Oyster drill functional eradication field study - caging outplant experiment in San Francisco Bay from 2017-2018

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Project
» Investigating mechanisms underlying adaptive capacity to ocean warming (URO)

Contributors	Affiliation	Role
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Abstract
Established non-native species can have significant impacts on native biodiversity without any possibility of complete eradication. In such cases, one management approach is functional eradication, the reduction of introduced species density below levels that cause unacceptable effects on the native community. In this project we evaluated the potential for functional eradication of introduced predatory oyster drills (Urosalpinx cinerea) using a community science approach in San Francisco Bay. We combined observational surveys, targeted removals, and a caging experiment to evaluate the effectiveness of this approach in mitigating the mortality of prey Olympia oysters (Ostrea lurida), a conservation and restoration priority species. This dataset describes a field outplant experiment designed to evaluate the effectiveness of the eradication efforts.

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Coverage

Location: Richardson Bay, San Francisco Bay, CA, USA, intertidal rocky shore and mudflats
Spatial Extent: **N**:37.9 **E**:-122.47 **S**:37.86 **W**:-122.51
Temporal Extent: 2017-01-01 - 2018-12-31

Methods & Sampling

Site selection

To quantify the relationship between oyster drills and native oysters, we established eight intertidal field sites in Richardson Bay, CA. Of these sites, we further focused on a subset of four sites, establishing two sites for community science-based oyster drill removals and two sites as paired controls. One of our removal sites, Lani's Beach (hereafter Lani's) was selected because of easy access, high public use, and because it is valuable to the community due to its use in outdoor educational programs at the immediately adjacent Richardson Bay Audubon Center & Sanctuary. Lani's was paired with a control area that was separated by 50 m along shore (Cheng et al. 2021; Fig. 1, Supplementary Information S1). Second, we used two sites located on Aramburu Island because of extensive habitat restoration activities that were completed by the Audubon Society in 2010. The Aramburu removal and control sites were separated by * 140 m along shore.

Benthic sampling

To quantify the abundance of *Urosalpinx* and its relationship to native oysters, we conducted quadrat surveys at each of the eight field sites. At each site, we established a permanent 30 m transect at 0.5 m above mean lower low water (MLLW). Along each transect, we censused all oyster drills and oysters at the surface and by overturning all stones within 10 randomly distributed 0.5 x 0.5 m quadrats. Quadrats were randomly stratified such that five were conducted between 0 and 15 m of the transect and the remaining five occurred between 15 and 30 m. For each site, surveys occurred two to five times (20–50 quadrats, mean = 40.5 quadrats) during the low tides of summer, fall, and winter of 2017 and spring and summer of 2018.

Functional eradication of drills

At each removal site, we established a 60 m swath of shoreline (along shore) from the lower mud zone to the upper barnacle zone (approximately 15 m across shore) to serve as the focal area for removals. For the removal sites, the 60 m total swath included the 30 m fixed transect with additional 15 m buffer zones on each side (along shore). Paired with each eradication site, we established a similar swath of shoreline to serve as a control area except snails were not removed from these areas. Control and removal zones were also separated by stretches of shoreline that did not have hard substrate, potentially limiting the movement of oyster drills. All areas were marked with stakes for the duration of the experiment. We organized drill removal events, inviting members of the public to assist us in finding and removing drills. To increase community participation, we scheduled drill removals on weekends and only during daylight low tides. In 2017, we organized four removal days at Lani's and three at Aramburu; in 2018, we held three removal days at each location. Between 20 and 35 people participated at each event and were provided project background and training prior to removal efforts. Teams then worked for 1–2 h, removing snails by hand from the focal areas described above. Teams also searched for snails on the surface of the mud, but these were rarely found. To ensure complete spatial coverage of the removal area, we divided removal and buffer areas into * 2 m wide swaths running perpendicular to shore and assigned volunteers to these zones. Collected snails were taken to the Smithsonian Environmental Research Center's Tiburon, CA laboratory (housed at the Estuary and Ocean Science Center, San Francisco State University) and frozen.

Oyster outplant experiment

To determine whether snail removal efforts were sufficient to increase oyster survival, we conducted a field caging experiment in July 2018. This experiment also allowed us to determine whether the physical conditions at each site were able to support oyster survival and growth in the absence of oyster drills. First, we constructed experimental units by attaching 8–10 hatchery reared Olympia oysters (Puget Sound Restoration Fund, California Department of Fish and Wildlife Permit #2018–5211, mean oyster count = 9.8, SD = 0.42, mean oyster size = 0.71 cm2, SD = 0.22 cm2) with cyanoacrylate glue to ceramic wall tiles (Daltile model RE1544HD1P4, 10.6 x 10.6 cm). Tiles were individually numbered and held in flow-through seawater tables for two days to verify secure attachment between oysters and tiles. The tiles were also photographed prior to deployment to evaluate potential differences in oyster size. We then randomly assigned tiles to one of three treatments: (1) uncaged, fully exposed to predators; (2) caged, no exposure to predators; (3) cage controls. Cages were made of polyethylene aquaculture netting (Memphis Net and Twine PN3, 62.5 mm mesh), wrapped with plastic window screening (Phifer BetterVue Screen, 1 mm mesh), which improved the exclusion of oyster drills in pilot experiments. The cage controls were designed to evaluate cage artifacts, such as shading and reduction of water flow. Cage controls were identical to the caged treatment except for openings (2.5 x 5 cm) that were cut into each cage, which allowed drills access to oysters. Tiles and cages were installed facing horizontally, attached with plastic cable ties to bricks, which were in turn attached to metal rebar driven into the substrate. The bricks were used to keep the experimental units upright and secured to the rebar. Experimental units were randomly stratified by caging treatment type along the +0.5 m MLLW tidal elevation within each removal and control zone at our two field sites (8 replicates x 3 cage treatments x 2 eradication treatments x 2 sites = 96 experimental units). Tiles and cages were checked one day after deployment (after exposure to two periods of submergence by high tide) to confirm cage integrity. After 30 days of exposure to field conditions, we recovered 95 of 96 experimental tiles (one uncaged tile was lost) and returned them to the laboratory where each was photographed and examined under a dissecting microscope for signs of predator induced mortality (i.e., bore holes from oyster drills). Of the 32 caged tiles, we excluded 4 from analysis because predator exclusion cages were compromised, allowing entry by oyster drills. Oysters were recorded into one of four categories: alive, dead, drilled, or missing. Oysters were scored as alive if the valves retracted upon tapping with a probe. If oyster valves were tightly closed and resistant to tapping, we forced valves open, revealing tissue (alive) or lack thereof (dead). Oysters were classified as dead if no body tissue was found in valves or if the upper valve was not present but the lower valve remained. Oysters were scored as drilled if a bore hole was evident in one of the oyster valves and no body tissue remained.

Data Processing Description

Oyster growth was measured using ImageJ by hand drawing polygons around oyster shells.

BCO-DMO Curation Notes

This section documents curation actions performed prior to publication review with the submitter, and additional information relevant to understanding and reusing this dataset. It distinguishes changes made to the submitted (meta)data from unresolved issues and/or enhancements that improve future reuse and interoperability.

CURATION ACTIONS PERFORMED ON DATA

- Loaded "Counts" sheet from Benthic survey Richardson Bay COUNTS 11 Sept 2018 cjz BSC BCO-DMO.xlsx, header row 1, named table benthic_survey_counts; set missing values to "", "nd", "na", "N/A", "NA"
- Renamed columns with disallowed characters: cover.boxes to cover_boxes, live barn (squares) to live_barn_squares, dead barn (squares) to dead_barn_squares, drill eggs (squares) to drill_eggs_squares
- Converted Date column from MM-DD-YY display format to ISO 8601 date (YYYY-MM-DD), overwriting original Date column
- Extracted non-numeric annotated values (e.g. "1 77 mm", "photo") from mussel, live_barn_squares, and dead_barn_squares columns into new companion columns mussel_flag, live_barn_squares_flag, dead_barn_squares_flag, leaving original cells blank for those rows, to allow the count columns to be typed as integer without losing annotation data
- Output as 1006955_v1_benthic_survey_counts.csv

CURATION ACTIONS PERFORMED ON METADATA

- BCO-DMO's standard metadata entry and text formatting steps were performed. See: https://www.bco-dmo.org/how-to/standard-curation-edits

ISSUES POTENTIALLY IMPACTING REUSE

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Problem Description

No known problems with the data

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Related Publications

Cheng, B. S., Blumenthal, J., Chang, A. L., Barley, J., Ferner, M. C., Nielsen, K. J., Ruiz, G. M., & Zabin, C. J. (2021). Severe introduced predator impacts despite attempted functional eradication. Biological Invasions, 24(3), 725–739. https://doi.org/10.1007/s10530-021-02677-3
Results

Schneider, C. A., Rasband, W. S., & Eliceiri, K. W. (2012). NIH Image to ImageJ: 25 years of image analysis. Nature Methods, 9(7), 671–675. https://doi.org/10.1038/nmeth.2089
Software

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

Investigating mechanisms underlying adaptive capacity to ocean warming (URO)

Coverage: Coastal marine waters of western Atlantic ocean from 31 to 44 degrees latitude N

NSF Award Abstract:
Understanding how marine life copes with drastically different environmental conditions now and into the future is essential for the management and conservation of biodiversity in the ocean. One complicating factor is the observation that populations within a given species are often fine-tuned to the environment that they live in. Yet, it is often unclear what components of the environment create these differences across populations. This project focuses on Atlantic oyster drills, a predatory snail that consumes farmed and wild oysters on the Atlantic coast of North America, the location of one of the strongest temperature gradients in the world. The investigators combine field and laboratory studies to understand how differences in temperature affect the growth and survival of oyster drills sourced from populations throughout their range. This information is paired with molecular analyses to help determine genetic and physiological differences among populations. In addition to benefitting oyster reefs, this information broadly contributes to the understanding of how marine life will respond to rapidly changing environmental conditions. The project also supports the education and marine science training of students at the undergraduate, graduate, and postdoctoral level. In partnership with the non-profit organization Waterstrong, the investigators will provide marine science and swimming skills training to thirty girls from historically underrepresented groups.

Predicting how marine communities will respond to rapid environmental change is difficult because species responses can vary across populations and because organisms may evolve over time. Knowledge of how such evolutionary potential arises and is maintained is limited. A useful approach for examining species response to environmental change is to investigate how species have locally adapted to environmental differences across their range. This project tests competing mechanisms that can generate countergradient variation (CnGV; a widespread form of local adaptation) in an ecologically important marine species (Atlantic oyster drill, Urosalpinx cinerea). The objectives of this integrative research are to 1) quantify the strength of seasonality and mean temperature in generating CnGV and to 2) identify if these responses are correlated across biological traits using a combination of field sampling and common garden experimentation. These objectives are complemented with a molecular approach that 3) quantifies neutral genetic structure across populations and 4) identifies the roles of genetic adaptation and transcriptional plasticity in facilitating physiological adaptation to environmental change. The proposed work is significant because it provides a novel test for different environmental drivers of a commonly observed form of local adaptation. This research also reveals the genetic underpinnings of how such local adaptation arises and will give insight into the adaptive capacity of organisms to rapid change.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Other project information:
Further information about this project and related work can be found on the UMass Amherst website "MARINE GLOBAL CHANGE ECOLOGY" (http://bscheng.com).

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023571

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