Juvenile oyster growth from risk-addition experiment conducted on oyster reefs in the Guana Tolomato Matanzas National Estuarine Research Reserve from June to November 2012

Website: https://www.bco-dmo.org/dataset/885493
Data Type: Other Field Results
Version: 1
Version Date: 2022-12-20

Project
» Collaborative research: Quantifying the influence of nonconsumptive predator effects on prey population dynamics (Predatory NCEs and Scale)

Contributors	Affiliation	Role
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White, J. Wilson	University of North Carolina - Wilmington (UNC-Wilmington)	Co-Principal Investigator
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Abstract
The eastern oyster (Crassostrea virginica) is a foundation species in northeast Florida estuaries, including the Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR), where intertidal reefs are extensive. Estuarine research to assess sustainability and oyster population, plus various monitoring studies and oyster reef restoration projects have been undertaken, with an additional focus on testing theory regarding the effects of predation risk in the natural environment. As part of a study that manipulatively “pressed” risk cues onto oyster prey, a field experiment was conducted on oyster reefs in the Guana Tolomato Matanzas National Estuarine Research Reserve (Ponte Vedra Beach, Florida) from June to November 2012. Three areas within the southern areas of the GTM NERR (south of Matanzas inlet) were used in the experiment: Summer Island North (SIN), Marine Land (ML) and Pellicer Flats (PF). The SIN site occurred closest to the inlet (farthest from freshwater input), the PF site occurred farthest from inlet and closest to freshwater input, while the ML site occurs between the inlet and the freshwater input. Oyster survival, growth and recruitment were checked monthly. At the mid point and conclusion of the experiment, individual oysters were also destructively sampled to quantify differences in oyster traits (shell versus tissue mass) as a function of experimental treatment and location. This submission concerns the growth of juvenile oysters.

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Coverage

Spatial Extent: **N**:29.695 **E**:-81.216 **S**:29.658 **W**:-81.234
Temporal Extent: 2012-06 - 2012-11

Methods & Sampling

As part of a study that manipulatively “pressed” risk cues onto oyster prey, a field experiment was conducted on oyster reefs in the Guana Tolomato Matanzas National Estuarine Research Reserve (Ponte Vedra Beach, Florida) from June to November 2012. Three areas within the southern areas of the GTM NERR (south of Matanzas inlet) were used in the experiment: Summer Island North (SIN), Marine Land (ML), and Pellicer Flats (PF). The SIN site occurred closest to the inlet (farthest from freshwater input), the PF site occurred farthest from the inlet and closest to freshwater input, and the ML site occurs between the inlet and the freshwater input. Oyster survival, growth, and recruitment were checked monthly. At the midpoint and conclusion of the experiment, individual oysters were also destructively sampled to quantify differences in oyster traits (shell versus tissue mass) as a function of experimental treatment and location. This dataset concerns the growth of juvenile oysters.

Each experimental unit consisted of a focal oyster cage: 18 centimeters (cm) × 13 centimeters (cm) × 18 centimeters (cm) centered between two opposing smaller cages for predators (13 cm × 13 cm × 13 cm). One predator was placed in each of the two smaller cages, which were held flush to the exterior of the central focal cage with cable ties, so that oysters in the central cage were exposed to predator cues from two directions, but were protected from being eaten. All cages were constructed with PVC-coated wire mesh (6-millimeter mesh openings) and were sewn shut as well as together with Maxi Edge trimmer line (0.17 cm diameter). To mimic the turbulent dispersion of water-borne cues on natural oyster reefs, we placed four sun-bleached oyster shells in each predator cage to disperse water flow. At each site, we established four transects (6 meters in length) parallel to the shoreline and separated by 3 meters on a mudflat. Along each transect, six experimental units were deployed at 1 meter intervals. In this estuary, settlement of larval oysters to the benthos primarily occurs in two large pulses in the spring and fall of each year. The experiment began in June 2012, after the spring recruitment pulse, and ended in November 2012, after the fall recruitment pulse.

Within each site, experimental units were randomly assigned among four levels of the cue factor: no cue, mud crab (*Panopeous herbstii*) cue, crown conch (*Melongena corona*) cue, and multiple predator cue (mud crab cue as juveniles, then crown conch cue as adults). There were 24 total experimental units per site (n = 6 for each cue treatment). The mud crabs had a mean carapace width of 38 millimeters (mm), and the crown conchs had a mean shell length of 83 mm. Predators were replaced weekly with new animals collected from nearby oyster reefs. Each replicate of a cue treatment contained two mud crabs or two conchs. This density of experimental predators per unit area is within the range of natural predator density on oyster reefs throughout the Matanzas River Estuarine system (MRE).

Within each central oyster-holding cage, we installed 12 ceramic tiles (8 cm × 8 cm) by drilling a hole into the top of the tiles and fastening the tiles to the inner wall with cable ties. Prior to the installation of tiles, juvenile oysters of equal age and size (6–8 mm shell length) were produced in a local hatchery (Research Aquaculture Inc., Jupiter, FL). Ten of these juvenile oysters were attached to each tile with superglue (Loctite gel).

Within each predator cue treatment, we randomly assigned the 12 tiles among four levels of simulated consumptive effect: none, juvenile stage only, adult stage only, or both stages. This produced 6 x 3 = 18 replicates for each combination of predator cue and simulated CE at each site. Simulated predation rates were based on oyster survival curves from previous field experiments in this estuary. On a weekly basis, we manually culled juvenile oyster density according to a log-transformed survival curve for juvenile oysters (log-survival = -0.0072´days + 0.074, approximately 5 percent removal per week). This prescribed culling was applied until the oysters grew to 20–25 mm, which is when they become less vulnerable to mud crabs and approach sexual maturity. Once oysters reached 25 mm in length, we manually culled oysters on a weekly basis in accordance to a log-transformed survival curve for adult oysters (log-survival = -0.029´days + 0.049, approximately 19 percent removal per week). After four months (124 days), we harvested all experimental units to quantify adult oyster survival, growth, and condition index in accordance with the methods outlined above for juvenile oysters. In addition, we quantified the abundance of larval recruits on each tile to estimate how site, predator cue, and CE influenced the natural colonization of oysters.

Data Processing Description

BCO-DMO Processing description:
- Adjusted field/parameter names to comply with BCO-DMO naming conventions
- Added a conventional header with dataset name, PI names, version date

- Added columns for “Latitude” and “Longitude” and rounded to 2 decimal places (or to the hundredth place)

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Data Files

File
juvenile_growth.csv (Comma Separated Values (.csv), 21.32 KB) MD5:21c4912a7e71e86d810613d61fff6879 Primary data file for dataset ID 885493

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Related Publications

Kimbro, D. L., Tillotson, H. G., & White, J. W. (2020). Environmental forcing and predator consumption outweigh the nonconsumptive effects of multiple predators on oyster reefs. Ecology, 101(7). Portico. https://doi.org/10.1002/ecy.3041
Results

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Related Datasets

IsRelatedTo

Kimbro, D. L., White, J. W. (2023) **Adult oyster survival from risk-addition experiment conducted on oyster reefs in the Guana Tolomato Matanzas National Estuarine Research Reserve from June to November 2012.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-12-05 doi:10.26008/1912/bco-dmo.884130.1 [view at BCO-DMO]

Kimbro, D. L., White, J. W., Tillotson, H. G. (2023) **Adult oyster condition index from risk-addition experiments in the Guana Tolomato Matanzas National Estuarine Research Reserve from June to November 2012.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-01-10 doi:10.26008/1912/bco-dmo.885078.1 [view at BCO-DMO]

Kimbro, D. L., White, J. W., Tillotson, H. G. (2023) **Adult oyster growth from risk-addition experiment conducted on oyster reefs in the Guana Tolomato Matanzas National Estuarine Research Reserve from June to November 2012.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-12-05 doi:10.26008/1912/bco-dmo.884362.1 [view at BCO-DMO]

Kimbro, D. L., White, J. W., Tillotson, H. G. (2023) **Juvenile oyster condition index from risk-addition experiment conducted on oyster reefs in the Guana Tolomato Matanzas National Estuarine Research Reserve from June to November 2012.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-12-28 doi:10.26008/1912/bco-dmo.885817.1 [view at BCO-DMO]

Kimbro, D. L., White, J. W., Tillotson, H. G. (2023) **Juvenile oyster survival from risk-addition experiment conducted on oyster reefs in the Guana Tolomato Matanzas National Estuarine Research Reserve from June to November 2012.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-12-13 doi:10.26008/1912/bco-dmo.885259.1 [view at BCO-DMO]

Kimbro, D. L., White, J. W., Tillotson, H. G. (2023) **Oyster recruitment from risk-addition experiment conducted on oyster reefs in the Guana Tolomato Matanzas National Estuarine Research Reserve from June to November 2012.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-01-10 doi:10.26008/1912/bco-dmo.885720.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
site	site identification (PF, SIN, ML)	unitless
latitude	latitude of study site North	decimal degrees
longitude	latitude of study site East (West is negative)	decimal degrees
treatment	treatment designations: MC (mud crab), CC (crown conch), MC+CC (mud crab first, then crown conch) and NP (no predator cue)	unitless
tile_type	culling treatment applied (No.cull, Juv.cull, Adult.cull, Juv.Adult..cull)	unitless
cage_number	unique identification given to each experimental cage. Each experimental unit consisted of a focal oyster cage (18 cm x 13 cm x 18 cm) centered between two opposing smaller cages for predators (13 cm x 13 cm x 13 cm)	unitless
tile_number	unique identification given to each tile, with multiple tiles occurring in each experimental cage	unitless
mean_size_start	average size of individual oysters on tile at the time of initial deployment	millimeters (mm)
mean_size_mid	average size of oysters on tile at the time of harvest (1 month after deployment)	millimeters (mm)
growth	difference between mean_size_end and mean_size_start	millimeters (mm)

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	calipers
Generic Instrument Description	A caliper (or "pair of calipers") is a device used to measure the distance between two opposite sides of an object. Many types of calipers permit reading out a measurement on a ruled scale, a dial, or a digital display.

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Project Information

Collaborative research: Quantifying the influence of nonconsumptive predator effects on prey population dynamics (Predatory NCEs and Scale)

Coverage: Sub-tropical estuarine waters (29.67,-81.21)

NSF Award Abstract:

Predators can affect populations of their prey in two ways: by consuming them ("consumptive effects" or "CE"s), or by causing the prey to change behavior to avoid contact with the predator. For example, prey often spend less time feeding and more time watching out for predators, which comes with the cost of lower food intake and thus slower growth. Such "non-consumptive effects" (NCEs) have been described for a wide range of terrestrial and marine prey species, from elk to clams, but mostly in short-term (< 1 month) experiments. These prior results suggest that in some cases, the behavioral changes (NCEs) have a bigger effect on prey populations than consumption by predators (CEs). However, those short-term, controlled experiments may artificially inflate the perceived importance of NCEs. Over longer time periods, prey may adapt or become acclimated to predation risk, and NCEs may become less important. Additionally, environmental variability (e.g., differences in the availability of the prey's food between study sites) may have a bigger effect on prey populations than NCEs do. This project will use a combination of short- (months) and long-term (years) field experiments and mathematical models to evaluate the role of NCEs on Florida oyster reefs. The prey species in this study is the eastern oyster, an important marine resource in the southeast US for harvesting and habitat creation; the main oyster predator is a mud crab. In this study, results from mathematical models of oyster populations will be compared to experimental data from the field to see whether including NCEs in the model leads to better model predictions. Better understanding of NCEs in oysters should improve management of that important marine resource. Furthermore, the mathematical model will be used to develop broader, generalizable conclusions about the importance of NCEs that could be applied to other important prey species. This project will provide data useful for oyster resource management, will support public education regarding the ecological importance of NCEs, and will enhance the scientific engagement of underrepresented groups in the study region. The project will support a partnership with the Guana Tolomato Matanzas National Estuarine Research Reserve in Florida, including data sharing, sponsoring an oyster management symposium, and funding the development of multimedia scientific outreach materials at the reserve that will be used by a large and diverse population of K-12 students in the surrounding community. The project will train a postdoctoral researcher, two graduate students, two undergraduate students, and research results will be disseminated by those students and the principal investigators at scientific conferences, in journal publications, and in online content through an ongoing partnership with a Florida public television station.

Predators can alter prey population dynamics by causing fear-based shifts in prey traits (nonconsumptive effect, NCE). The importance of NCEs for prey populations - relative to direct consumption by predators (consumptive effects, CEs) - remains uncertain, particularly because short-term studies of NCEs cannot estimate their effect over multiple prey generations. This project addresses that knowledge gap by combining short- and long-term field experiments with population models to investigate the importance of NCEs on oyster population dynamics in a Florida estuary. The central question is whether accounting for NCEs improves the ability to predict long-term trends in oyster population abundance. Several types of NCEs are present in this system: exposure to water-containing predator odors reduces oyster larval recruitment and causes juvenile oysters to increase shell thickness, reducing their somatic growth. In addition to CEs and NCEs, environmental gradients in stress, food, and propagule delivery are also present in this system. Those environmental factors can have strong effects on post-settlement survivorship, growth, and recruitment of oysters, so the relative importance of predator CEs and NCEs may vary along those spatial gradients as well. This project will consist of four components. (1) A series of short-term field experiments to test how NCEs vary with predator density and environmental variables, and whether one of the NCEs (increased shell thickness) actually reduces vulnerability to predators. (2) A population model, parameterized using experimental results; model simulations will quantify how the relative importance of NCEs should vary over time, space, and environmental gradients. (3) A longer-term (3.5 year) field experiment; the results from this experiment will be compared to model predictions to test whether accounting for NCEs improves predictions of long-term variation in oyster population dynamics. (4) A general form of the model will be developed to broadly investigate the effect of NCEs on non-equilibrium, transient population dynamics. By combining models and field experiments, this project will bridge the gap between the theoretical understanding of how NCEs affect population dynamics and empirical tests of that theory, advancing the field towards the goal of predicting how multiple interacting factors structure communities.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1736943
NSF Division of Ocean Sciences (NSF OCE)	OCE-1820540

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