# Abundance Indices of Black Sea Bass Collected during SEAMAP Shallow Water Trawl Surveys in the South Atlantic Bight (1990-2010)

G. Walter Ingram, Jr.
NOAA, NMFS, Southeast Fisheries Science Center,
Mississippi Laboratories, Pascagoula, MS

## Introduction and Methodologies

One of the most important objectives of fishery-independent surveys is to make inference about the size (in numbers and/or biomass) and age structure of targeted populations. Annual abundance indices based on such surveys are usually derived from catch or catch-per-unit-effort (CPUE) data and are a vital part of current management regimes of many fisheries. Collection, analysis and dissemination of such information are paramount functions of NOAA Fisheries and South Carolina Department of Natural Resources (SCDNR).

The purpose of this document is to provide annual abundance indices of black sea bass to the SEDAR 25 Data Workshop for possible use in stock assessment. Data were collected during SEAMAP (Southeast Area Monitoring and Assessment Program) Shallow Water Trawl Surveys (hereafter referred to as trawl surveys) conducted by SCDNR in the U.S. South Atlantic Bight (SAB) from 1990-2010.

Fish in many cases are overdispersed as a result of behavior and/or physical oceanographic processes, resulting in catch data which is not normal. Therefore, samples taken from such overdispersed populations contain many small or zero values and few very large values, and simple estimates of mean abundance from sample data may either be too low if many low values are included or too high if very large values are included. Model-based estimators have been popularized since they may reduce the likelihood of false conclusions about trends in abundance (McConnaughey and Conquest 1992). They may also produce estimators with better precision (Pennington 1983, 1996; Lo *et al*. 1992).

One model-based alternative to the arithmetic mean of the sample is the delta-lognormal method (Lo *et al*. 1992). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992).

The delta-lognormal (DL) index of relative abundance ($I_y$) as described by Lo *et al*. (1992) can be estimated as

(1) $I_y = c_y p_y$,

where $c_y$ is the estimate of mean CPUE for positive catches only for year $y$; $p_y$ is the estimate of mean probability of occurrence during year $y$. Both $c_y$ and $p_y$ can be estimated using generalized linear models. Data used to estimate abundance for positive catches ($c$) and probability of occurrence ($p$) are assumed to have a lognormal distribution and a binomial distribution, respectively, and can be modeled using the following equations:

(2) $$\ln(\mathbf{c}) = \mathbf{X\beta} + \boldsymbol{\varepsilon}$$

and

(3) $$\mathbf{p} = \frac{e^{\mathbf{X\beta}+\boldsymbol{\varepsilon}}}{1 + e^{\mathbf{X\beta}+\boldsymbol{\varepsilon}}}$$, respectively,

where **c** is a vector of the positive catch data, **p** is a vector of the presence/absence data, **X** is the design matrix for main effects, **β** is the parameter vector for main effects, and **ε** is a vector of independent normally distributed errors with expectation zero and variance $\sigma^2$.

The variables $c_y$ and $p_y$ can be estimated as least-squares means for each year along with their corresponding standard errors, SE($c_y$) and SE($p_y$). From these estimates, $I_y$ can be calculated, as in equation (1), and its variance calculated as

(4) $$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y) + 2c_y p_y \mathrm{Cov}(c, p),$$

where

(5) $$\mathrm{Cov}(c, p) \approx \rho_{\mathrm{c,p}}\left[\mathrm{SE}(c_y)\mathrm{SE}(p_y)\right],$$

and $\rho_{c,p}$ denotes correlation of *c* and *p* among years.

The survey methodologies and descriptions of the data sets used herein have been previously presented in detail (Anonymous 2007, SEDAR13-DW1, see attached document). Due to inconsistencies in survey methods, data from 1986 to 1989 were dropped from analyses. The submodels of the DL model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha$ = 0.05. Variables that were used in each submodel included year, sampling area (associated with each state, see Anonymous 2007, SEDAR13-DW1), season (Spring: months 4 and 5; Summer: months 6, 7, and 8; and Fall: months 10 and 11; other months were not sampled or due to limited sampling were dropped), bottom temperature, bottom salinity, depth, and the interactions between sampling area and season, and sampling area and year. Binomial submodel performance was evaluated using AIC, while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots. Black sea bass CPUE (both in number and biomass of fish per trawl-hour) was modeled using this approach. Finally, a length frequency histogram was developed to determine which portion of the stock was represented in these analyses.

## Results and Discussion

Figure 1 is a length frequency histogram of black sea bass collected and measured in this survey. There were 2238 individuals measured with a mean total length of 15.85 cm.

The variables that were retained in the binomial submodel were year, sampling area, and bottom salinity. Table 1 summarizes the type 3 analyses of the parameters used in the final binomial submodel and their significance. For the lognormal submodel for both numbers and biomass, the year, season and sampling area, depth variables were retained as well as the interaction effect of season*sampling area (Tables 2 & 3). Figures 2 & 3 illustrate the interaction effect between sampling area and season on the modeled non-zero CPUE of black seabass in both numbers and biomass; and indicate that during the summer sampling season both the FL and NC sampling areas have higher non-zero CPUE in both numbers and biomass. Figures 4 & 5 are QQ plots of the residuals of the lognormal submodels for non-zero CPUE in both numbers and biomass; and indicate that the lognormal submodel for non-zero CPUE in biomass performs better than that of non-zero CPUE in numbers. Figures 6 & 7 and Tables 4 & 5 summarize the indices of black sea bass (number per trawl-hour and biomass per trawl-hour) developed from the delta-lognormal model.

## Acknowledgements

I would like to thank SCDNR for their diligent work with the SEAMAP Shallow Water Trawl Survey, and specifically Jeanne Boylan for quick and efficient responses to data requests.

## References

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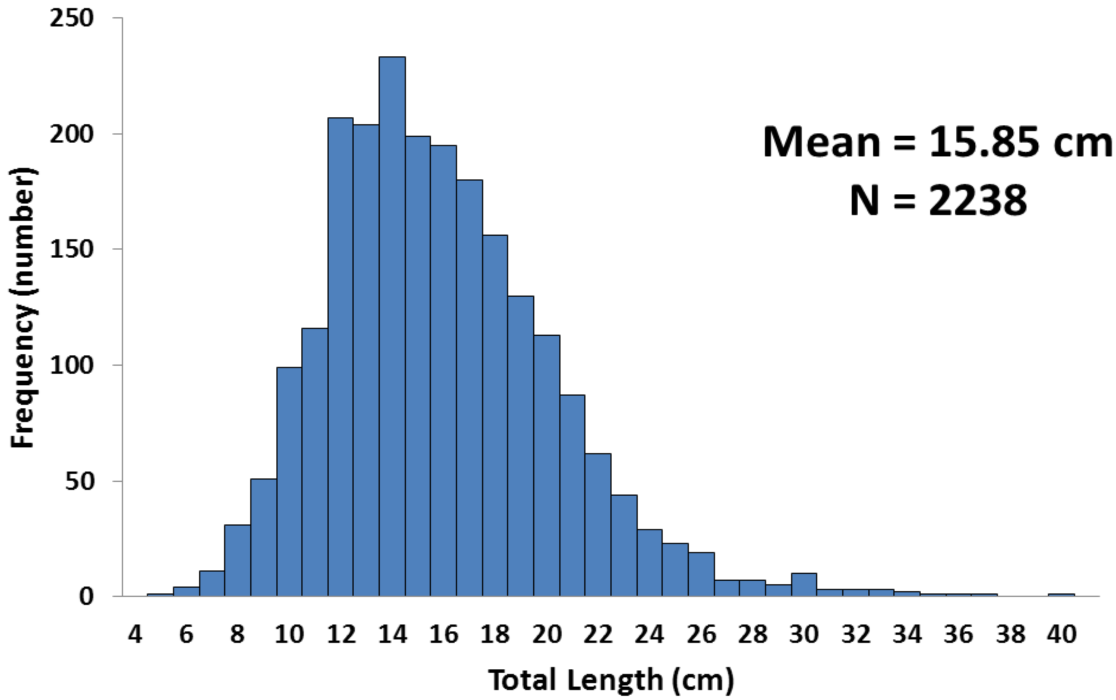


Figure 1. Length frequency histogram of black sea bass collected in this SEAMAP Shallow Water Trawl Surveys in the South Atlantic Bight.

Table 1. Type 3 tests of fixed effects for the binomial submodel.

| *Effect* | *Num DF* | *Den DF* | *Chi-Square* | *F Value* | *Pr > ChiSq* | *Pr > F* |
|---|---|---|---|---|---|---|
| *Year* | 20 | 6085 | 110.11 | 5.51 | <.0001 | <.0001 |
| *Sampling Area* | 3 | 6085 | 195.14 | 65.05 | <.0001 | <.0001 |
| *Bottom Salinity* | 1 | 6085 | 10.62 | 10.62 | 0.0011 | 0.0011 |

Table 2. Type 3 tests of fixed effects for the lognormal submodel for nonzero CPUE in numbers.

| *Effect* | *Num DF* | *Den DF* | *F Value* | *Pr > F* |
|---|---|---|---|---|
| *Year* | 20 | 616 | 2.30 | 0.0011 |
| *Season* | 2 | 616 | 1.78 | 0.1697 |
| *Sampling Area* | 3 | 616 | 12.61 | <.0001 |
| *Depth* | 1 | 616 | 7.46 | 0.0065 |
| *Season* Sampling Area* | 6 | 616 | 3.74 | 0.0012 |

Table 3. Type 3 tests of fixed effects for the lognormal submodel for nonzero CPUE in biomass.

| *Effect* | *Num DF* | *Den DF* | *F Value* | *Pr > F* |
|---|---|---|---|---|
| *Year* | 20 | 616 | 1.73 | 0.0251 |
| *Season* | 2 | 616 | 2.12 | 0.1211 |
| *Sampling Area* | 3 | 616 | 16.70 | <.0001 |
| *Depth* | 1 | 616 | 11.13 | 0.0009 |
| *Season* Sampling Area* | 6 | 616 | 3.26 | 0.0037 |

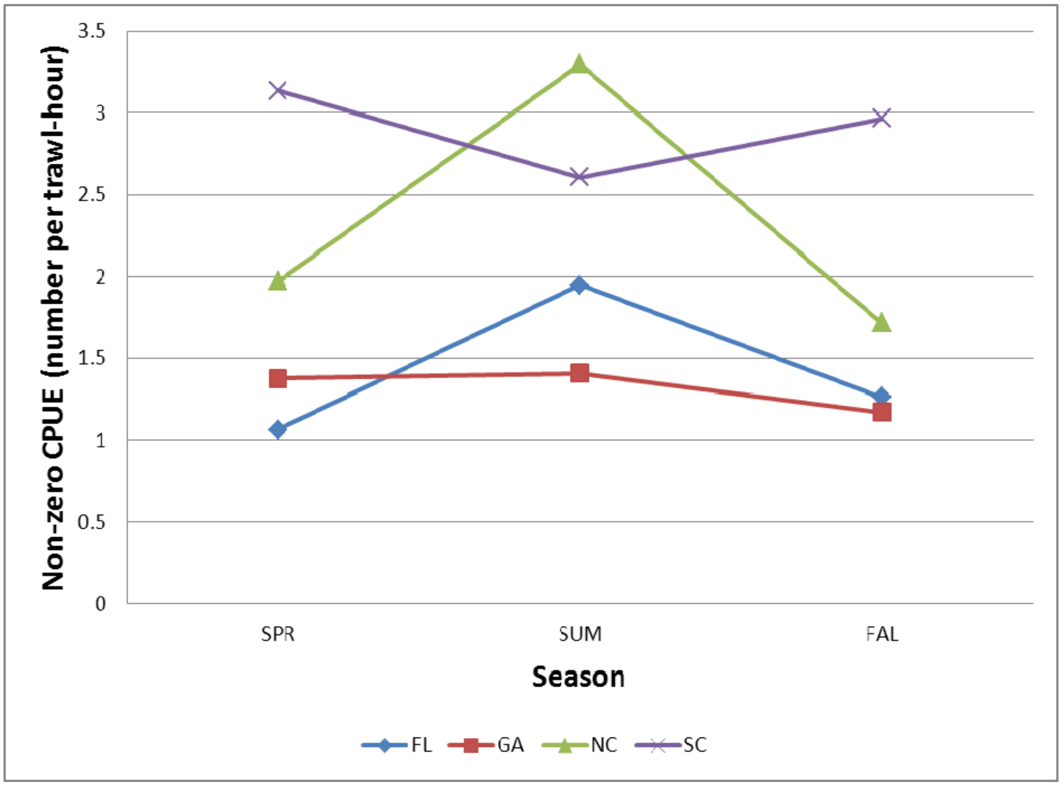


Figure 2. The interaction effect between sampling area and season on the modeled non-zero CPUE in numbers for black sea bass.

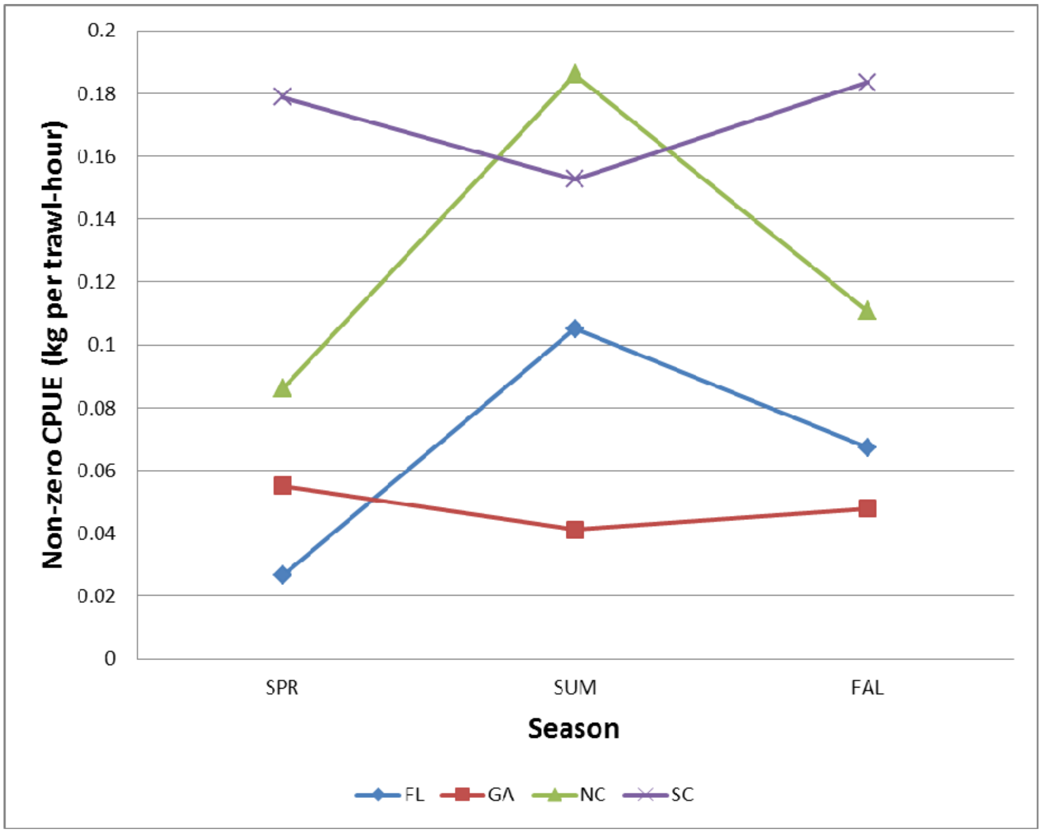


Figure 3. The interaction effect between sampling area and season on the modeled non-zero CPUE in biomass for black sea bass.

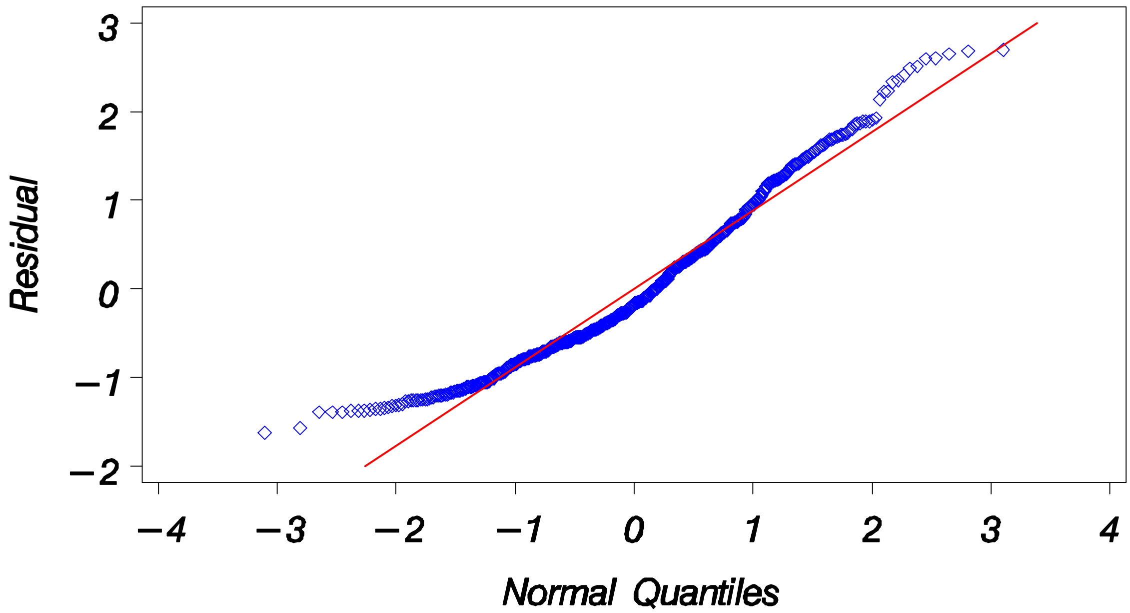


Figure 4. QQ plot of residuals of the lognormal submodel for CPUE in numbers.

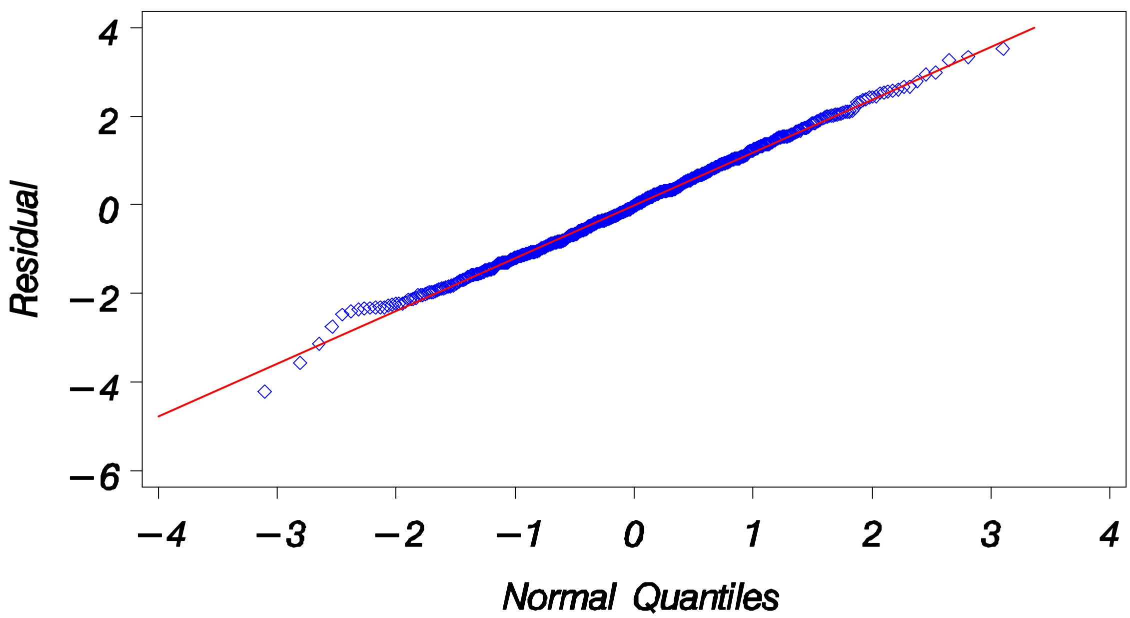


Figure 5. QQ plot of residuals of the lognormal submodel for CPUE in biomass.

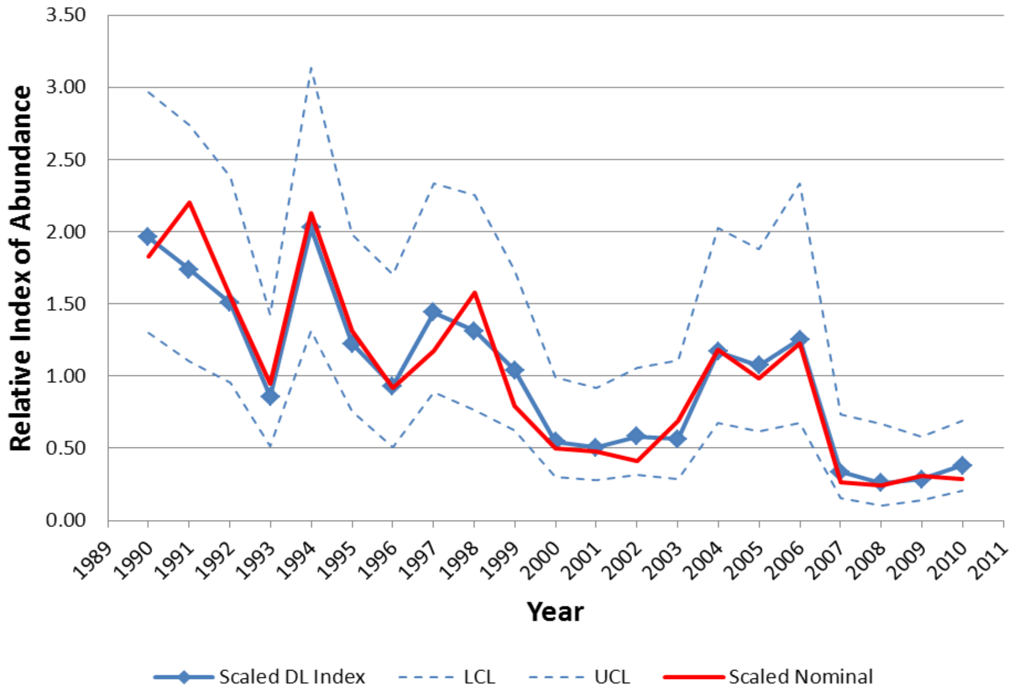


Figure 6. Index of relative abundance of black sea bass collected in SEAMAP shallow water trawls in the South Atlantic Bight based on CPUE in numbers. The vertical axis represents relative CPUE units. Both the index values and the nominal values are scaled to mean of one for the time series.

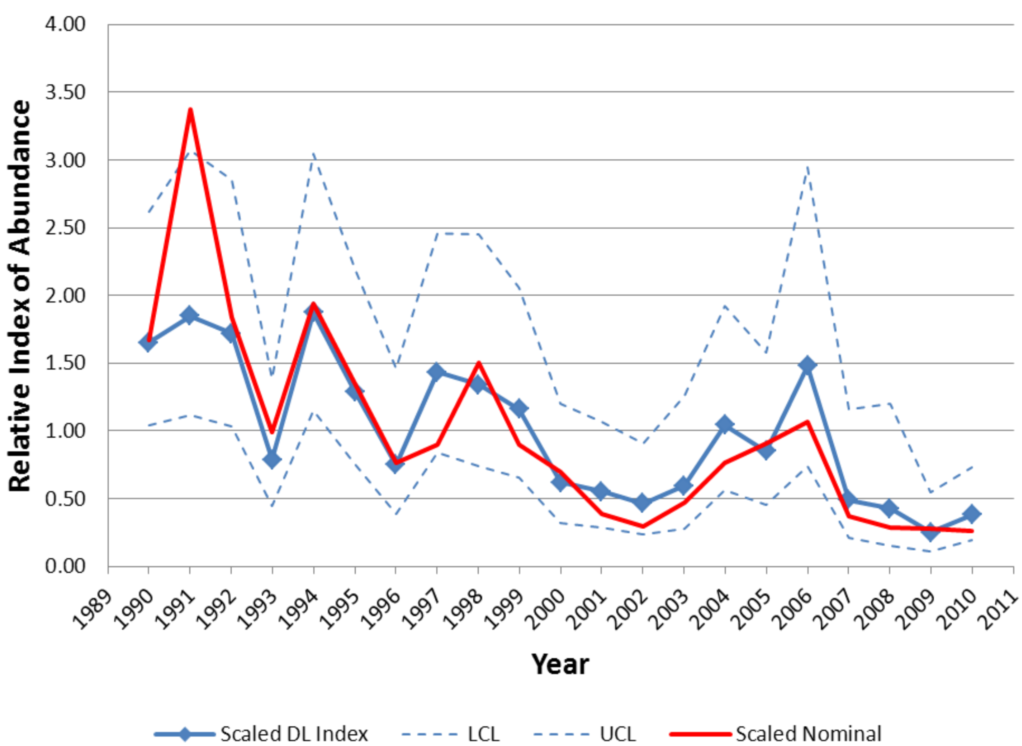


Figure 7. Index of relative abundance of black sea bass collected in SEAMAP shallow water trawls in the South Atlantic Bight based on CPUE in biomass. The vertical axis represents relative CPUE units. Both the index values and the nominal values are scaled to mean of one for the time series.

Table 4. Indices of black sea bass collected in SEAMAP shallow water trawls in the South Atlantic Bight developed using the delta-lognormal (DL) model. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the nominal and DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

| *Survey Year* | *Frequency* | *N* | *DL Index* | *Scaled Nominal* | *Scaled DL Index* | *CV* | *LCL* | *UCL* |
|---|---|---|---|---|---|---|---|---|
| 1990 | 0.2044 | 274 | 0.4884 | 1.8252 | 1.9611 | 0.2085 | 1.2981 | 2.9626 |
| 1991 | 0.1710 | 269 | 0.4325 | 2.1994 | 1.7368 | 0.2301 | 1.1028 | 2.7353 |
| 1992 | 0.1661 | 277 | 0.3755 | 1.5475 | 1.5078 | 0.2303 | 0.9570 | 2.3757 |
| 1993 | 0.1300 | 277 | 0.2133 | 0.9511 | 0.8566 | 0.2572 | 0.5164 | 1.4209 |
| 1994 | 0.1805 | 277 | 0.5051 | 2.1278 | 2.0284 | 0.2203 | 1.3124 | 3.1349 |
| 1995 | 0.1444 | 277 | 0.3049 | 1.3137 | 1.2242 | 0.2435 | 0.7575 | 1.9784 |
| 1996 | 0.0903 | 277 | 0.2320 | 0.9188 | 0.9316 | 0.3081 | 0.5102 | 1.7012 |
| 1997 | 0.1444 | 277 | 0.3586 | 1.1767 | 1.4397 | 0.2445 | 0.8892 | 2.3312 |
| 1998 | 0.1119 | 277 | 0.3265 | 1.5797 | 1.3112 | 0.2756 | 0.7633 | 2.2524 |
| 1999 | 0.1264 | 277 | 0.2592 | 0.7899 | 1.0407 | 0.2590 | 0.6251 | 1.7324 |
| 2000 | 0.0903 | 277 | 0.1362 | 0.4997 | 0.5470 | 0.3055 | 0.3010 | 0.9943 |
| 2001 | 0.0850 | 306 | 0.1263 | 0.4815 | 0.5070 | 0.3035 | 0.2800 | 0.9181 |
| 2002 | 0.0817 | 306 | 0.1447 | 0.4086 | 0.5809 | 0.3068 | 0.3188 | 1.0583 |
| 2003 | 0.0654 | 306 | 0.1407 | 0.6931 | 0.5650 | 0.3465 | 0.2882 | 1.1080 |
| 2004 | 0.0980 | 306 | 0.2916 | 1.1819 | 1.1707 | 0.2796 | 0.6763 | 2.0267 |
| 2005 | 0.0980 | 306 | 0.2674 | 0.9850 | 1.0736 | 0.2847 | 0.6143 | 1.8763 |
| 2006 | 0.0752 | 306 | 0.3123 | 1.2257 | 1.2541 | 0.3178 | 0.6744 | 2.3321 |
| 2007 | 0.0458 | 306 | 0.0840 | 0.2627 | 0.3374 | 0.4055 | 0.1546 | 0.7362 |
| 2008 | 0.0294 | 306 | 0.0648 | 0.2408 | 0.2602 | 0.4971 | 0.1017 | 0.6661 |
| 2009 | 0.0506 | 336 | 0.0711 | 0.3057 | 0.2856 | 0.3684 | 0.1399 | 0.5828 |
| 2010 | 0.0744 | 336 | 0.0947 | 0.2857 | 0.3804 | 0.3042 | 0.2098 | 0.6896 |

Table 5. Indices of black sea bass collected in SEAMAP shallow water trawls in the South Atlantic Bight developed using the delta-lognormal (DL) model. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (biomass per trawl-hour), the nominal and DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

| *Survey Year* | *Frequency* | *N* | *DL Index* | *Scaled Nominal* | *Scaled DL Index* | *CV* | *LCL* | *UCL* |
|---|---|---|---|---|---|---|---|---|
| 1990 | 0.2044 | 274 | 0.0313 | 1.6661 | 1.6508 | 0.2339 | 1.0405 | 2.6191 |
| 1991 | 0.1710 | 269 | 0.0351 | 3.3711 | 1.8491 | 0.2580 | 1.1129 | 3.0722 |
| 1992 | 0.1661 | 277 | 0.0326 | 1.8365 | 1.7183 | 0.2578 | 1.0346 | 2.8540 |
| 1993 | 0.1300 | 277 | 0.0149 | 0.9923 | 0.7853 | 0.2879 | 0.4466 | 1.3810 |
| 1994 | 0.1805 | 277 | 0.0355 | 1.9418 | 1.8734 | 0.2470 | 1.1516 | 3.0478 |
| 1995 | 0.1444 | 277 | 0.0244 | 1.3547 | 1.2887 | 0.2726 | 0.7544 | 2.2015 |
| 1996 | 0.0903 | 277 | 0.0142 | 0.7637 | 0.7505 | 0.3435 | 0.3848 | 1.4636 |
| 1997 | 0.1444 | 277 | 0.0272 | 0.8986 | 1.4345 | 0.2745 | 0.8368 | 2.4592 |
| 1998 | 0.1119 | 277 | 0.0254 | 1.5023 | 1.3420 | 0.3081 | 0.7349 | 2.4506 |
| 1999 | 0.1264 | 277 | 0.0220 | 0.8960 | 1.1625 | 0.2899 | 0.6586 | 2.0518 |
| 2000 | 0.0903 | 277 | 0.0118 | 0.6944 | 0.6200 | 0.3411 | 0.3193 | 1.2039 |
| 2001 | 0.0850 | 306 | 0.0104 | 0.3873 | 0.5510 | 0.3379 | 0.2855 | 1.0635 |
| 2002 | 0.0817 | 306 | 0.0088 | 0.2970 | 0.4640 | 0.3424 | 0.2384 | 0.9031 |
| 2003 | 0.0654 | 306 | 0.0113 | 0.4732 | 0.5934 | 0.3888 | 0.2802 | 1.2568 |
| 2004 | 0.0980 | 306 | 0.0198 | 0.7608 | 1.0436 | 0.3128 | 0.5664 | 1.9228 |
| 2005 | 0.0980 | 306 | 0.0161 | 0.9043 | 0.8497 | 0.3169 | 0.4577 | 1.5772 |
| 2006 | 0.0752 | 306 | 0.0280 | 1.0630 | 1.4783 | 0.3549 | 0.7424 | 2.9439 |
| 2007 | 0.0458 | 306 | 0.0093 | 0.3701 | 0.4887 | 0.4510 | 0.2067 | 1.1556 |
| 2008 | 0.0294 | 306 | 0.0081 | 0.2891 | 0.4281 | 0.5505 | 0.1530 | 1.1979 |
| 2009 | 0.0506 | 336 | 0.0047 | 0.2793 | 0.2489 | 0.4108 | 0.1130 | 0.5483 |
| 2010 | 0.0744 | 336 | 0.0072 | 0.2583 | 0.3791 | 0.3396 | 0.1958 | 0.7341 |

# SEAMAP-SA Shallow Water Trawl Survey

## METHODS AND MATERIALS

Samples are taken by trawl from the coastal zone of the South Atlantic Bight (SAB) between Cape Hatteras, North Carolina, and Cape Canaveral, Florida (Figure 1). Multi-legged cruises are conducted in spring (early April - mid-May), summer (mid-July - early August), and fall (October - mid-November).

Stations are randomly selected from a pool of stations within each stratum. The number of stations sampled in each stratum is determined by optimal allocation. A total of 102 stations are sampled each season within twenty-four shallow water strata, representing an increase from 78 stations previously sampled in those strata by the trawl survey (1990-2000). Strata are delineated by the 4 m depth contour inshore and the 10 m depth contour offshore. In previous years (1990-2000), stations were sampled in deeper strata with station depths ranging from 10 to 19 m in order to gather data on the reproductive condition of commercial penaeid shrimp. Those strata were abandoned in 2001 in order to intensify sampling in the more shallow depth-zone.

The R/V *Lady Lisa*, a 75-ft (23-m) wooden-hulled, double-rigged, St. Augustine shrimp trawler owned and operated by the South Carolina Department of Natural Resources (SCDNR), is used to tow paired 75-ft (22.9-m) mongoose-type Falcon trawl nets (manufactured by Beaufort Marine Supply; Beaufort, S.C.) without TED's. The body of the trawl is constructed of #15 twine with 1.875-in (47.6-mm) stretch mesh. The cod end of the net is constructed of #30 twine with 1.625-in (41.3-mm) stretch mesh and is protected by chafing gear of #84 twine with 4-in (10-cm) stretch "scallop" mesh. A 300 ft (91.4-m) three-lead bridle is attached to each of a pair of wooden chain doors which measured 10 ft x 40 in (3.0-m x 1.0-m), and to a tongue centered on the head-rope. The 86-ft (26.3-m) head-rope, excluding the tongue, had one large (60-cm) Norwegian "polyball" float attached top center of the net between the end of the tongue and the tongue bridle cable and two 9-in (22.3-cm) PVC foam floats located one-quarter of the distance from each end of the net webbing. A 1-ft chain drop-back is used to attach the 89-ft foot-rope to the trawl door. A 0.25-in (0.6-cm) tickler chain, which is 3.0-ft (0.9-m) shorter than the combined length of the foot-rope and drop-back, is connected to the door alongside the foot-rope.

Trawls are towed for twenty minutes, excluding wire-out and haul-back time, exclusively during daylight hours (1 hour after sunrise to 1 hour before sunset). Each net is processed separately and assigned a unique collection number (port=odd, starboard=even); however, data from the paired trawls are pooled for analysis to form a standard unit of effort (tow), with the port (odd) collection number assigned to the tow.

Contents of each net are sorted separately to species, and total biomass and number of individuals are recorded for all species of finfish, elasmobranchs, decapod and stomatopod crustaceans, cephalopods, sea turtles, xiphosurans, and cannonball jellies. Only total biomass is recorded for all other miscellaneous invertebrates (excluding cannonball jellies) and algae, which are treated as two separate taxonomic groups. Marine turtles are released in good condition according to NMFS permitting guidelines.

Where large numbers of individuals of a species occur in a collection, the entire catch is sorted and all individuals of that species are weighed, but only a randomly selected subsample are processed and total number is calculated. For large trawl catches, the contents of each net are weighed prior to sorting and a randomly chosen subsample of the total catch is then sorted and processed.

In every collection, each of the priority species is weighed collectively and individuals are measured (Table 1). For large collections of the priority species, a random subsample consisting of thirty to fifty individuals is weighed and measured. Depending on the species, measurements of finfish are recorded as total length or fork length, measured to the nearest centimeter. Additional data are collected on individual specimens of penaeid shrimp (total length in mm, sex, female ovarian development, male spermatophore development, occurrence of mated females), blue crabs (carapace width in mm, individual weight, sex, presence and developmental stage of eggs), sharks (total and fork lengths in cm, individual weight, sex), horseshoe crabs (prosoma width and length in mm, individual weight, sex), and sea turtles (curved and straight lengths and widths in cm, individual weight, PIT and flipper tag numbers).

Gonad and otolith specimens from three sciaenid species (*Cynoscion regalis, Menticirrhus americanus, Micropogonias undulatus)* are also collected during seasonal cruises. A representative sample of specimens from each centimeter size range within each stratum are measured to the nearest mm (TL and SL), weighed to the nearest gram, and assigned a sex and maturity code. Sagittal otoliths and a representative series of gonadal tissue are removed, preserved, and transported to the laboratory at MRRI, where samples are processed.

Hydrographic data collected at each station include surface and bottom temperature and salinity measurements taken with a Seabird SBE-19 CTD profiler, sampling depth, and an estimate of wave height.

# HISTORY OF SEAMAP SHALLOW WATER TRAWL SAMPLING METHODS

## Pilot Phase 1986

- Participating states sample their respective coastal waters
- Stratified random sampling design
- Daylight sampling in November-December
- 20-minute tows (bottom time)
- 35' high-rise nets
- Trawl samples sorted to species with each species weighed and the individuals counted and measured.

1987 - 88

- SCDNR took over all sampling in South Atlantic Bight
- Fixed-station sampling design
- 4 stations with 3 sites each : beach, near-beach, inlet
- Day/night sampling in monthly cruises of ~ 7 sea days
- 75' mongoose-type falcon trawls
- 20-minute tows (bottom time)
- Priority species sorted, weighed and measured. Non-priority species divided into taxonomic groups (decapod, stomatopod, finfish, elasmobranch, cephalopod, and miscellaneous invertebrates) and each group weighed and a species list was compiled.

## Full survey

1989

- SCDNR continues to do all sampling in South Atlantic Bight (Cape Canaveral, FL to Cape Hatteras, NC)
- Number of stations proportionally allocated to area of each stratum (2 to 8 per stratum).
- Initial random selection of stations, with stations sampled during all cruises
- Night sampling (Spring); Daylight sampling (Summer and fall)
- 24 inner (15-30 ft), 24 outer strata (30-60 ft)
- 75' mongoose-type falcon trawls; 20-minute tows (bottom time)
- Contents of each trawl sorted to species, and total biomass and number of individuals recorded for all species of finfish, elasmobranchs, decapod and stomatopod crustaceans, and cephalopods
    - Each priority species weighed collectively and individuals measured to the nearest centimeter
    - Additional data - Penaeid shrimp: total length (mm), sex, female ovarian development, male spermatophore development, and occurrence of mated females. Blue crab: Carapace width (mm), individual weight, sex, maturity, and presence and developmental stage of eggs. Sharks: weighed, measured (total length and fork length), and sex noted (1994-present). Marine turtle measurements and tagging.
    - Only total biomass recorded for all other miscellaneous invertebrates and algae

1990 - 2000

- Daylight sampling
- Seasonal cruises (Spring, Summer, Fall)
- 24 inner strata sampled all cruises. 10 outer strata in southern half of the SAB sampled in spring, and 7 outer strata off North Carolina sampled in fall
- Same gear, processing of trawl samples as 1989

1998 -2000

- Additional stations added to all strata to create pool of trawlable sites
- Stations chosen randomly from pool of stations in each stratum. Number of stations sampled within each stratum fixed.

2001-present

- Total number of stations sampled in inner strata increased from 78 to 102
- Outer strata no longer sampled
- Number of stations sampled within each stratum selected annually by optimal allocation. Random selection of stations within each stratum.
- Sharks, marine turtles, and horseshoe crabs added to list of priority species
- Age and growth sampling for selected sciaenid species

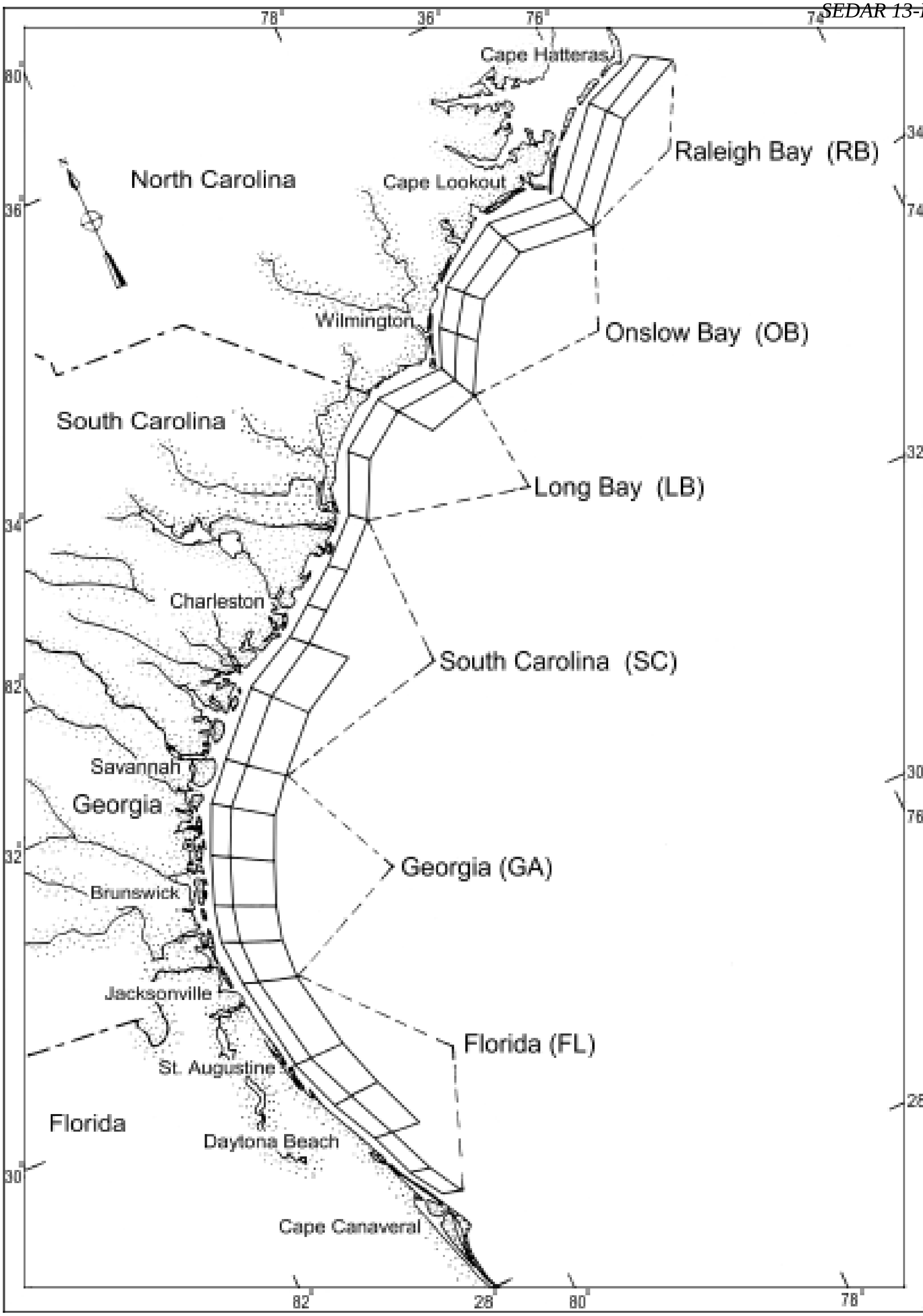


Figure 1. Strata sampled by the SEAMAP-SA Shallow Water Trawl Survey. Inner (shallow) strata sampled during all seasons throughout the survey. Outer (deep) strata were sampled (south in spring, north in fall) from 1990-2000. (Strata are not drawn to scale.)

Table 1. Priority species of the SEAMAP-SA Shallow Water Trawl Survey. (Although data were taken in previous years, sharks, marine turtles, and horseshoe crabs were added to the list of priority species in 2001).

**Finfish** (1989-present)

*Archosargus probatocephalus*
*Brevoortia smithi*
*Brevoortia tyrannus*
*Centropristis striata*
*Chaetodipterus faber*
*Cynoscion nebulosus*
*Cynoscion regalis*
*Leiostomus xanthurus*
*Menticirrhus americanus*
*M. littoralis*
*M. saxatilis*
*Micropogonias undulatus*
*Mycteroperca microlepis*
*Paralichthys albigutta*
*P. dentatus*
*P. lethostigma*
*Peprilus paru*
*P. triacanthus*
*Pogonias cromis*
*Pomatomus saltatrix*
*Sciaenops ocellata*
*Scomberomorus cavalla*
*S. maculatus*

**Elasmobranchs** (1994-present)

All shark species

**Marine Turtles** (1989-present)

*Caretta caretta*
*Chelonia mydas*
*Dermochelys coriacea*
*Lepidochelys kempi*

**Decapods** (1989-present)

*Callinectes sapidus*
*Farfantepenaeus aztecus*
*F. duorarum*
*Litopenaeus setiferus*

**Xiphosurans** (1995-present)

*Limulus polyphemus*