

Supplemental materials for *Support for the Slope Sea as a major spawning ground for Atlantic bluefin tuna: evidence from larval abundance, growth rates, and particle-tracking simulations*

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Canadian Journal of Fisheries and Aquatic Sciences

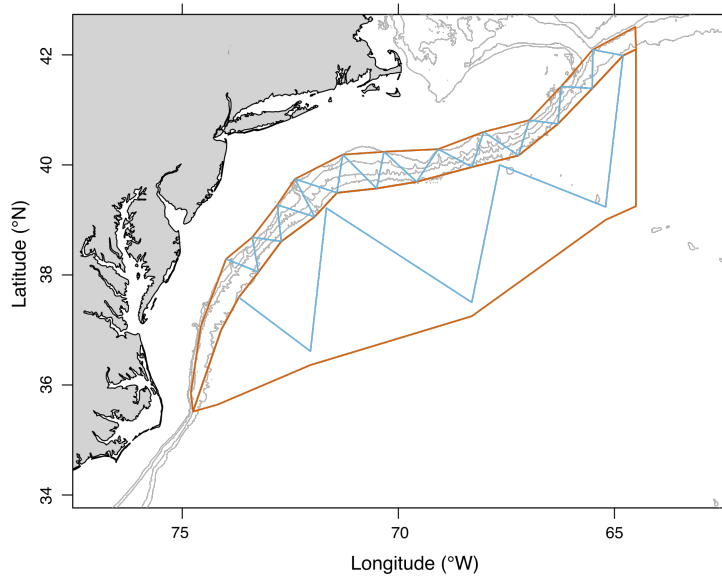


Figure 1: Survey design for the the Atlantic Marine Assessment Program for Protected Species (AMAPPS) cruises. The red polygon outlines show the offshore and shelfbreak strata areas, and the blue lines show the typical cruise track for the visual survey. These strata are used for calculating a stratified mean abundance of bluefin larvae during the HB1603 cruise. Bathymetric contours at 100, 200, 1000, and 2000 m depth are shown in light grey (accessed through GEBCO). Coastlines are the coastlineWorldFine data from the ocedata package in R and the aspect ratio for plotting is automatically chosen by R for the latitude and longitude at the center of the plot.

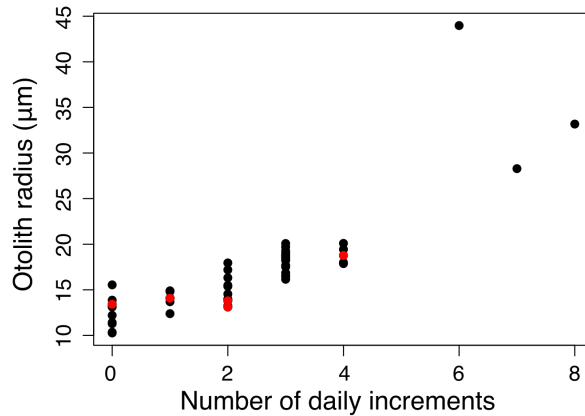


Figure 2: Using otolith size to determine if sampled otoliths include only sagittae. We plotted otolith radius against the number of daily increments. Measurements from larvae where we could not visually determine if we had sampled a sagittal otolith are highlighted in red. We determined that the two otoliths that are the smallest amongst otoliths with two daily increments should be excluded from further analyses.

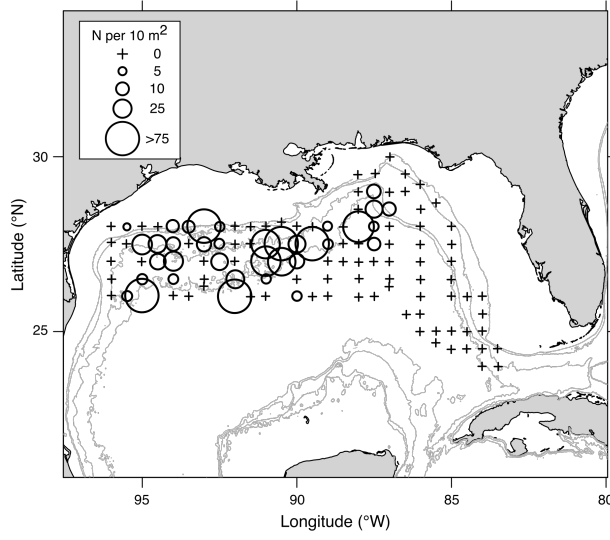


Figure 3: Abundance of Atlantic bluefin tuna larvae in the Gulf of Mexico in 2016. Abundance of Atlantic bluefin tuna (*Thunnus thynnus*) larvae, expressed as  $n$  per  $10\text{ m}^2$ . Data is shown for bongo samples collected with  $333\text{-}\mu\text{m}$  mesh as part of the SEAMAP sampling program. Bathymetric contours at 100, 200, 1000, and 2000 m depth are shown in light grey (accessed through GEBCO). Coastlines are the coastlineWorldFine data from the ocedata package in R and the aspect ratio for plotting is automatically chosen by R for the latitude and longitude at the center of the plot.

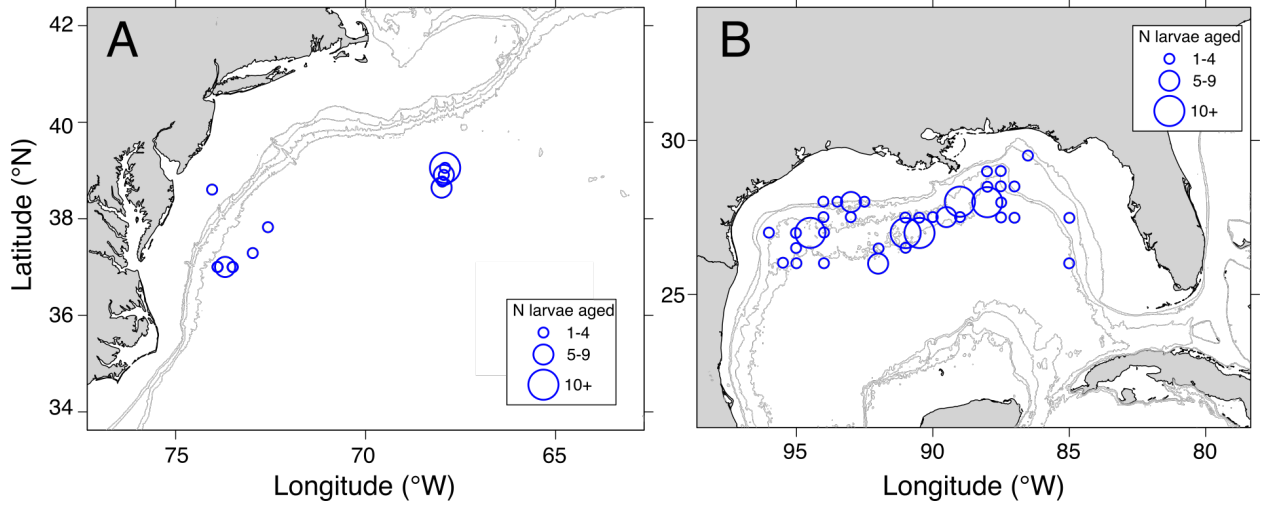


Figure 4: Maps of larvae used in otolith analyses for (A) the Slope Sea and (B) the Gulf of Mexico. Circles, with size scaled to the number of aged larvae from each net, are plotted at the geographic collection location. Bathymetric contours at 100, 200, 1000, and 2000 m depth are shown in light grey (accessed through GEBCO). Coastlines are the coastlineWorldFine data from the ocedata package in R and the aspect ratio for plotting is automatically chosen by R for the latitude and longitude at the center of the plot.

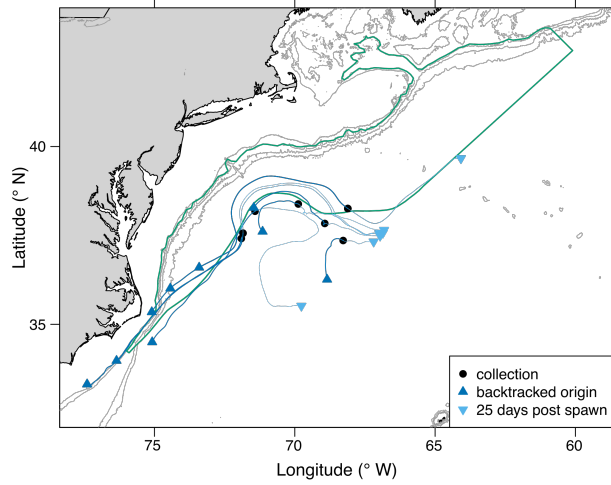


Figure 5: Subset of simulated trajectories that experience model boundary effects. Larval trajectories were simulated backwards in time to estimate spawning location, and forwards in time until the onset of directed swimming behavior. These 10 larval trajectories, corresponding to 13 larvae at 7 collection locations, all exit the Slope Sea domain before the forward tracking simulation completes. They were all collected in the vicinity of the north wall of the Gulf Stream near a persistent northward meander. Additionally, 6 of these trajectories, representing 8 larvae, have estimated spawning locations near Cape Hatteras. Circles show the collection sites, upward facing triangles plot the estimated spawning locations, and downward facing triangles plot the estimated location at the onset of directed swimming behavior. Bathymetric contours at 100, 200, 1000, and 2000 m depth are shown in light grey (accessed through GEBCO). Coastlines are the coastlineWorldFine data from the ocedata package in R and the aspect ratio for plotting is automatically chosen by R for the latitude and longitude at the center of the plot. The green polygon is defined by the 200-m isobath on the inshore side and the average position of the north wall of the Gulf Stream during the simulation period on the offshore side. We use this definition here to highlight the persistent meander that influences the trajectories included here.

Table 1: Station information for collections of Atlantic bluefin tuna larvae in the Slope Sea in 2016. Three types of nets were used, indicated in the “Gear” column: “6B3” refers to the 61-cm bongo with 333- $\mu\text{m}$  mesh, “2B1” is the 20-cm bongo with 165- $\mu\text{m}$  mesh, and “2N3” is the 2-by-1 m frame net with 333- $\mu\text{m}$  mesh. N is the number of bluefin tuna larvae identified from those net samples, with the number of aged larvae given in parentheses. Station abundance (in n per 10 m<sup>2</sup>) is listed for the 61-cm bongo samples.

Cruise	Station	Date	Gear	Latitude (°N)	Longitude (°W)	Bottom Depth (m)	SST (°C)	N (Aged)	Abundance (n per 10 m <sup>2</sup> )
GU1608	224	June-18-2016	6B3	38.18	71.42	3061	23.54	1	0.80
GU1608	229	June-19-2016	6B3	37.83	72.57	2911	23.65	6 (1)	3.60
GU1608	231	June-19-2016	6B3	37.48	73.12	2916	24.26	2	1.58
GU1608	234	June-19-2016	2B1	37.00	73.50	2862	25.98	2 (2)	
GU1608	234	June-19-2016	6B3	37.00	73.50	2862	25.98	23 (3)	13.53
GU1608	235	June-19-2016	2B1	37.00	73.70	2721	25.16	1	
GU1608	235	June-19-2016	6B3	37.00	73.70	2721	25.16	43 (5)	27.47
GU1608	236	June-20-2016	2B1	37.00	73.90	2490	24.62	3 (3)	
GU1608	236	June-20-2016	6B3	37.00	73.90	2490	24.62	25 (2)	19.40
GU1608	240	June-20-2016	6B3	36.65	74.30	2037	26.7	1	1.34
HB1603	16	July-1-2016	6B3	37.41	71.91	3351	28.33	1	8.83
HB1603	17	July-1-2016	2N3	37.56	71.85	3284	24.56	3	
HB1603	21	July-1-2016	2N3	37.33	72.87	3049	27.92	2 (2)	
HB1603	36	July-4-2016	6B3	38.38	69.88	3529	28.05	1	6.38
HB1603	42	July-6-2016	6B3	37.84	68.93	4124	27.69	1	2.67
HB1603	45	July-7-2016	6B3	37.36	68.28	4831	26.64	1	2.98
HB1603	49	July-7-2016	6B3	38.26	68.11	4406	27.8	5	9.39
HB1603	50	July-8-2016	2N3	39.04	67.92	3724	25.56	49 (13)	
HB1603	50	July-7-2016	6B3	39.07	67.90	3629	25.62	7 (3)	14.64
HB1603	51	July-8-2016	2N3	38.91	67.94	3793	25.56	20 (9)	
HB1603	51	July-8-2016	6B3	38.91	67.94	3805	25.56	4 (1)	17.90
HB1603	52	July-8-2016	6B3	38.78	67.98	4053	25.67	5 (1)	18.58
HB1603	53	July-8-2016	6B3	38.65	68.00	4170	25.85	9 (6)	31
HB1603	68	July-12-2016	6B3	38.61	74.04	55	24.57	1 (1)	1.92
HB1603	70	July-13-2016	6B3	39.38	71.69	2200	23.94	2	6.15
HB1603	121	July-31-2016	6B3	39.57	70.99	2450	25.99	6	31.75
HB1603	125	Aug-1-2016	6B3	39.73	70.13	2058	26.13	1	5.80

Table 2: Sensitivity of larval abundance calculations to the choice of which stations to include. SEAMAP refers to the Gulf of Mexico sampling program. The Slope Sea cruises in 2016 were GU1608 on the NOAA Ship *Gordon Gunter* and HB1603 on the NOAA Ship *Henry B. Bigelow*. The Slope Sea cruises in 2013 were GU1302 on the NOAA Ship *Gordon Gunter* and HB1303 on the NOAA Ship *Henry B. Bigelow*. Configurations indicate how the mean abundance (including zero stations) and mean abundance at positive stations were calculated. Days indicates the number of days elapsed between the first and last station included in a given configuration.

Configuration	Days	Area (km <sup>2</sup> )	Mean abund. (n per 10 m <sup>2</sup> )	Mean abund. at pos. stations (n per 10 m <sup>2</sup> )
GU1608+HB1603, June 17-Aug 15, all stations	60	390839	1.96	11.29
GU1608+HB1603, June 17-Aug 15, 1000m and deeper	60	283959	2.80	11.78
HB1603, June 28-Aug 15, 1000m and deeper	49	262471	2.79	13.01
HB1603, June 28-Aug 8, all stations	42	359528	2.05	12.15
HB1603, June 28-Aug 8, 1000m and deeper	42	262471	3.19	13.01
HB1603, June 28-Aug 24, stratified mean	58	308704	1.94	12.94
HB1603, June 28-Aug 8, stratified mean	42	308704	2.55	12.94
HB1603, June 28-July 28, stratified mean	31	308704	2.46	11.12
SEAMAP 2016, April 30-May 30, all stations	31	447676	12.00	39.68
GU1302+HB1303, June 21-Aug 18, 1000 m or deeper	59	282758	3.69	28.59
HB1303, July 2-Aug 18, all stations	48	385274	1.24	18.20
HB1303, July 2-Aug 12, 1000 m or deeper	42	244086	3.21	18.20
HB1303, July 2-Aug 18, stratified mean	48	308704	2.66	17.42
HB1303, July 2-Aug 1, stratified mean	31	308704	5.43	16.28