Landscape parameters of seagrass, fish and macroinvertebrate communities within Artificial Seagrass Units (ASU) in Back Sound, NC from July to September 2018

Website: https://www.bco-dmo.org/dataset/891670
Data Type: Other Field Results
Version: 1
Version Date: 2023-03-27

Project
» Collaborative Research: Habitat fragmentation effects on fish diversity at landscape scales: experimental tests of multiple mechanisms (Habitat Fragmentation)

Contributors	Affiliation	Role
Fodrie, F. Joel	University of North Carolina at Chapel Hill (UNC-Chapel Hill-IMS)	Principal Investigator
Yeager, Lauren	University of Texas - Marine Science Institute (UTMSI)	Co-Principal Investigator
Lopazanski, Cori	University of North Carolina at Chapel Hill (UNC-Chapel Hill-IMS)	Scientist
Poray, Abigail K.	University of North Carolina at Chapel Hill (UNC-Chapel Hill-IMS)	Scientist
Yarnall, Amy	University of North Carolina at Chapel Hill (UNC-Chapel Hill-IMS)	Scientist, Contact
Heyl, Taylor	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
To parse the ecological effects of habitat area and patchiness on faunal community structure and dynamics of estuarine nekton, we employed artificial seagrass unit (ASU) landscapes at a scale relevant to habitat fidelity of common fish and macroinvertebrates (days to weeks) in this temperate study system. We designed and deployed 25 unique, 234-square meter landscapes, composed of a total of 2059 1-meter squared ASUs. These landscapes were designed along orthogonal axes of artificial seagrass area (i.e., percent cover of each landscape = 10-60 percent) and fragmentation per se (i.e., percolation probability; 0.1-0.59) to delineate their independent and interactive effects on seagrass fish and macroinvertebrate communities. We also opportunistically examined how initial landscape configurations were altered by a stochastic event (i.e., Hurricane Florence), which affected our landscapes in an analogous fashion to natural seagrass (i.e., uprooting ASUs/rhizomes and burying ASUs/plants under sediments). Landscape parameters and designs were determined by Dr. Lauren A. Yeager at the Marine Science Institute, of the University of Texas at Austin. Landscape construction was led by Drs. F. Joel Fodrie and Amy H. Yarnall for the Estuarine Ecology Laboratory of the University of North Carolina at Chapel Hill’s Institute of Marine Sciences.

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Coverage

Spatial Extent: **N**:34.707 **E**:-76.589 **S**:34.701 **W**:-76.603
Temporal Extent: 2018-07 - 2018-09

Methods & Sampling

To examine fragmentation components independently and interactively, we conducted this study on Oscar Shoal and an adjacent unnamed shoal in Back Sound, NC, USA (34°42′20" N to 34°41′60" N, 76°36′ 15" W to 76°35′17" W) during the summer of 2018. Both shoals were shallow (less than 0.5-meter depth at low tide) and historically supported expansive, ephemeral seagrass meadows (Peterson et al., 2001) that have been absent over the last decade. During 2018, these shoals had large expanses of sandy area speckled with small patches of seagrass (which were avoided during landscape siting) composed of a mixture of eelgrass, *Zostera marina* (Linnaeus 1753), and shoal grass, *Halodule wrightii* (Ascherson 1868) (Yeager et al., 2016). Both shoals were adjacent to deep boating channels between two large salt marsh complexes to the north (North River Marsh) and south (Middle Marsh).

We generated 25 unique 18-meters × 13-meters (234 square meter) landscapes along orthogonal axes of percent cover of seagrass within the landscape footprint (10 percent, 22.5 percent, 35 percent, 47.5 percent, and 60 percent) and fragmentation *per se* (i.e., percolation probability: 0.1, 0.225, 0.35, 0.475, 0.59). Blueprints for landscape construction in the field were generated by a modified random cluster (MRC) method (Saura and Martinez-Millan, 2000) using the *randomHabitat* function in the *secr* package in R (Efford, 2016). In using the MRC method, landscapes of low percolation probability exhibit low connectivity from one ASU to the next (i.e., are highly fragmented), which approaches a lower limit of realistic landscape fragmentation at percolation probability = 0.1 (Saura and Martinez-Millan, 2000). Additionally, patch cohesion is maximized (i.e., landscapes are contiguous) when percent cover reaches approximately 60 percent and percolation probability approaches approximately 0.59 (Saura and Martinez-Millan, 2000). Therefore, we chose 60 percent cover and percolation probability = 0.59 as the upper limits of our landscape parameters, and 10 percent cover and percolation probability = 0.1 as the lower limits. We also note that the generated landscapes fell within the range of the number of patches (approximately 1-15 patches) observed within natural, low seagrass area landscapes (approximately 250-375 square meters) in our system (Yeager et al., 2016). For simplicity, landscape parameters will be hereafter described in the context of percent cover and fragmentation *per se* (i.e., low percolation probability is high fragmentation *per se*). Landscapes were constrained to fall within 2 percent of the area input parameter and maintain consistent edge-to-area ratios within individual fragmentation *per se* treatment levels (*secr* package in R; Efford, 2016). Within an individual landscape defined by more than 1 seagrass patch, discrete patches of artificial seagrass were separated from one another by a minimum of 0.86-meter (short-side length of an ASU) of sandy matrix in all directions.

Each landscape contained 22 to 135 ASUs (total ASUs constructed = 2059) constructed to mimic shoot density, shoot width, and canopy height of *Zostera marina* meadows in this system (Yeager et al., 2016). For each ASU, 30-centimeter (cm) lengths of green splendorette curling ribbon (0.5-cm width) were tied to approximately 1-square meter bases of rigid black plastic VEXAR (0.86-meter x 1.2-meter, 2.5-centimeter) mesh so that each ASU had uniformly spaced "shoots" (450 square meters) with two 15-centimeter length "leaves". Each ASU required approximately 3 hours to construct, with the entire manufacturing effort requiring the equivalent of three full-time person work years (with work divided among a number of technicians and community volunteers).

Twenty-five ASU landscapes were deployed over the course of 10 days (21-May to 31-May 2018) in haphazard order and placement: 19 were located on Oscar Shoal and the remaining 6 were located on the adjacent, unnamed shoal. All landscapes were more than 50 meters apart from each other and greater than 30 meters from natural seagrass patches. Individual ASUs were secured to the sediment surface and each other with lawn staples (16 per ASU) and zip ties (0-4 per ASU, based on the presence/absence of adjacent ASUs), respectively. The site with 60 percent cover and 0.59 percolation probability (i.e., "60 percent-0.59"; hereafter sites will be named by this convention), was replicated (on 8-Jun 2018) as a 26th landscape to evaluate potential differences in ecological response metrics influenced by the identity of the two shoal environments.

Hurricane Florence

The study area and artificial landscapes were directly impacted by Hurricane Florence during 13-16 Sept 2018. Despite ASU re-enforcements made prior to Florence's landfall (i.e., additional lawn staples and cable ties), our landscapes experienced substantial disturbance akin to natural seagrasses in the vicinity, in many cases completely removing or burying ASUs which altered the landscape percent cover and fragmentation *per se* parameters. Because of this substantial disturbance, we opportunistically examined how our landscapes were altered by Hurricane Florence as a proxy for how extreme storm events may alter natural seagrass meadows. We recalculated landscape parameters based on ASU-by-ASU checks made after Hurricane Florence. Post-Florence landscape percent cover and percolation probabilities were recalculated both including and excluding ASUs that were fully buried under sediment. Within natural habitats, depending on sedimentation intensity, seagrass burial may represent temporary or permanent habitat loss (Cabaço et al., 2008). Holding the original landscape 234-square meter footprint constant, the percent cover of each landscape was recalculated from the remaining number of ASUs (including and excluding buried ASUs). Percolation probability is a fragmentation *per se* input parameter for landscape generation (Saura and Martinez-Millan, 2000) but is not generally used to describe existing or natural landscapes. Therefore, to determine how landscape fragmentation *per se* was altered, we first determined the linear relationship between the initial number of seagrass patches and our percolation probability treatments (y = 0.61 – 0.06x, r^2 = 0.912). We then used this relationship to predict post-Florence landscape percolation probabilities from the remaining number of patches in each landscape (including and excluding buried ASUs).

Known Issues:
See Hurricane Florence section in methods. Some landscapes were completely removed or buried and landscape parameters are denoted with 0 or NA.

Data Processing Description

Blueprints for landscape construction in the field were generated by a modified random cluster (MRC) method (Saura and Martinez-Millan, 2000) using the *randomHabitat* function in the *secr* package in R (Efford, 2016) and landscapes were constrained to fall within 2 percent of the area input parameter and maintain consistent edge-to-area ratios within individual fragmentation *per se* treatment levels (*secr* package in R; Efford, 2016).

All data were entered electronically into an Excel spreadsheet.

BCO-DMO Processing Description:
- Missing data identifier 'NA' replaced with blank (BCO-DMO's default missing data identifier)
- Added "Latitude" and "Longitude" columns and rounded to three decimal places
- Rounded columns "Actual_cover", "landscape_shape_index", "largest_patch_index", "perim_area_ratio", "frac_dim_index", "patch_cohexion_index" to 3 decimal places
- Removed "%" symbol in data cells

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Data Files

File
asu_frag_landscape_parameters.csv (Comma Separated Values (.csv), 8.05 KB) MD5:a6242db81c9076ceff4aabfc02765476 Primary data file for dataset 891670, Version 1.

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Related Publications

Cabaço, S., Santos, R., & Duarte, C. M. (2008). The impact of sediment burial and erosion on seagrasses: A review. Estuarine, Coastal and Shelf Science, 79(3), 354–366. https://doi.org/10.1016/j.ecss.2008.04.021
Methods

Efford, M. (2016). secr 2.10-spatially explicit capture–recapture in R.
Software

Peterson, C. H., Fodrie, J. F., Summerson, H. C., & Powers, S. P. (2001). Site-specific and density-dependent extinction of prey by schooling rays: generation of a population sink in top-quality habitat for bay scallops. Oecologia, 129(3), 349–356. https://doi.org/10.1007/s004420100742
Methods

Saura, S., & Martínez-Millán, J. (2000). Landscape Ecology, 15(7), 661–678. https://doi.org/10.1023/a:1008107902848 https://doi.org/10.1023/A:1008107902848
Methods

Yarnall, A. H., Yeager, L. A., Lopazanski, C., Poray, A. K., Morley, J. M., Hurlbert, A., and Fodrie, F.J. Habitat area more consistently affects seagrass faunal communities than fragmentation per se.
Results

Yeager, L. A., Keller, D. A., Burns, T. R., Pool, A. S., & Fodrie, F. J. (2016). Threshold effects of habitat

fragmentation on fish diversity at landscapes scales. Ecology, 97(8), 2157–2166. doi:10.1002/ecy.1449
Methods

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Related Datasets

IsRelatedTo

Yarnall, A., Fodrie, F. J. (2024) **Data from scallop survival assays conducted as part of a larger concurrent study of fragmentation effects on estuarine faunal communities with Artificial Seagrass Units (ASU) in Back Sound, NC from July to September 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-10-04 doi:10.26008/1912/bco-dmo.939581.1 [view at BCO-DMO]
Relationship Description: Datasets collected concurrently as part of the same study in Back Sound, NC.

Yarnall, A., Fodrie, F. J., Lopazanski, C., Poray, A. K., Yeager, L. (2023) **Epibenthic faunal densities sampled from within Artificial Seagrass Units (ASU) in Back Sound, NC from June to October 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-03-15 doi:10.26008/1912/bco-dmo.891859.1 [view at BCO-DMO]

Yarnall, A., Fodrie, F. J., Lopazanski, C., Poray, A. K., Yeager, L. (2023) **Landscape fine-scale complexity of seagrass, fish and macroinvertebrate communities within Artificial Seagrass Units (ASU) in Back Sound, NC from July to September 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-03-17 doi:10.26008/1912/bco-dmo.891652.1 [view at BCO-DMO]
Relationship Description: Datasets collected concurrently as part of the same study in Back Sound, NC.

Yarnall, A., Fodrie, F. J., Lopazanski, C., Poray, A. K., Yeager, L. (2023) **Settlement rates of fishes and crab megalopa within Artificial Seagrass Units (ASU) in Back Sound, NC from June to August 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-03-20 doi:10.26008/1912/bco-dmo.891835.1 [view at BCO-DMO]

Yarnall, A., Fodrie, F. J., Lopazanski, C., Poray, A. K., Yeager, L. (2023) **Squidpop consumption probability within Artificial Seagrass Units (ASU) in Back Sound, NC from October to November 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-03-15 doi:10.26008/1912/bco-dmo.891794.1 [view at BCO-DMO]

Yarnall, A., Fodrie, F. J., Morley, J., Yeager, L. (2023) **Fish densities sampled by Dual Frequency Identification Sonar (DIDSON) within Artificial Seagrass Units (ASU) in Back Sound, NC from June to October 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-03-13 doi:10.26008/1912/bco-dmo.891779.1 [view at BCO-DMO]

Yarnall, A., Fodrie, F. J., Morley, J., Yeager, L. (2023) **Fish measurements sampled by Dual Frequency Identification Sonar (DIDSON) within Artificial Seagrass Units (ASU) in Back Sound, NC from July to September 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-03-10 doi:10.26008/1912/bco-dmo.891686.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Site_ID	Artificial seagrass unit (ASU) landscape name (Percent cover value-Percolation probability value)	unitless
Latitude	Latitude North (South is negative) of sampling site	decimal degrees

Longitude	Longitude East (West is negative) of sampling site	decimal degrees
Per_cov	Percent cover treatment of ASUs in 234 square meter landscape footprint (10, 22.5, 35, 47.5, 60)	percent (%)
Frag	ASU landscape fragmentation per se treatment indexed by percolation probability (0.1, 0.225, 0.35, 0.475, 0.59)	unitless
Landscape_timeperiod	Original landscape design parameters or Post-Hurricane Florence re-calculated landscape parameters?	unitless
Buried_ASUs	Are buried ASUs included or excluded from post-Florence landscape parameter calculations?	unitless
Actual_cover	True percent cover of landscape (may not exactly match the treatment level)	percent (%)
Actual_Frag	True percolation probability of landscape (may not exactly match the treatment level)	unitless
Total_area	Total area of ASUs	square meters (m^2)
N_patches	Number of ASU patches	unitless
landscape.shape.index	Total landscape perimeter (meters), divided by the square root of the total landscape area (square meters), adjusted by a constant for a circular standard (vector) or square standard (raster)	unitless
largest.patch.index	The percentage of the landscape comprised by the largest patch	percent (%)
perim.area.ratio	Total landscape perimeter (meters) divided by the total landscape area (square meters)	(m^-1)
frac.dim.index	The sum of 2 times the logarithm of patch perimeter (meters) divided by the logarithm of patch area (square meters) for each patch in the landscape, divided by the number of patches; the raster formula is adjusted to correct for the bias in perimeter	unitless
patch.cohesion.index	Characterises the connectedness of patches. It can be used to asses if patches are located aggregated or rather isolated	unitless

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Instruments

Dataset-specific Instrument Name	Ohaus H-5276
Generic Instrument Name	scale or balance
Generic Instrument Description	Devices that determine the mass or weight of a sample.

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Project Information

Collaborative Research: Habitat fragmentation effects on fish diversity at landscape scales: experimental tests of multiple mechanisms (Habitat Fragmentation)

Coverage: North Carolina

Amount and quality of habitat is thought to be of fundamental importance to maintaining coastal marine ecosystems. This research will use large-scale field experiments to help understand how and why fish populations respond to fragmentation of seagrass habitats. The question is complex because increased fragmentation in seagrass beds decreases the amount and also the configuration of the habitat (one patch splits into many, patches become further apart, the amount of edge increases, etc). Previous work by the investigators in natural seagrass meadows provided evidence that fragmentation interacts with amount of habitat to influence the community dynamics of fishes in coastal marine landscapes. Specifically, fragmentation had no effect when the habitat was large, but had a negative effect when habitat was smaller. In this study, the investigators will build artificial seagrass habitat to use in a series of manipulative field experiments at an ambitious scale. The results will provide new, more specific information about how coastal fish community dynamics are affected by changes in overall amount and fragmentation of seagrass habitat, in concert with factors such as disturbance, larval dispersal, and wave energy. The project will support two early-career investigators, inform habitat conservation strategies for coastal management, and provide training opportunities for graduate and undergraduate students. The investigators plan to target students from underrepresented groups for the research opportunities.

Building on previous research in seagrass environments, this research will conduct a series of field experiments approach at novel, yet relevant scales, to test how habitat area and fragmentation affect fish diversity and productivity. Specifically, 15 by 15-m seagrass beds will be created using artificial seagrass units (ASUs) that control for within-patch-level (~1-10 m2) factors such as shoot density and length. The investigators will employ ASUs to manipulate total habitat area and the degree of fragmentation within seagrass beds in a temperate estuary in North Carolina. In year one, response of the fishes that colonize these landscapes will be measured as abundance, biomass, community structure, as well as taxonomic and functional diversity. Targeted ASU removals will then follow to determine species-specific responses to habitat disturbance. In year two, the landscape array and sampling regime will be doubled, and half of the landscapes will be seeded with post-larval fish of low dispersal ability to test whether pre- or post-recruitment processes drive landscape-scale patterns. In year three, the role of wave exposure (a natural driver of seagrass fragmentation) in mediating fish community response to landscape configuration will be tested by deploying ASU meadows across low and high energy environments.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1635950

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