

Supplementary Methods:

Depth cut-off analysis

We used the Northeast Fisheries Science Center spring bottom trawl survey to assess the mean depth sand lance occur on Georges Bank compared to the surrounding Northeast US shelf. Details of the survey and sampling gear are found within Politis *et al.* (2014). Briefly, the survey spans from 1968 to present, with each survey encompassing 300–400 stations sampled in a random stratified design, ranging from the Western Scotian Shelf to Cape Hatteras.

We performed a logistic regression for the presence/absence of sand lance in relation to depth for trawls on Georges Bank and a logistic regression for the presence/absence of sand lance in relation to depth for trawls on the rest of the Northeast US shelf. Given our knowledge that sand lance are rarely caught at depths >40 m on Stellwagen Bank (Silva *et al.* 2021), we estimated the depth that had the equivalent probability of occurrence of sand lance for Georges Bank as the probability of occurrence at 40 m for the rest of the Northeast US shelf. This value was then used as the depth cut-off for particle seeding on Georges Bank.

We then compared our results using 60 m as the depth cut-off for Georges Bank with the results from an analysis using 40 m as a cut-off. Retention metric values were higher when a 40 m cut-off was used compared to a 60 m value, but overall trends were remarkably similar (Figure S4).

Tidal experiment

We released particles hourly on January 1, 2002 (date arbitrary) to compare the effect of hour of release (and therefore initial tidal state) on the final locations of particles released from Stellwagen Bank. As with other simulations, 1230 particles were released from each 5, 15, 25, and 35 m depths and were treated as depth-keeping. Final destinations were visualized by hour of release to see if particle trajectories were noticeably different by time of release.

Particle Dispersal Comparison

To look at small scale discrepancies in dispersal trajectories due to numerical interpolation errors and chaotic flows near stagnation points, we seeded particles at 10 m spacing (484 particles) at the center of Georges Bank and tracked their forward trajectory for 75 days. The results are visualized in Videos S7 (ten minute time step) and S8 (one minute time step). Videos show that particles disperse and separate large distances even when placed very close together. While such phenomena are unavoidable, it can serve effectively as a diffusion pattern.

Table S1: Collection locations, dates, and counts for age-0 sand lance used for otolith microstructure analysis. GSC represents the Great South Channel.

Region	Date	Station	Longitude	Latitude	Count
GSC	190521	Ch 2	-69.78	41.57	2
GSC	190521	Ch 3	-69.77	41.59	3
GSC	190521	Ch 4	-69.79	41.58	4
GSC	190521	Ch 5	-69.83	41.58	4
GSC	190521	Ch 6	-69.87	41.56	4
GSC	190523	Ch 7	-69.87	41.75	2
GSC	190523	Ch 8	-69.87	41.75	7
GSC	190523	Ch 9	-69.87	41.73	10
GSC	190523	Ch 10	-69.87	41.71	9
GSC	190523	Ch 11	-69.87	41.70	5
Stellwagen	190603	S11	-70.24	42.18	4
Stellwagen	190603	S12	-70.27	42.18	8
Stellwagen	190603	S13	-70.31	42.17	9
Stellwagen	190604	N13	-70.40	42.39	2
Stellwagen	190604	N14	-70.42	42.40	9
Stellwagen	190604	N15	-70.44	42.41	15
GSC	190617	Ch 9	-69.87	41.73	1
GSC	190617	Ch10	-69.87	41.71	10
GSC	190617	Ch 12	-69.86	41.70	7
GSC	190617	Ch 13	-69.88	41.72	10
GSC	190617	Ch 14	-69.86	41.69	11
GSC	190617	Ch 15	-69.86	41.68	9

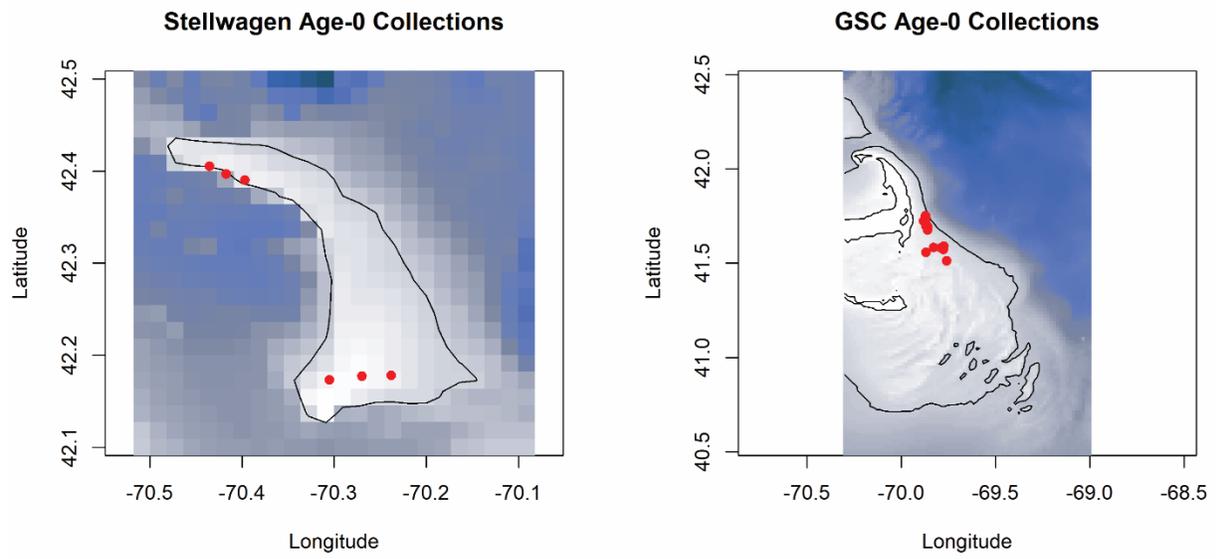


Figure S1: Collection locations of age-0 sand lance on Stellwagen Bank and in the Great South Channel in summer 2019. Shading indicates bathymetry and contours represent the coastline and 40 m isobath.

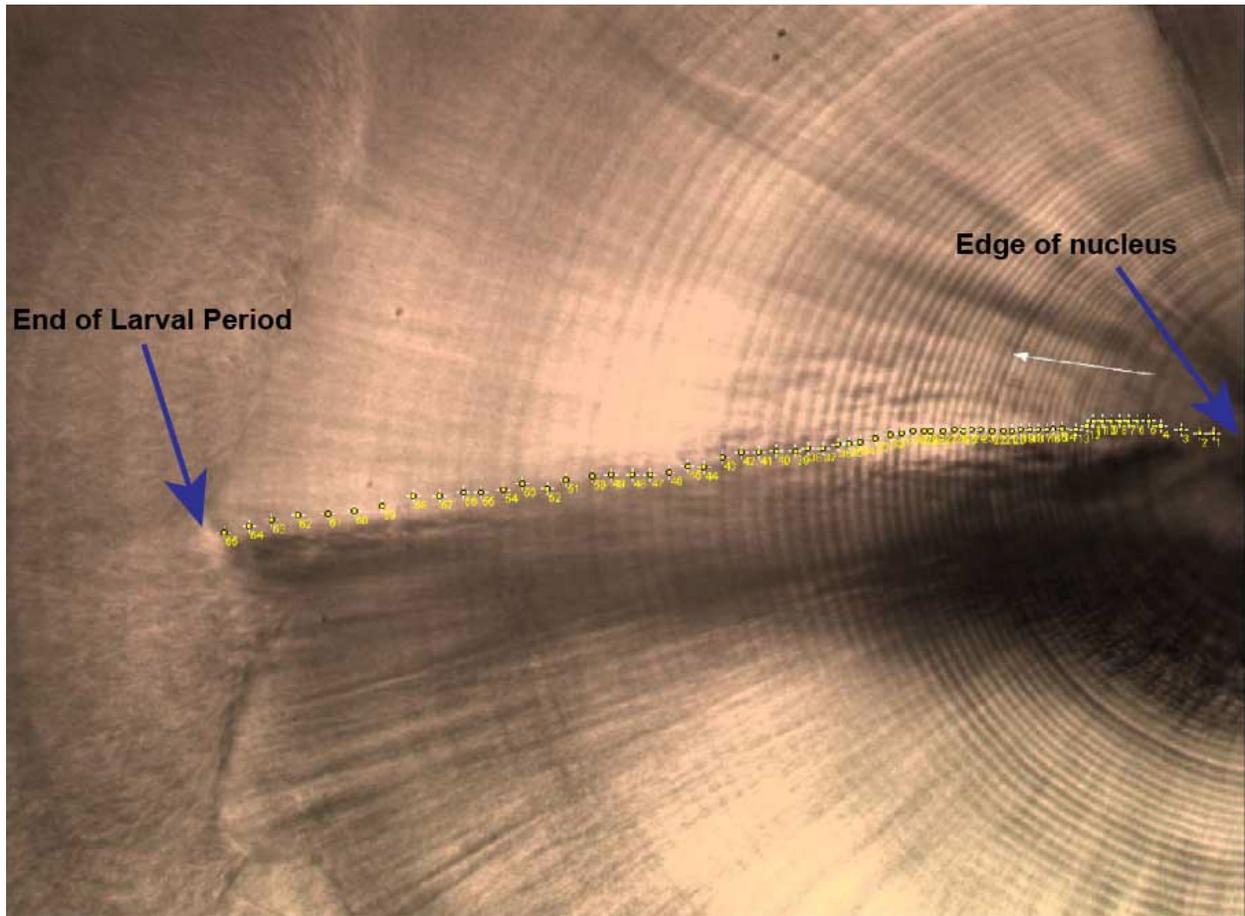


Figure S2: Image of the larval period of an otolith with daily rings indicated by points. Note that not all rings are clear in this image as image stacks were used to view each portion of the otolith on multiple focal planes.

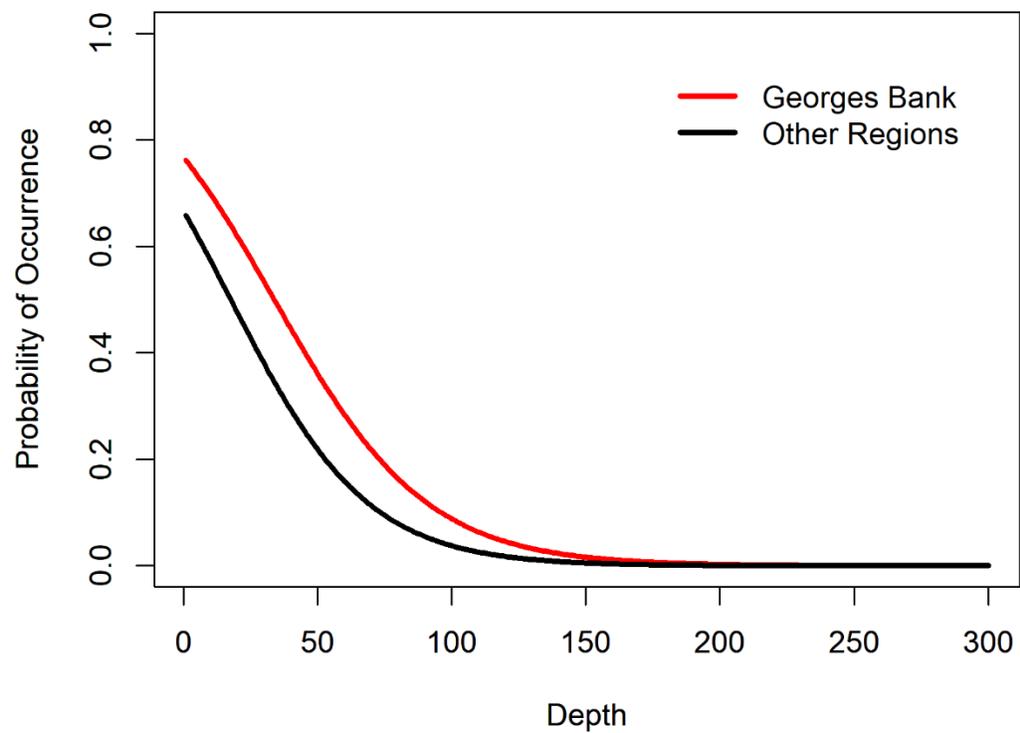


Figure S3: Probability of sand lance occurrence of sand lance from the NEFSC spring bottom trawl survey in relation to depth on Georges Bank (red) and the rest of the Northeast US shelf.

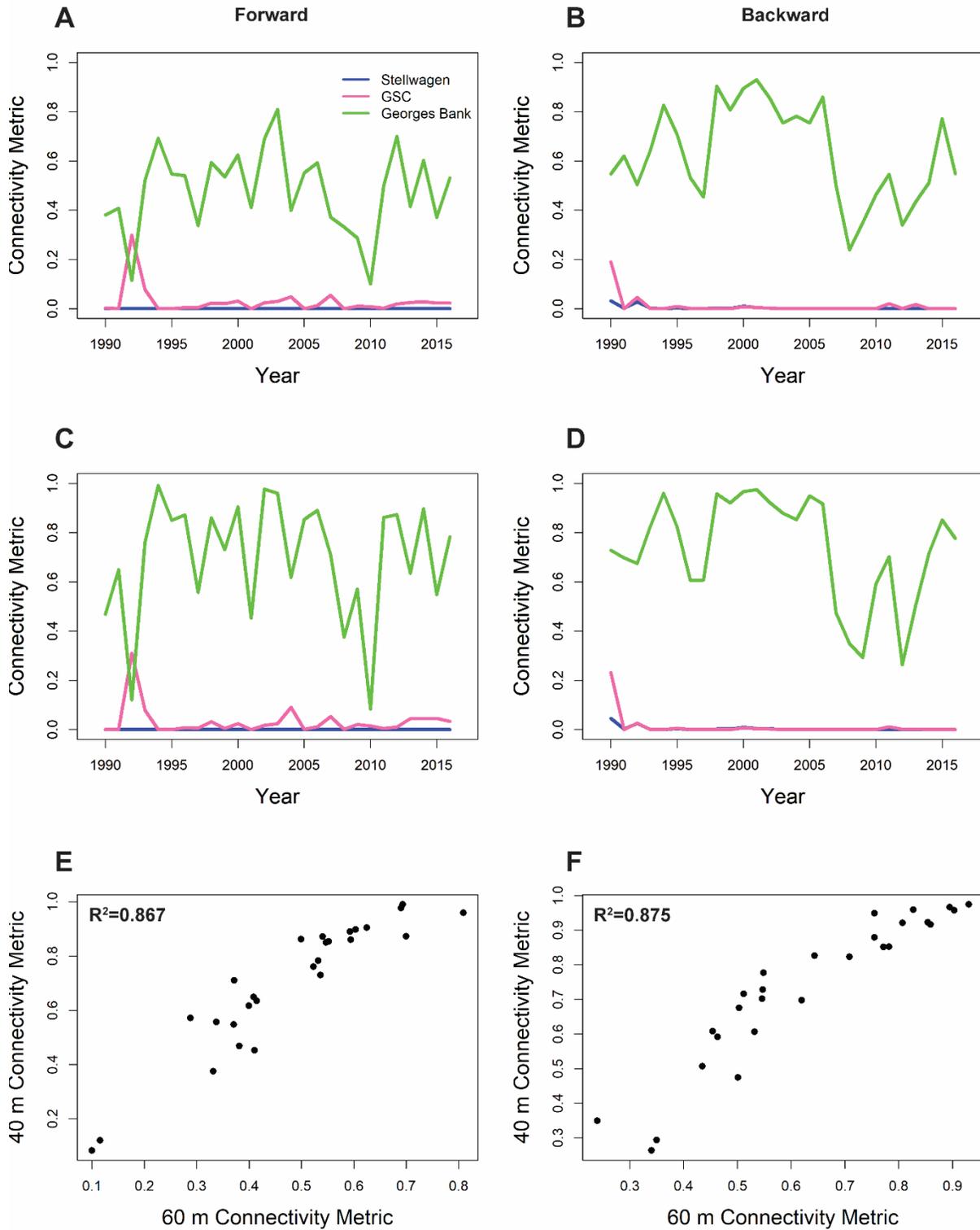


Figure S4: Comparison of annual connectivity metrics for Georges Bank if 60 m is used as the cut-off depth of releases (A, B) or 40 m (C, D). Panels E and F show the correlation between the two metrics for forward (E) and backward (F) releases.

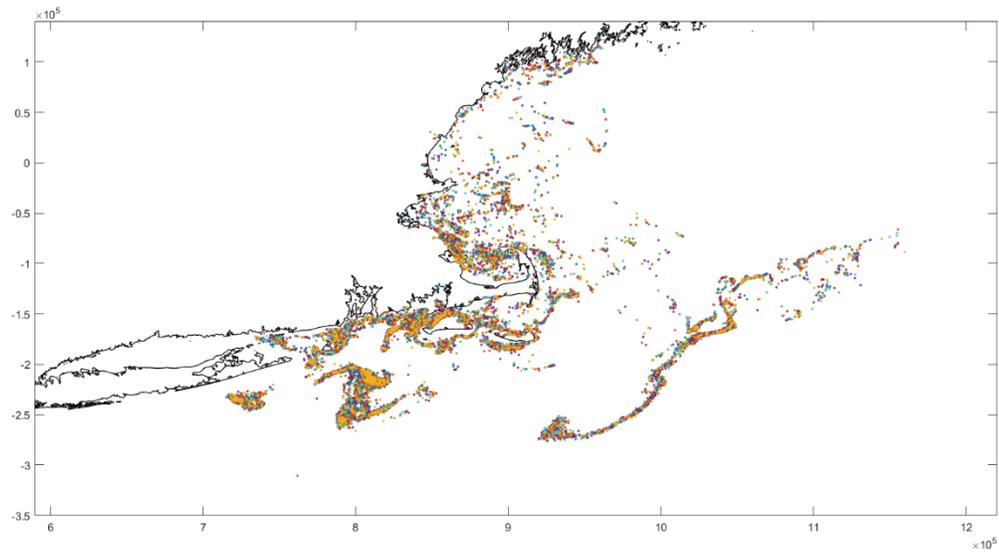


Figure S5: Final locations (85 days after release) for particles released hourly on January 1, 2002. Colors represent hour of release. Aggregations indicate little variability among final locations based on hour of release.

Supplementary Videos:

Video S1: Particle densities through 75 days of forward tracking from Stellwagen Bank by year of release.

Video S2: Particle densities through 75 days of backward tracking from Stellwagen Bank by year of release.

Video S3: Particle densities through 73 days of forward tracking from the Great South Channel by year of release.

Video S4: Particle densities through 73 days of backward tracking from the Great South Channel by year of release.

Video S5: Particle densities through 73 days of forward tracking from Georges Bank by year of release.

Video S6: Particle densities through 73 days of backward tracking from Georges Bank by year of release.

Video S7: Particle tracking of particles spaced 10 m apart in Georges Bank showing dispersion using a 10 minute time step for 75 days.

Video S8: Particle tracking of particles spaced 10 m apart in Georges Bank showing dispersion using a 1 minute time step for 75 days.

Supplemental References:

- Morse, R. E., Friedland, K. D., Tommasi, D., Stock, C., & Nye, J. (2017). Distinct zooplankton regime shift patterns across ecoregions of the US Northeast continental shelf Large Marine Ecosystem. *Journal of Marine Systems*, 165, 77-91.
- Perretti, C. T., Fogarty, M. J., Friedland, K. D., Hare, J. A., Lucey, S. M., McBride, R. S., ... & Wuenschel, M. J. (2017). Regime shifts in fish recruitment on the Northeast US Continental Shelf. *Marine Ecology Progress Series*, 574, 1-11.
- Politis, P. J., Galbraith, J. K., Kostovick, P., & Brown, R. W. (2014). Northeast Fisheries Science Center Bottom Trawl Survey Protocols for the NOAA Ship Henry B. Bigelow.
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- Suca, J. J., Wiley, D. N., Silva, T. L., Robuck, A. R., Richardson, D. E., Glancy, S. G., ... & Llopiz, J. K. (2021). Sensitivity of sand lance to shifting prey and hydrography indicates forthcoming change to the northeast US shelf forage fish complex. *ICES Journal of Marine Science*.