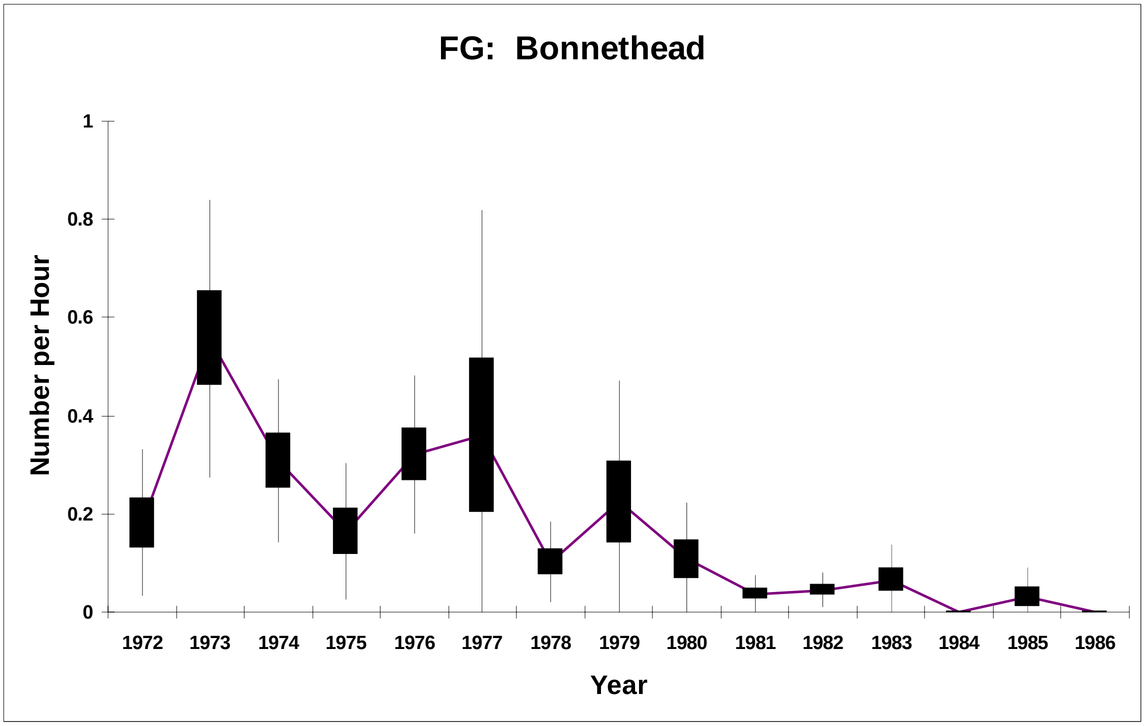

Figure 5. Bonnethead in the Fall Groundfish (FG) time series.

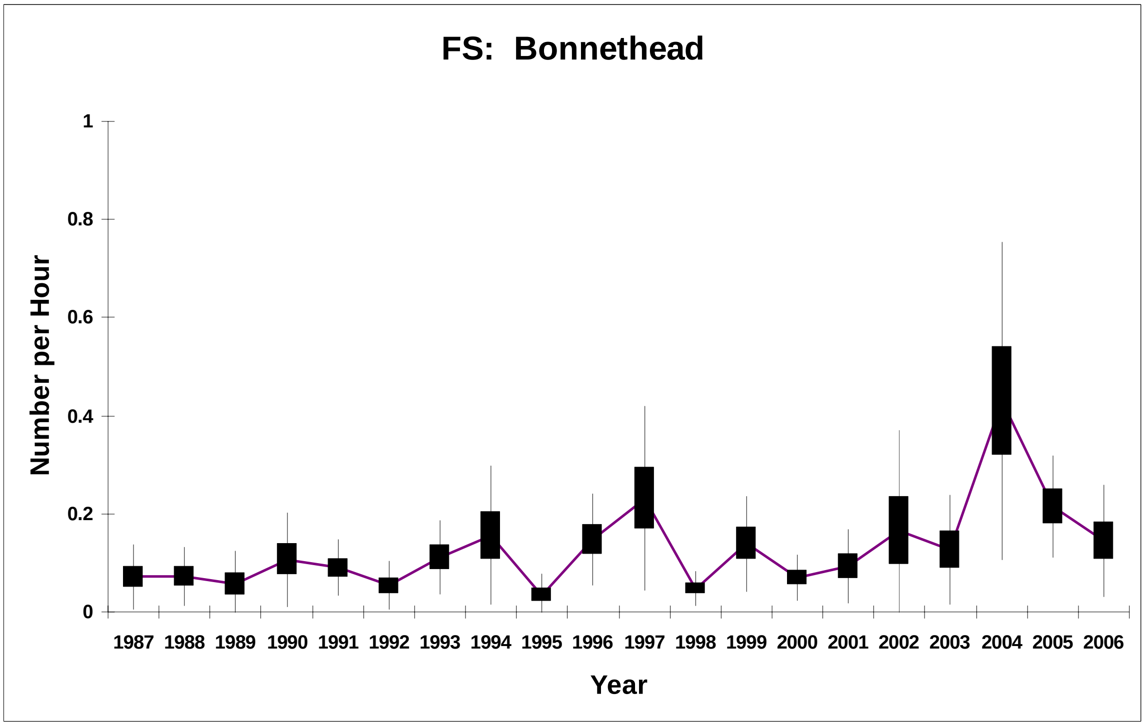

Figure 6. Bonnethead in the Fall SEAMAP (FS) time series.

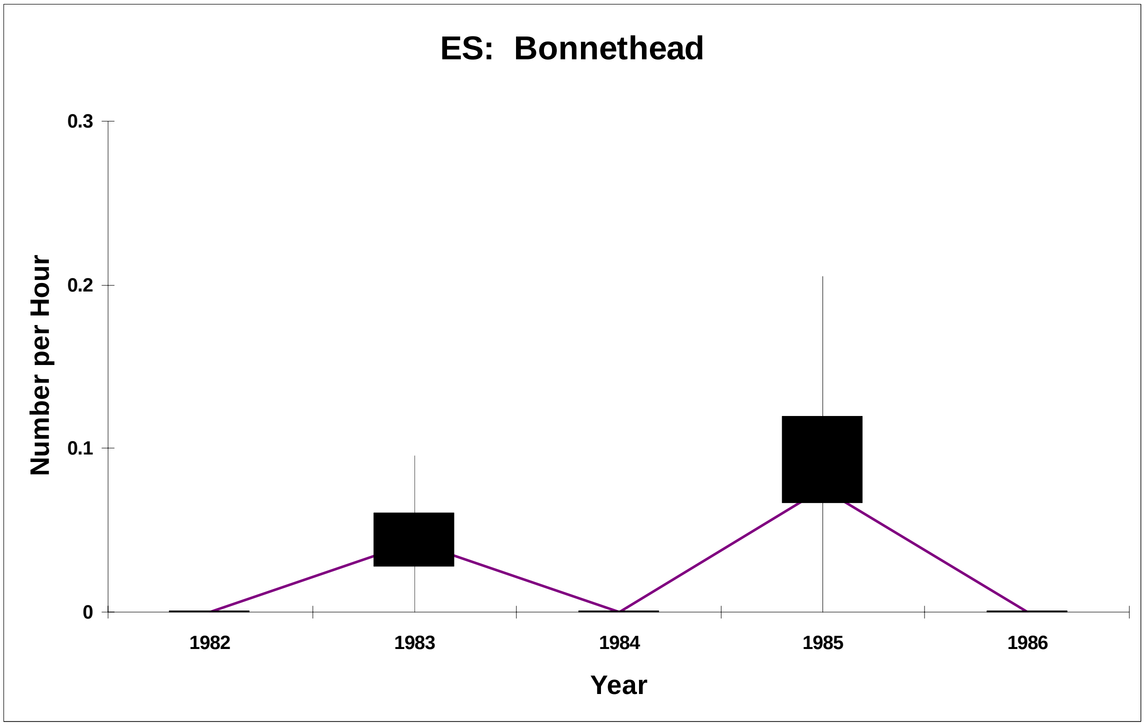

Figure 7. Bonnethead in the Early SEAMAP (ES) time series.

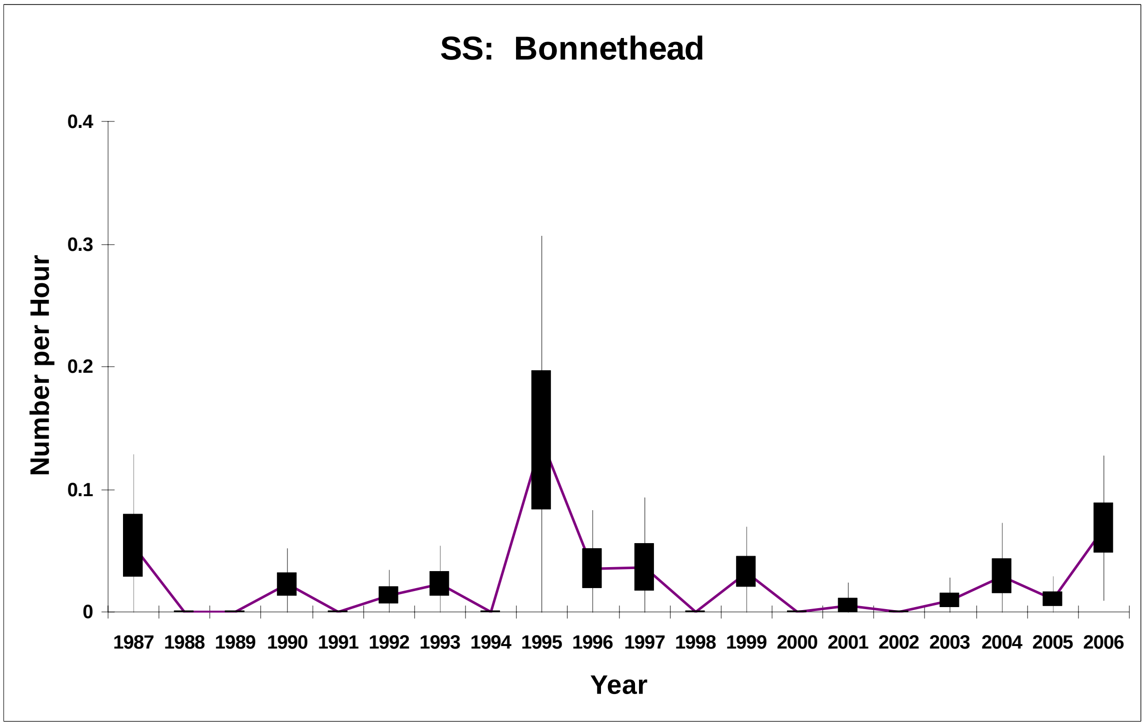

Figure 8. Bonnethead in the Summer SEAMAP (SS) time series.

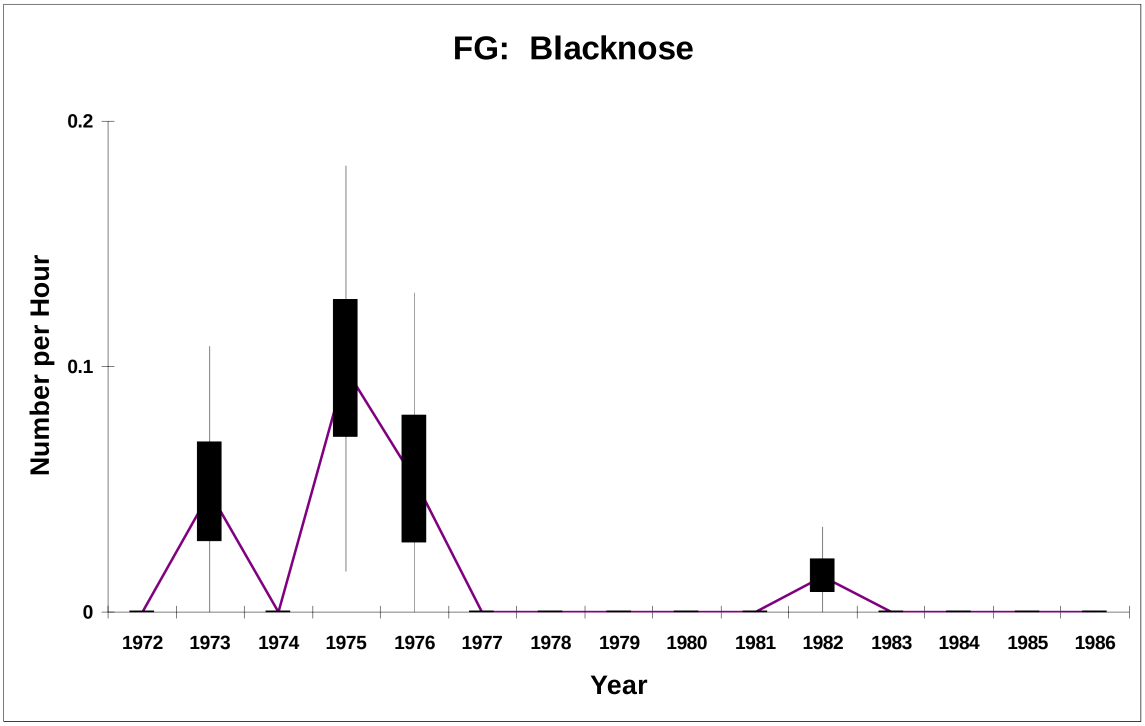

Figure 9. Blacknose in the Fall Groundfish (FG) time series.

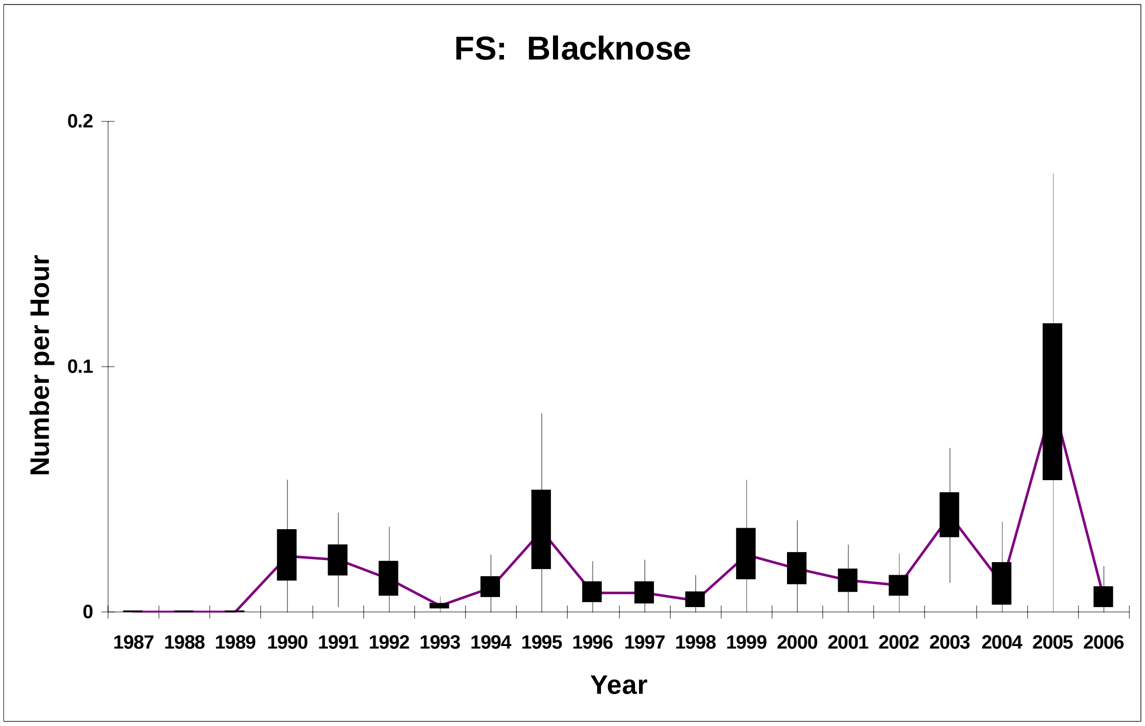

Figure 10. Blacknose in the Fall SEAMAP (FS) time series.

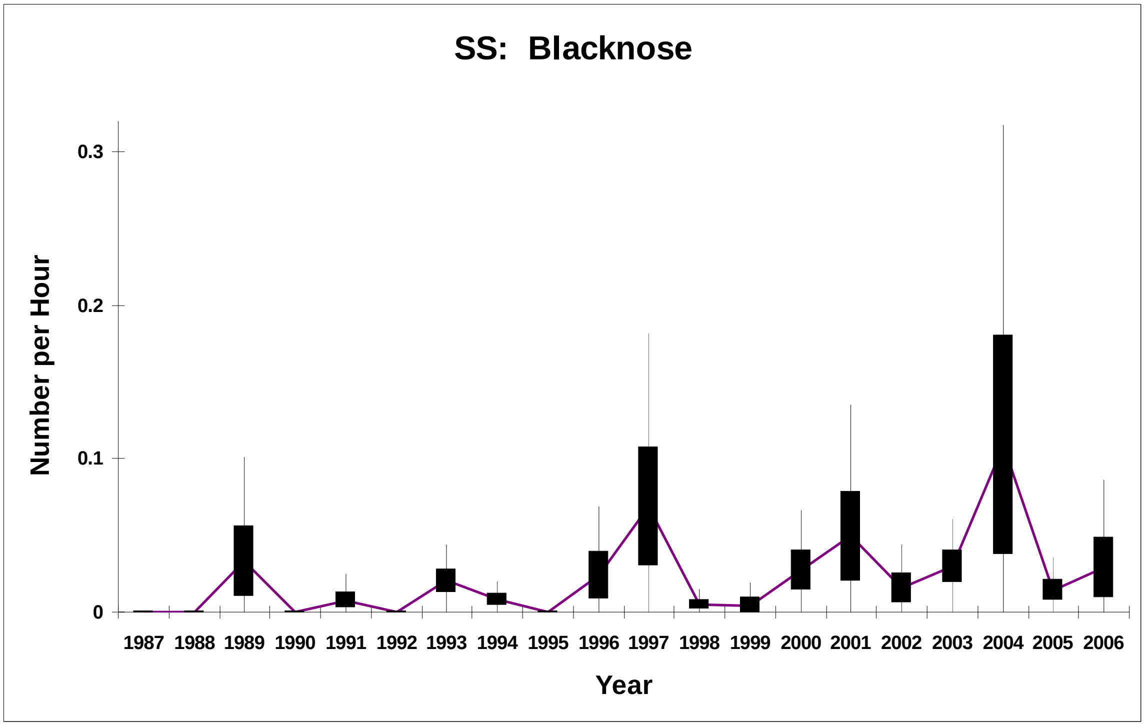

Figure 11. Blacknose in the Summer SEAMAP (SS) time series. (There were no blacknose reported in the ES time series.)

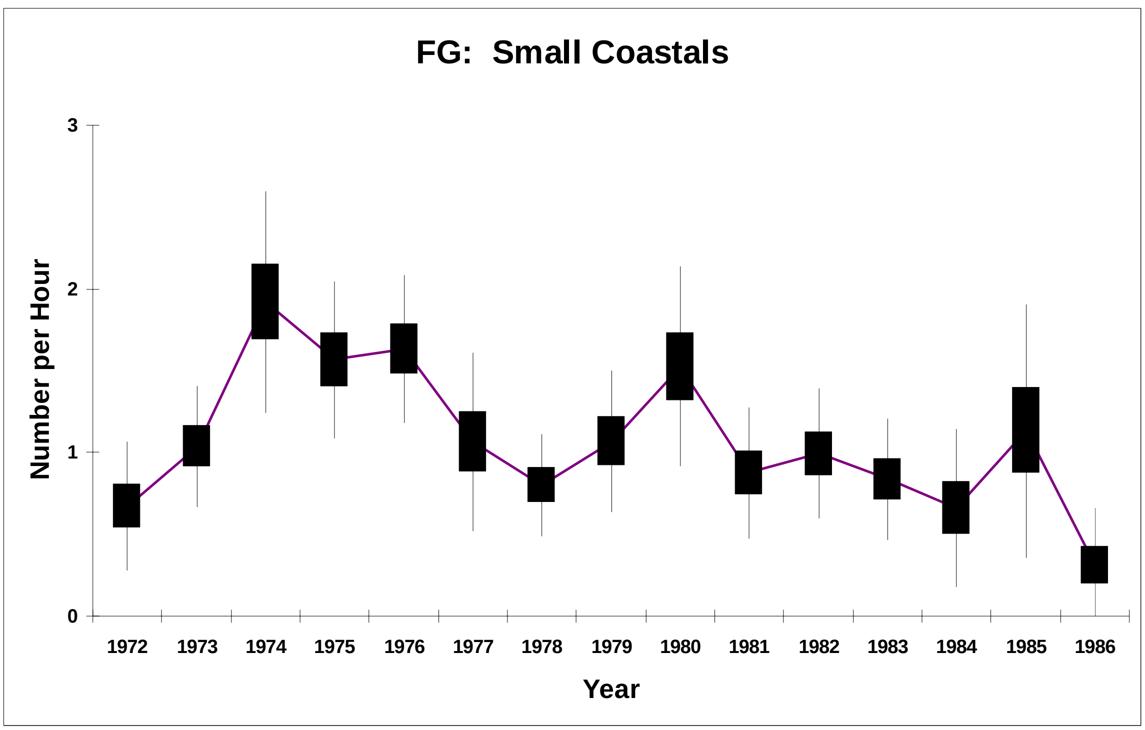

Figure 12. Combined small coastal sharks in the Fall Groundfish (FG) time series.

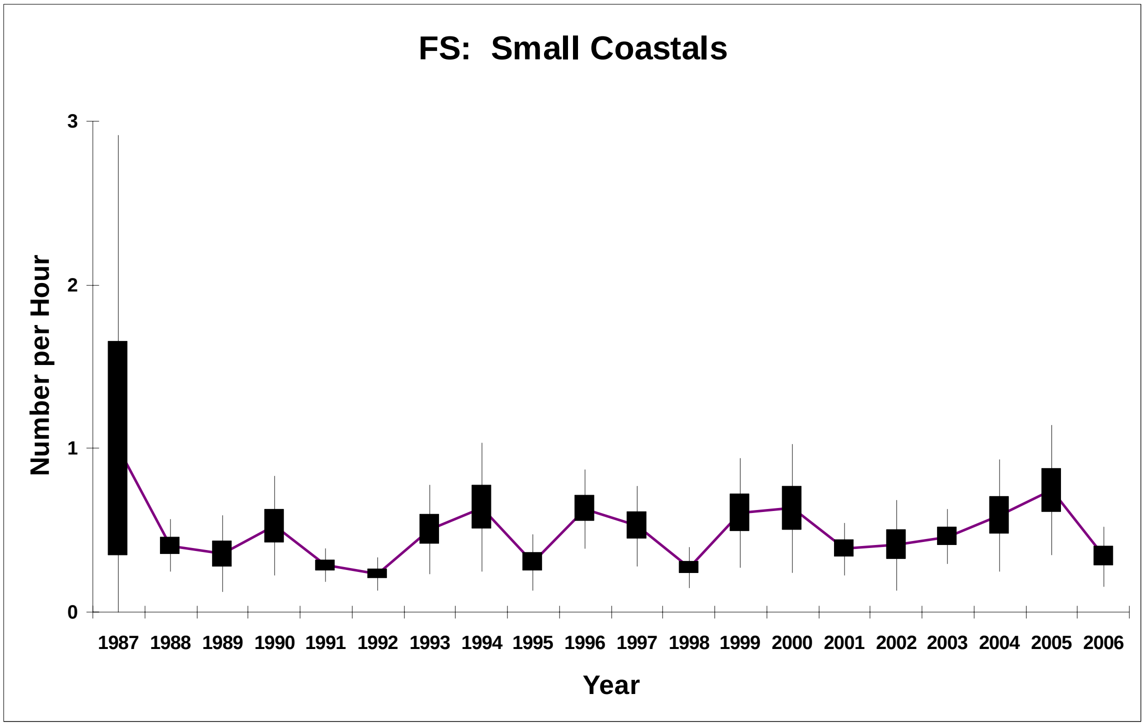

Figure 13. Combined small coastal sharks in the Fall SEAMAP (FS) time series.

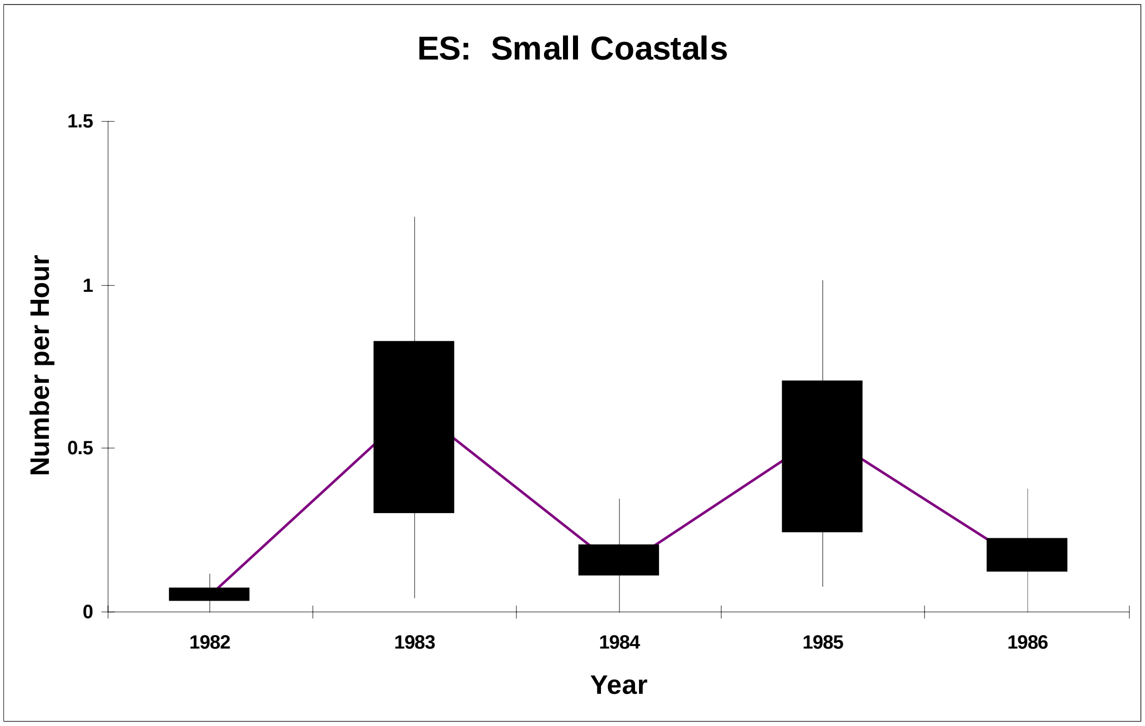

Figure 14. Combined small coastal sharks in the Early SEAMAP (ES) time series.

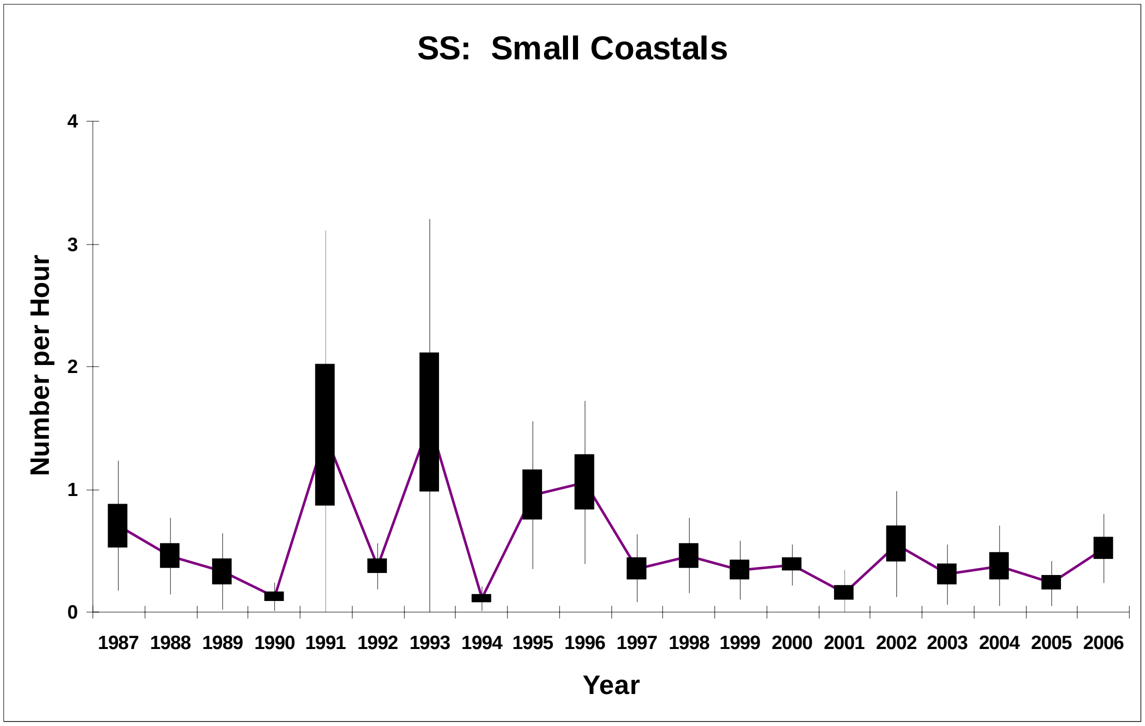

Figure 15. Combined small coastal sharks in the Summer SEAMAP (SS) times series.

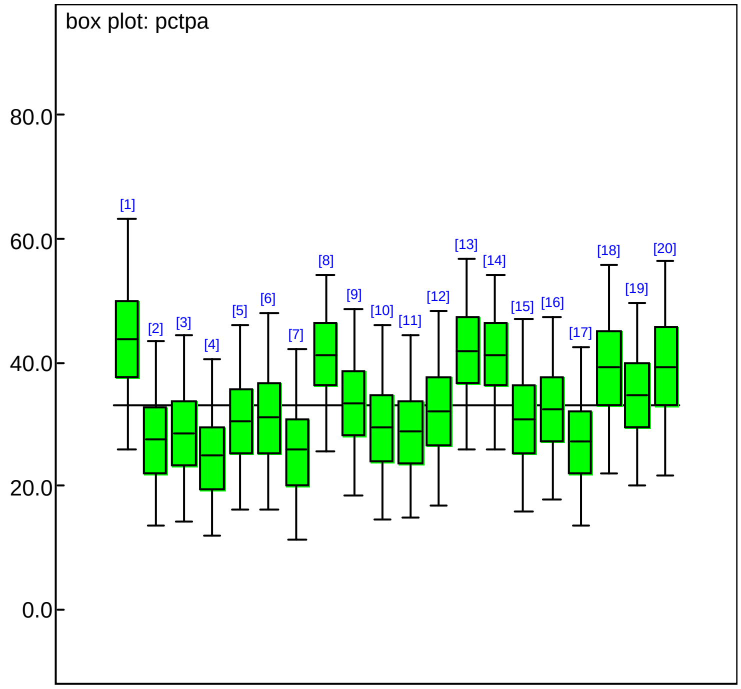

Figure 16. Estimates of percent of sharpnose population in the FG survey area during the annual FS surveys. Years are 1987-2006.

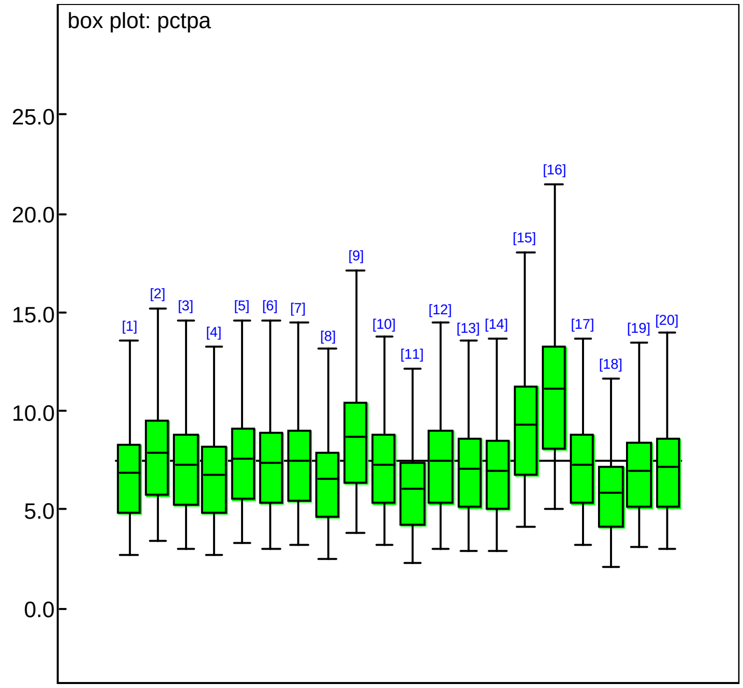

Figure 17. Estimates of percent of bonnethead population in the FG survey area during the annual FS surveys.

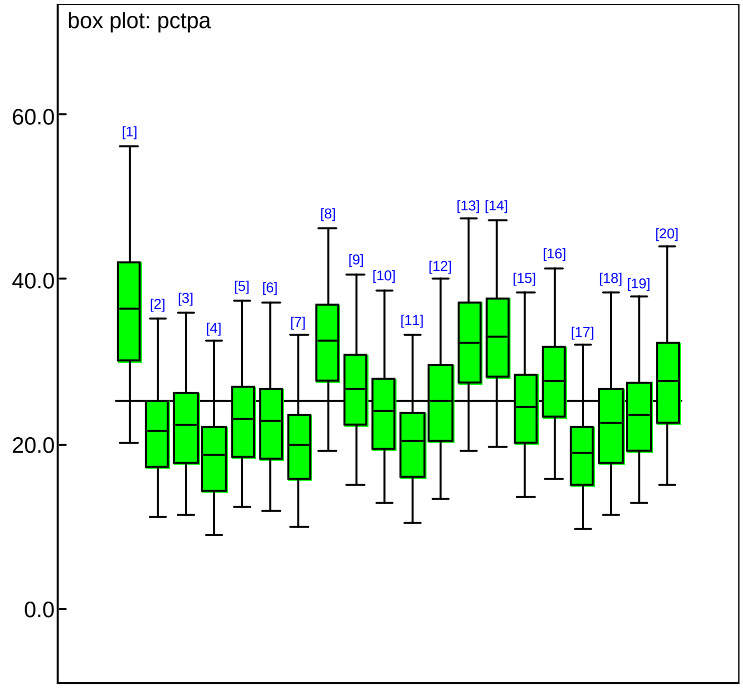

Figure 18. Esitmates of the percent of the combined small coastals population in the FG survey area during the annual FS surveys.

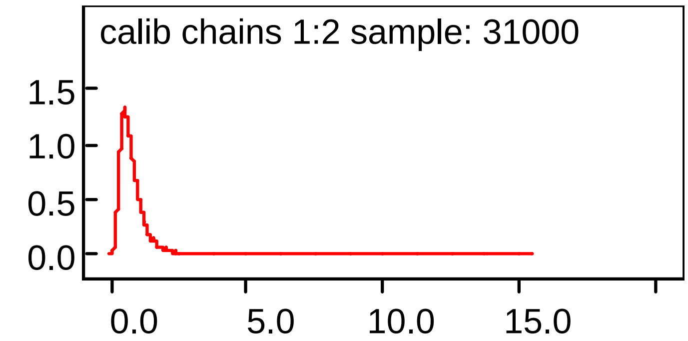

Figure 19. BUGS distribution of factor calibrating the sharpnose FG results to FS units. Quantiles for this distribution were 2.5%: 0.22; 25%: 0.46; median: 0.66; 75%: 0.95; 97.5%: 2.0

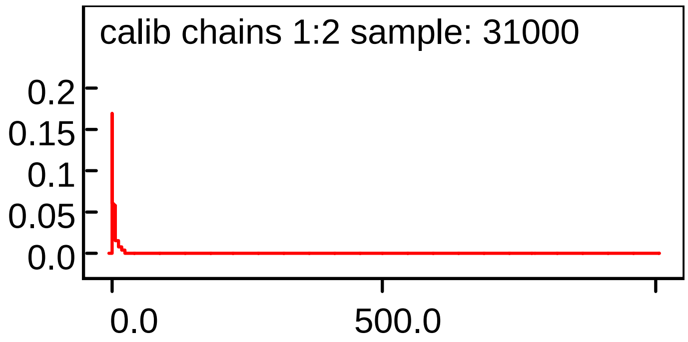

Figure 20. BUGS distribution of factor calibrating the bonnethead FG results to FS units. Quantiles for this distribution were 2.5%: 0.25; 25%: 1.32; median: 3.0; 75%: 6.9; 97.5%: 38

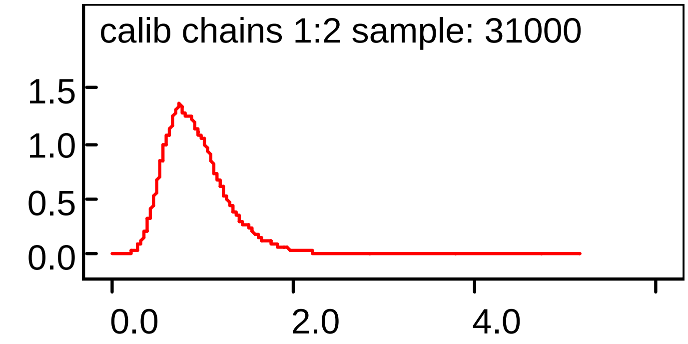

Figure 21. BUGS distribution of factor calibrating the combined small coastal FG results to FS units. Quantiles were 2.5%: 0.42; 25%: 0.70; median: 0.89; 75%: 1.13; 97.5%: 1.86

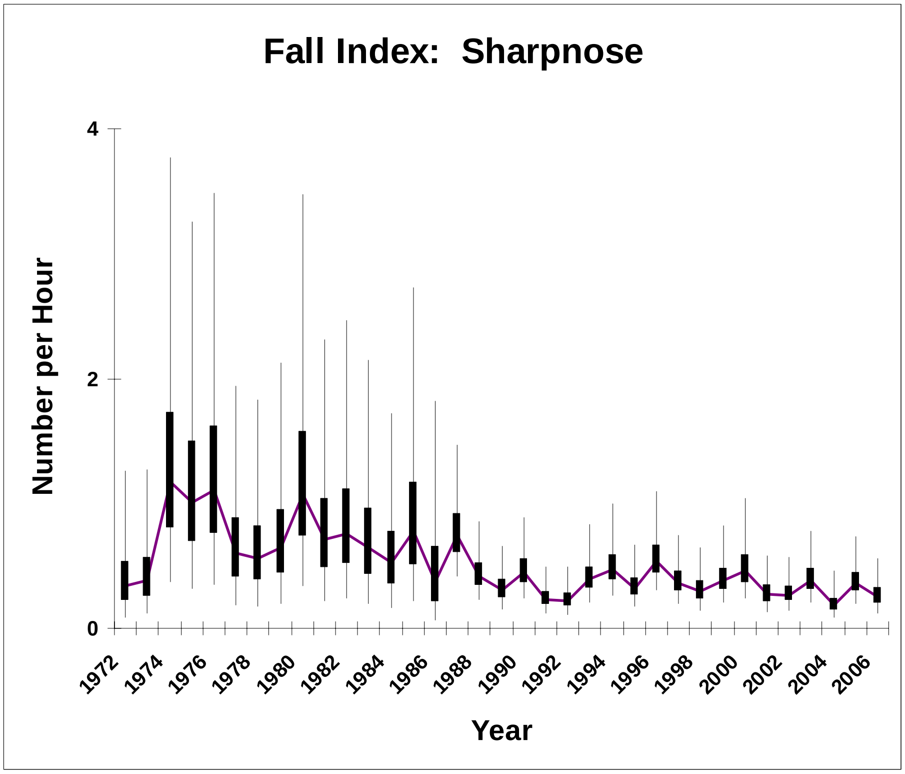

Figure 22. Extended Fall Index for sharpsnose.

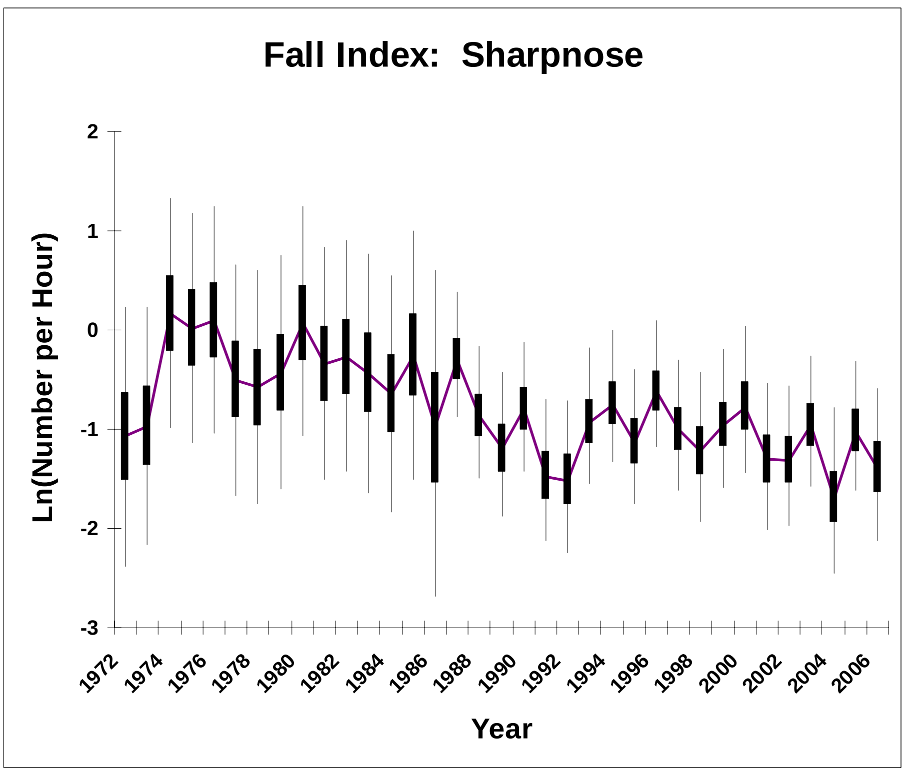

Figure 23. Extended Fall Index for Sharpnose on a log scale.

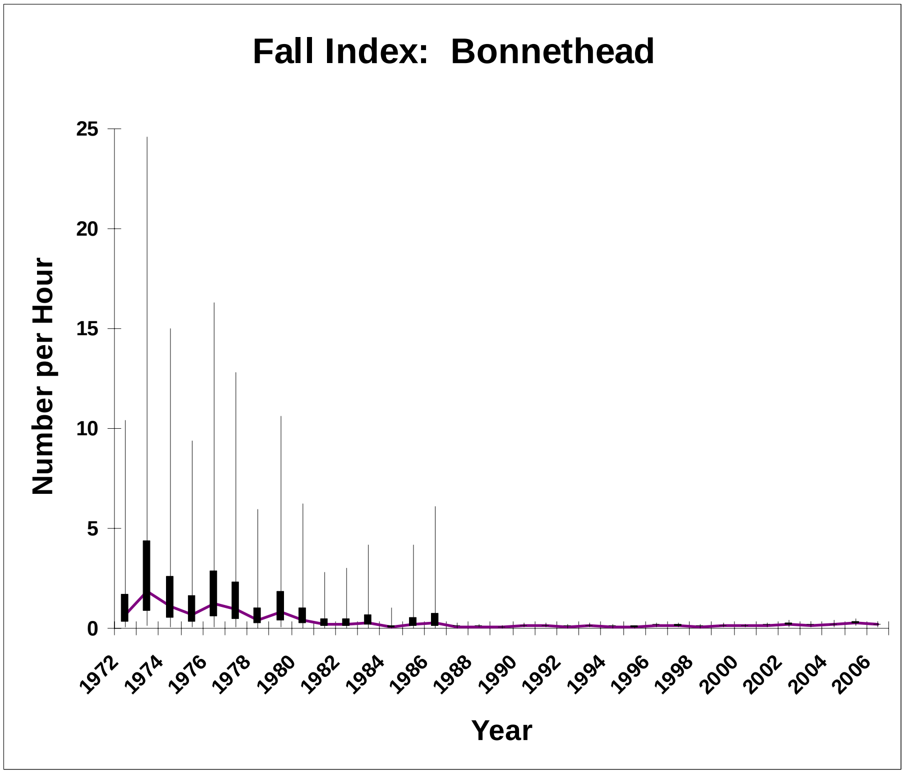

Figure 24. Extended Fall Index for Bonnethead.

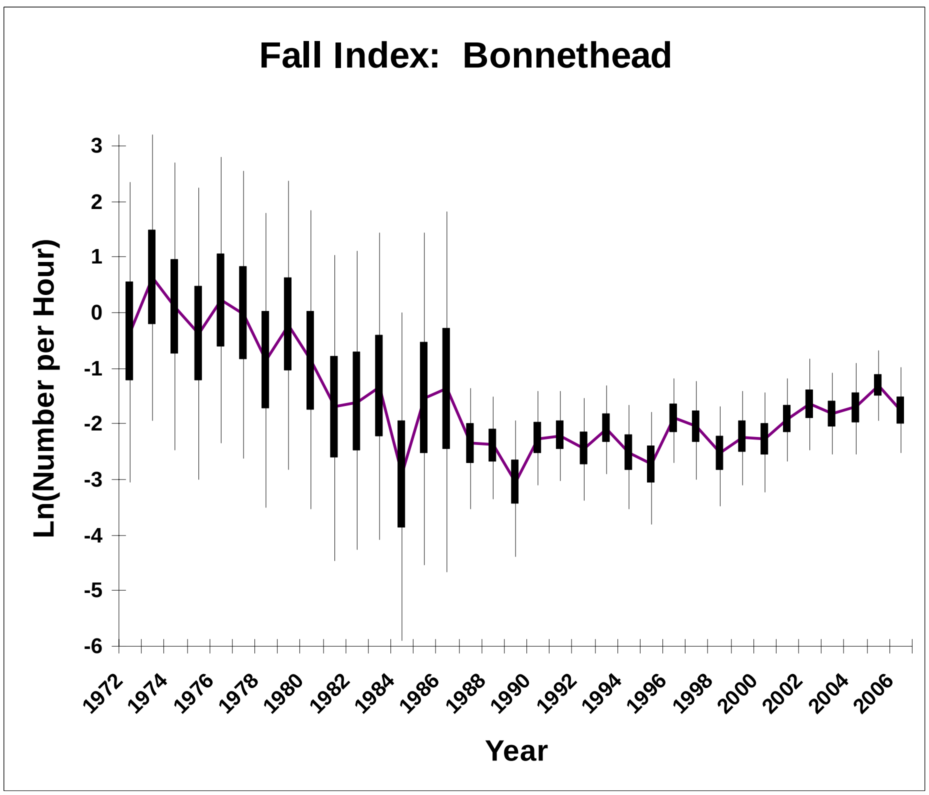

Figure 25. Extended Fall Index for Bonnethead on a log scale.

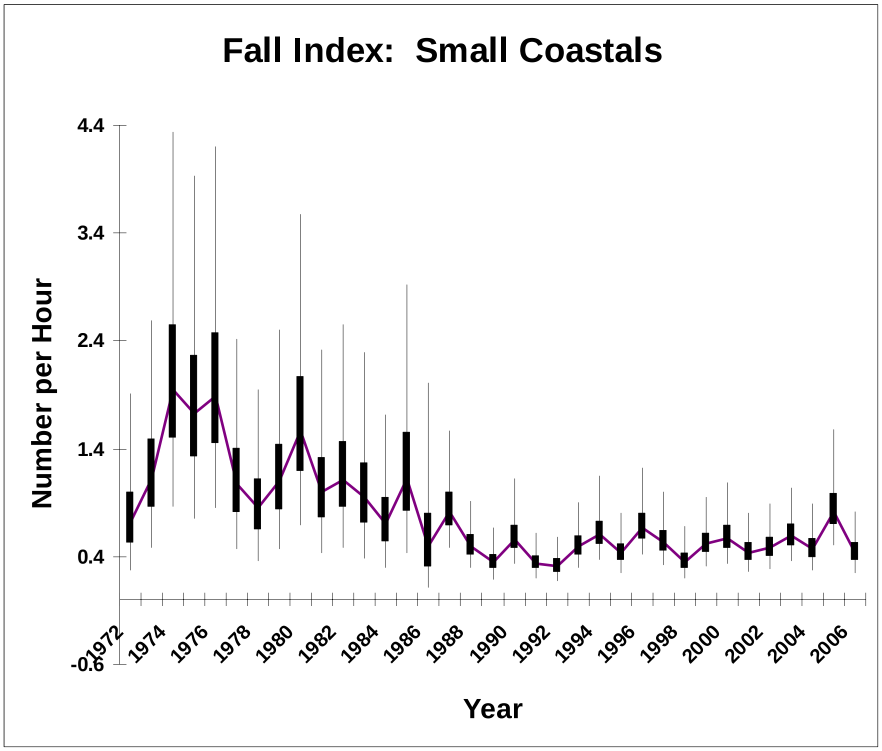

Figure 26. Extended Fall Index for small coastals combined.

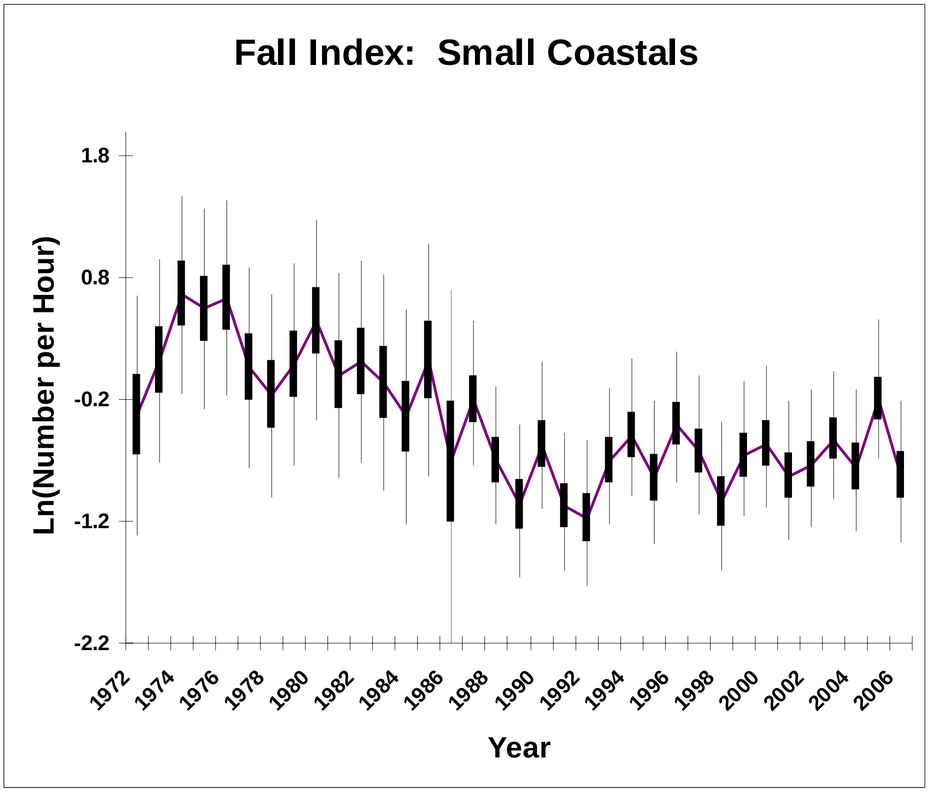

Figure 27. Extended Fall Index for small coastals combined, on a log scale.

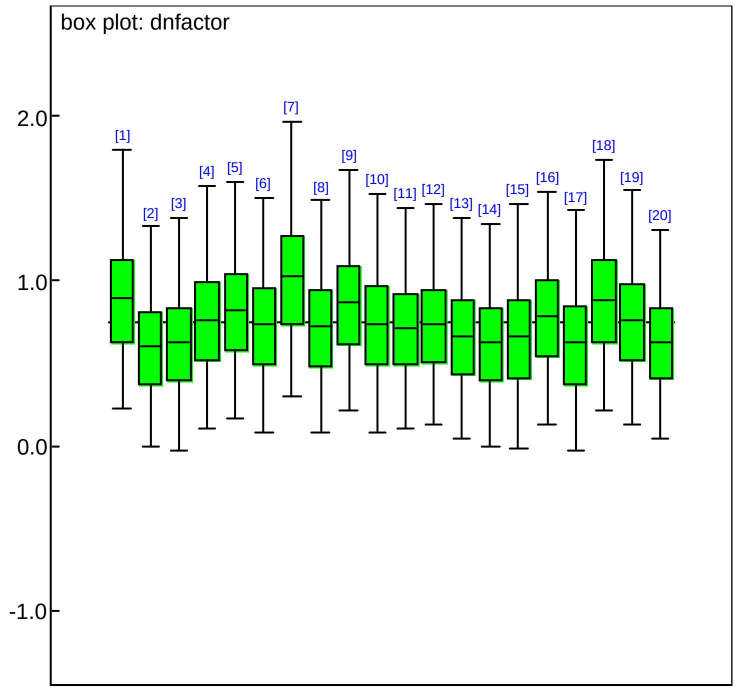

Figure 28. Atlantic Sharpnose. Night:day difference each year (1987-2006) on a log scale for calibrating the ES time series into SS units. (Graph for small coastals combined was very similar.)

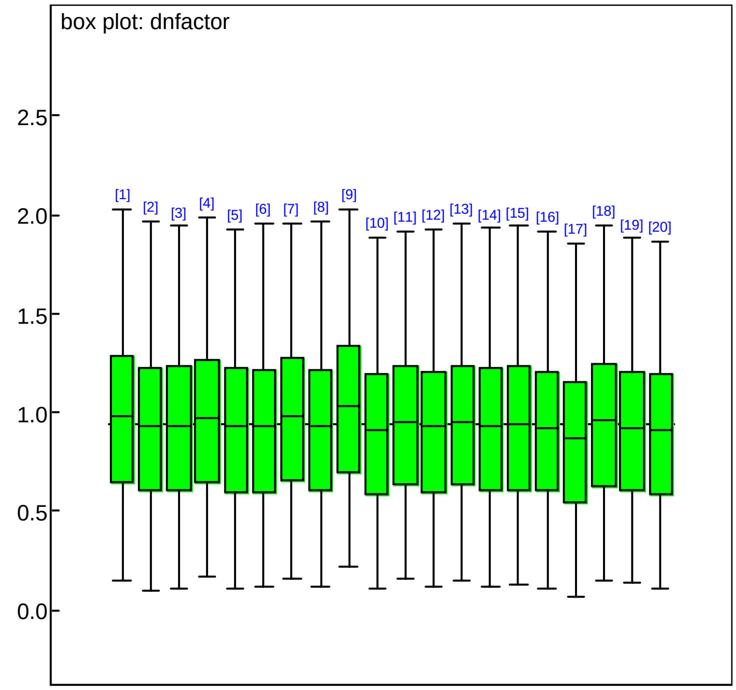

Figure 29. Bonnetehead. Night:day difference each year (1987-2006) on a log scale for calibrating the ES time series into SS units.

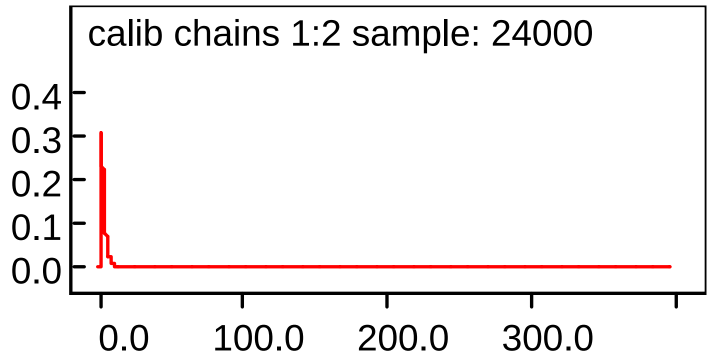

Figure 30. BUGS distribution of factor calibrating the sharpnose ES results to SS units. Quantiles for this distribution were 2.5%: 0.37; 25%: 0.1.17; median: 2.09; 75%: 3.76; 97.5%: 12.1 (The pattern and quantiles for small coastals combined were very similar.)

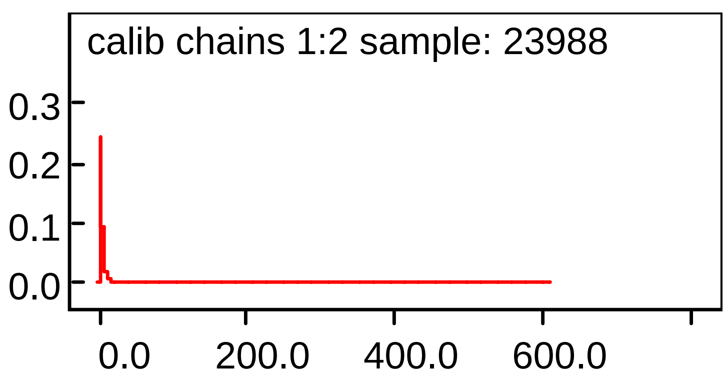

Figure 31. BUGS distribution of factor calibrating the bonnethead ES results to SS units. Quantiles for this distribution were 2.5%: 0.32; 25%: 1.27; median: 2.5; 75%: 4.9; 97.5%: 19.5

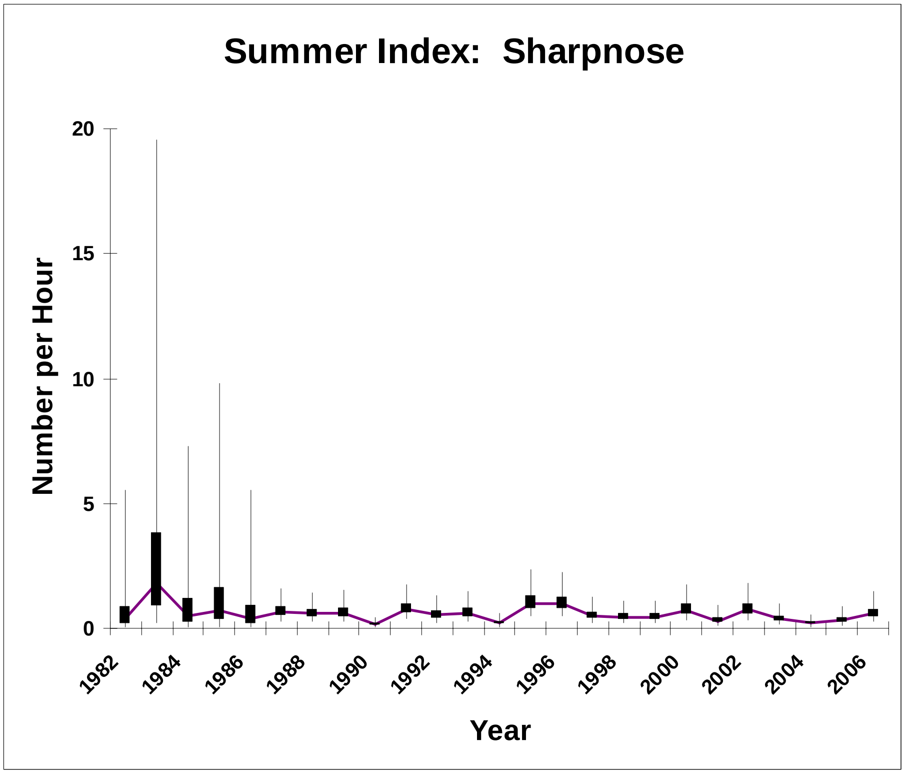

Figure 32. Extended Summer Index for sharpnose.

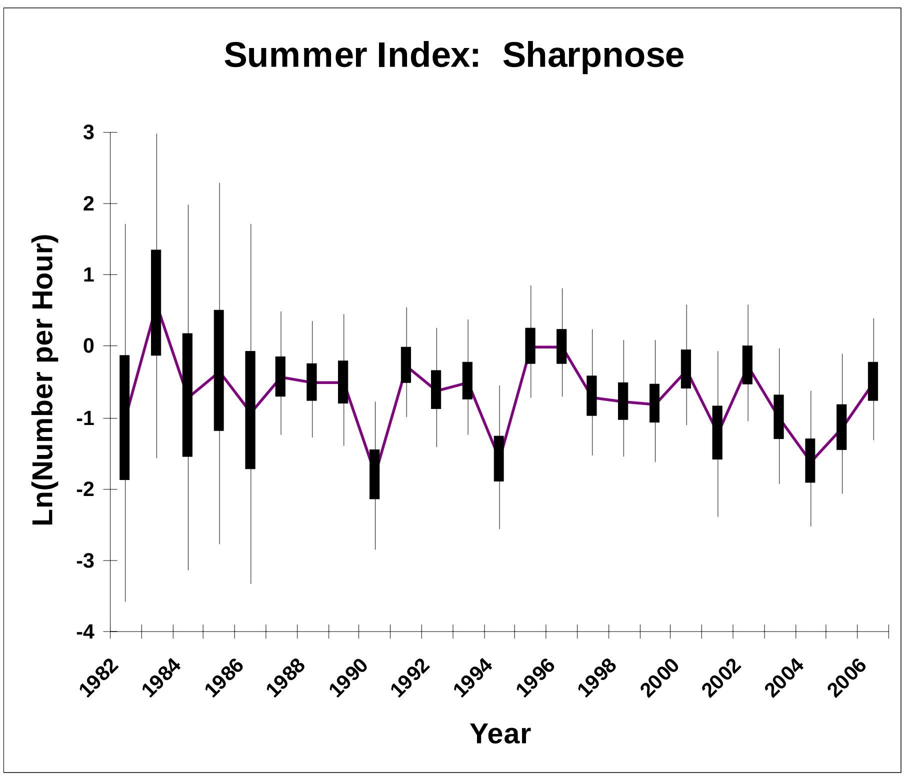

Figure 33. Extended Summer Index for sharpnose on a log scale.

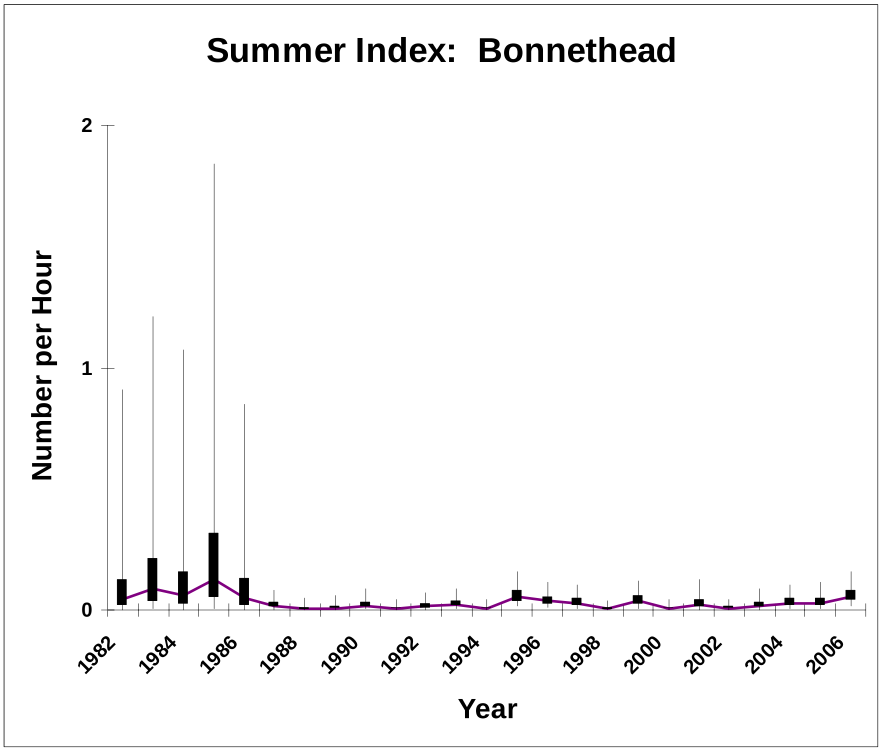

Figure 34. Extended Summer Index for bonnethead.

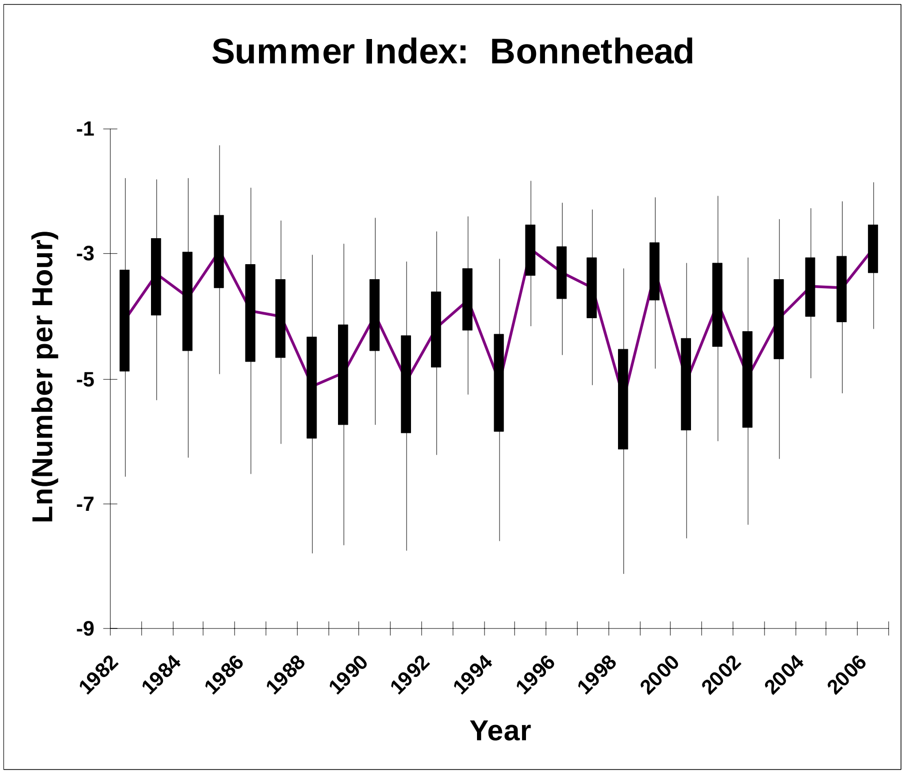

Figure 35. Extended Summer Index for bonnethead on a log scale.

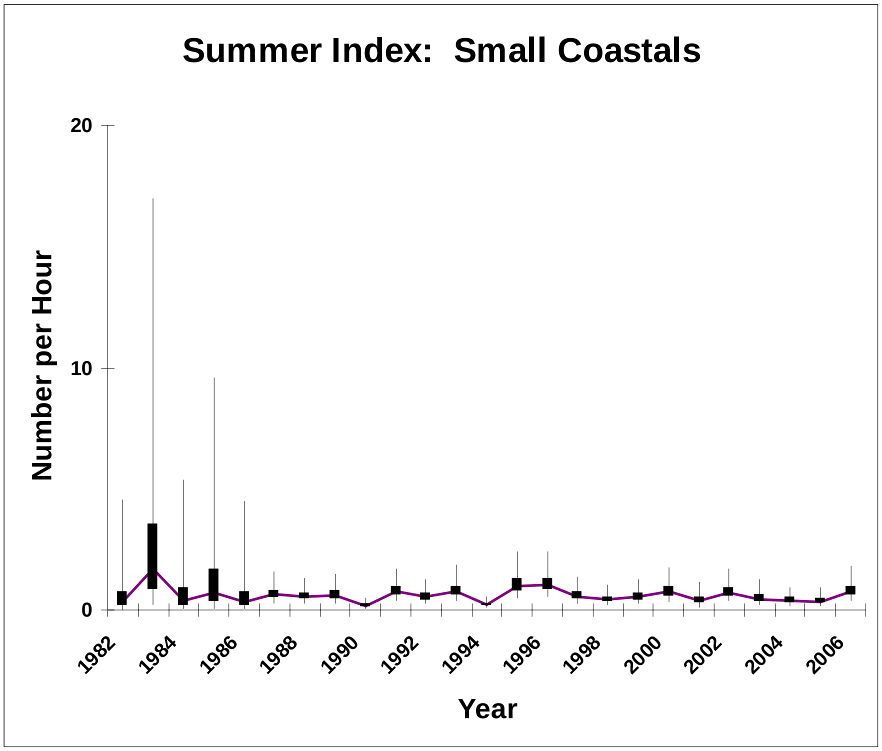

Figure 36. Extended Summer Index for small coastals combine.

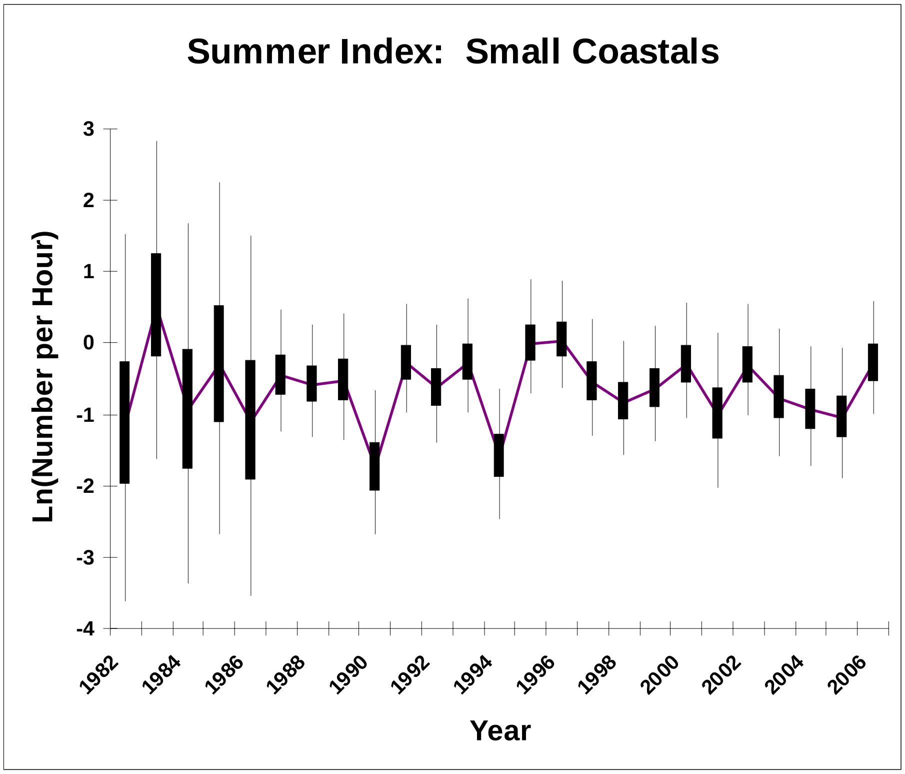

Figure 37. Extended Summer Index for small coastals combined, on a log scale.