Supplementary materials

Overview

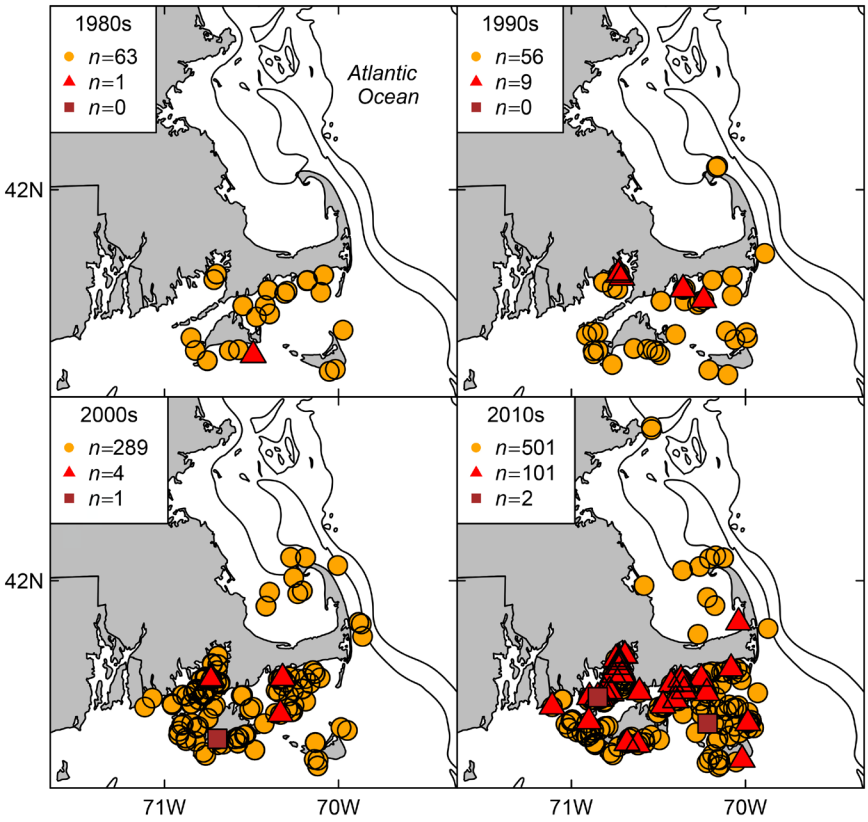
The distributional data for the Massachusetts Division of Marine Fisheries (MA-DMF) survey alone is provided in Supplementary Figures 1 (mature females) and 3 (age-0 juveniles [≤12 cm in total length (TL)]). These figures can be compared to main text Figures 6 and 7, respectively, to evaluate the effect of this survey without any data from the National Marine Fisheries Service Northeast Fisheries Science Center (NMFS-NEFSC) survey.

The relationship between size and age, which shows that age-0 juveniles are ≤12 cm TL in autumn, is shown in Supplementary Figure 2 for both the MA-DMF and NMFS-NEFSC surveys.

The distributional data for age-0 juveniles collected by the NMFS-NEFSC survey alone, during autumn, is plotted in Supplementary Figure 4. Although the central tendency of the black sea bass (*Centropristis striata*) population has been shifting northward over time, this figure shows no fish north of 43°N during the period 1978–2016. Sampling occurred throughout the Gulf of Maine but the map is truncated to show symbols more clearly.

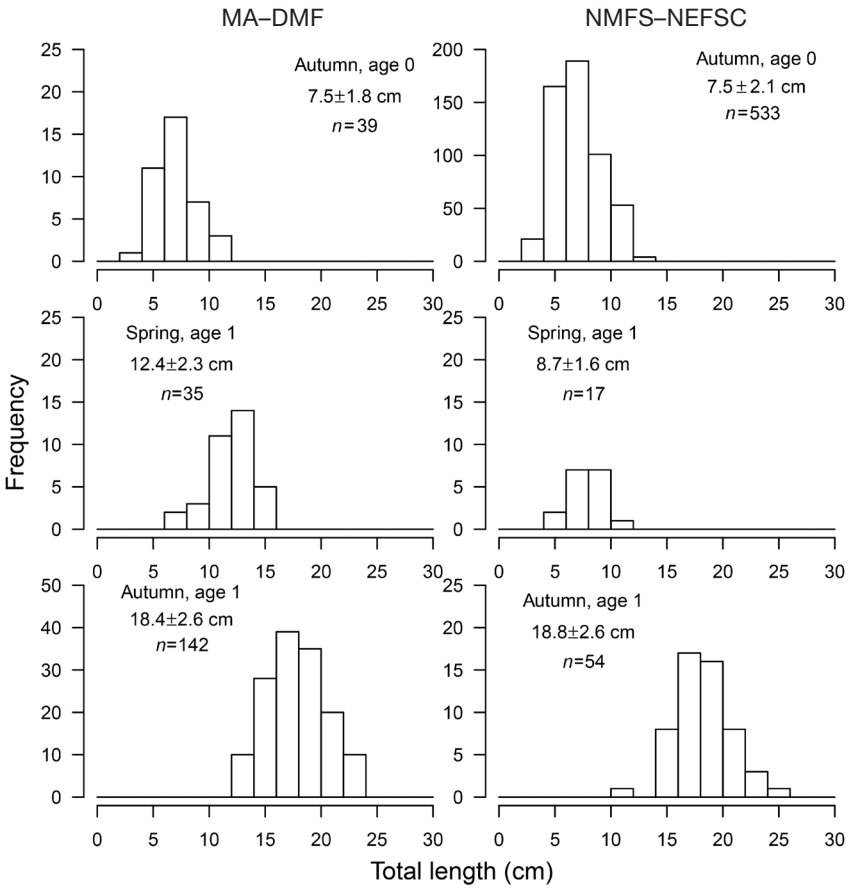
The distributional data for adult females collected by the NMFS-NEFSC survey alone, during spring, is plotted in Supplementary Figure 5. Although the central tendency of the black sea bass population has been shifting northward over time, this figure shows no fish north of 43°N during the period 1984–2016. In fact, much of the collective change in distribution appears to be driven by more onshore (versus offshore) movement, particularly along the south shore of Long Island, New York, rather than north (versus south) movement into the Gulf of Maine. The last few years have shown more easterly movement as well. As in Supplementary Figure 4, sampling occurred throughout the Gulf of Maine but the map is truncated to show symbols clearly.

A comparison of eastern longitude with respect to year and temperature is plotted in Supplementary Figure 6. Analysis in the main text focused on inshore waters around Cape Cod (i.e., compare with Figure 8), but plotting of the broader NMFS-NEFSC data in Supplementary Figure 4 suggested that nursery grounds are expanding to Georges Bank off the coast of New Jersey and therefore we include this preliminary analysis as well. Larval data are shown in Figure 7.



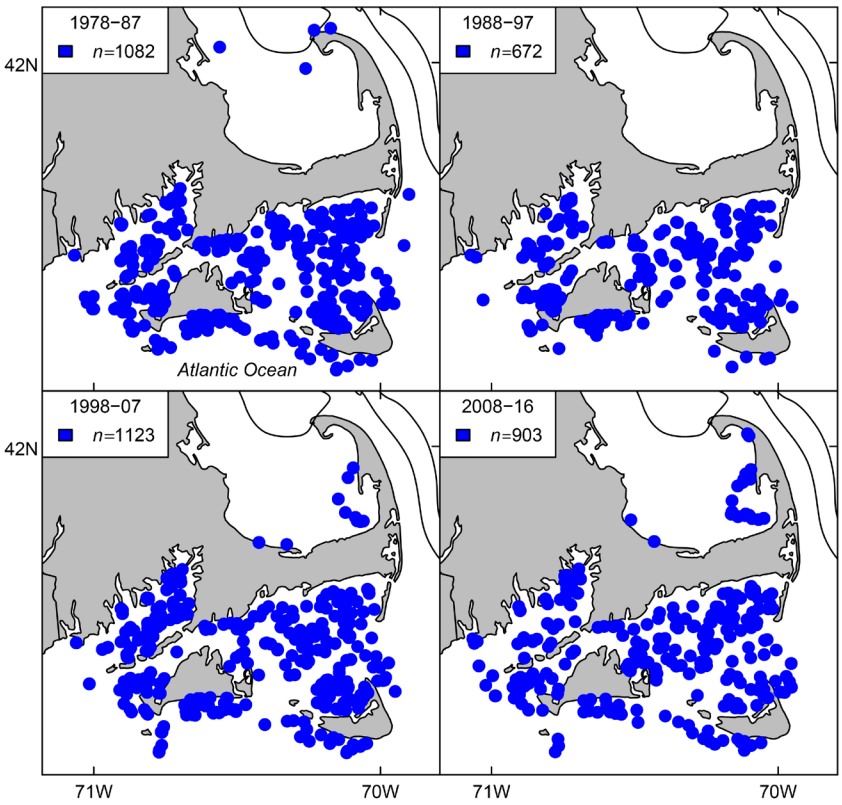
Supplementary Figure 1

Occurrence of mature female black sea bass (*Centropristis striata*) in trawl surveys conducted by the Massachusetts Division of Marine Fisheries (MA-DMF) during spring from 1983 to 2016. Most adult black sea bass, those classified to maturity stage at sea and used for analyses herein, were from the MA-DMF survey (compare locations of capture with those seen in Figure 6, main text). Mature fish are depicted in 3 spawning conditions: developing (orange circles), spawning (red triangles), and postspawning (brown squares). Numbers of fish in each spawning condition (*n*) are provided. Black lines indicate the 50- and 100-m isobaths.



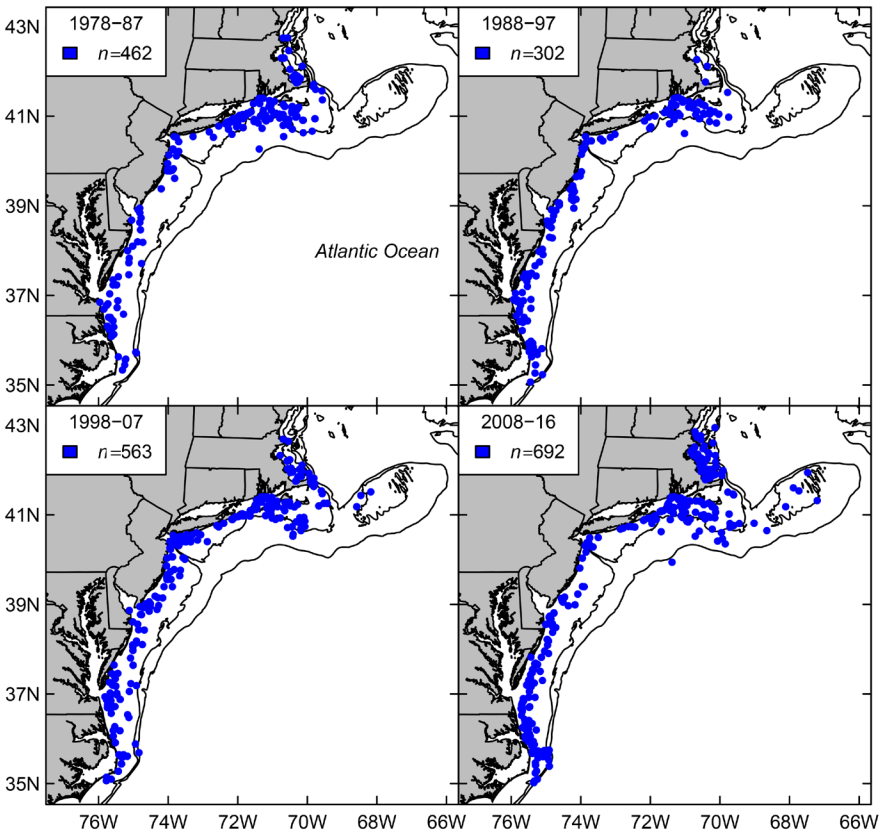
Supplementary Figure 2

Age-0 and age-1 black sea bass (*Centropristis striata*) could be readily distinguished by size in autumn. Plotted by season here are length frequencies determined from 2 different trawl surveys conducted by the Massachusetts Division of Marine Fisheries (MA-DMF) and the National Marine Fisheries Service Northeast Fisheries Science Center (NEFSC) from 1983 to 2016 (no age-0 fish were collected in spring). The mean values, with standard deviations (SDs), are indicated with sample size (*n*). NEFSC data are a subset of sampling sites with geographic distribution that overlaps the coverage of the MA-DMF survey (>41°N and 69°–72°W). Aging methods are those of Penttila and Dery (1988).



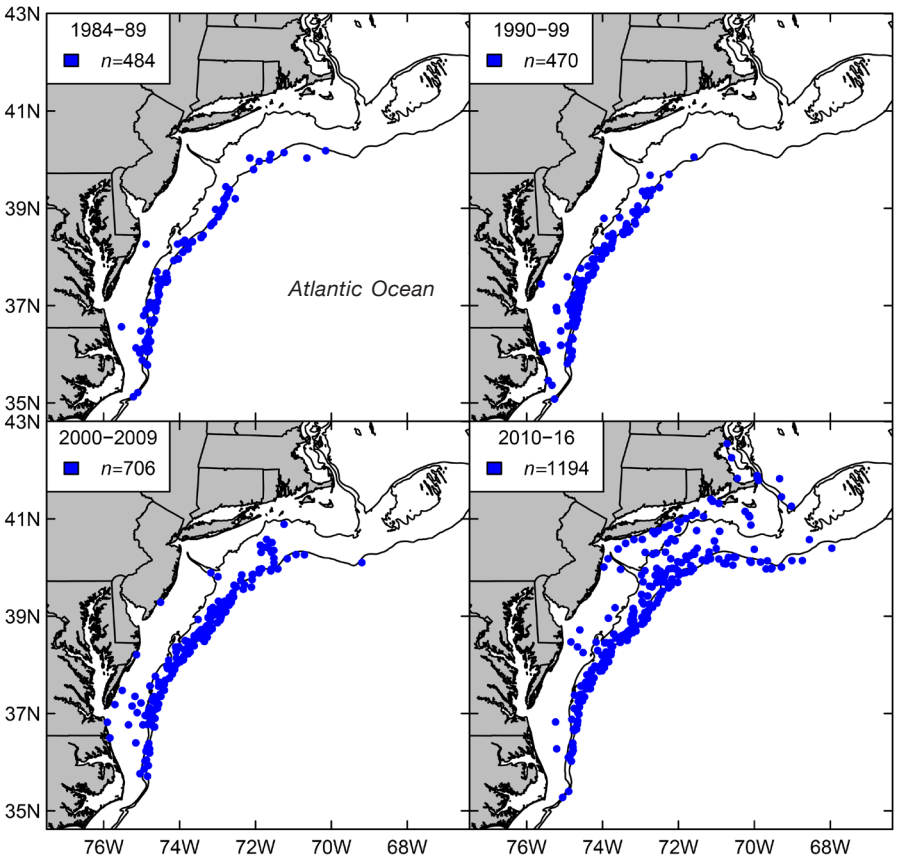
Supplementary Figure 3

Occurrence (blue dots) of age-0 juvenile black sea bass (*Centropristis striata*) in trawl surveys conducted during autumn by the Massachusetts Division of Marine Fisheries from 1978 to 2016. Most age-0 black sea bass used for analyses in this study were from the MA-DMF survey (compare locations of capture with Fig. 7, main text). The number of juveniles (*n*), defined in autumn as ≤12 cm in total length, are provided. Black lines indicate the 50 and 100 m isobaths.



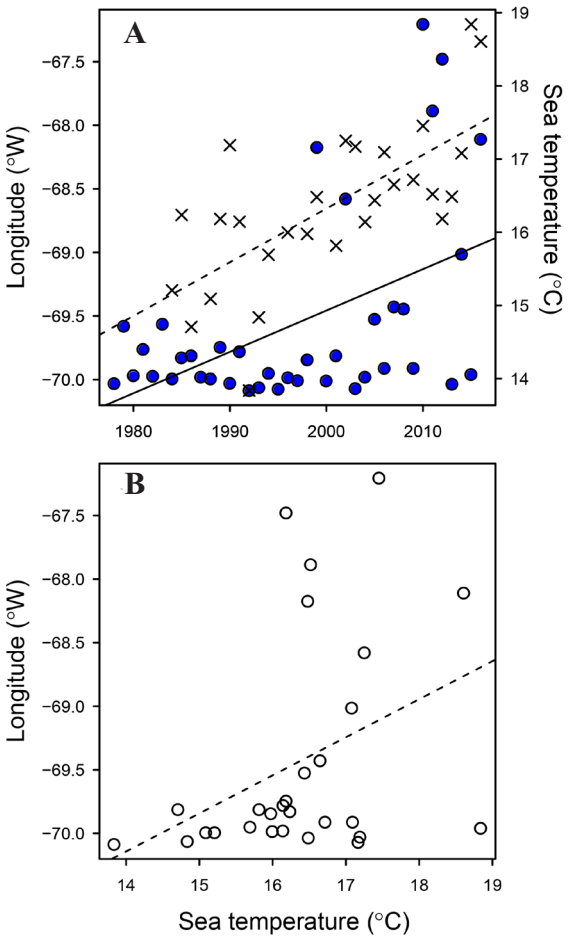
Supplementary Figure 4

Occurrence (blue dots) of age-0 black sea bass (*Centropristis striata*) in trawl surveys conducted during autumn by the Northeast Fisheries Science Center from 1978 to 2016. The number of juveniles (*n*), defined in autumn as ≤12 cm in total length, are provided. Sampling locations south of 35°N are not shown because fish there are a separate stock. No black sea bass were collected farther north than the areas indicated by the symbols, although sampling did occur well into Canadian territorial seas. Black lines indicate the 50- and 100-m isobars.



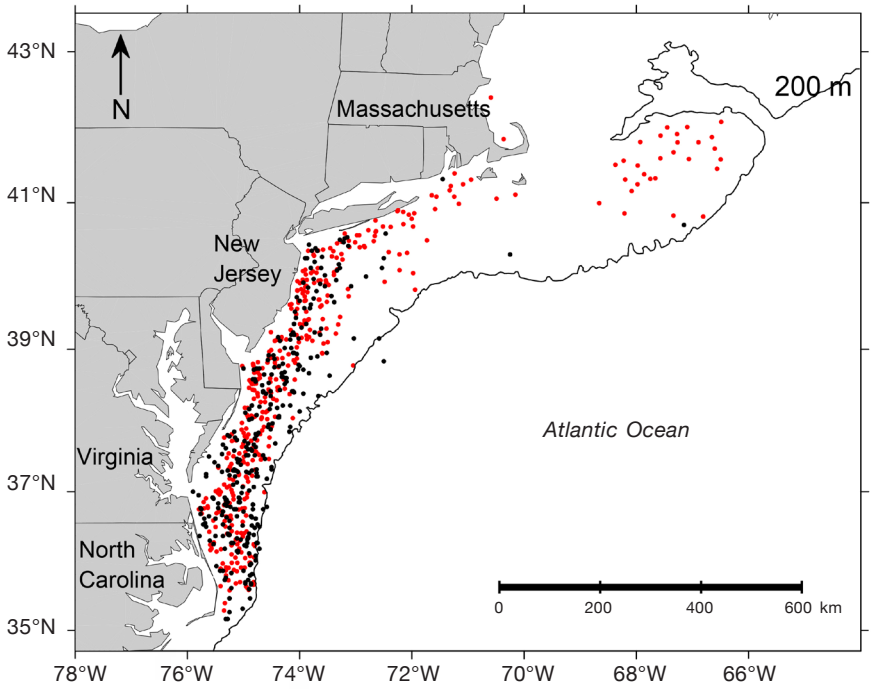
Supplementary Figure 5

Occurrence (blue dots) of female black sea bass (*Centropristis striata*) in trawl surveys conducted by the Northeast Fisheries Science Center during spring from 1984 to 2016. The numbers of adults (*n*), evaluated as female on the basis of macroscopic observation of their gonads, are provided. Sampling locations south of 35°N are not shown because the fish there are a separate stock. No black sea bass were collected farther north than the areas indicated by the symbols, although sampling did occur well into Canadian territorial seas. Black lines indicate thee 50- and 100-m isobars.



Supplementary Figure 6

(**A**) Increasing distribution (solid circles=decreasing longitude) of age-0 black sea bass (*Centropristis striata*) over time from 2 trawl surveys conducted during autumn from 1978 to 2016 by the Massachusetts Division of Marine Fisheries and the Northeast Fisheries Science Center. This longitudinal distribution is also plotted against the reference of increasing sea-surface temperatures (×=mean for September of each year) in the southern Gulf of Maine (as was done in Fig. 8 of the main text). Both regression slopes were significantly different from zero (autumn distribution, solid line: y=–0.013+0.033x, P<0.01; coefficient of determination [r^2]=0.23; September temperatures, dashed line: y=–130+0.074x, P<0.001; r^2=0.47). (**B**) Year-to-year comparison of minimum longitude and mean September sea-surface temperature (dashed line, y=–74.3 + 0.30x, P=0.052, r^2=0.14). Temperature data for 1984–2016 were collected from NOAA Buoy Station 44013, 30 km east of Boston, Massachusetts (see Methods, main text, for link).



Supplementary Figure 7

Distribution of ichthyoplankton tows that contained black sea bass (*Centropristis striata*) and that were made during the periods of 1) 1977–1989 (National Marine Fisheries Service [NMFS] Marine Resources Monitoring, Assessment and Prediction Program [MARMAP] sampling, black dots) and 2) 1999–2016 (Northeast Fisheries Science Center [NEFSC] Ecosystem Monitoring Program [EcoMon] sampling, red dots) across the continental shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia. The northernmost and easternmost positive tows were observed in the most recent period. The black line shows the 200 meter isobath. Details of historical collection methods are available in Walsh et al. (2015); recent unpublished data were made available by H. Walsh, Oceans and Climate Branch, NEFSC, NMFS.