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# CHARACTERISTICS OF BLUE, *PRIONACE GLAUCA*, AND SHORTFIN MAKO, *ISURUS OXYRINCHUS*, SHARK BY-CATCH OBSERVED ON PELAGIC LONGLINES IN THE NORTHWEST ATLANTIC, 1992-2003

Lawrence R. Beerkircher[1]

*SUMMARY*

*From May 1992 to December 2003, scientific observers from the National Marine Fisheries Service's (NMFS) Miami Laboratory documented 7,226 hauls of U.S. pelagic longline vessels operating in the northwestern Atlantic. Observers recorded the bycatch of 55681 blue, Prionace glauca, and 2897 shortfin mako, Isurus oxyrinchus, sharks. Eighty percent of blue sharks and 69% of mako sharks were alive on gear retrieval. Over 75 % of blue sharks were released alive; 61 % of mako sharks were retained and at least 23 % were released alive. Mean fork lengths for blue sharks ranged from 140 cm FL in the northeast distant (NED) spatial area to 207 cm FL in the tuna north-tuna south (TUN/TUS) area; for mako sharks, the range was 133 cm FL in the NED to 210 cm FL in the Caribbean (CAR). Length frequencies and sex ratios by spatial strata are presented for both species. Nominal catch per unit effort (CPUE) for both species was highest in the NED. Bootstrap procedures were used to estimate yearly mean CPUE and 95% confidence limits for various spatial strata. Results should be interpreted while taking into account seasonal patterns of fishing effort, changes in fishing techniques over the time period, and potential observer error.*

*RÉSUMÉ*

*De mai 1992 à décembre 2003, des observateurs scientifiques du Laboratoire de Miami du National Marine Fisheries Service's (NMFS) ont documenté 7.226 mouillages de palangriers pélagiques nord-américains opérant dans le Nord-Ouest de l'Atlantique. Les observateurs ont consigné les prises accessoires de 55.681 requins peaux bleues (Prionace glauca) et de 2.897 requins taupes bleues (*Isurus oxyrinchus*). Quatre-vingt pour cent des requins peaux bleues et 69% des requins taupes bleues étaient en vie lors de la récupération de l'engin. Plus de 75% des requins peaux bleues ont été remis en liberté vivants; 61% des requins taupes bleues ont été retenus à bord et au moins 23% remis à l'eau vivants. Les longueurs à la fourche moyennes du requin peau bleue oscillaient entre 140 cm FL dans la zone spatiale distante du Nord-Est (NED) et 207 cm FL dans la zone thon-nord thon-sud (TUN/TUS) : pour les requins taupes bleues, la gamme s'étendait entre 133 cm FL dans la zone NED et 210 cm FL dans les Caraïbes (CAR). Les fréquences de taille et les sex-ratios par strate spatiale sont présentés pour les deux espèces. La capture nominale par unité d'effort (CPUE) pour les deux espèces était plus élevée dans la zone NED. Des procédures par bootstrap ont été utilisées pour estimer la CPUE moyenne annuelle et des limites de confiance de 95% pour diverses strates spatiales. Les résultats devraient être interprétés en tenant compte des schémas saisonniers de l'effort de pêche, des changements dans les techniques de pêche survenus dans le temps et des erreurs éventuelles des observateurs.*

*RESUMEN*

*Desde mayo de 1992 hasta diciembre de 2003, observadores científicos del laboratorio de Miami del Nacional Marine Fisheries Service (Servicio Nacional de Pesquerías Marinas, NMFS) documentaron 7.226 lances de palangreros pelágicos estadounidenses que operaron en el Atlántico noroccidental. Los observadores registraron una captura fortuita de 55.681 tintoreras (Prionace glauca) y 2.897 marrajos dientusos (Isurus oxyrinchus). El ochenta por*

[1] U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Southeast Fisheries Science Center, Miami Lab., 75 Virginia Beach Dr., Miami, Florida, 33149 U.S.A. Lawrence.R.Beerkircher@noaa.gov

*ciento de las tintoreras y el 69% de los marrajos dientusos estaban vivos en el momento de recuperar el arte. Más del 75% de las tintoreras se liberaron vivas y el 61% de los marrajos dientusos se retuvieron a bordo, liberándose vivos menos de un 23%. La longitud media a horquilla de la tintorera osciló entre 140 cm FL en la zona espacial distante del noreste (NED) y 207 cm FL en la zona túnidos norte-túnidos sur (TUN/TUS); para el marrajo dientuso, la talla osciló entre 133 cm FL en la NED y 201 cm FL en el mar Caribe (CAR). Se presentan las frecuencias de talla y las ratios de sexos por estrato espacial para ambas especies. La captura nominal por unidad de esfuerzo (CPUE) para ambas especies fue más elevada en la NED. Se utilizaron procedimientos de muestreo repetitivo (bootstrap) para estimar la CPUE media anual y límites de confianza del 95% para los diferentes estratos espaciales. Los resultados deben interpretarse teniendo en cuenta los patrones estacionales del esfuerzo pesquero, los cambios de las técnicas de pesca durante el periodo de tiempo considerado y los potenciales errores de los observadores.*

*KEYWORDS*

*Long lining, Commercial fishing, Pelagic fisheries, Statistical sampling*

## 1. Introduction

In 1992, the National Marine Fisheries Service's (NMFS) Miami Laboratory initiated scientific sampling of the U.S. large pelagic fisheries longline fleet, as mandated by the U.S. Swordfish Fisheries Management Plan and subsequently the Atlantic Highly Migratory Species Fishery Management Plan (1998). This sampling effort is referred to as the Pelagic Observer Program (POP). The POP trains scientific observers to record detailed information concerning gear characteristics, location and time the gear is set and retrieved, environmental conditions, status and disposition of the marine life caught by the gear (alive or dead, kept or discarded), as well as morphometric measurements (length and weight) and sex identification of the animal. Observers also record incidental interactions with marine mammals, sea turtles, and sea birds. Collections of biological samples (anal fin rays, heads, reproductive tissue, vertebral centra, etc.) from some species are used to support research studies directed at critical questions about fish biology and life history. A more detailed description of the program can be found in Beerkircher *et al.* (2004).

Elasmobranchs represent a large proportion of the observed catch (29% by number from 1992-2002, Beerkircher et al. 2004), although this fishery generally does not target sharks due to limited markets or regulatory restrictions. Pelagic sharks such as the blue, *Prionace glauca*, and the shortfin mako, *Isurus oxyrinchus,* make up a substantial amount of the shark bycatch in this fishery. The blue shark has no market value to the U.S. Atlantic fishery; the shortfin mako, however, is a marketable catch and is often retained.

To help provide management-relevant information regarding blue and shortfin mako sharks, this paper will examine 12 years of observer data in the U.S. pelagic longline fishery and detail the catch characteristics of these species. Potential sources of bias that might influence the data's interpretation are identified and discussed.

## 2. Methods and materials

### *2.1 Data*

Data from the POP collected from program's inception in May of 1992 though December 2003 were examined for observations of blue and shortfin mako shark bycatch. Because the U.S. pelagic fleet operates over a moderately large area, and the target species and fishing techniques vary within that area, the northwestern Atlantic was broken down into 7 spatial strata that were created using existing area delineations or a combination of existing area delineations: northeast distant (NED), northeast coastal/mid Atlantic bight (NEC/MAB), south Atlantic bight/Florida east coast (SAB/FEC), Gulf of Mexico (GOM), Caribbean (CAR), Sargasso Sea/north central Atlantic (SAR/NCA), and tuna north/tuna south (TUN/TUS) (**Figure 1)**. Data from the NED stratum during 2001 to 2003 are observations from experimental fishing effort where fishing gear designed to reduce sea turtle interaction was tested.

### *2.2 Catch characteristics*

For both species, catch status, (condition of the animal upon gear retrieval either alive, dead, damaged due to sharks or other predators feeding on the carcass, or unknown) catch disposition (condition of the animal after gear interaction either kept, released alive, released dead, or unknown), and sex ratio was examined for each spatial strata. For the marketable mako shark, yearly catch disposition was examined in the NED and NEC/MAB strata to examine any changes over time Length information was used to estimate mean fork length (FL) for males, females, and combined data (including sex unknown) and construct length frequencies for males, females, and sex unknown for each spatial stratum; although for blue sharks in the CAR, TUN/TUS, and GOM strata length frequencies either used combined data or were not constructed at all due to very low catch. For shortfin mako sharks, length frequencies in the CAR, SAR/NCA, and TUN/TUS strata used combined data or were not constructed at all. Observed fork lengths below the reported size at birth for blue sharks, (35 cm FL; Pratt 1979) were not used in length analyses. For shortfin mako, sizes below the reported size-at-birth (63 cm FL; Mollet et al. 2000) were accepted down to 59 cm FL as whole fresh specimens collected by observers had been examined by the author at this size. Because this fishery often releases sharks alive without being brought on deck, estimated lengths were included in all length analyses. Observers were instructed to estimate fork length to the nearest foot and then convert to centimeters. Therefore, relatively large increments were used in the length frequencies, 20 cm and 15 cm for blue and shortfin mako sharks, respectively.

### *2.3 CPUE*

Nominal catch per unit effort (CPUE), expressed as number caught per 1000 hooks set, was calculated for each area for both species. Bootstrap procedures with 1,000 bootstrap replications (Efron and Tibshirani 1993) were used to estimate the mean yearly CPUE for both species; upper and lower 95% confidence limits were taken from the 97.5$^{th}$ and 2.5$^{th}$ percentiles of the ranked replicant means, respectively.

## 3. Results and discussion

### *3.1 Effort*

During May 1992 though December 2003, the POP observers documented 7226 hauls of pelagic longline gear, representing over five million hooks fished (**Table 1**). For three of the chosen spatial strata, effort was observed in every year of the study period; strata with limited observations were the NED (no observed hauls in 1996 and 1998), the SAR/NCA (no observed hauls in 1992), the CAR (no observed hauls in 2000) and the TUN/TUS (no observed hauls 1992-1995 and 2000-2003). Effort was observed in every month in the NEC/MAB, SAB/FEC, and GOM; the other areas exhibited more season patterns of observed effort (**Table 2**). During the study period, 55681 blue sharks and 2897 shortfin mako sharks were reported by observers; nominal CPUE was highest in the NED for both species, followed by the NEC/MAB. CPUE of blue and shortfin mako sharks was much lower for all other areas.

Observed effort represented approximately 4 % of the overall effort reported by the fishery, although that figure can be highly variable between years and spatial strata (Beerkircher *et al.* 2004). With particular respect to this study, it should be noted that observer coverage in the NED during 2001-2003 was 100% to monitor an experimental fishing project. Observers documented 1184513 hooks during the experiment, 78% of the total observed hook effort in the NED and 23 % of the overall observed hook effort. Potential confounding effects of including experimental effort in this study are discussed below.

### *3.2 Catch characteristics*

Overall catch status for blue sharks was 80% alive; this figure was slightly variable between strata, ranging from a low of 78% in the NED to a high of 94% in the CAR (**Table 3**). Shortfin mako were alive upon gear retrieval 69% of the time, which was consistent in the two areas where this species was captured frequently (NED and NEC/MAB). Catch disposition reflected catch status and marketability of the species; for blue sharks 22% of observed animals were discarded dead, while for shortfin mako sharks animals were discarded dead in only 9% of the observations (**Table 4**). Mako shark disposition over time (**Figure 2**) suggests that in the NEC/MAB stratum, the percent of captured animals kept for market has remained steady or perhaps slightly risen, but no trend is clear in the NED. Because the vessels that fish the NED are a much more homogeneous group than the NEC/MAB vessels in terms of vessel size, target species, and amount of any fishing year spent using pelagic gear; the pattern seen could indicate a increased willingness by vessels in the NEC/MAB to retain mako sharks in response to changing markets, more restrictive regulatory regimes, or an increase in species abundance in this area.

Sex ratios for blue sharks were generally close to even, except in the NEC/MAB where males outnumbered females 2.6:1 (**Table 5**). Large numbers of this species were recorded as sex unknown because individuals are often alive and not brought on board for close examination. The sex ratio information agrees with the information presented in Pratt (1979) for the NEC/MAB area, which Pratt identified as a mating area for this species. In the shortfin mako shark, sex ratios were close to even where sample size is high (NED and NEC/MAB) and dominated by males at least 2:1 in most other areas. This is contrary to the results reported in Casey and Kohler (1992), who found a 1:1 ratio for sizes up to 240 cm and females dominating the ratio for individuals over 240 cm; however, the relative sample size of individuals outside the NED or NEC/MAB strata make positive conclusions difficult.

Blue shark FL by spatial strata are presented in **Table 6**. Mean FL were much smaller for the NED (140 cm) than in all other areas. As a general tend, the largest mean lengths were found in areas south of 35 ° North latitude. Mean fork lengths for both males and females were below the reported size of maturity (183 cm males, 185 cm females; Pratt 1979) for the NED and NEC/MAB strata. Length frequency data for this species (**Figure 3**) are similar for most areas but indicate a higher proportion of smaller animals in the NED and NEC/MAB; this area may be an important nursery for blue sharks. Shortfin mako length data display a similar pattern to the blue shark; mean fork lengths are smallest in the NED and the NEC/MAB (133 cm and 138 cm, respectively) while areas below 35 ° North latitude exhibit comparatively much larger mean sizes. In most areas, mean FL was below the reported size of maturity for males (179 cm) and females (258 cm) (Stevens, 1983). The appearance of shortfin mako individuals at or near the reported size at birth in the NED (**Figure 4**) during the summer and fall combined with a parturition season of late winter-early spring (Mollet et al. 2000) support the speculation of Casey and Kohler (1992) that this species has widely dispersed pupping areas, and that the Gulf Stream carries the neonates to food-rich areas of the continental shelf off the northeastern coast of North America. For both the blue and the shortfin mako shark, the trend of smaller animals appearing in the NED and NEC/MAB areas, where observed fishing effort substantially occurs in summer and fall, suggests that these species use these areas as nursery grounds.

### *3.3 CPUE*

Nominal CPUE for blue sharks indicate that this species is overwhelmingly more relatively abundant in the NED than in any other stratum (29 animals per 1000 hooks), although they are also abundant in the NEC/MAB (9 animals per 1000 hooks). In other areas, the blue shark is much less common and in the GOM is very rare (.007 animals per 1000 hooks) (**Table 1**). The shortfin mako displays a more even distribution, however the NED and NEC/MAB are still the strata showing highest abundance (1.1 and 0.9 animals per 1000 hooks, respectively).

Series of bootstrapped yearly mean CPUE and 95% confidence limits for blue sharks (**Figure 5**) and shortfin mako sharks (**Figure 6**) show quite similar patterns for the NED and to a certain extent the NEC/MAB. This suggests that even though blue and shortfin mako sharks have different life histories, patterns of CPUE for these species' populations in the northwestern Atlantic may be influenced by environmental conditions and fishing mortality in the same way. The general trend seen in the time series of larger confidence limits associated with higher mean CPUE reflects the patchy distribution of animals in the pelagic environment. The trend for mako seen in the NEC/MAB seems to suggest in increase in mako relative abundance in this area during 1998-2003. As discussed above, fishers may have responded to species availability by retaining a higher percentage of captured fish during this time (**Figure 2**).

The CPUE time series for the NED strata should be interpreted with caution. During the years 2001-2003 this fishery was monitored by 100% observer coverage while engaged in experiments designed to reduce sea turtle interactions and minimize harm to sea turtles when interactions occurred. Although approximately half the hooks set represented "control" effort (intended to represent routine fishing techniques), the other half of observed effort was experimental and not consistent with the fishing effort that took place in this strata 1992-2000. Further, during 2002 and 2003, vessels participating in the experiment operated under a permit that capped the number of sea turtles that could be caught. In order to avoid sea turtle interactions, it is possible that participating vessels fished in different water conditions then they would have done in previous years. How much the experiment influenced the CPUE (and possibly catch characteristics) of blue and shortfin mako sharks in the NED during 2001-2003 is uncertain at this time, although the preliminary report (Watson et al. 2004) suggests that some treatments used during the experiment reduced blue shark catch by as much as 37%. Further investigation of the effects of experimental treatments on both blue and shortfin mako catch should be conducted before using observer (and logbook) data from the NED during 2001-2003.

The discussion above assumes the quality of observer data has remained constant throughout temporal and spatial strata, however, given fluctuating funding and emphasis on observer program quality, as well as increased agency emphasis on sharks, it is possible that species identification problems are more prevalent in the early years of this data set than in more recent data. Further, because in the early years of the data set observer training and program management was split between the NMFS Woods Hole Lab in the north and the Miami Lab in the south, differences in training and observer quality potentially result in spatial differences in data set accuracy, particularly in regard to sharks. Several shark species are morphologically very similar, including the shortfin mako, the longfin mako (*Isurus paucus*) and the porbeagle (*Lamna nasus*). Discussion of the resulting potential "observer effects", however, would be speculative; such effects may be no more or less confounding than subtle changes in gear and fishing practices, or ecological and habitat changes.

## 4. Conclusion

This study clearly reinforces the idea of habitat sharing by blue and shortfin mako sharks, and that in general the catch characteristics are similar between spatial strata. Because these data suggest that, for the northwestern Atlantic, both blue and shortfin mako sharks are most abundant in the NED stratum, the potential effects of experimental fishing on the data should be considered by users of the POP data.

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**Table 1.** Years of observed effort, hauls observed, hooks observed, and numbers caught and catch per unit effort (CPUE, expressed as number caught per 1000 hooks) of blue and shortfin mako sharks by spatial stratum.

| *Area* | *Years of data* | *Hauls* | *Hooks* | *Blue* | *Mako* | *Blue* | *Mako* |
|---|---|---|---|---|---|---|---|
| | | | | *Numbers caught* | | *CPUE* | |
| NED | 1992-1995, 1997, 1999-2003 | 1830 | 1518310 | 44349 | 1653 | 29.209 | 1.089 |
| NEC/MAB | 1992-2003 | 1446 | 1048247 | 9889 | 899 | 9.434 | 0.858 |
| SAB/FEC | 1992-2003 | 1316 | 646506 | 620 | 139 | 0.959 | 0.215 |
| SAR/NCA | 1993-2003 | 343 | 250623 | 487 | 33 | 1.943 | 0.132 |
| GOM | 1992-2003 | 2018 | 1528367 | 11 | 157 | 0.007 | 0.103 |
| CAR | 1992-1999, 2001-2003 | 209 | 109105 | 160 | 12 | 1.466 | 0.110 |
| TUN/TUS | 1996-1999 | 64 | 46825 | 165 | 4 | 3.524 | 0.085 |
| TOTAL | 1992-2003 | 7226 | 5147983 | 55681 | 2897 | | |

**Table 2.** Observed effort (hauls) by month for each spatial stratum.

| *Month* | *NED* | *NEC/MAB* | *SAB/FEC* | *CAR* | *SAR/NCA* | *GOM* | *TUN/TUS* |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 82 | 45 | 40 | 128 | 185 | 0 |
| 2 | 0 | 51 | 122 | 58 | 140 | 118 | 23 |
| 3 | 0 | 22 | 156 | 31 | 5 | 148 | 8 |
| 4 | 0 | 30 | 183 | 12 | 52 | 115 | 0 |
| 5 | 1 | 56 | 171 | 12 | 18 | 255 | 15 |
| 6 | 40 | 142 | 148 | 0 | 0 | 181 | 1 |
| 7 | 369 | 171 | 95 | 0 | 0 | 169 | 0 |
| 8 | 312 | 298 | 119 | 12 | 0 | 167 | 17 |
| 9 | 468 | 138 | 54 | 0 | 0 | 162 | 0 |
| 10 | 580 | 213 | 79 | 7 | 0 | 182 | 0 |
| 11 | 60 | 177 | 77 | 18 | 0 | 177 | 0 |
| 12 | 0 | 66 | 67 | 19 | 0 | 159 | 0 |

**Table 3.** Catch status (condition of the animal upon gear retrieval) for blue and shortfin mako sharks by spatial stratum.

| | Blue | | | | Mako | | | |
|---|---|---|---|---|---|---|---|---|
| *Area* | *Live* | *Dead* | *Damage* | *Unknown* | *Live* | *Dead* | *Damage* | *Unknown* |
| NED | 34637 | 9239 | 127 | 346 | 1174 | 465 | 10 | 4 |
| NEC/MAB | 8818 | 1015 | 1 | 55 | 621 | 267 | 7 | 4 |
| SAB/FEC | 556 | 58 | 5 | 1 | 94 | 42 | 1 | 0 |
| SAR/NCA | 453 | 34 | 0 | 0 | 17 | 16 | 0 | 0 |
| GOM | 9 | 2 | 0 | 0 | 99 | 55 | 3 | 0 |
| CAR | 150 | 10 | 0 | 0 | 3 | 9 | 0 | 0 |
| TUN/TUS | 139 | 25 | 1 | 0 | 2 | 2 | 0 | 0 |
| TOTAL | 44762 | 10383 | 134 | 402 | 2010 | 856 | 22 | 9 |

**Table 4.** Catch disposition (condition of animal after interaction with gear) for blue and shortfin mako sharks by spatial stratum.

| | Blue | | | | | Mako | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Area* | *Kept* | *Dead* | *Alive* | *Lost* | *Unknown* | *Kept* | *Dead* | *Alive* | *Lost* | *Unknown* |
| NED | 212 | 10868 | 32092 | 939 | 238 | 878 | 186 | 476 | 113 | 0 |
| NEC/MAB | 0 | 1064 | 8645 | 125 | 55 | 670 | 43 | 140 | 46 | 0 |
| SAB/FEC | 1 | 62 | 544 | 12 | 1 | 107 | 3 | 17 | 12 | 0 |
| SAR/NCA | 0 | 36 | 426 | 25 | 0 | 22 | 1 | 1 | 9 | 0 |
| GOM | 1 | 2 | 8 | 0 | 0 | 89 | 26 | 33 | 9 | 0 |
| CAR | 1 | 10 | 144 | 5 | 0 | 9 | 1 | 0 | 2 | 0 |
| TUN/TUS | 0 | 26 | 139 | 0 | 0 | 3 | 0 | 0 | 1 | 0 |
| TOTAL | 215 | 12068 | 41998 | 1106 | 294 | 1778 | 260 | 667 | 192 | 0 |

**Table 5.** Sex information for blue and shortfin mako sharks by spatial stratum.

| | Blue | | | Mako | | |
|---|---|---|---|---|---|---|
| *Area* | *Male* | *Female* | *Unknown* | *Male* | *Female* | *Unknown* |
| NED | 11934 | 11507 | 20907 | 615 | 685 | 353 |
| NEC/MAB | 2114 | 822 | 6953 | 435 | 341 | 123 |
| SAB/FEC | 59 | 76 | 485 | 77 | 35 | 27 |
| SAR/NCA | 87 | 88 | 312 | 17 | 7 | 9 |
| GOM | 4 | 1 | 6 | 74 | 37 | 46 |
| CAR | 7 | 29 | 124 | 7 | 3 | 2 |
| TUN/TUS | 39 | 21 | 105 | 0 | 4 | 0 |
| TOTAL | 14244 | 12544 | 28892 | 1225 | 1112 | 560 |

**Table 6.** Mean fork length (FL) in cm for blue and shortfin mako sharks by spatial stratum. Means are presented for males (M), females (F) and total measured animals (T) where data was available. N/A = data not available.

| | | *Blue* | | *Shortfin mako* | |
|---|---|---|---|---|---|
| *Area* | *Sex* | *FL* | *n* | *FL* | *n* |
| | M | 139 | 11174 | 138 | 589 |
| NED | F | 133 | 11172 | 131 | 638 |
| | T | 140 | 41739 | 133 | 1550 |
| | M | 180 | 1848 | 145 | 367 |
| NEC/MAB | F | 175 | 706 | 130 | 303 |
| | T | 179 | 8943 | 138 | 774 |
| | M | 201 | 59 | 185 | 53 |
| SAB/FEC | F | 185 | 73 | 178 | 29 |
| | T | 187 | 549 | 177 | 100 |
| | M | N/A | N/A | 178 | 68 |
| GOM | F | N/A | N/A | 155 | 33 |
| | T | 196 | 10 | 175 | 143 |
| | M | N/A | N/A | N/A | N/A |
| CAR | F | N/A | N/A | N/A | N/A |
| | T | 200 | 120 | 210 | 11 |
| | M | 218 | 86 | N/A | N/A |
| SAR/NCA | F | 199 | 84 | N/A | N/A |
| | T | 203 | 468 | 185 | 32 |
| | M | N/A | N/A | N/A | N/A |
| TUN/TUS | F | N/A | N/A | N/A | N/A |
| | T | 207 | 165 | 178 | 4 |

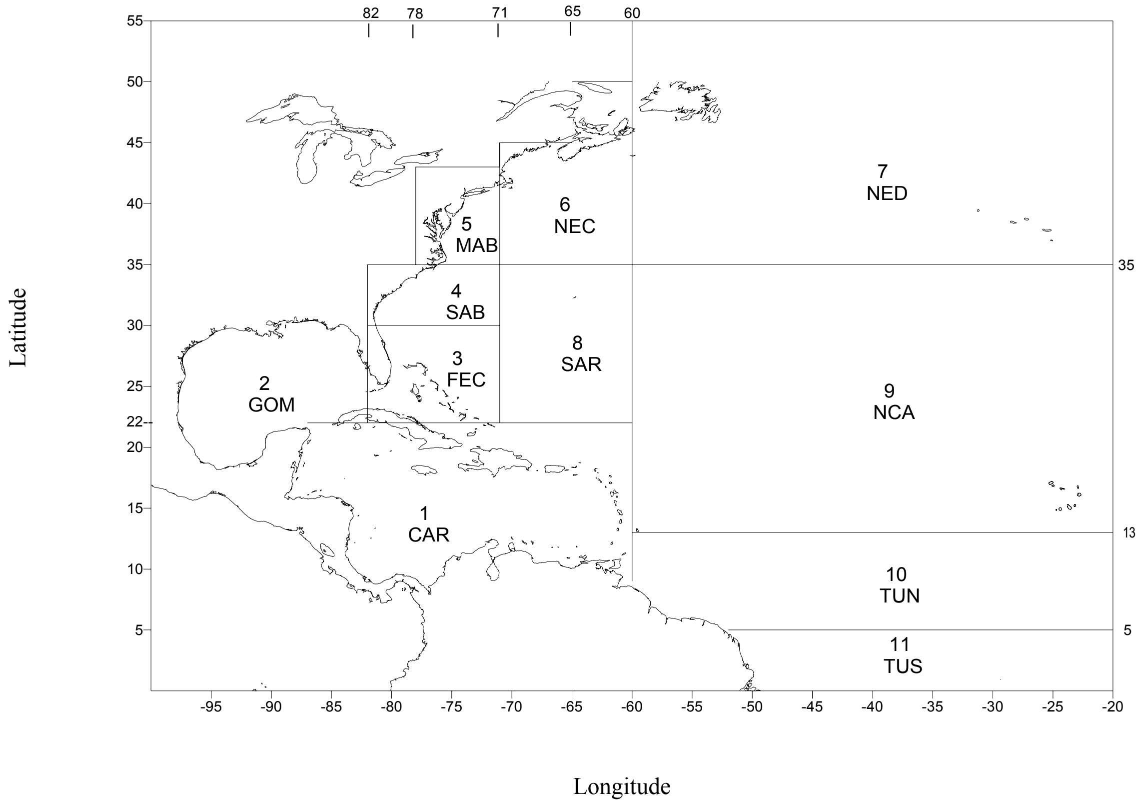



**Figure 1.** Spatial strata for the northwestern Atlantic. This study combines NEC with MAB, SAB with FEC, SAR with NCA, and TUN with TUS.

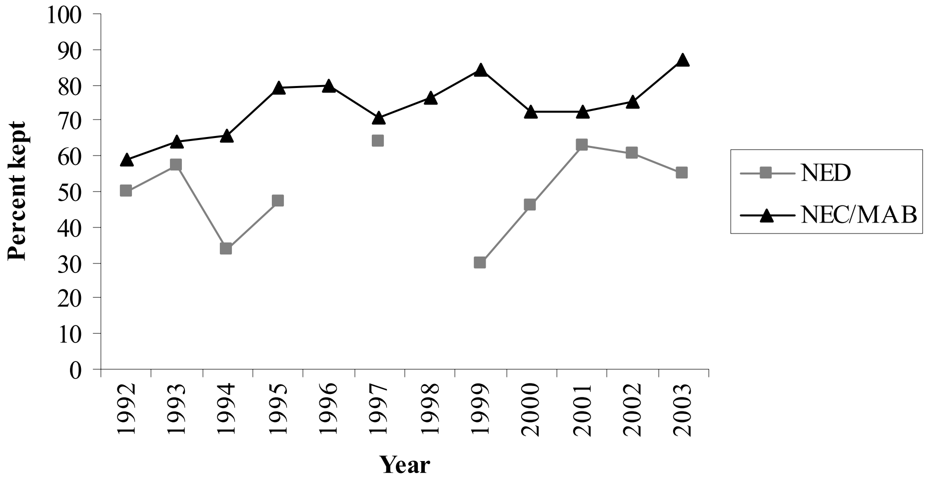
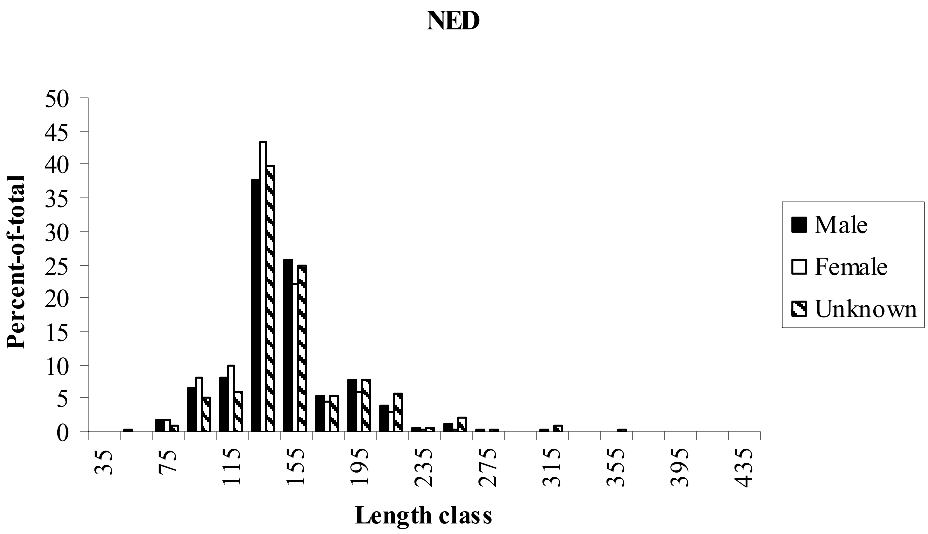
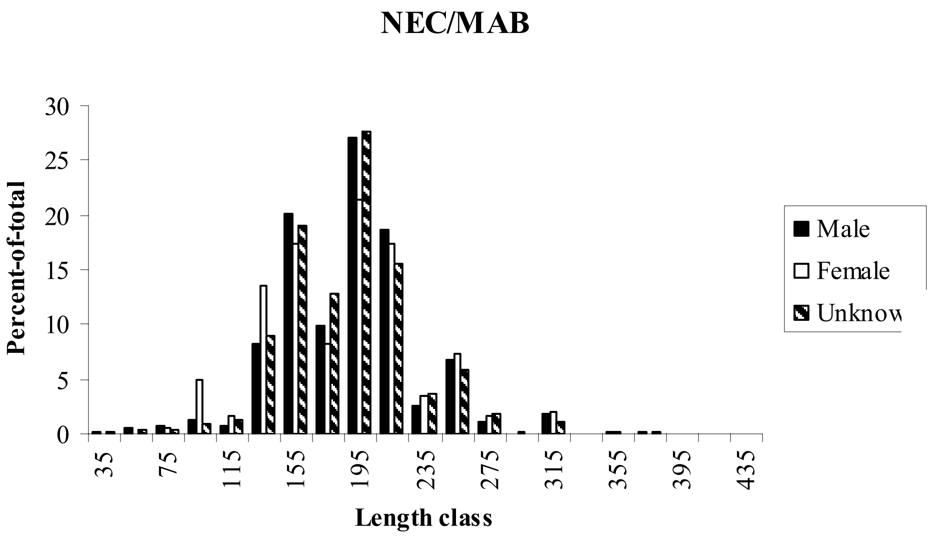



**Figure 2.** Catch disposition, expressed as percent kept, for shortfin mako sharks in the NED and NEC/MAB strata for 1992-2003.



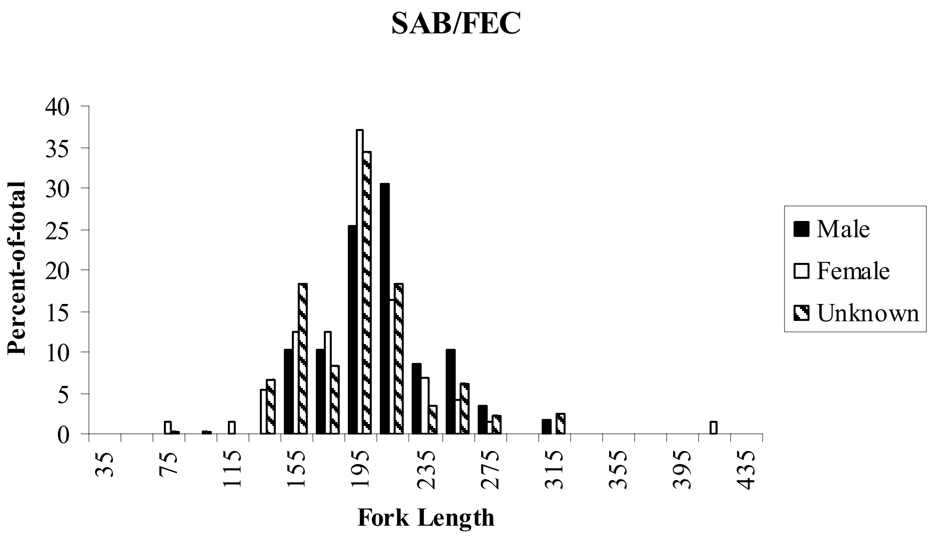
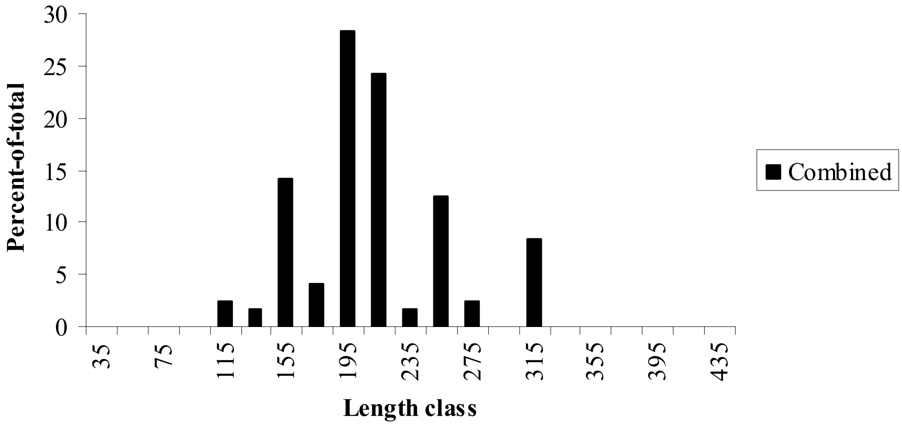
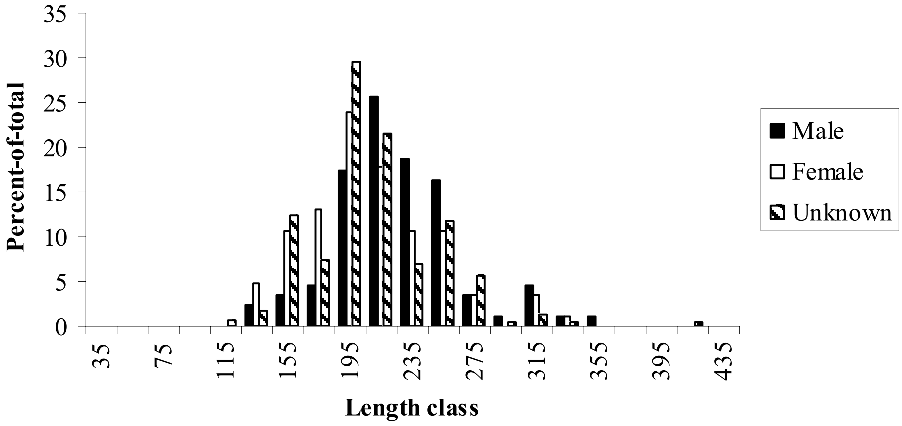




**Figure 3.** Fork length frequency (cm) for blue sharks in the northwestern Atlantic by spatial stratum. Lengths are separated into males, females, or sex unknown categories where data permitted. For stratum with less than 10 observations in either the male or female category, length data were combined.

## CAR




## SAR/NCA




## TUN/TUS

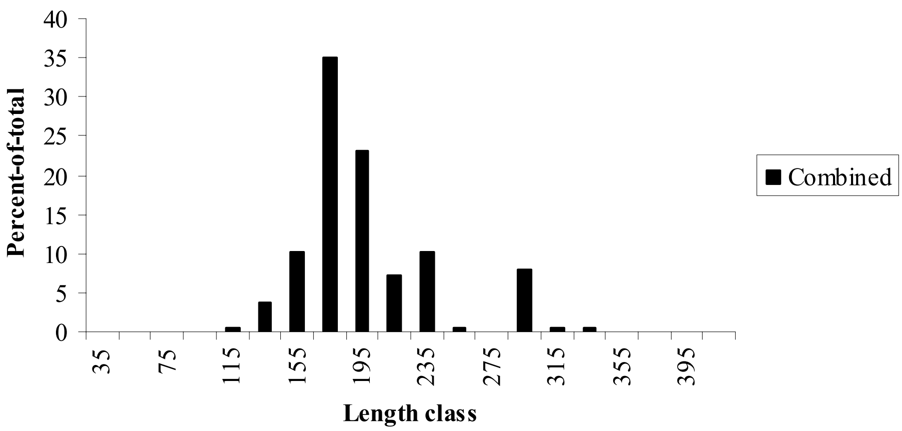



**Figure 3.** Continued.

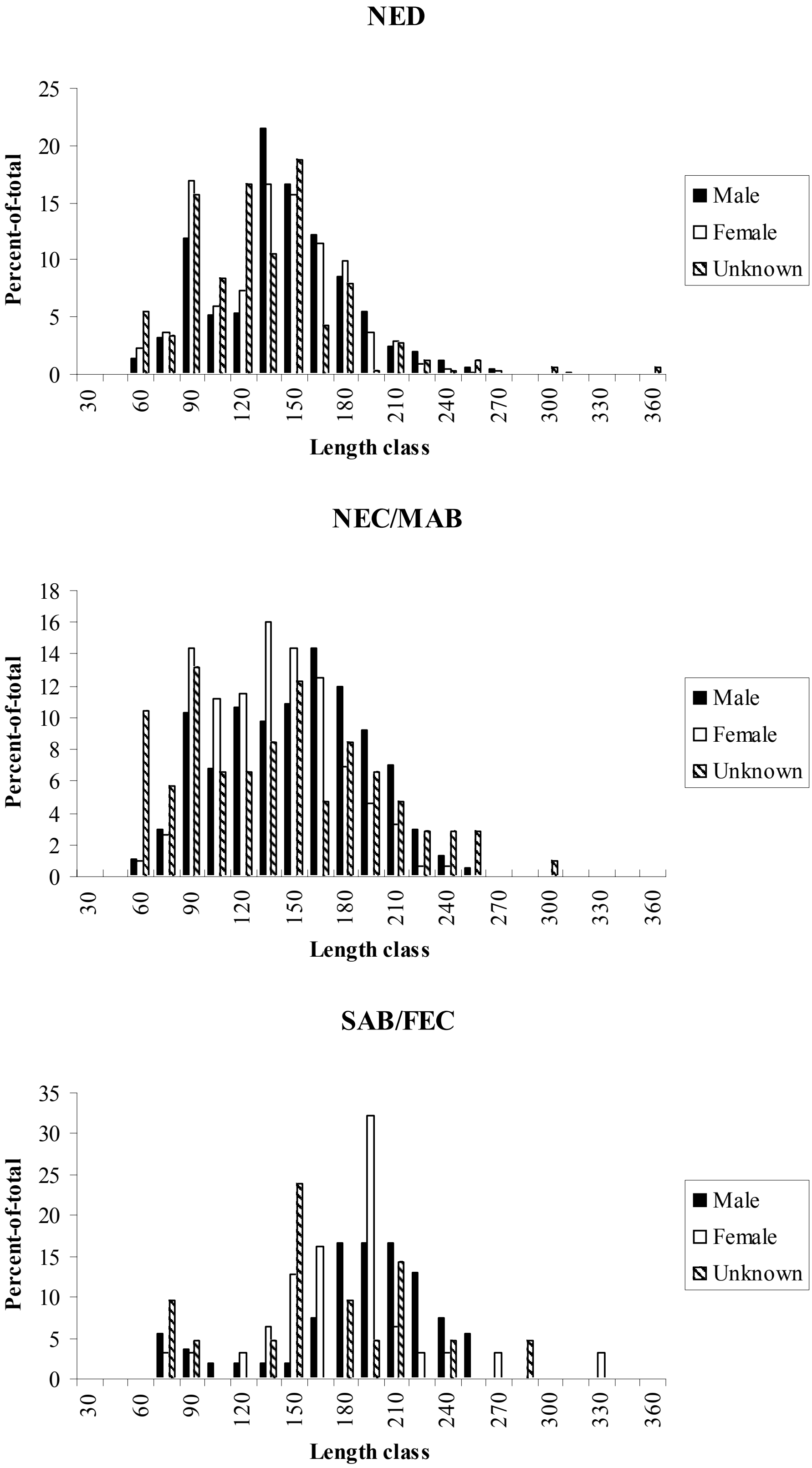
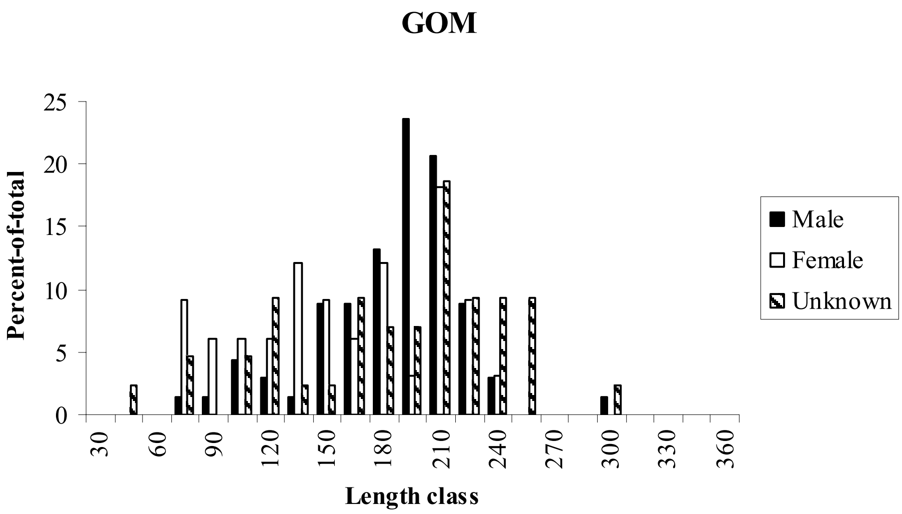



**Figure 4.** Fork length frequency (cm) for shortfin mako sharks in the northwestern Atlantic by spatial stratum. Lengths are separated into males, females, or sex unknown categories where data permitted. For stratum with less than 10 observations in either the male or female category, length data were combined.



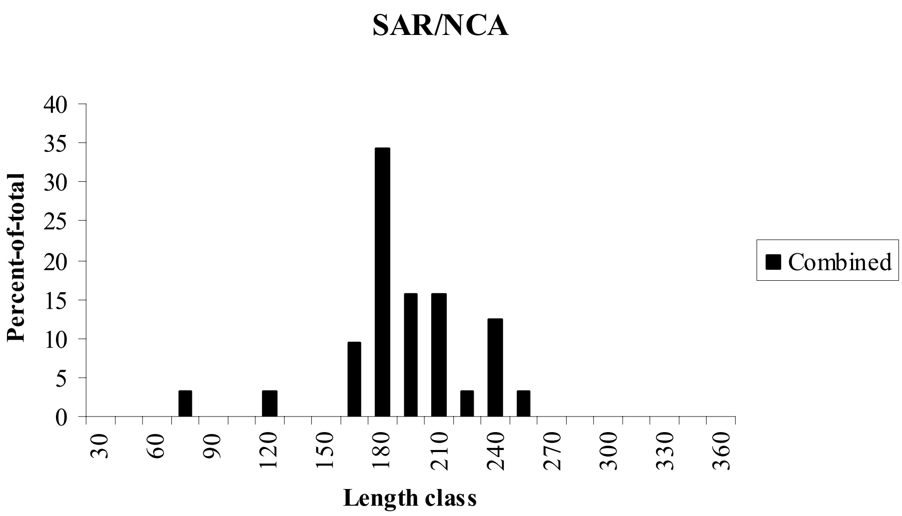




**Figure 4.** Continued.

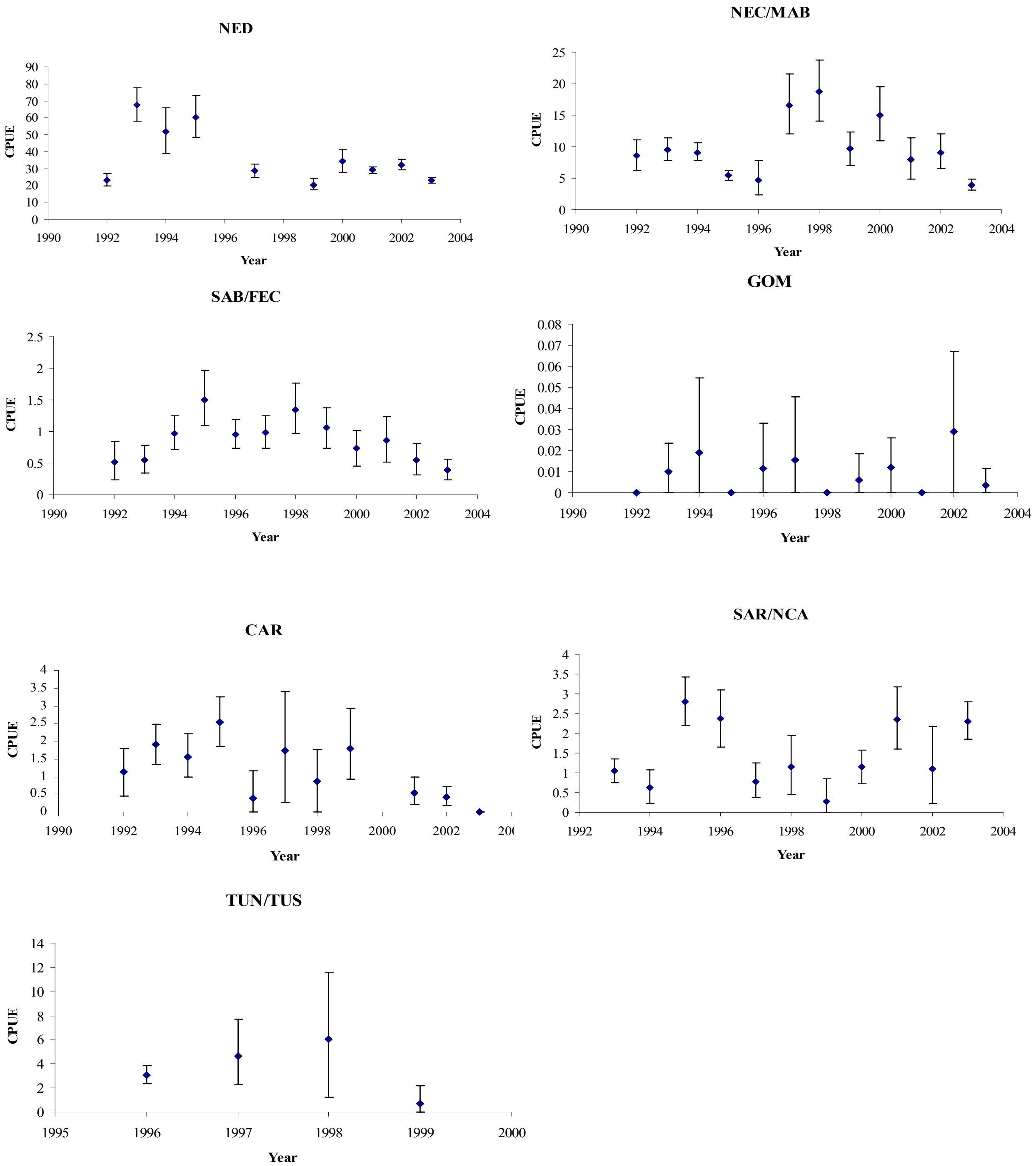



**Figure 5.** Bootstrapped estimates of yearly mean catch per unit effort (CPUE) expressed as numbers caught per 1000 hooks for blue sharks in the northwestern Atlantic by spatial stratum. Vertical bars represent bootstrap 95% confidence limits.

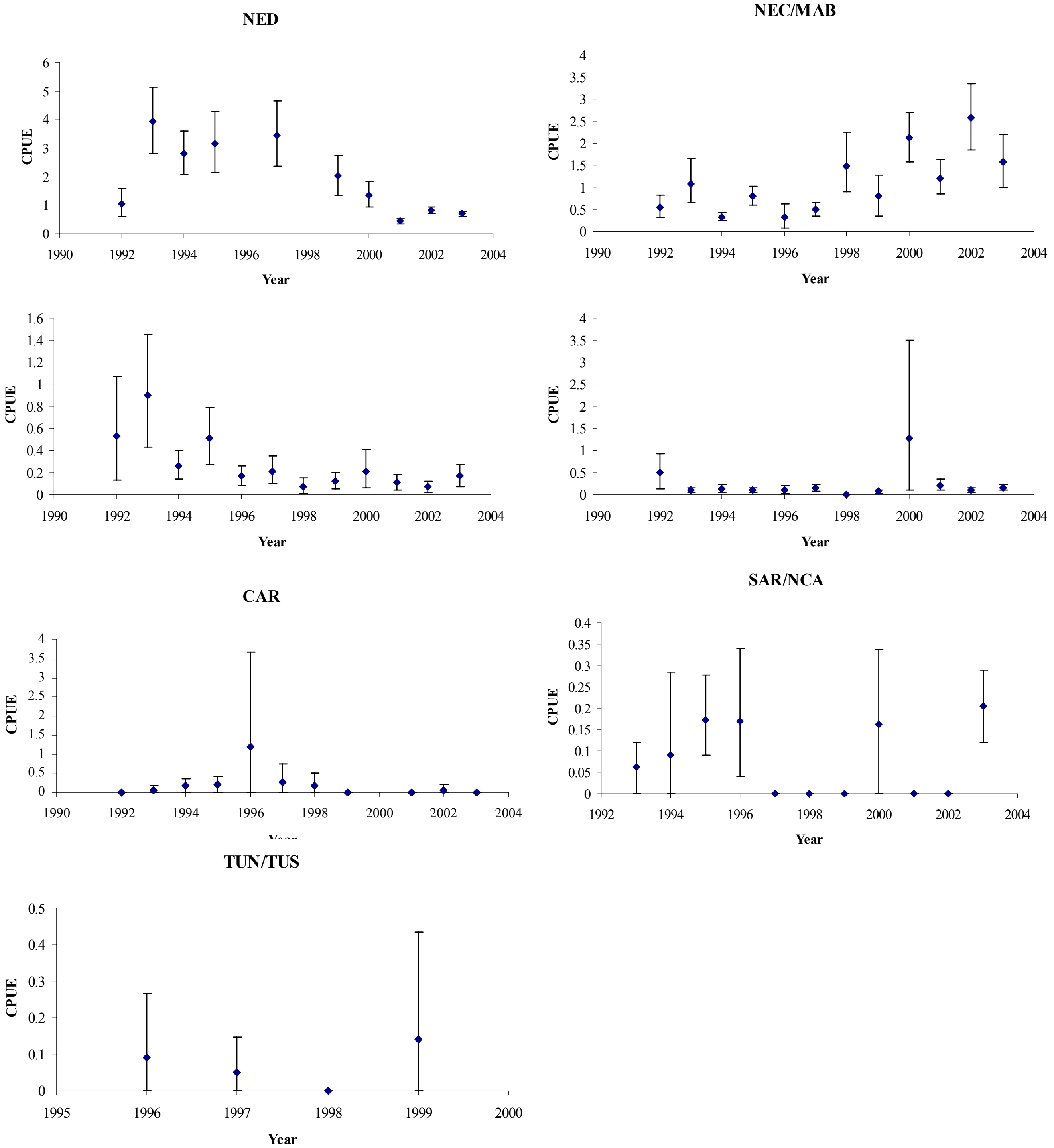



**Figure 6.** Bootstrapped estimates of yearly mean catch per unit effort (CPUE) expressed as numbers caught per 1000 hooks for shortfin mako sharks in the northwestern Atlantic by spatial stratum. Vertical bars represent bootstrap 95% confidence limits.