4.0 NEW JERSEY FISHERIES INDEPENDENT MONITORING DATA

Fishery resource managers rely upon dependent (e.g., state or federally funded commercial fisheries sampling program [dock-side or sea sampling]) and independent (i.e., state or federally funded fisheries research sampling program) data to assess population trends in fish and fisheries. Because of limited equipment, staff, and funding, state and federal agencies often use dependent data (e.g., commercial landings or self-reporting logbook) to monitor commercial fisheries. In contrast to commercial fisheries, the regulatory framework for monitoring recreational fisheries has yet to be established so resource managers must frequently rely upon independent data (i.e., dock/boat ramp intercept or creel surveys), such as the Marine Recreational Fishery Statistics Survey (MRFSS), to monitor the dynamics of recreational fisheries. To better assess fish populations and make informed management decisions, many states have established various independent monitoring programs to supplement existing fishery information for local fish stocks. One of the oldest independent fisheries monitoring programs in the U.S. is the New Jersey Ocean Stock Assessment (OSA) program. The NJDEP, Division of Fish and Wildlife, established the OSA program in August 1988 to develop comprehensive baseline data for coastal recreational fishes and their forage items; develop a recruitment indices for recreational fishes and documentation of annual relative abundance of young-of-the-year (YOY) fish; provide a scientific basis to formulate or modify existing management plans for recreational fishes; and provide information to complement other state and federal data for estimating populations and developing predictive models for managing fish stocks (Byrne 2008).

4.1 STUDY AREA

The Study Area borders a barrier island chain along the New Jersey coastline and extends 37 km (20 nautical miles [NM]) perpendicular to shore (i.e., 125.8 km x 37 km [78.2 mi x 22.9 mi] in size; **Figure 4-1**). Overall, the Study Area encompasses approximately 2,516 square kilometers (km^2; 1,360 square nautical miles [NM^2]) and stretches from an area adjacent to Seaside Park in the north (approximate 39°55′56″N; 74°0410″W) to Stone Harbor in the south (approximate 39°01′58″N; 74°46′11″W). Major rivers that have outflows into the region include the Toms River (north), Mullica River via Great Bay (central), and Great Egg Harbor River via Great Egg Harbor (south). For the purpose of these analyses, the New Jersey Environmental Baseline Study Area for this assessment was overlaid with the New Jersey OSA program's study area (**Figure 4-1**; Byrne 2008). As discussed below (**Section 4.1.1.2**), it should be noted that the individual strata (areas) within the New Jersey OSA program's study area were primarily based by depth profile isobaths. Given that these isobaths (i.e., depth profiles) were initially hand drawn using National Oceanic and Atmospheric Administration (NOAA) navigational charts when the state's program was developed, GPS coordinates were unavailable. Therefore, each individual New Jersey OSA sampling strata (area) was digitized using ArcView GIS software according to confirmed depth isobaths and pre-determined latitudinal coordinates defined by NMFS NEFSC Northwest Atlantic Groundfish Survey.

4.1.1 Methodology

4.1.1.1 Data

To evaluate trends in fish and invertebrate populations in the Study Area, ocean trawl data (New Jersey OSA survey program) from 2003 to 2008 were compiled and sorted into two separate groups according to landings (i.e., top 10 species numerically collected) and economic value (i.e., top 5 species [$US]). The top five species having economic value was based on an evaluation of the New Jersey commercial landings during 2003 through 2008 (see **Chapter 3.0**). The segregated data were summarized and evaluated according to the nine New Jersey OSA strata (areas 15 to 23) corresponding with the Study Area (**Figure 4-1**; Byrne 2008; NJDEP 2009).

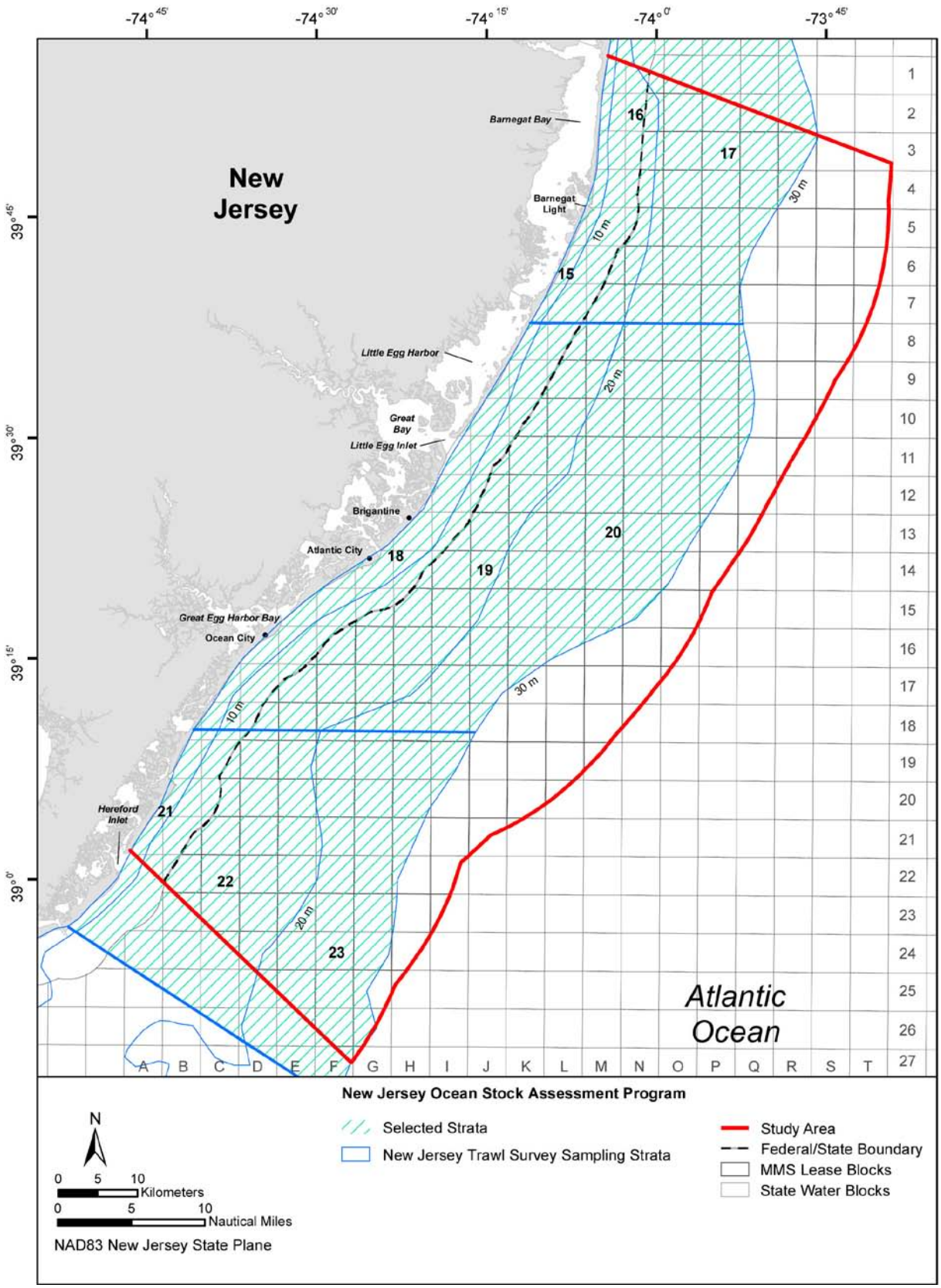

Figure 4-1. The New Jersey Ocean Stock Assessment (OSA) Program sampling strata (areas 15 to 23) within the Study Area. Source information: NJDEP (2008b). Map adapted from: Byrne (2008).

4.1.1.2 New Jersey Open Stock Assessment Survey Design

The New Jersey OSA survey area encompasses about 2,898 km^2 (1,566 NM^2) consisting of the coastal waters from Ambrose Channel, New Jersey (i.e., the entrance to New York Harbor) to Cape Henlopen Channel, New Jersey (i.e., the entrance to Delaware Bay); it includes the waters from about the 5.5-m (18-ft) to the 27.4-m (90-ft) isobaths (ASMFC 1994). To evaluate spatial dynamics, the New Jersey OSA survey program divides the New Jersey coastline into 15 strata zones (areas 12 to 26) based on depth and location (latitude). To be consistent with established federal sampling programs, the OSA survey incorporates the latitudinal boundaries defined by NMFS NEFSC Northwest Atlantic Groundfish Survey. The exceptions are those strata at the northern and southern ends of the New Jersey coastline where NMFS extends its survey into New York or Delaware waters. The New Jersey OSA survey truncates the boundaries to exclude these northern and southern strata, confining the survey area to include only waters adjacent to the New Jersey coastline, except for the ocean waters off Delaware Bay. The longitudinal boundaries consist of the 9.1-m (30-ft), 18.3-m (60-ft), and 27.4-m (90-ft) isobaths where these bottom contours are irregular and the stratum boundaries are smoothed by eye (ASMFC 1994). In general, the longitudinal strata boundaries are similar, but not identical, to the corresponding NMFS boundaries of its Northwest Atlantic Groundfish Survey. To reduce sampling bias, each stratum is divided into smaller blocks that represent potential sampling sites; each block is identified by a number assigned sequentially within each stratum. Mid-shore (9.1 to 18.3 m [30 to 60 ft]) and offshore (18.3 to 27.4 m [60 to 90 ft]) blocks are 2.0 minutes (min) longitude by 2.5 min latitude, whereas inshore (5.5 to 9.1 m [18 to 30 ft]) blocks are 1.0 min longitude by 1.0 min latitude. Inshore block dimensions are smaller because inshore strata are narrower and encompass less area than the mid and offshore strata; the smaller block size permits a greater number of potential sampling sites than would be possible with larger dimensions. Blocks also truncated by stratum boundaries have less area than whole blocks and those reduced in area by more than one-half are generally not assigned a number (Byrne 2008).

4.1.1.3 Survey Experimental Approach

Sampling surveys were conducted bi-monthly (once every two months: February, April, June, August, October, and December) from 1988 to 1990. Beginning in 1990, the December 1990 and February 1991 surveys were replaced by a single winter survey in January 1991. Today, this temporal sampling approach continues with only one winter survey in January, followed by surveys in April, June, August, and October for a total of five surveys per year (ASMFC 1994). Since August 1991, the sampling survey effort has consisted of 39 hauls (i.e., two samples from each strata plus one additional haul in each of the nine larger strata). The winter survey consists of two hauls for all strata. Before August 1991, the sampling survey effort varied because of high charter vessel costs, but generally followed the same approach with a minimum annual sampling survey effort of two hauls per stratum. Sampling stations (survey site location) were randomly selected. Because strata shapes were elongate and the sampling effort was limited, a station selection procedure was used to reduce any spatial distribution sampling bias. The station selection procedure consists of limiting the first station to the top half of the block numbers and the second station to the bottom half; however, if a third station was selected then no limitations were imposed. For instance, haul one would be selected from blocks 1 to 25 blocks, haul two from blocks 26 to 50, and haul three from blocks 1 to 50 for a stratum with 50 blocks. For each station, three additional alternate sites were also selected using the same procedures described above to account for fixed fishing gear, bottom obstructions, or other impediments that prevented sampling at the initial station (Byrne 2008).

4.1.1.4 Survey Gear

Survey gear consisted of a two-seam, three-in-one otter trawl, which tapered from three-to-one. The trawl was constructed of polyethylene twine with forward netting (i.e., wings and belly) that had 12-cm (4.7-in) stretch mesh and 8-cm (3.1-in) stretch mesh rear netting. The otter trawl cod-end was 7.6-cm (3.0-in) stretch mesh and it was lined with a 6.4-mm (0.25-in) bar mesh liner. The otter trawl head rope was 25 m (82 ft) and the footrope 30.5 m (100 ft) long. The trawl bridle was 36.6 m (120 ft) long, the top leg consisted of a 1.27-cm (0.5-in) wire rope, and the bottom leg consisted of a 1.91-cm (0.75-in) wire rope covered with 6.03-cm (2.375-in) rubber cookies. The groundline length between the bridle and otter trawl

doors was 18.3 m (60 ft) long; it was constructed of 1.91-cm (0.75-in) wire rope covered with 6.03-cm (2.375-in) rubber cookies. The trawl doors were wooden with steel shoes and were 2.44 m (8.0 in) x 1.27 m (4.83 in); each trawl door weighed approximately 453.5 kg (1,000 lbs; Byrne 2008).

All tows were performed during daylight defined as the hours between sunrise and sunset. The trawl tow duration was 20 min (i.e., the time the net was deployed to when the winch brakes were set to begin haul back) and the surface ground speed was maintained between 2.5 and 3.0 knots (kts; 2.9 and 3.5 miles per hour [mph]); one 20-min tow generally covered a distance of around 1.85 km (1.0 NM). Tow durations that were shortened because of hangs, bottom obstructions, fixed fishing gear, or other problems were considered an adequate sample provided the tow time was more than 15 min and there was no major damage to the net. For those tows that were less than 15 min, the tows were repeated unless there were extenuating circumstances (e.g., the bottom was known as a difficult area to sample). To standardize these shorter tow times (<20 min), extrapolation was applied under the assumption that there was a direct linear association between catch size and tow time. At each otter trawl deployment, 91.5 m (300 ft) of wire was released regardless of the depth to maintain a tow wire depth ratio of approximately 3:1 at the deepest sampling depth (27.4 m [90 ft]). This tow wire depth ratio was also selected to ensure that there was a sufficient distance between the vessel and the net when towing in shallow water (~9.1 m [30 ft]; Byrne 2008).

The New Jersey OSA program has used two different survey vessels for sampling the New Jersey coastline: the FIV Amy Diane (1988 to 1991) and the RJVARGO Maine (1991 to present). Both vessels were similar in size (24.4 m [80 ft] length, 78.7 m [24 ft] beam, and 3.1 m [10 ft] draft) and capabilities. Using SCANMAR equipment, the net's towing dimensions were generally similar under both vessels, but the vertical opening of the net with the RJVARGO Maine was greater than that of the FIV Amy Diane. The mean SCANMAR measurements for the FIV Amy Diane and RJVARGO Maine were: 39.6 m (130 ft) door spread, 11.6 m (38 ft) wing spread, 2.13 m (7 ft) vertical opening, and 39.6 m (130 ft) door spread, 11.9 m (39 ft) wing spread, and 3.4 m (11 ft) vertical opening, respectively (Byrne 2008).

4.1.1.5 Field Collections

At each sampling station, and before the gear was deployed, environmental conditions were recorded. To measure salinity and dissolved oxygen at the surface and bottom, water samples were collected with 1.2 liter (L; 0.9317 gallons [gal]) Kemmerer bottle and conductance meter and Winkler titration methods were applied, respectively. Surface and bottom temperatures were measured with a thermistor.

Once the tow was completed the catch (fish and macroinvertebrates) was identified to species, enumerated, and sorted using plastic buckets and wire fish baskets. The total weight, or a representative sample (i.e., large catches), of each species was taken with a hanging metric scale and the length (fork or total) was measured to the nearest cm for fish and the disk width (cm) for stingrays (Dasyatidae). Depending on the macroinvertebrate species, various other measurements were recorded. For example, the carapace width (mm) was measured for crabs, the carapace length (mm) for lobsters, and mantle length (mm) for squids. Catches containing large numbers of relatively small specimens were sub-sampled, sorted, weighed, and individuals were measured. To determine the total catch, extrapolation was applied to the sub-sample under the assumption that there was direct association between the number and types of species in the sub-sample as in the total catch (Byrne 2008).

4.1.1.6 Data Analysis

New Jersey OSA program data (2003 to 2008) were filtered and compiled into two separate datasets according to commercial and recreational importance of fish and invertebrates (i.e., state or federally managed species). This six year dataset (2003 to 2008) was aggregated according to collection (top 10 species numerically collected) and economic value (top 5 species collected). For each dataset, data were summarized, graphed, and various factors (i.e., numbers [cumulative and by individual species], relative abundance [density; numbers of fish per meter squared], and size by area, season, and year) were evaluated using standard statistical approaches. Prior to analyses, all datasets were tested for normality and homoscedacity (variance [equivalently standard deviation] are equal) using Kolmogorov-Smirnov and

Bartlett tests (Zar 1999), respectively. Datasets with a normal distribution were analyzed using parametric methods (Analysis of Variance [ANOVA]). Non-normal data were log-transformed [log (X+1)] to meet the underlying assumptions of normality (Zar 1999) and if after transformation the data still did not meet the assumptions of normality, then non-parametric methods (Kruskal-Wallis test) were applied. For all analyses, statistical significance was defined as $P<0.05$. A *post-hoc* multiple comparison test (i.e., Tukey or Nemenyi) was used to perform pairwise comparisons among those factors that were detected as significant (e.g., annual number of individuals collected among species). Chi-square goodness of fit was applied to length-frequency data to infer whether the population from which it came conforms to a specified theoretical distribution (Zar 1999). Length data were evaluated using either parametric or non-parametric methods. All analyses were conducted using Microsoft Excel® and Fortran (Version 10).

The catchability of sampling gear may differ among fish species, implying the species composition obtained from the survey may not be representative of actual fish community structure in the ecosystem; however, this may not affect spatial and temporal comparisons of fish assemblages, as long as the sampling catchability for a fish species is consistent throughout time and space.

4.2 RESULTS

4.2.1 Survey Effort

The New Jersey OSA program completed a total of 1,120 tows off the coast of New Jersey within nine strata (areas 15 to 23) over a six-year period (2003 to 2008). The total survey area was around 2,202.1 km^2 (1,368.3 square miles [mi^2]). The mean number of tows per year was 187 and the total number of tows in each stratum (areas 15 to 23) ranged from 60 in area 15 to 87 in area 17. The average number of tows (2003 to 2008) in each area was 13 tows per year.

4.2.2 Trawl Species Composition

A total of 2,639,040 individuals (fish and invertebrates) were collected by the New Jersey OSA program representing 11 groups of fish and macroinvertebrates (state [ASMFC] or federally [FMCs and NMFS: EFH] managed species) consisting of 32 species from 2003 to 2008 (**Table 4-1**). According to these data, 61% (n = 1,619,401) consisted of the top 10 (numerically; n = 1,430,061 or 88%) and top five (n = 351,985 or 22%) species having the most economical value (US $; **Figure 4-2**).

Table 4-1. Groups of fish and macroinvertebrates collected and classified by the New Jersey Ocean Stock Assessment (OSA) Program from 2003 to 2008.

Fish/Macroinvertebrate Groups	Species
Anadromous	Alewife, Blueback Herring, American Shad, Atlantic Sturgeon, and Atlantic Striped Bass
Drums	Atlantic Croaker, Spot, and Weakfish
Flatfish	Summer Flounder, Winter Flounder, Witch Flounder, and Windowpane Flounder
Sharks and Skates	Little Skate, Winter Skate, Clearnose Skate, and Spiny Dogfish
Macroinvertebrates	American Lobster, Horseshoe Crab, and Squid
Cods and Hakes	Atlantic Cod, Red Hake, and Silver Hake
Anglerfish	Goosefish (Monkfish)
Eelpout	Ocean Pout
Schooling Fish	Atlantic Herring, Spanish Mackerel, Atlantic Menhaden, Butterfish, and Scup
Reef Fish	Black Sea Bass and Tautog
Coastal Pelagic	Bluefish

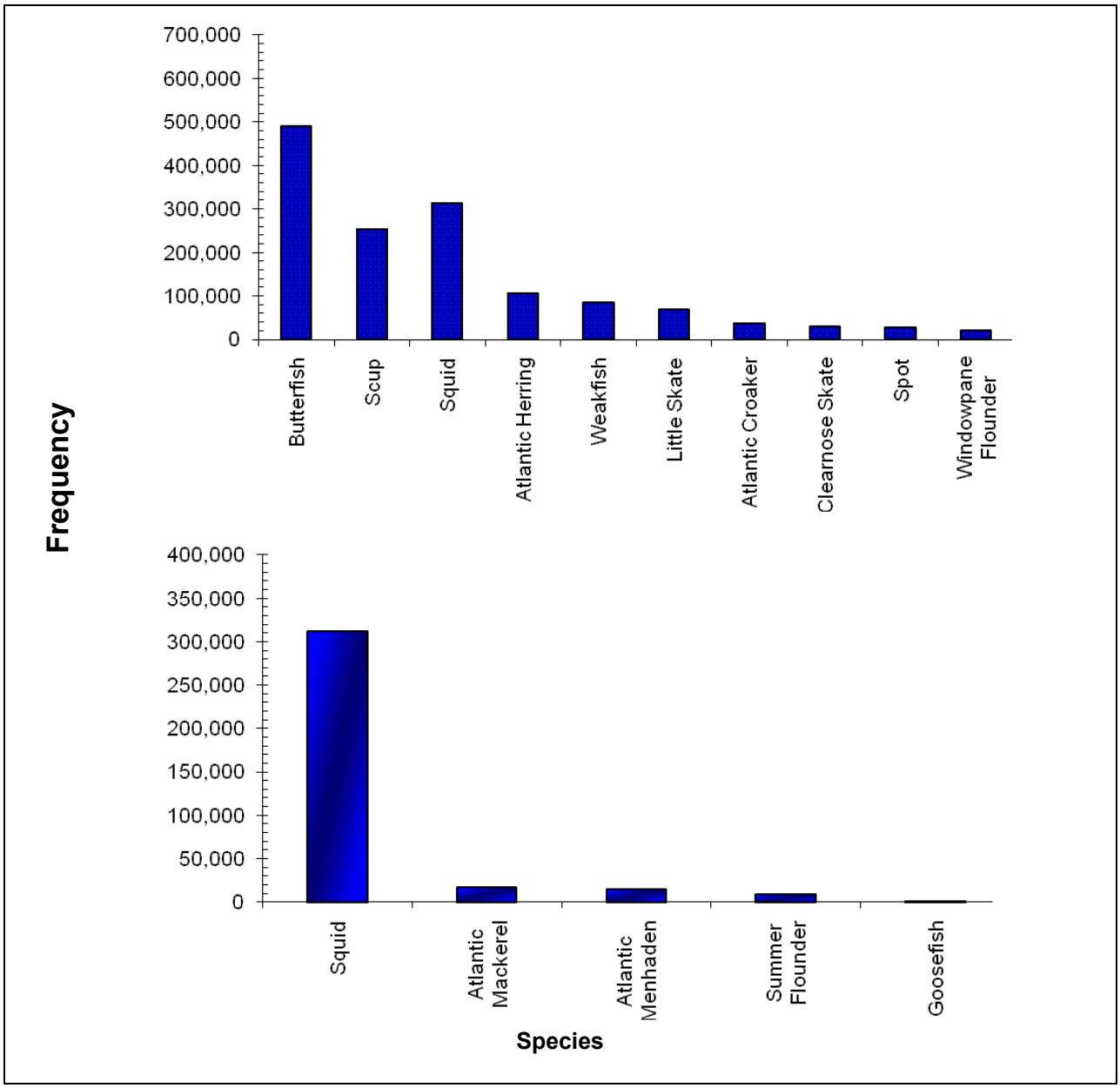

Figure 4-2. The frequency distribution of the most dominant (Top Graph: top 10 species) and economically valuable species (Bottom Graph: top 5 species) collected by the New Jersey Ocean Stock Assessment (OSA) Program off the coast of New Jersey from 2003 to 2008.

4.2.3 Annual Dynamics

The data demonstrated that there was annual variability in the total number of individuals (fish and vertebrates) collected from 2003 to 2008. Overall, the total number of individuals (fish and invertebrates) collected (top 10 species) ranged from 156,673 in 2007 to 353,250 in 2006 with a mean of 238,360 individuals (fish and macroinvertebrates) per year (**Figure 4-3**). The cumulative number of individuals collected from 2003 to 2008 was significantly different among species by year (P = 0.001) and area (P = 0.0448). The most dominant species collected was butterfish (n = 489,376 or 34%). A *post-hoc* Tukey multiple comparison test demonstrated that there was a significant difference detected between the annual total number of butterfish collected and little skate, Atlantic croaker, clearnose skate, spot, and

windowpane flounder (P<0.05); however, no significant difference was detected between the annual total number of butterfish collected and scup, squid, Atlantic herring, and weakfish (P>0.05). The total number of butterfish collected ranged from 26,213 in 2005 to 190,685 in 2008 with a mean of 81,563 butterfish per year.

The overall annual relative abundance for all species combined, expressed in density (number of fish per m^2), ranged from 0.006 fish/m^2 (0.000558 fish/ft^2) in 2003 to 0.04 fish/m^2 (0.003717 fish/ft^2) in 2004 with a mean of 0.01 fish/m^2 (0.000929 fish/ft^2) per year (**Figure 4-4**). A species specific evaluation showed that squid had the greatest (0.06/m^2 [0.005576/ft^2]) mean relative abundance and windowpane flounder the lowest (0.0041/m^2 [0.000381/ft^2]). The mean relative abundance of squid ranged from a low of 0.014/m^2 (0.001301/ft^2) in 2008 to a high of 0.257/m^2 (0.023885/ft^2) in 2004 with a mean of 0.256/m^2 (0.023792/ft^2) per year (**Figure 4-4**).

The total number of individuals (fish and invertebrates) collected (top 5 species) having economic value ranged from 31,812 in 2003 to 82,872 in 2008 with a mean of 58,664 individuals (fish and macroinvertebrates) per year (**Figure 4-3**). The overall number of individuals collected having economic value from 2003 to 2008 was significantly different among species by year (P = 0.001).The most dominant species collected having economic value was squid (n = 312,299 or 89%). A *post-hoc* Tukey multiple comparison test demonstrated that there was a significant difference detected between the annual total number of squid collected and the other five species, but no statistical difference was detected between the total number of summer flounder and Atlantic mackerel collected (P>0.05) or between the total number of Atlantic mackerel collected and Atlantic menhaden. In addition, there was no statistical difference detected between the total number of summer flounder collected and goosefish or Atlantic menhaden (P>0.05); the Tukey test showed that the total number of Atlantic menhaden and goosefish collected were also similar (P>0.05).The total number of squid collected ranged from 28,696 in 2003 to 80,693 in 2006 with a mean of 52,050 squid per year.

The overall annual relative abundance for all species combined ranged from 0.002 fish/m^2 (0.000186 fish/ft^2) in 2003 to 0.05 fish/m^2 (0.004647 fish/ft^2) in 2005 with a mean of 0.01 fish/m^2 (0.000929 fish/ft^2) per year (**Figure 4-4**). A species specific evaluation showed that squid had the greatest (0.06 squid/m^2 [0.005576 squid/ft^2]) mean relative abundance and goosefish the lowest (0.0 fish/m^2 [0.0 fish/ft^2]; **Figure 4-4**).

4.2.4 Seasonal Dynamics

The data demonstrated that there was seasonal variability in the total number of individuals (fish and vertebrates) collected from 2003 to 2008. Overall, the total number of individuals (fish and invertebrates) collected (top 10 species) ranged from 67,520 (4.5% of the total catch) in winter to 801,753 (52.9%) in summer with a mean of 379,066 individuals per season (**Figure 4-5**). In summer, the most numerically dominant species was butterfish (n = 349,852 or 43.6%), while the least was Atlantic herring (n = 104 or 0.01%). The mean relative abundance of butterfish in summer ranged from 0.005633/m^2 (0.005235/ft^2) in 2007 to 0.136614/m^2 (0.012696/ft^2) in 2008 with a mean of 0.046684/m^2 (0.004339/ft^2) per year (summer season). The most numerically dominant species in winter was Atlantic herring (n = 47,521 or 70%) and the least was spot (n = 1 or 0.001%). The mean relative abundance of Atlantic herring in winter ranged from 0.00467/m^2 (0.000434/ft^2) in 2005 to 0.20498/m^2 (0.019050/ft^2) in 2007 with a mean of 0.018254/m^2 (0.001696/ft^2) per year (winter season).

The total number of individuals (fish and invertebrates) collected (top 5 species) having economic value ranged from 7,765 (2.2%) in winter to 208,457 (59.2%) in summer with a mean of 140,794 individuals per season (**Figure 4-5**). In summer, the most numerically dominant species was squid (n = 202,995 or 97%) and the least was goosefish (n = 29 or 0.01%). The mean relative abundance of squid in summer ranged from 0.012830/m^2 (0.001192/ft^2) in 2003 to 0.057316/m^2 (0.005327/ft^2) in 2004 with a mean of 0.027025/m^2 (0.002512/ft^2) per year (summer season). Likewise, the most numerically dominant species collected in winter was squid (n = 5,188 or 66.8%) and the least was goosefish (n = 3 or 0.04%). The mean relative abundance of squid in winter ranged from 0.0/m^2 (0.0/ft^2) in 2004 to 0.11342/m^2 (0.010541/ft^2) in 2007 with a mean of 0.001977/m^2 (0.000184/ft^2) per year (winter season).

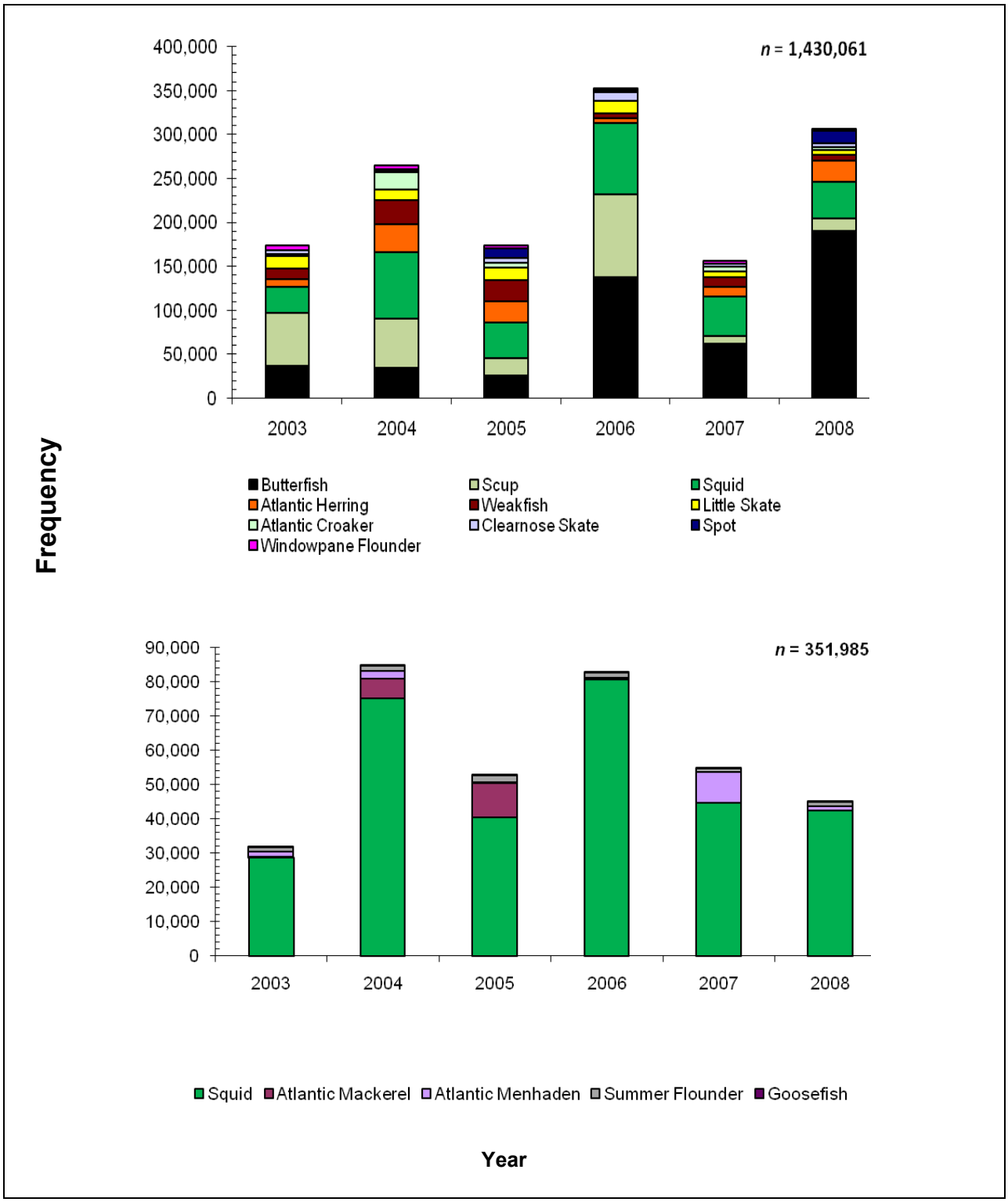

Figure 4-3. The annual frequency distribution of the most dominant (Top Graph: top 10 species) and economically valuable species (Bottom Graph: top 5 species) collected by the New Jersey Ocean Stock Assessment (OSA) Program off the coast of New Jersey from 2003 to 2008.

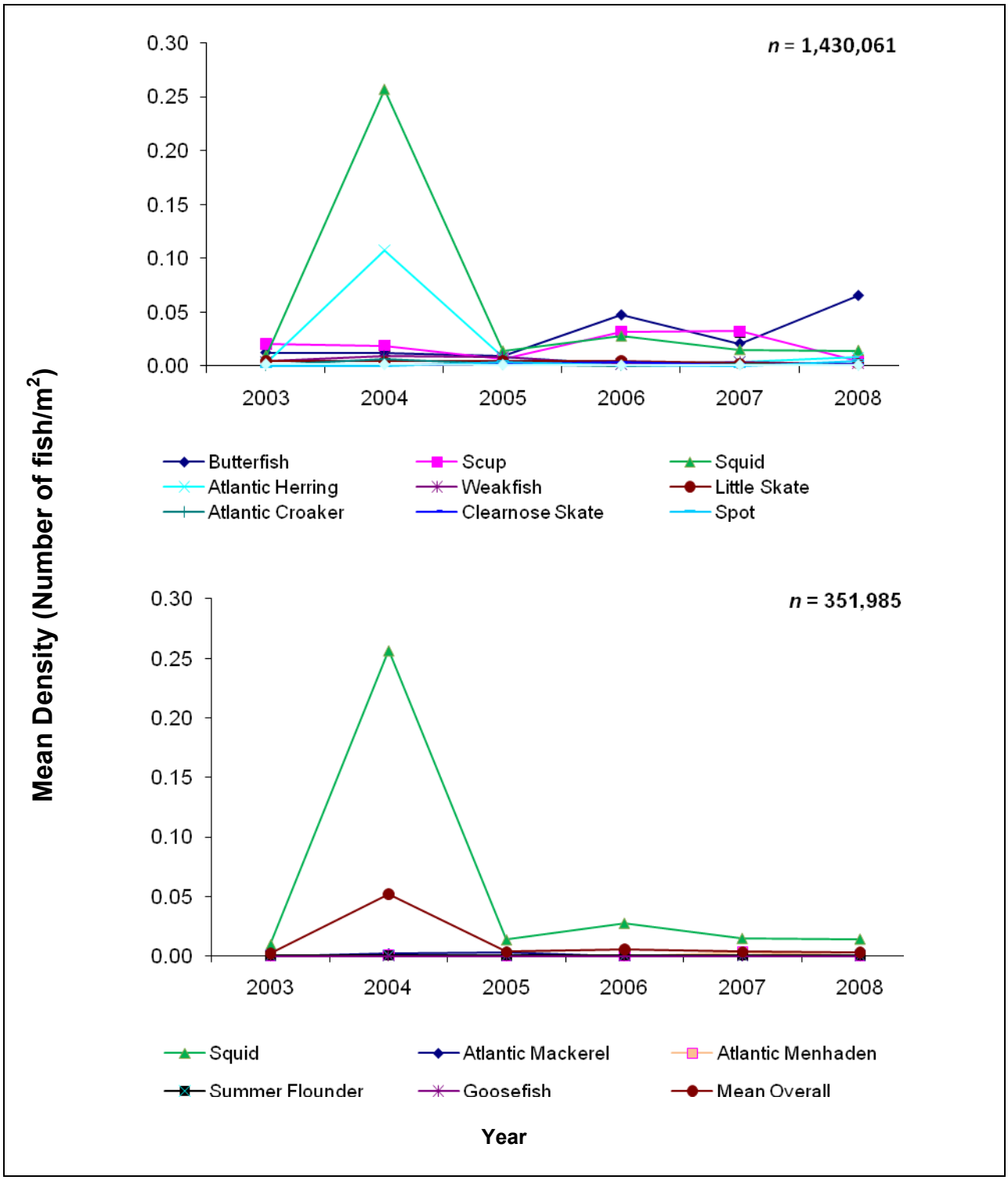

Figure 4-4. The annual mean relative abundance (number of fish/m^2) of the most dominant (Top Graph: top 10 species) and economically valuable species (Bottom Graph: top 5 species) collected by the New Jersey Ocean Stock Assessment (OSA) Program off the coast of New Jersey from 2003 to 2008.

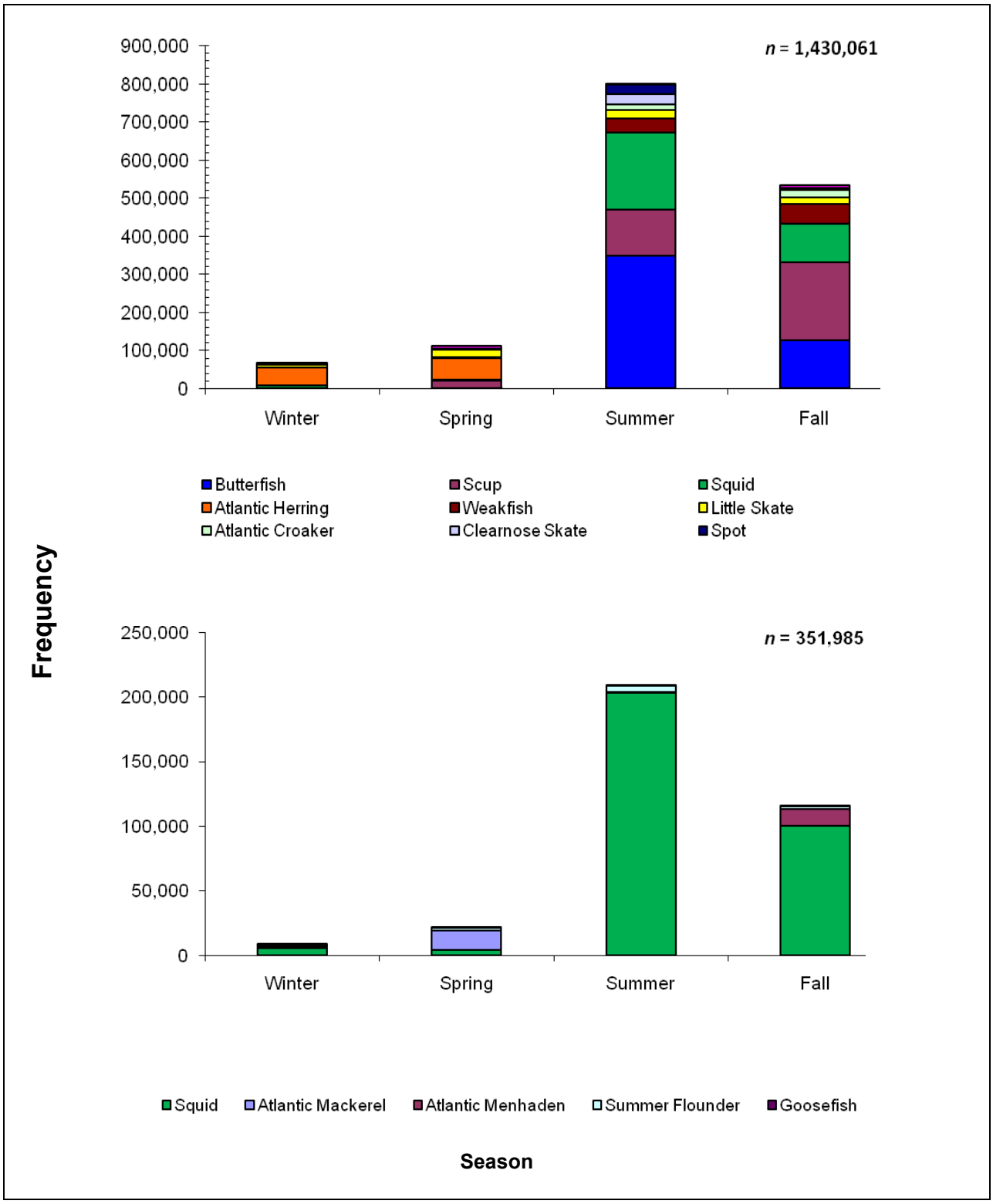

Figure 4-5. The seasonal frequency distribution of the most dominant (Top Graph: top 10 species) and economically valuable species (Bottom Graph: top 5 species) collected by the New Jersey Ocean Stock Assessment (OSA) Program off the coast of New Jersey from 2003 to 2008.

4.2.5 Spatial Dynamics

The data demonstrated that there was no variability in the total number of individuals (fish and vertebrates) collected from 2003 to 2008 by sampling location, but there was a significant difference detected for the total number of individuals collected for a specific species by area. The total number of individuals collected (top 10 species) from 2003 to 2008 ranged from 85,225 (5.6%) in area 21 to 261,093 (17.2%) in area 16 (**Figures 4-6** and **4-8**). Overall, there was no significant difference detected in the cumulative numbers of individuals collected by area (P>0.05); however, there was a significant difference detected between the total number of individuals collected for a specific species by area (P<0.001). A species specific evaluation determined that the most numerically dominant species in area 21 was butterfish (n = 19,253 or 23%), while the least was Atlantic herring (n = 1,662 or 2%). In area 16, the most numerically dominant species was also butterfish (n = 124,528 or 48%) and the least was spot (n = 321 or 0.12%; **Table 4-2**).

The overall mean relative abundance for all species combined ranged from 0.005 fish/m^2 (0.000465 fish/ft^2) in area 23 to 0.012 fish/m^2 (0.001152 fish/ft^2) in area 16 with a mean of 0.0009 fish/m^2 (0.000084 fish/ft^2) per area (**Figure 4-7**). Overall, butterfish had the greatest (0.027/m^2 [0.002509/ft^2]) mean relative abundance and windowpane flounder the lowest (0.001/m^2 [0.000093/ft^2]). The mean relative abundance of butterfish ranged from 0.006/m^2 (0.000558/ft^2) in area 23 to 0.065/m^2 (0.006041/ft^2) in area 19 with a mean of 0.027/m^2 (0.002509/ft^2) per area (**Figure 4-7**).

The total number of individuals collected (top 5 species) having economical value ranged from 2,988 (0.2%) in area 21 to 64,397 (4.2%) individuals in area 15 (**Figures 4-6** and **4-8**). Overall, there was no significant difference detected in the cumulative numbers of individuals collected by area (P>0.05), or the interaction (two-way ANOVA) between area and year (P>0.05); however, there was a significant difference detected between the total number of individuals collected for a particular species by area (P<0.001). The most numerically dominant species in area 21 was squid (n = 1,875 or 62.8%), while the least was goosefish (n = 0). In area 15, the most and least numerically dominant species were squid (n = 48,566 or 75%) and goosefish (n = 0), respectively.

The overall mean relative abundance for all species combined ranged from 0.0003 fish/m^2 (0.000029 fish/ft^2) in area 18 to 0.006 fish/m^2 (0.000558 fish/ft^2) in area 15 with a mean of 0.004 fish/m^2 (0.000372 fish/ft^2) per area (**Figure 4-7**). Overall, squid had the greatest (0.017/m^2 [0.001579/ft^2]) mean relative abundance and goosefish the lowest (0.0/m^2 [0.0/ft^2]). The mean relative abundance of squid ranged from 0.0008/m^2 (0.00074/ft^2) in area 18 to 0.028/m^2 (0.002602/ft^2) in area 23 with a mean of 0.017/m^2 (0.001579/ft^2) per area (**Figure 4-7**).

4.2.6 Size Composition

Butterfish was the most numerically abundant species collected by the New Jersey OSA program from 2003 to 2008. A total of 758,975 butterfish were collected and measured (2003 to 2008) ranging in length from 2 to 23 cm (0.78 to 9.1 in) fork length (FL) with a mean of 10.3 cm FL (4.1 in). The annual mean butterfish size ranged from a low of 9.90 cm (3.9 in) FL in 2006 and 2008 to a high of 11.12 cm (4.4 in) FL in 2003 (**Figure 4-9**). The most numerically abundant species collected by the New Jersey OSA program from 2003 to 2008 having economic value was squid. A total of 10,106 squid were collected and measured (2003 to 2008) ranging in length from 1 to 6.3 cm (0.04 to 2.5 in) with a mean of 1.2 cm (0.46 in). The mean annual squid mantel length ranged from 1.1 cm (0.49 in) in 2004 to 1.3 cm (0.5 in) in 2006 (**Figure 4-10**).

Overall, there was a significant difference detected in the annual mean butterfish size among years (P = 0.0005). Moreover, a chi-square test of goodness-of-fit demonstrated that the length frequency distribution for butterfish was significantly different among years (P<0.001). Likewise, findings were similar for the annual mean size and length frequency distribution for the other primary species collected and measured (scup [P = 0.0005; P<0.001, respectively], squid [P = 0.0005; P<0.001, respectively], Atlantic herring [P = 0.0005; P<0.001, respectively], weakfish [P = 0.0005; P<0.001, respectively], and summer flounder [P = 0.0001; P = 0.0005, respectively]). In contrast, there was no significant difference detected in the annual mean size or frequency distribution for goosefish (P = 0.75, P = 0.9, respectively).

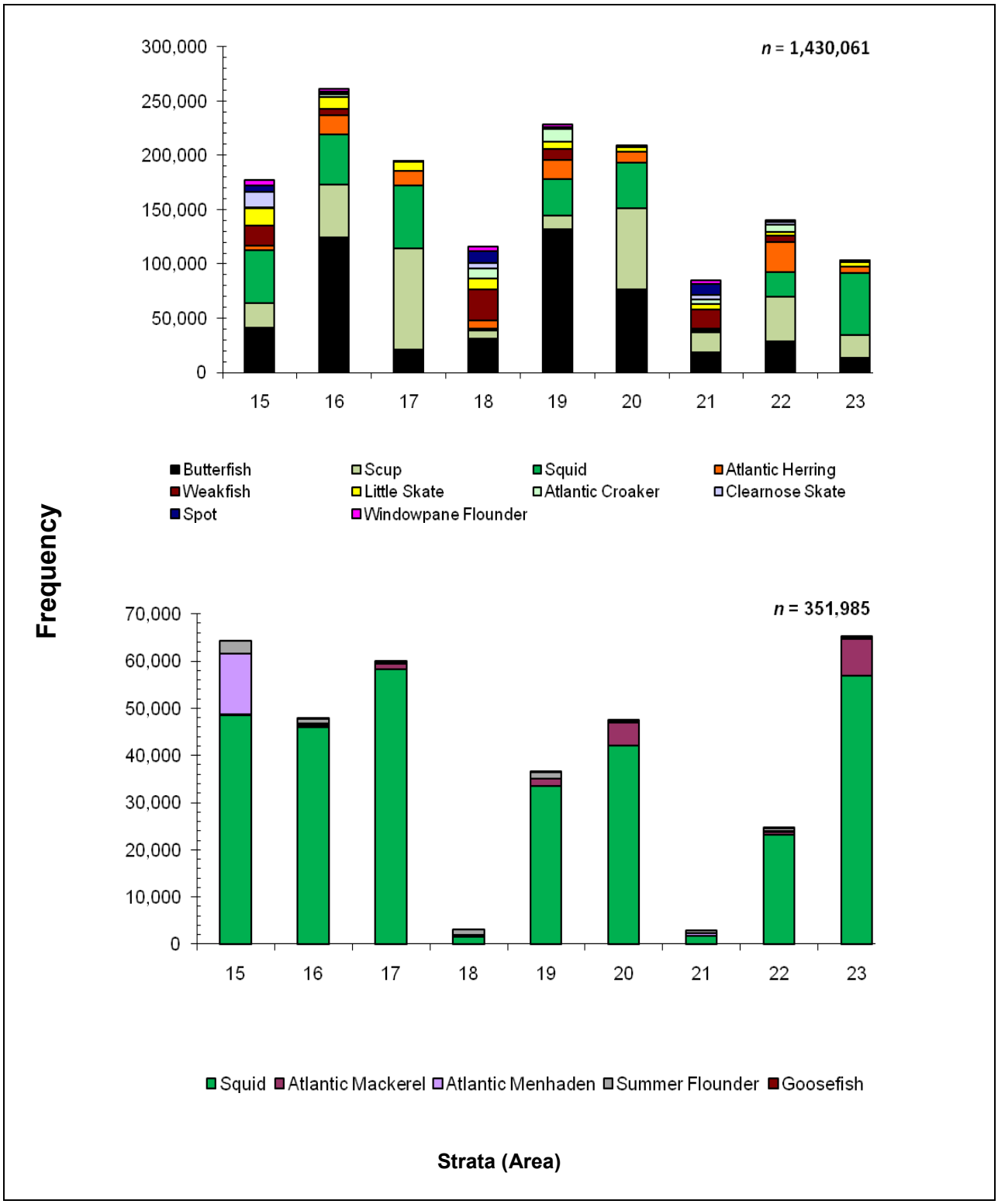

Figure 4-6. The spatial frequency distribution of the most dominant (Top Graph: top 10 species) and economically valuable species (Bottom Graph: top 5 species) collected by the New Jersey Ocean Stock Assessment (OSA) Program off the coast of New Jersey from 2003 to 2008.

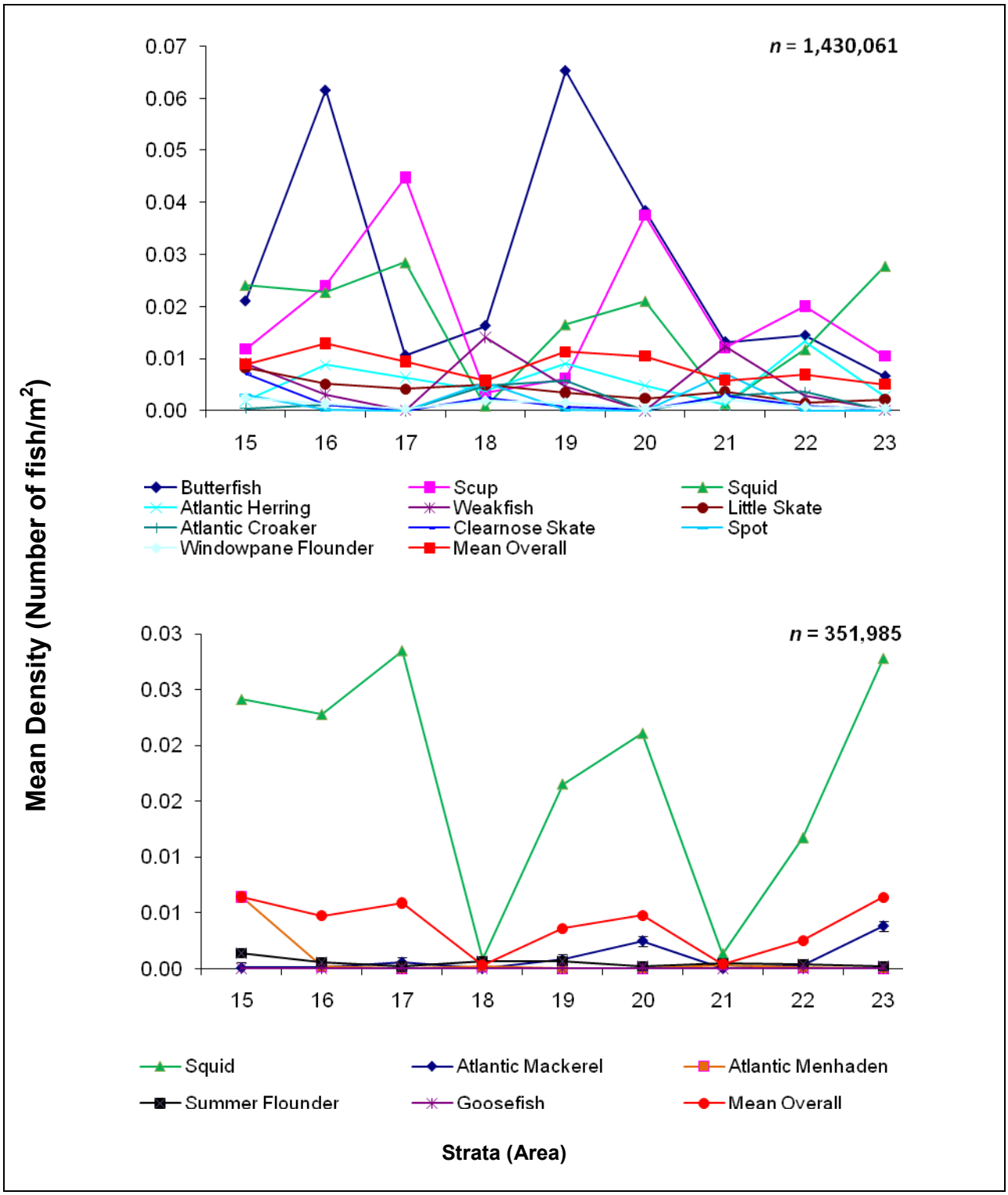

Figure 4-7. The spatial mean relative abundance (number of fish/m^2) of the most dominant (Top Graph: top 10 species) and economically valuable species (Bottom Graph: top 5 species) collected by the New Jersey Ocean Stock Assessment (OSA) Program off the coast of New Jersey from 2003 to 2008.

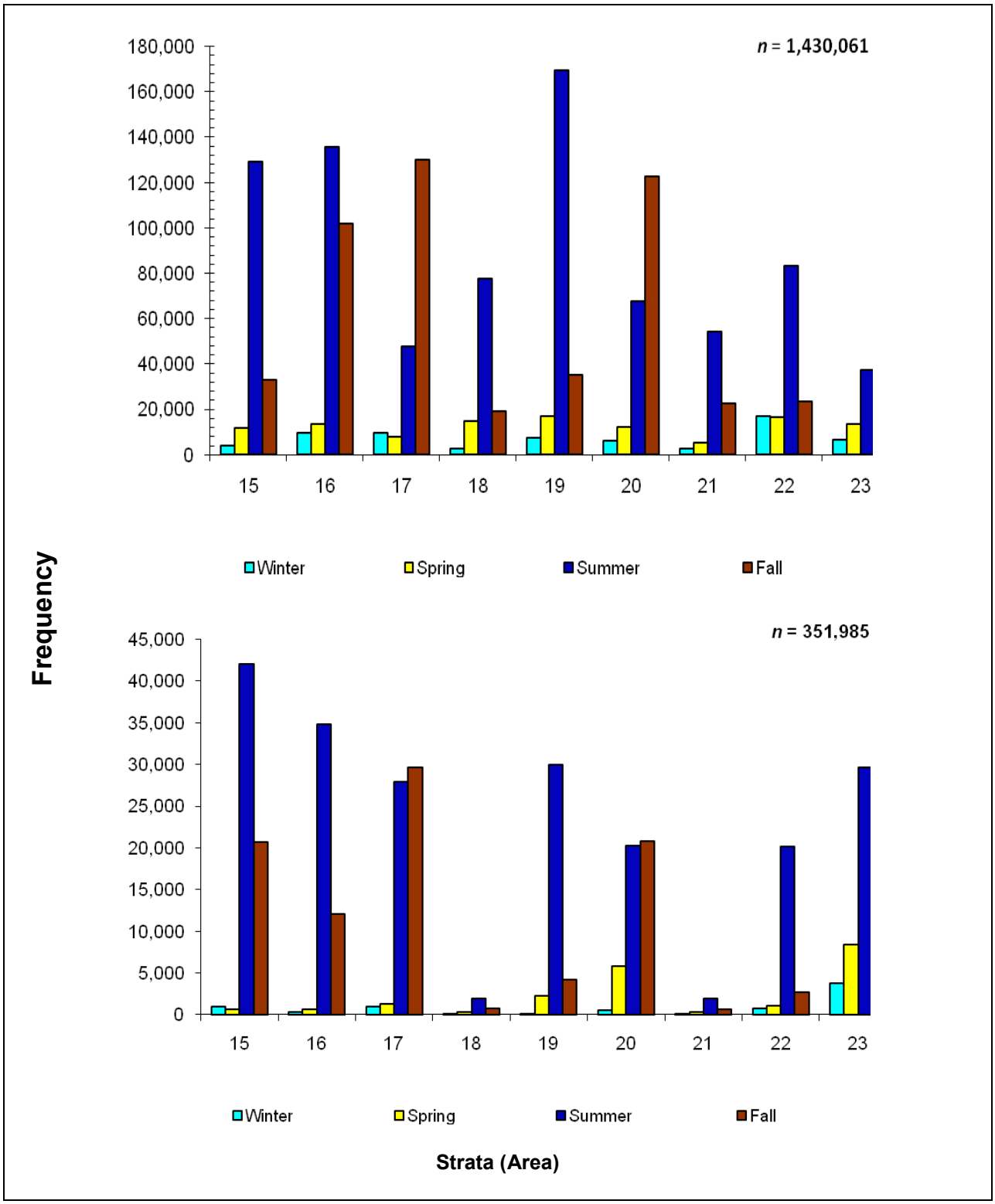

Figure 4-8. The spatial and seasonal frequency distribution of the most dominant (Top Graph: top 10 species) and economically valuable species (Bottom Graph: top 5 species) collected by the New Jersey Ocean Stock Assessment Program off the coast of New Jersey from 2003 to 2008.

Table 4-2. The most dominant species (top 10 species) collected by the New Jersey Ocean Stock Assessment (OSA) Program from 2003 to 2008 in areas 15 to 23 (NJDEP 2009). The shaded cells depict the most numerically dominate species in each area.

Species	Areas								
	15	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Butterfish	41,328	124,528	21,337	31,614	131,960	76,678	19,253	29,152	13,526
Scup	23,211	48,759	92,885	7,037	12,645	74,916	17,758	40,574	21,516
Squid	48,566	46,123	58,324	1,659	33,547	42,104	1,875	23,168	56,933
Atlantic Herring	3,724	17,791	13,120	7,694	18,129	9,656	1,662	27,793	5,484
Weakfish	18,478	6,139	62	28,562	9,444	20	17,549	5,737	244
Little Skate	16,333	10,380	8,547	9,872	6,960	4,666	5,267	2,953	4,472
Atlantic Croaker	821	2,343	14	9,879	11,769	13	4,032	7,214	73
Clearnose Skate	14,217	2,187	99	4,863	1,468	146	4,250	1,900	347
Spot	6,071	321	0	11,060	137	0	10,408	116	4
Windowpane Flounder	4,933	2,522	549	3,758	2,935	612	3,171	1,632	785
Total	**177,682**	**261,093**	**194,937**	**115,998**	**228,994**	**208,811**	**85,225**	**140,239**	**103,384**
Percent	**11.7**	**17.2**	**12.9**	**7.7**	**15.1**	**13.8**	**5.6**	**9.2**	**6.8**

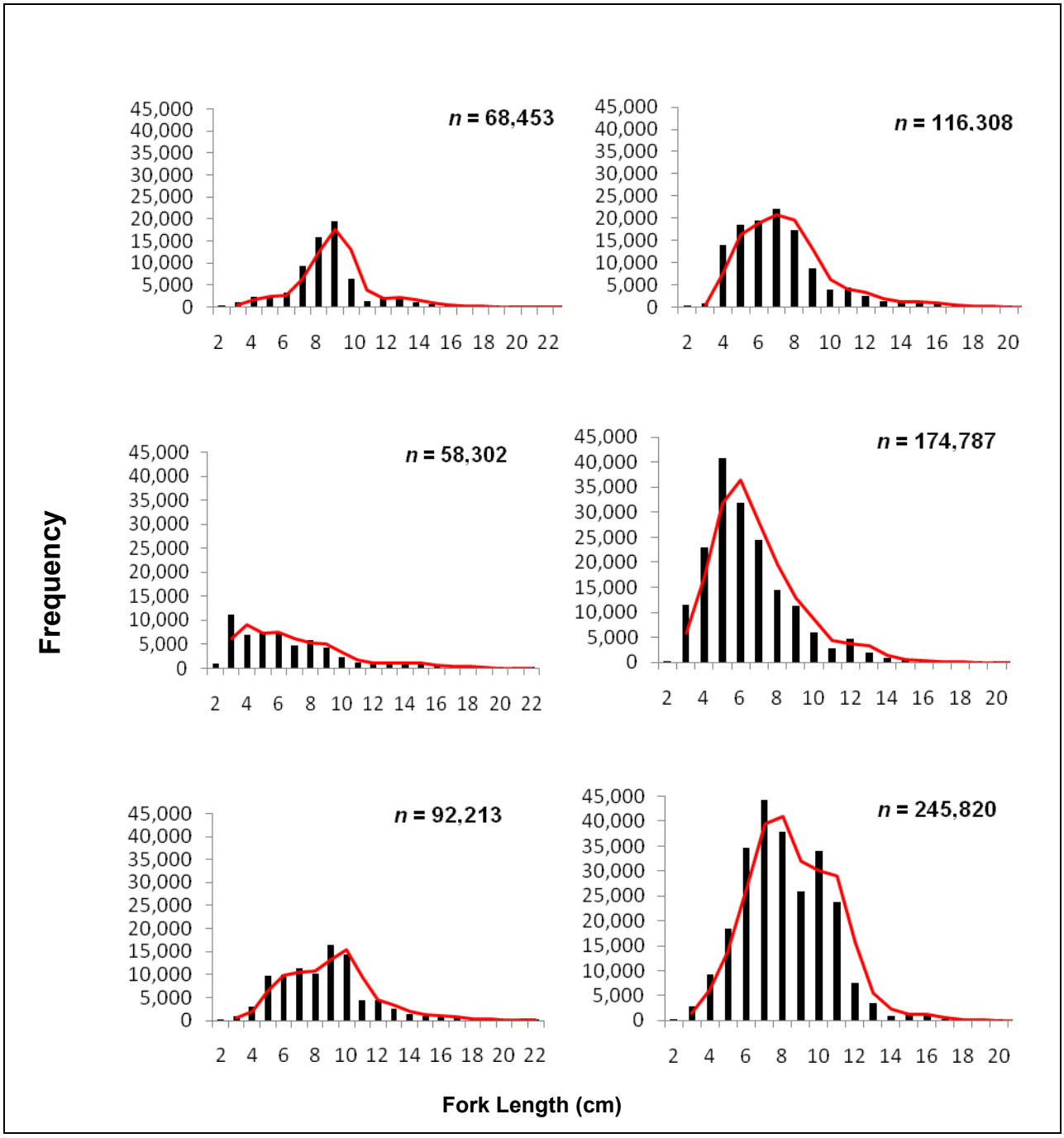

Figure 4-9. The length-frequency distribution of butterfish collected and measured by New Jersey Ocean Stock Assessment (OSA) Program off the coast of New Jersey from 2003 (top left graph) to 2008 (bottom right graph). The solid line depicts the moving average.

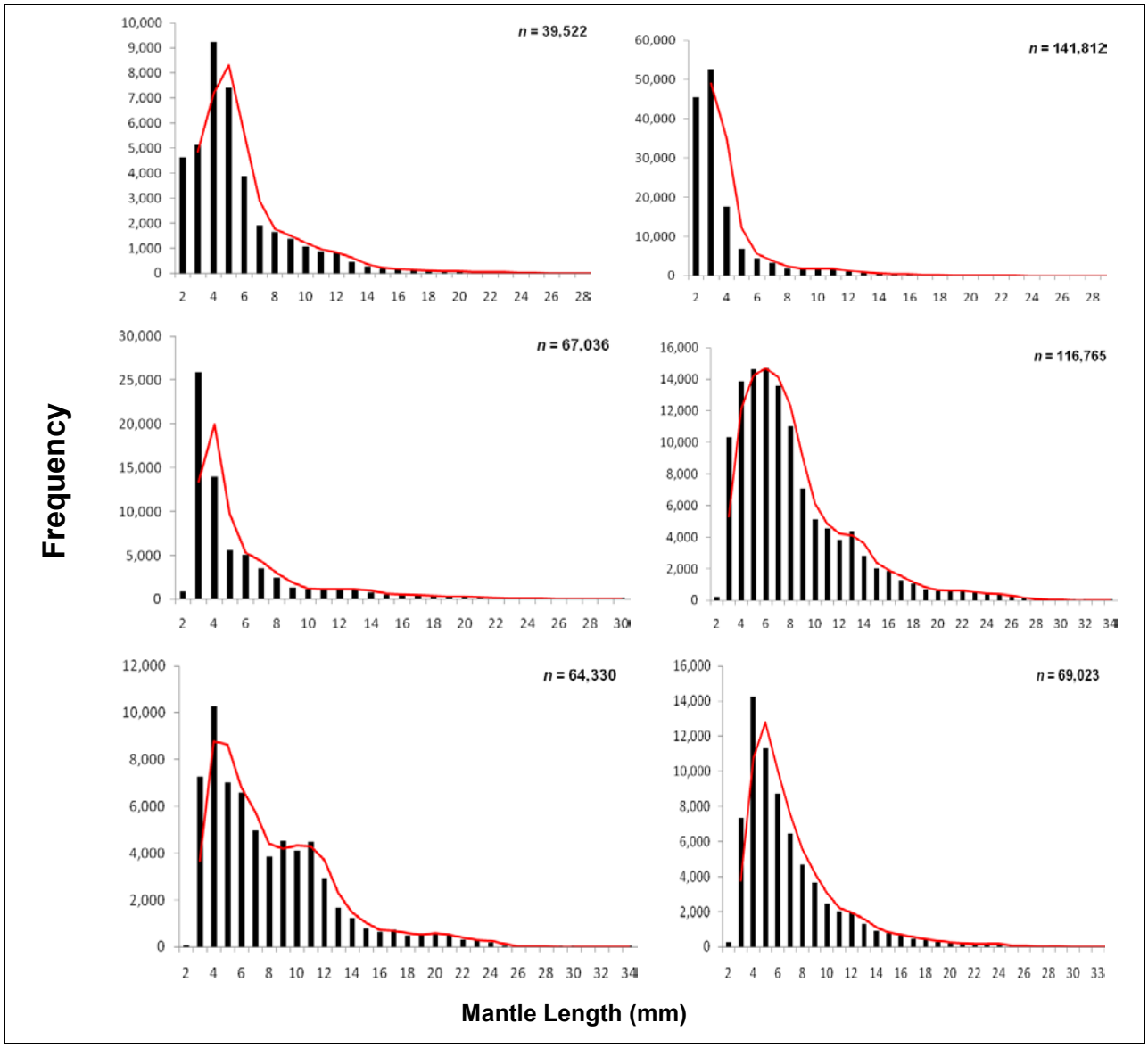

Figure 4-10. The length-frequency distribution of squid collected and measured by New Jersey Ocean Stock Assessment (OSA) Program off the coast of New Jersey from 2003 (top left graph) to 2008 (bottom right graph). The solid line depicts the moving average.

A *post-hoc* Tukey multiple comparison test for butterfish did not detect any significant difference in mean size among years 2003 to 2004, 2003 to 2005, 2003 to 2006, 2003 to 2007 or any other combination; however, the test did show there was a significant difference in mean squid size between the years 2003 and 2008.

4.3 DISCUSSION AND CONCLUSION

The New Jersey coastal waters consist of various nearshore (e.g., estuaries, bays, salt marshes, tidal creeks, and coastal beaches) and offshore environments (e.g., sand ridges, continental shelf, canyons, hard bottom, and artificial reefs [e.g., ship wrecks and man-made structures]) that provide critical habitats for many state and federally managed fish and invertebrates. Marine fish depend upon and utilize many types of habitats (e.g., seagrasses, salt marshes, solitary corals, and rocky intertidal areas) at different life stages. In general, the nearshore waters (estuaries, bays, and coastal beaches) are utilized by early life

stages (larvae and juveniles), while the offshore waters provide habitat for sub-adult and adult life stages of various fish and invertebrates. Despite the importance of understanding how habitats and population dynamics are interrelated in this region, the relationship between these habitats to fish dynamics in the northeastern U.S. is not well understood or documented (Able et al. 2010).

Acknowledging that most fish studies conducted in this region have only evaluated the nearshore coastal habitats (<3-m [9.7-ft] depth contour; e.g., Hagan and Able 2003; Able et al. 2010), it is difficult to compare the findings of this present study to other investigations in this region given that this study specifically evaluated the fish assemblages found in the deeper nearshore coastal waters (9.1 to 27.4 m [30 to 90 ft]); the area between the surf zone and the offshore waters. In fact, very little information is available about this transition zone. Thus, the findings of this study not only contribute to our knowledge of the New Jersey coastal fish communities, but also support the notion that the nearshore coastal waters between the surf zone and offshore environments off New Jersey serve as habitats for various fish and invertebrates of commercial and recreational importance. Based on the findings of this study, the nearshore waters off New Jersey are equally important to butterfish, scup, Atlantic herring, and weakfish. The data also showed that although there were similarities in species composition over time, there was a significant difference among the abundance and size structure of individuals collected by year and area. In general, the findings revealed that the Study Area is dominated by a limited number of species, which is common for temperate fish assemblages.

Although the findings of this study demonstrate that there is a significant difference in the annual variability of fish abundance and mean size, it appears that the association between relative abundance and time is stable. The data revealed that there were not only annual differences in overall fish abundance, but there were seasonal differences in species composition and total numbers of individuals collected, which was probably related to localized spawning events or fluctuations in environmental (temperature) and oceanographic conditions (prevalent winds and currents transporting juveniles). Overall, summer and fall (52.9% and 35.2%, respectively) were the most important seasons in terms of relative fish abundance, while winter and spring (4.5% and 7.4%, respectively) the least. The findings revealed that specific species were more numerically dominant at certain times, which is probably associated with water temperature or daily movements. In summer, butterfish (44%) was the most abundant and Atlantic herring (0.01%) the least; however, in winter, Atlantic herring (70%) was the most abundant and spot (0.001%) the least. In spring and fall, the most abundant species were Atlantic herring (51%) and scup (38%), respectively. Evaluation of the spatial dynamics demonstrated that each area within the Study Area was just as important as the other in terms of overall annual abundance, but some areas were more important to specific species (**Table 4-2**). In general, butterfish were widely distributed and numerically dominated most of the areas (16 [48%], 18 [27%], 19 [58%], 20 [37%] and 21 [23%]). Squid was most abundant in areas 15 (27%) and 23 (55%), while scup was most abundant in areas 17 (48%) and 22 (29%). An evaluation of the seasonal abundance by area and species showed that butterfish abundance was highest in areas 16 and 19 in summer, while scup and squid abundance was highest in areas 17 and 23, respectively. In winter, Atlantic herring abundance was highest in area 22 and lowest in area 21. These numerically dominated species encompassed areas which contained substantial numbers of fishing hotspots/grounds within the Study Area (**Figure 4-11**).

In summary, this assessment of the coastal fishes off New Jersey demonstrates that the Study Area serves as important habitat to various commercially and recreationally valuable fish and invertebrate species. Overall, our findings indicated that although most collections (fish and invertebrates) occurred throughout the Study Area, most were in summer and fall (88.1%). The data showed that the total numbers of dominant species collected appeared to be evenly distributed across the entire Study Area by area and depth strata. The percentage of collections (fish and invertebrates) according to area ranged from a low of 5.6% in area 21 to a high of 15.1% in area 19. The percentage of collections (fish and invertebrates) according to depth strata ranged from a low of 25% (<10 m [32.8 ft]) to a high of 42% (10 to 20 m [32.8 to 65.6 ft]). These finding are expected given that many of these species are pelagic species, which tend to have extensive daily movement patterns; however, benthic species, such as clearnose skate and windowpane flounder, were more abundant in areas 15, 18, and 21, which corresponded to the areas having a depth profile less than 10 m (32.8 ft). As expected, this shows that benthic species are more closely associated with bottom depth than pelagic species (**Table 4-2**).

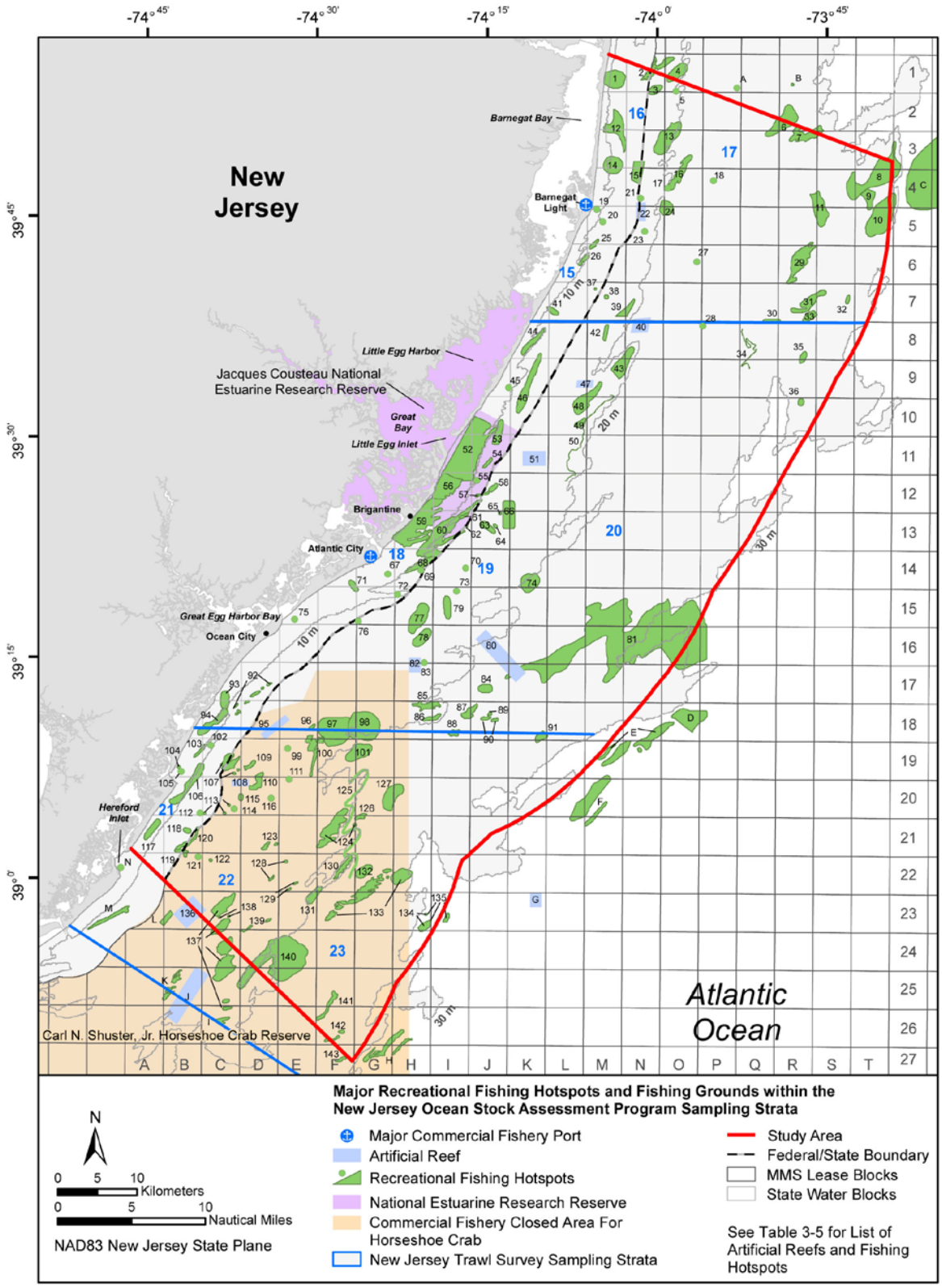

Figure 4-11. Major recreational fishing hotspots and fishing grounds found within the New Jersey Ocean Stock Assessment (OSA) Program sampling strata (areas 15 to 23). Source Information: NEFMC (2003a). Map adapted from Freeman and Walford (1974); Long et al. (1982); Saltwater Directions (2003a; 2003b; 2003c); Byrne (2008); and NJDEP (2008b).[10]

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