RELATIVE ABUNDANCE OF BONNETHEADS AND ATLANTIC SHARPNOSE SHARKS IN TWO FLORIDA GULF ESTUARIES, 1995 TO 2004

A.J. Ubeda, J. Tyminski, and R. Hueter

Center for Shark Research, Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, FL 34236

Introduction

The Center for Shark Research (CSR) at Mote Marine Laboratory has been conducting routine surveys of sharks along the Florida Gulf coast since 1991. In 1995-97, the CSR conducted a NMFS/MARFIN-funded project on shark nurseries to assess Florida's coastal areas as nurseries specifically for the blacktip shark (*Carcharhinus limbatus*). These areas of study encompass two major estuaries along the Florida Gulf coast. As a by product of this study, the CSR also quantified relative abundance of small shark species including bonnetheads (*Sphyrna tiburo*) and Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*), determined bycatch mortality and associated fishes in gill net fishing gear, and conducted basic biological studies in shark distribution, feeding, growth and reproduction in the Florida Gulf. Building upon the CSR's MARFIN study, research funded primarily through NMFS Highly Migratory Species (HMS) Division continued the CSR shark nursery studies in the Gulf of Mexico through 2004, which allowed a relatively continuous sampling of small shark species in these nurseries in all years except 1998.

This paper examines the results of relative abundance surveys for bonnetheads (*Sphyrna tiburo*) and Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) in two Florida Gulf estuaries monitored by the CSR since 1995. Trends in abundance of these species from 1995-2004 were analyzed to provide a standardized index of recruitment in the eastern Gulf of Mexico. The analyses were focused on two estuaries along the Florida Gulf coast: 1) Yankeetown, a relatively pristine area of open Gulf near the Withlacoochee River, south of Cedar Key and north of Crystal River and 2) Pine Island Sound, a semi-enclosed estuary in the Charlotte Harbor system that is moderately populated and industrialized (Figure 1).

Field Methods

Monthly, random stratified, fishery-independent sampling by gill net was conducted in the two Florida Gulf estuaries, from March through October from 1995 to 1997 for Yankeetown area, and in 1995 and 1997 for the Charlotte Harbor area (with sampling in summer months only during 1999-2004) in all years except 1998. In each area, two geographically fixed 10 km^2 grids were regularly sampled based upon previous exploratory surveys that revealed subareas with relatively high CPUE of these two species (Figure 2 and 3). For quantitative assessment of relative abundance, standardized sets were conducted each month in five of the ten 1x1 blocks for each grid (Figure 4).

Sets were made using 0.52 mm monofilament, 11.8 cm stretch mesh, 366x3 m weighted gill nets, used due to their relatively high selectivity for small species of elasmobranchs and relatively low bycatch of other species. The net was allowed to soak for at least one hour before being retrieved. All sharks caught were identified, sexed, measured, categorized by stage of maturity (immature or mature), weighed and live sharks were tagged and released. For both species, maturity was assessed from information obtained from the literature (Parsons 1983, 1993, Carlson and Parsons 1997) and by examining the claspers on male sharks (Gelsleichter et al. 2002). Physical data including depth, tide, salinity, temperature, dissolved oxygen, bottom type, and weather were collected for each set to characterize the study areas.

Data Analysis

Analyses for this paper were separated by the stage of maturity of the sharks. The numbers of immature and mature sharks for both species caught on each set were converted to CPUE. CPUE was calculated by dividing the number of animals caught by the soak time of the net (the time from the first float entering the water to the time that the last float came out of the water). CPUE data were standardized using the natural logarithm of the CPUE + 1 before being analyzed. Standardized catch rates from both stage of maturity were calculated using a General Linear Model (GLM) with month, year, area, grid and block (nested with grid) as factors. The GLM also included an interaction term between year and area to investigate if the estuaries had a different pattern of catch rates. Only the summer months (June, July and August) were including in these analyses.

Results

A total of 447 quantitative gill net sets were conducted between the two areas every summer from 1995 to 2004. To assess overall trends in catch rate, the GLM was applied to data collected from June through August (the months sampled most consistently). During the entire study, which encompassed other areas not including in these analyses, a total of 8,257 sharks were captured comprising 13 species of 4 families (Table 1).

Bonnethead Analysis

Mature bonnetheads:

This analysis indicated that there were significant differences in catch rates between all factors tested except month and area for the mature bonnethead sharks (Table 2). The lack of significance interaction for area indicated that the two areas did not have different patterns of annual catch rates. Regression analysis of the percentage of annual catch rates for the mature bonnetheads indicated that the slope of the catch time series for Yankeetown was significantly different from zero (slope = 0.066, R^2 = 0.4602) and slightly different from zero in Charlotte Harbor (slope = 0.0544, R^2 = 0.2715) (Figure 5).

Immature bonnetheads:

There were significant differences in catch rates between all factors tested except month for the immature bonnethead sharks (Table 2). The significant interaction term indicated that Yankeetown and Charlotte Harbor had different patterns of annual catch rates in immature sharks. Regression analysis of the percentage of annual catch rates for the immature bonnethead sharks indicated that the slope of the catch time series for Charlotte Harbor was different from zero (slope = 0.0586, R^2 = 0.375), but it was not significantly different from zero in Yankeetown (slope = 0.0073, R^2 = 0.0115) (Figure 6).

Atlantic Sharpnose Analysis

Mature sharpnose sharks:

There were significant differences in catch rates between all factors tested except month and grid (Table 3). Both areas had different patterns of annual catch rates. Regression analysis of the percentage of annual catch rates indicated that the slope of the catch series for Yankeetown was significantly different from zero (slope = 0.0593, R^2 = 0.6201); however, the slope of the catch series for Charlotte Harbor was not significantly different from zero (slope = 0.0016, R^2 = 0.1042) (Figure 7).

Immature sharpnose sharks:

There were significant differences in catch rates between all factors tested except month and year (Table 3). Both areas had different of annual catch rates. Regression analysis of the percentage of annual catch rates indicated that the slope of the catch series for Yankeetown were different from zero but not significantly different (slope = 0.011, R^2 = 0.3303), the same occurred for Charlotte Harbor (slope = 0.0066, R^2 = 0.0676) (Figure 8)

Discussion

Results of our studies indicate that there has been an increase in number of mature bonnetheads in both areas between 1995 and 2004. There has been also a slight increase in the number of immature bonnethead sharks for the Charlotte Harbor area, but there is no clear evidence of decline or increase in the number of immature sharks in the Yankeetown area. There appears to be increase in the number of mature and immature Atlantic sharpnose sharks between 1995 and 2004 for the Yankeetown area; however, the low number of catch rates for the Charlotte Harbor area for both maturity stage groups made it difficult to make solid conclusions about the status of this population. Interestingly, of the 336 the Atlantic sharpnose sharks captured in our surveys, only 7 individuals were females.

The results of our surveys were affected by periodic, and sometimes severe, blooms of red tide (*Karenia brevis*, a dinoflagellate toxic to fish). Elasmobranchs appear to be highly sensitive to the toxin associated with these blooms and can respond by evacuating affected areas. A severe red tide was documented in the Charlotte Harbor area in 2001 although blooms were present at varying levels during all the years of the study. Additionally, pulses of fresh waters as a result of the episodic opening of dams following

severe storm events probably affected our surveys since this type of event affect the distribution of elasmobranchs along the estuaries (Ubeda et al, unpublished data). Salinities in the Charlotte Harbor area have been measured as low as less than 15 ppt. Therefore, environmental perturbations (anthropogenic or not anthropogenic) could have influenced our results.

Conclusions

- There was an increase in the number of mature bonnetheads for both areas of our study. There was a slight increase in the number of immature bonnetheads for the Charlotte Harbor area, but there is no clear trend of increase or decline of immature bonnetheads for the Yankeetown area.
- There was an increase in the number of mature and immature Atlantic sharpnose sharks in Yankeetown area. For the Charlotte Harbor area, there is no clear trend of increase or decrease of this species; this is probably due to the low number of catches during the years of this study.
- Environmental perturbations can influence shark abundance data in a localized area.
- Long term monitoring programs for these areas are necessary in order to make conclusive predictions about the status of these species.

Acknowledgements

References

Carlson, J.K and G.R. Parsons. 1997. Age and growth of the bonnethead shark, *Sphyrna tiburo* with notes on clinal variation. Environ. Biol. Fish. 50:331-341

Gelsleichter, J., L.E.L. Rasmussen, C.A. Manire, J. Tyminski, B. Chang and L. Lombardi-Carlson. 2002. Serum steroid concentrations and development of reproductive organs during puberty in male bonnethead sharks, *Sphyrna tiburo*. Fish Physiol. Biochem. 26:389-401

Parsons, G.R. 1983. The reproductive biology of the Atlantic sharpnose shark, *Rhizoprionodon terraenovae* (Richardson). Fish. Bull. 81:61-73

Parsons, G.R. 1993. Geographic variation in reproduction between two populations of the bonnethead shark, *Sphyrna tiburo*. Environ. Biol. Fish. 38:25-35.

Table 1. Sharks species and numbers captured during all quantitative gill net sets during the entire study (1995-2004).

Common Name	Scientific Name	No. Captured
Blacktip	*Carcharhinus limbatus*	3,842
Bonnethead	*Sphyrna tiburo*	3,540
Atlantic sharpnose	*Rhizoprionodon terraenovae*	739
Great Hammerhead	*Sphyrna mokarran*	58
Blacknose	*Carcharhinus acronotus*	28
Scalloped Hammerhead	*Sphyrna lewini*	19
Bull	*Carcharhinus leucas*	14
Spinner	*Carcharhinus brevipinna*	7
Nurse	*Ginglymostoma cirratum*	3
Sandbar	*Carcharhinus plumbeus*	3
Lemon	*Negaprion brevirostris*	2
Finetooth	*Carcharhinus isodon*	1
Florida Smoothhound	*Mustelus norrisi*	1
	Total	8,257

Table 2. Results of the GLM for mature and immature bonnethead sharks

Effect	Deg. of Freedom	MATURE F	P	IMMATURE F	P
Month	2	1.3007	0.273408	1.9200	0.147872
Year	8	3.4702*	0.000684*	2.6905*	0.006773*
Area	1	3.4968	0.062173	4.2727*	0.039332*
Grid (Area)	2	24.8454*	0.000000*	3.6240*	0.027503*
Year*Area	7	5.7367*	0.000002*	7.4190*	0.000000*

Table 3. Results of the GLM for mature and immature Atlantic sharpnose sharks

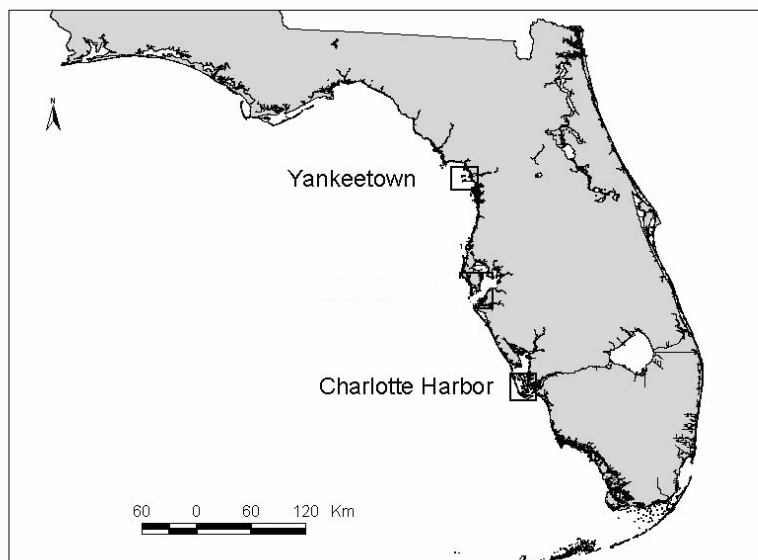| Effect	Deg. of Freedom	MATURE F	P	IMMATURE F	P
Month	2	0.9696	0.380067	1.71577	0.181071
Year	8	5.2947*	0.000002*	1.28934	0.247044
Area	1	97.7197*	0.000000*	5.16691*	0.023521*
Grid (Area)	2	0.1519	0.859097	3.41571*	0.033760*
Year*Area	7	5.6791*	0.000003*	2.56842*	0.013342*

Fig. 1 Project study sites.

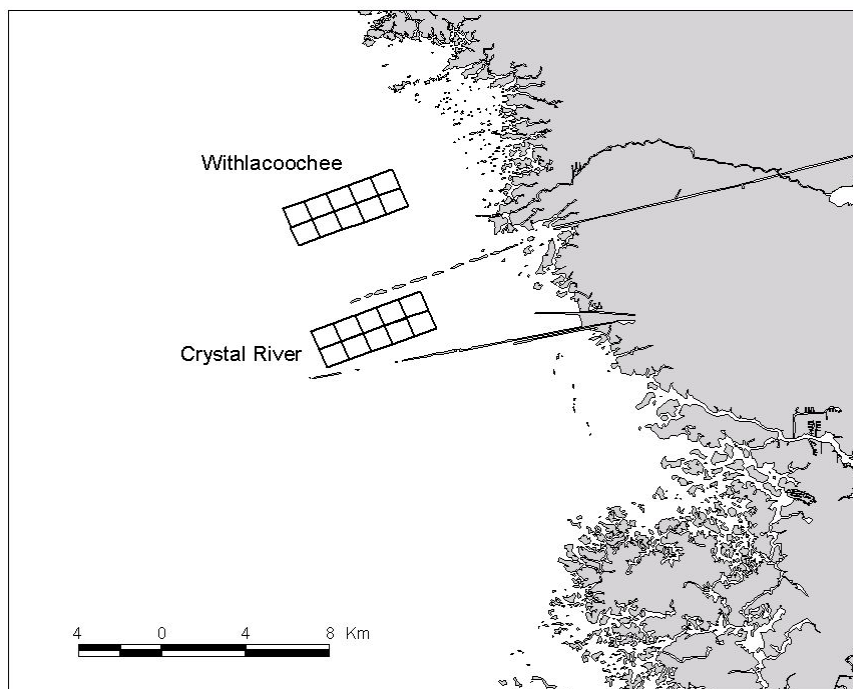Fig. 2 Yankeetown grid areas of Withlacoochee and Crystal River.

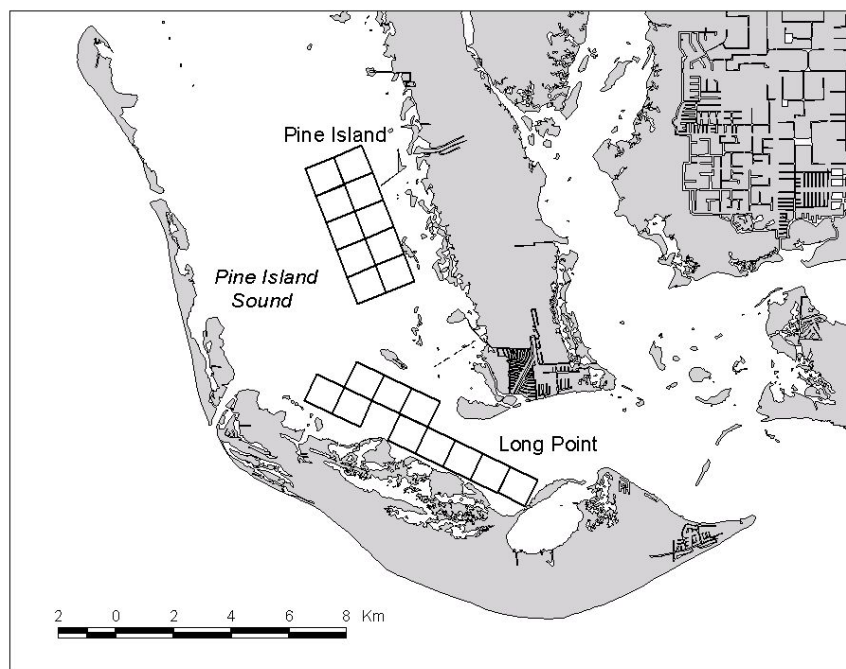Fig. 3 Charlotte Harbor grid areas of Pine Island and Long Point.

Fig. 4 Example of a typical monthly sampling in the two Yankeetown grids. Sampling consists of gill nets sets in 5 of the 10 quadrants for each grid.
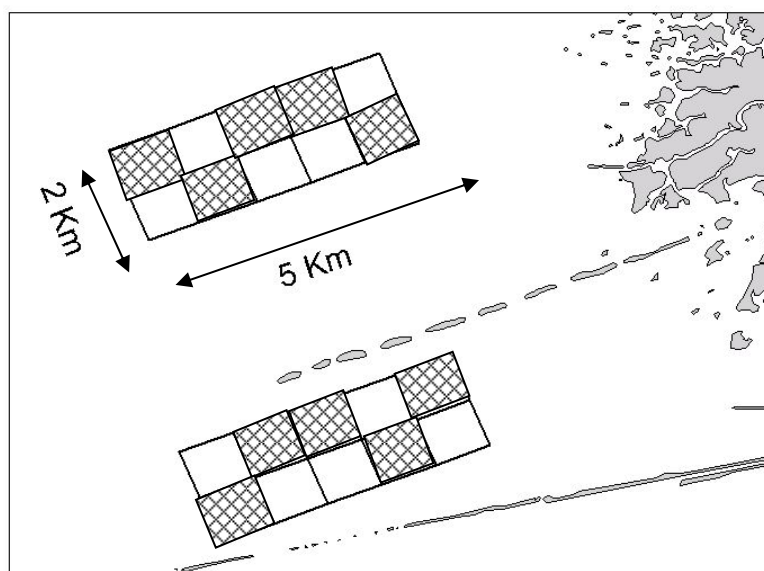
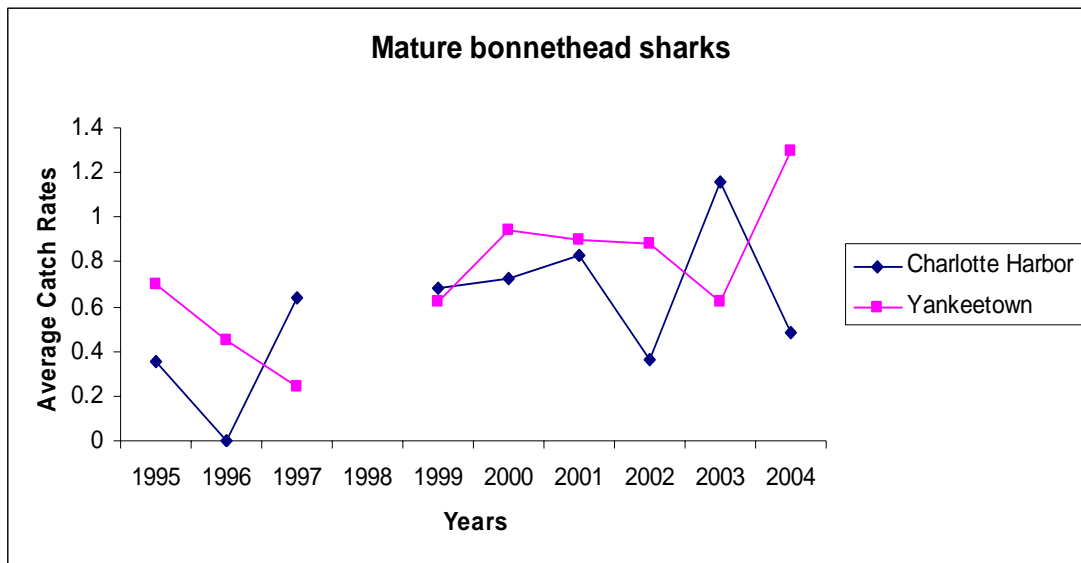Fig. 5 Mature bonnethead sharks average catch rates by year (June – August).

Fig. 6 Immature bonnethead sharks average catch rates by year (June – August).
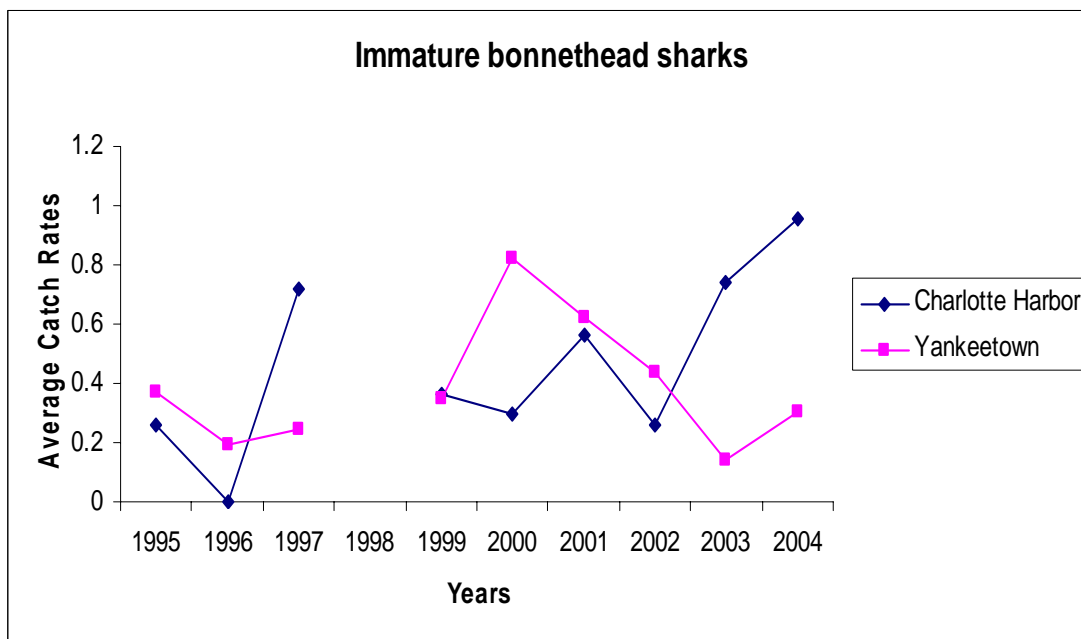
Fig. 7 Mature sharpnose sharks average catch rates by year (June – August).
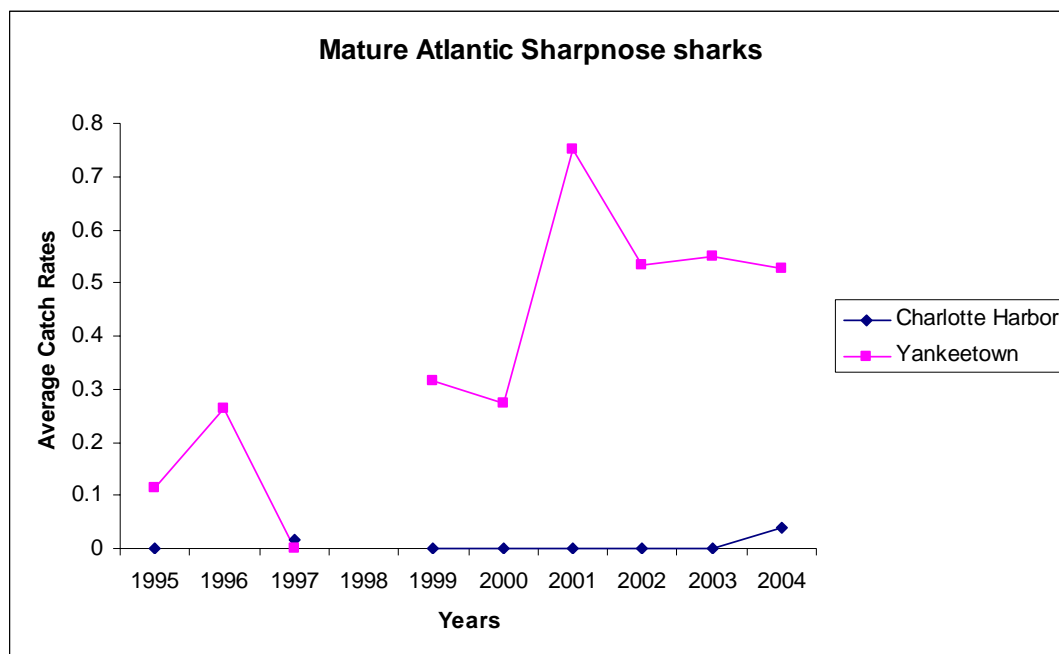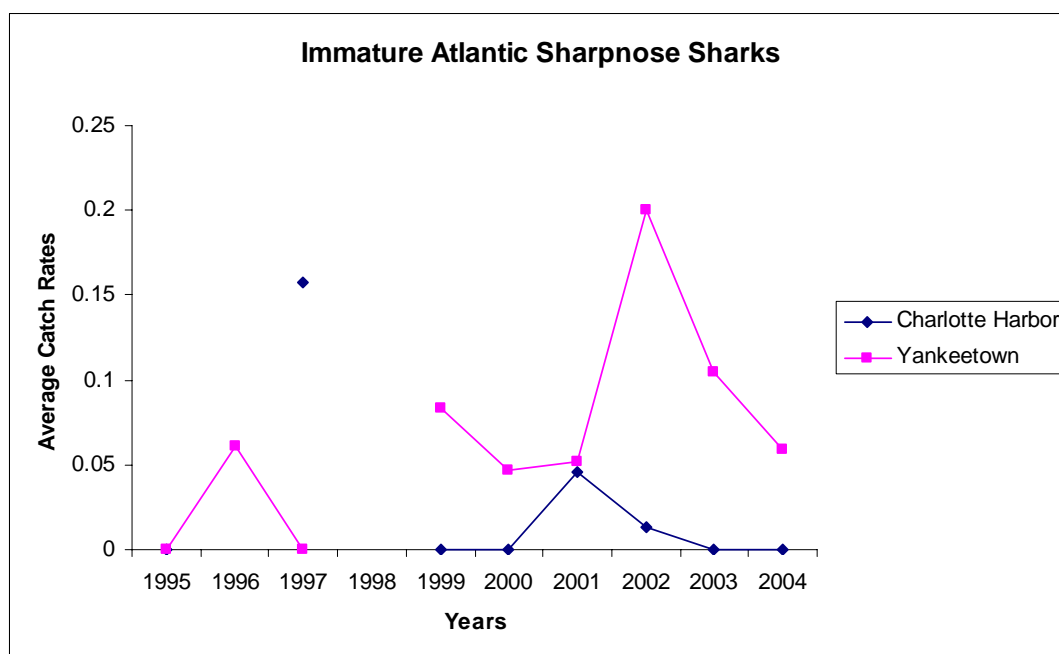

Fig. 8 Immature sharpnose sharks average catch rates by year (June – August)

ADDENDUM
SCS07/13-DW-38
Relative abundance of Bonnetheads and Atlantic Sharpnose sharks in two Florida gulf estuaries, 1995 to 2004
A.J. Ubeda, J.P. Tyminski, and W. Ingram, Jr.

After reviewing the document submitted to the SEDAR indices group, it was recommended that we:

- Standardize the catch rate data using the delta log method for both species
- Combine areas (YT and CH), and use them as a factor in the GLM model
- Combine the data from both species (complex) and use it in a new analysis using the GLM model
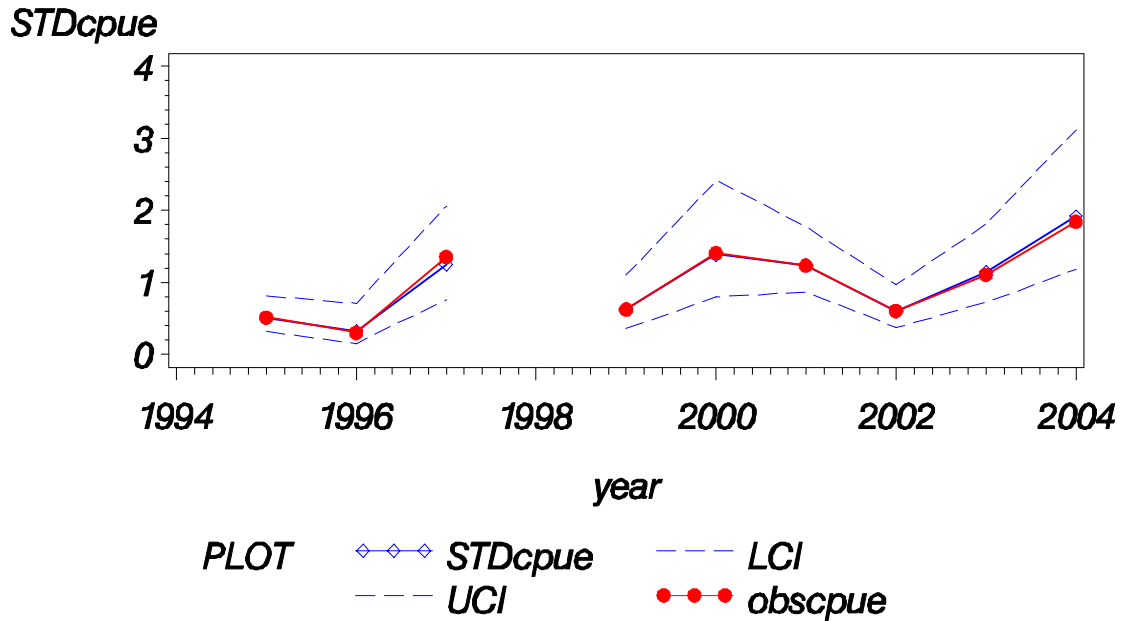
Results after recommendations were applied:

Immature Bonnetheads – Delta Lognormal CPUE for MOTE Gillnet (GN) – Index
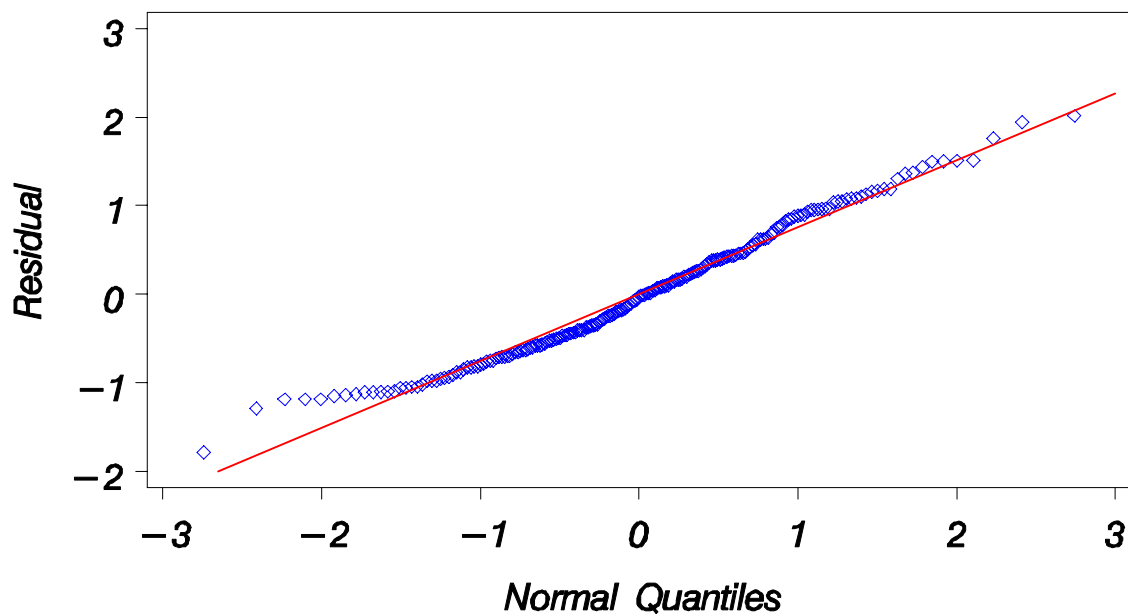
SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.40000	60	0.49323	0.50761	0.23858	0.31708	0.81264
1996	0.30000	30	0.31610	0.32531	0.40339	0.14964	0.70723
1997	0.59459	37	1.21643	1.25191	0.25241	0.76156	2.05796
1999	0.42500	40	0.60712	0.62483	0.28694	0.35599	1.09668
2000	0.50000	40	1.34997	1.38934	0.28296	0.79754	2.42028
2001	0.58333	60	1.20388	1.23899	0.18004	0.86682	1.77094
2002	0.40000	60	0.58117	0.59812	0.24200	0.37117	0.96383
2003	0.41667	60	1.11018	1.14256	0.23273	0.72176	1.80869
2004	0.48333	60	1.86690	1.92134	0.24627	1.18260	3.12155

Output

Delta lognormal CPUE for Mote GN Immature Bonnethead
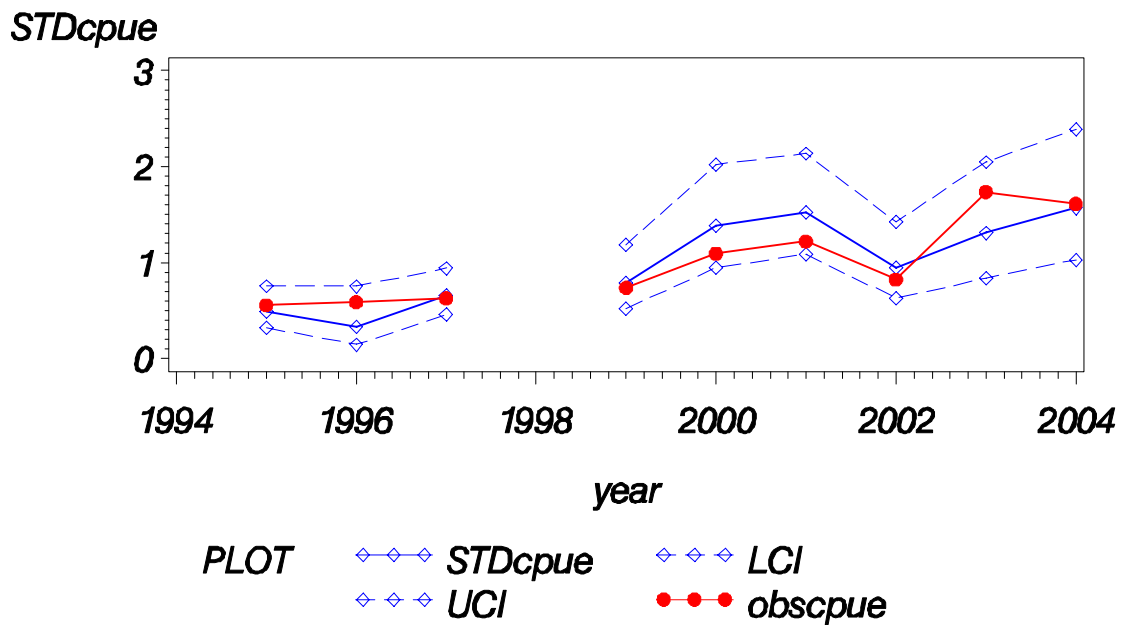## Observed and Standardized CPUE (95% CI)

Delta lognormal CPUE for Mote GN Immature Bonnethead
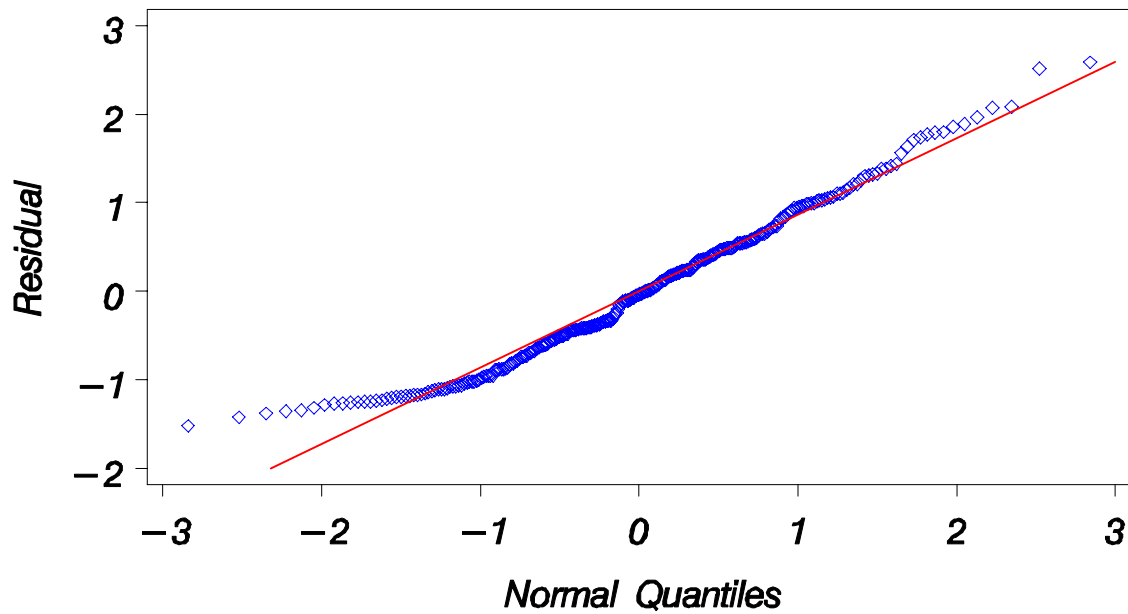## QQplot Residuals Positive cpue rates

Mature Bonnetheads – Delta Lognormal CPUE for MOTE Gillnet (GN) – Index Output

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.56667	60	0.88101	0.49170	0.21670	0.32036	0.75470
1996	0.50000	30	0.59713	0.33327	0.42533	0.14744	0.75333
1997	0.67568	37	1.17935	0.65822	0.18049	0.46010	0.94164
1999	0.62500	40	1.40887	0.78632	0.20731	0.52170	1.18514
2000	0.75000	40	2.47877	1.38345	0.19200	0.94559	2.02406
2001	0.68333	60	2.72845	1.52279	0.17045	1.08554	2.13617
2002	0.58333	60	1.69466	0.94582	0.20672	0.62825	1.42392
2003	0.70000	60	2.34627	1.30950	0.22604	0.83793	2.04644
2004	0.60000	60	2.81112	1.56893	0.21320	1.02915	2.39184

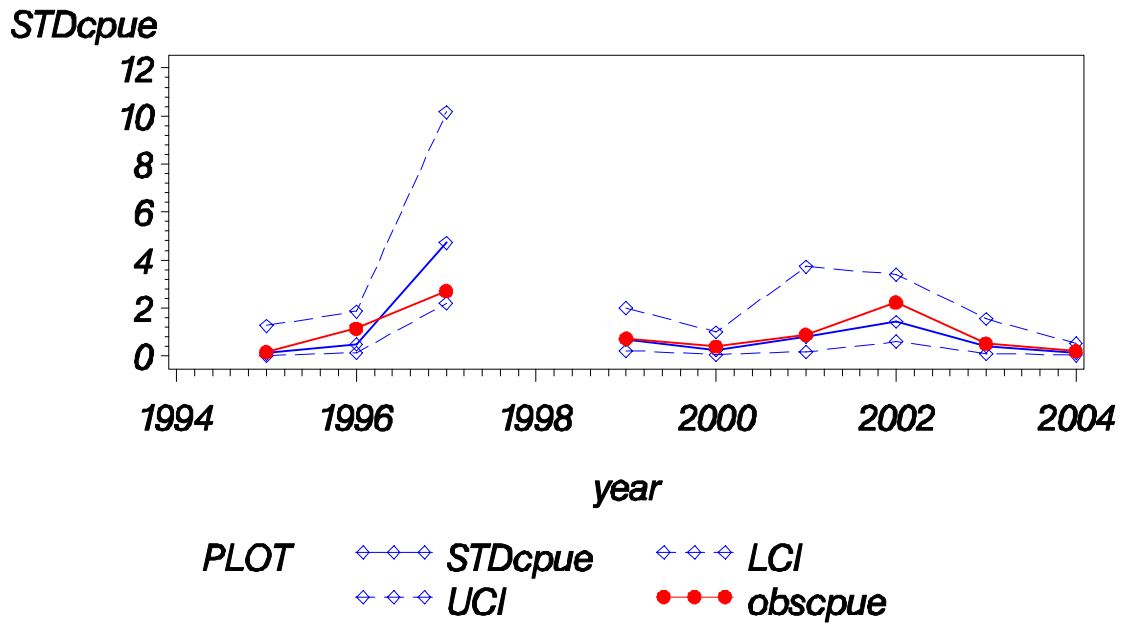Delta lognormal CPUE for Mote GN Mature Bonnethead Observed and Standardized CPUE (95% CI)

Delta lognormal CPUE for Mote GN Mature Bonnethead
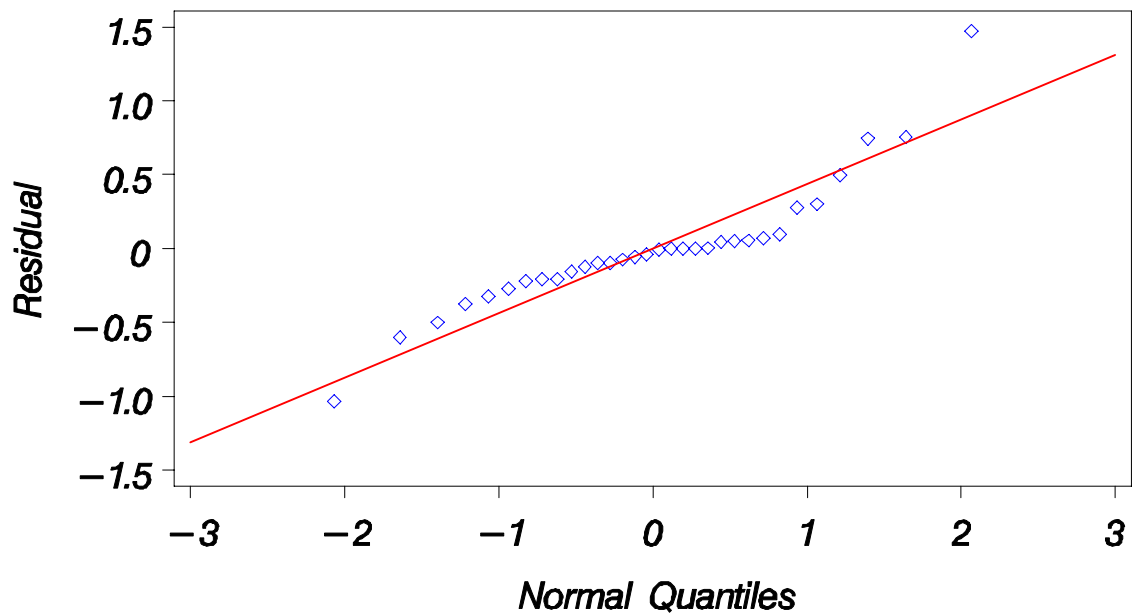## QQplot Residuals Positive cpue rates

**Immature Sharpnose sharks – Delta Lognormal CPUE for MOTE Gillnet (GN) –
Index Output**

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.01667	60	0.06999	0.11120	1.83733	0.00979	1.2629
1996	0.10000	30	0.30498	0.48456	0.75587	0.12631	1.8589
1997	0.18919	37	2.97111	4.72055	0.39828	2.19129	10.1691
1999	0.07500	40	0.42325	0.67247	0.58770	0.22624	1.9989
2000	0.05000	40	0.16062	0.25519	0.76467	0.06569	0.9914
2001	0.05000	60	0.50509	0.80250	0.89602	0.17283	3.7262
2002	0.15000	60	0.89736	1.42574	0.45586	0.59789	3.3999
2003	0.03333	60	0.25411	0.40373	0.75652	0.10514	1.5503
2004	0.03333	60	0.07809	0.12407	0.83079	0.02913	0.5284

Delta lognormal CPUE for Mote GN Immature Sharpnose
Observed and Standardized CPUE (95% CI)

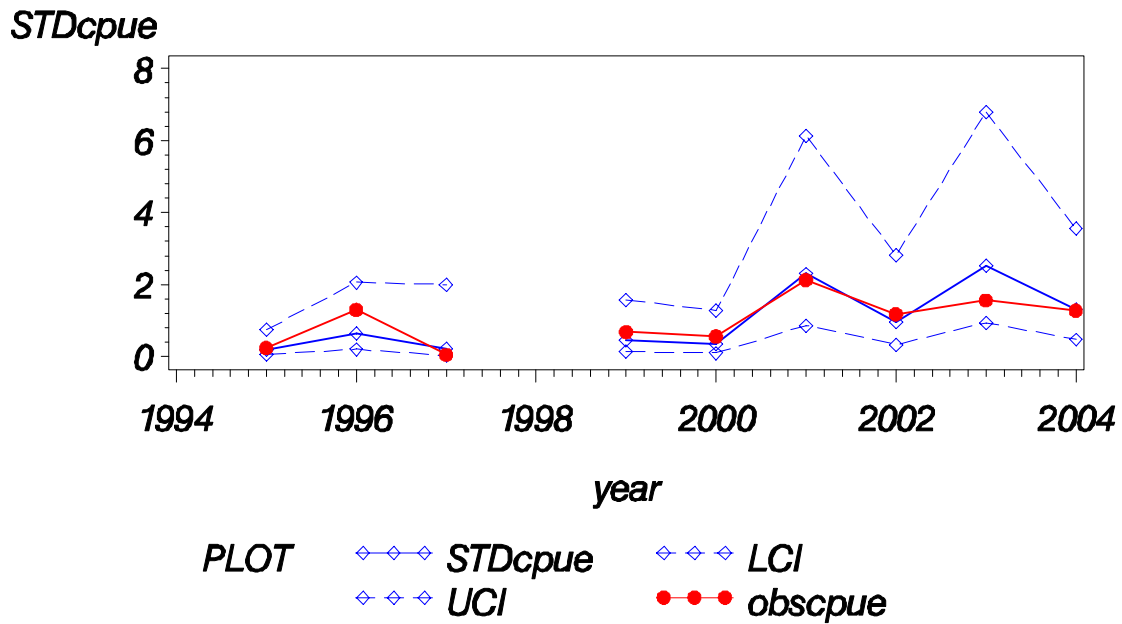PLOT   ◇◇◇ STDcpue   ◇ ◇ ◇ LCI
◇ ◇ ◇ UCI   ●●● obscpue

Delta lognormal CPUE for Mote GN Immature Sharpnose
QQplot Residuals Positive cpue rates

Mature Sharpnose sharks – Delta Lognormal CPUE for MOTE Gillnet (GN) – Index Output

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.08333	60	2.8678	0.20358	0.73082	0.05502	0.75326
1996	0.30000	30	9.1397	0.64881	0.62945	0.20432	2.06022
1997	0.02703	37	3.2102	0.22789	1.50016	0.02598	1.99880
1999	0.20000	40	6.5215	0.46295	0.67689	0.13554	1.58117
2000	0.20000	40	5.0407	0.35783	0.70658	0.10021	1.27766
2001	0.36667	60	32.4313	2.30222	0.52066	0.86446	6.13128
2002	0.33333	60	13.6616	0.96980	0.57411	0.33349	2.82024
2003	0.28333	60	35.5596	2.52429	0.52665	0.93841	6.79025
2004	0.23333	60	18.3502	1.30264	0.53537	0.47728	3.55525

Delta lognormal CPUE for Mote GN Mature Sharpnose Observed and Standardized CPUE (95% CI)

Delta lognormal CPUE for Mote GN Mature Sharpnose
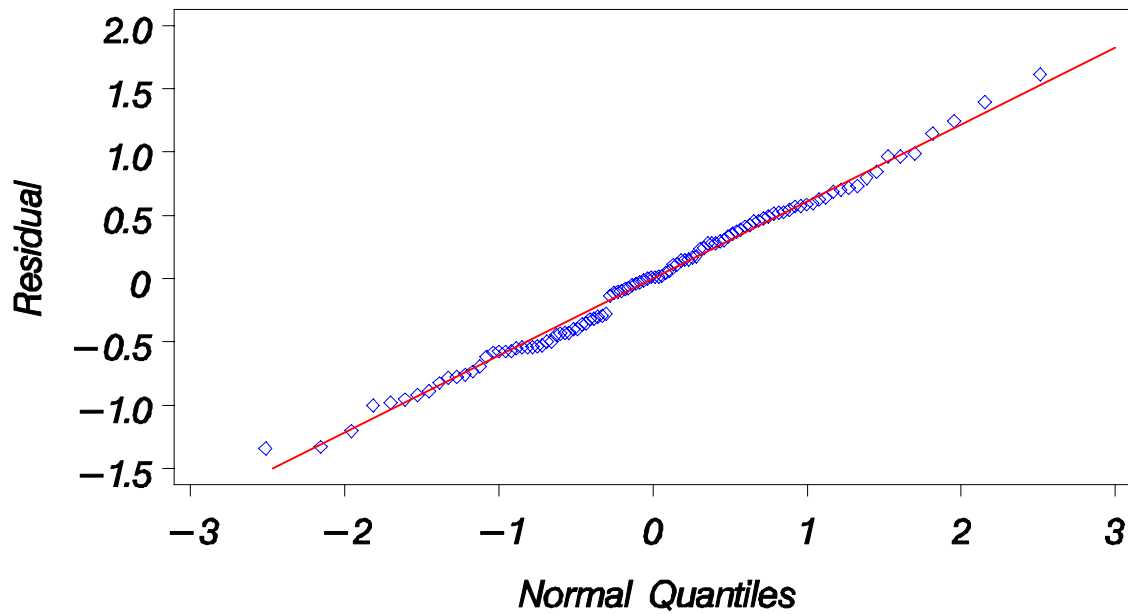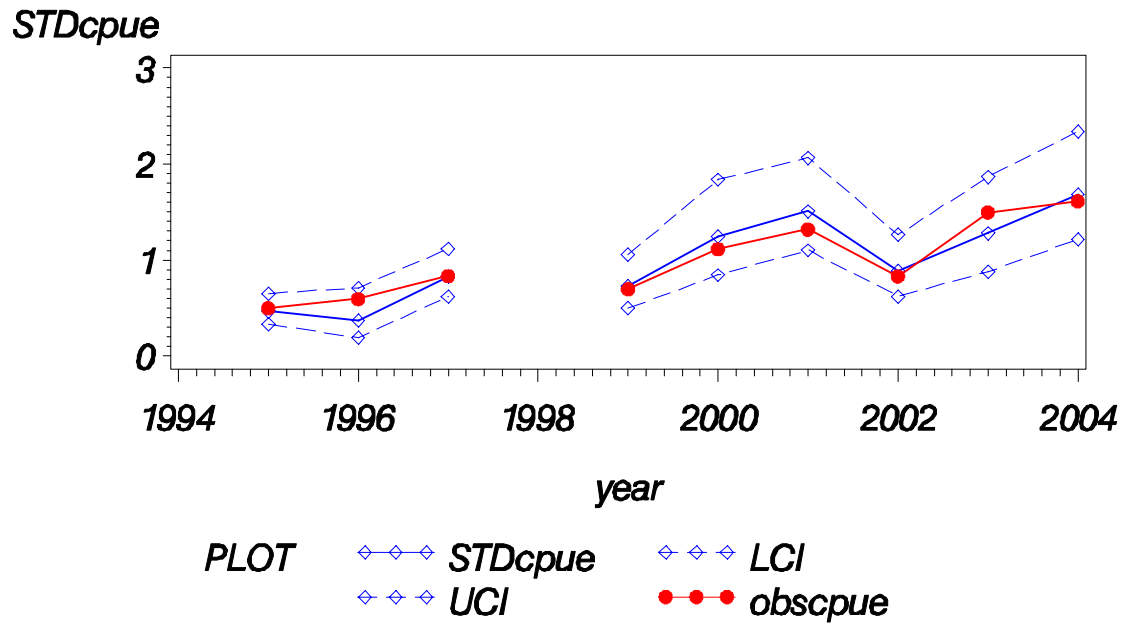## QQplot Residuals Positive cpue rates

Bonnetheads and sharpnose sharks (COMPLEX) – Gillnet CPUE data for Mote Marine Laboratory
Delta Lognormal CPUE for MOTE Gillnet (GN) – Index Output

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.66667	60	1.55924	0.46416	0.17126	0.33036	0.65216
1996	0.60000	30	1.24200	0.36972	0.33605	0.19220	0.71121
1997	0.83784	37	2.79260	0.83131	0.14813	0.61915	1.11618
1999	0.75000	40	2.44083	0.72660	0.19000	0.49857	1.05893
2000	0.80000	40	4.18517	1.24586	0.19652	0.84409	1.83887
2001	0.81667	60	5.07044	1.50939	0.15759	1.10347	2.06464
2002	0.73333	60	2.97842	0.88663	0.17848	0.62220	1.26344
2003	0.75000	60	4.29954	1.27991	0.19030	0.87771	1.86640
2004	0.73333	60	5.66507	1.68641	0.16479	1.21560	2.33957

Delta lognormal CPUE for Mote GN SCS
Observed and Standardized CPUE (95% CI)

Delta lognormal CPUE for Mote GN SCS
QQplot Residuals Positive cpue rates