Text S1. Study Sites

Justification for Timing of Egg Surveys

We surveyed eggs in April 2022 for Southern California sites and in June 2022 in Northern California according to peak laying seasons given that whelks reproduce seasonal and across latitudes (Spight & Emblem 1976, Spight 1975, Bean 2012). *M. lugubris* eggs are typically deposited in early spring to mid summer in Southern California (P. Wallingford, personal correspondence). We also began monitoring unofficially for egg masses at our local site in Thousand Steps Beach, Laguna Beach, California beginning in February, observing egg deposition beginning in late March into early April. For *A. spirata,* the laying season spans from spring to early summer in Southern California, laying slightly later in the season in Northern California (K. Monuki, J. Sones, & J. Bean, personal correspondence). Bean (2012) observed *A. spirata* depositing eggs usually between June and August in Northern California, hatching in through the summer (Bean 2012). Additionally, *A. spirata* egg masses take 40-50 days at 10˚C, representative of Northern California temperatures, and between 30-40 days at 16˚C, representative Southern California temperatures (K. Monuki unpublished data). Preliminary opportunistic measurements of *M. lugubris* egg mass development in the lab took 30+ days until hatching. Therefore, egg masses persist in the field for a few weeks to potentially months and are likely to be spotted in our surveys conducted during the peak seasons.

Text S2. Surveys of whelk population size and fecundity

Preliminary trials and justification for approach

We used two approaches for surveys including (1) transect quadrats and (2) 1 hr counts. For transect surveys, we started by laying out a 25-m horizontal transect (parallel to the waterline) with 5 vertical transects sited at random points and extending to the waters' edge (perpendicular to the waterline). Horizontal transects were placed at the top of the barnacle zone of the top of the intertidal zone. Along vertical transects, 0.25 x 0.25 m (0.0625 m2) quadrats were laid on the northside of the vertical transects. Eggs inside quadrats were recorded. However, only 13 of the 103 egg masses recorded were found via quadrat surveys. The quadrat counts were inadequate given the patchiness and crypticness of egg masses. Thus, we used 1 hr timed count similar to Sorte & Hofman (2004) and Wallingford & Sorte (2022) with trained observers at each site.

Text S3. Case Study at Thousand Steps Beach, Laguna Beach, CA

Site selection

Thousand Steps Beach was chosen due to the high density of whelks (between 4-5 per m^2; Wallingford & Sorte 2022). Loggers were placed across the intertidal zone recorded temperatures every 30 min and replaced every two weeks throughout the laying season from March 2022 to July 2022. We surveyed for egg masses 8 times about every 2-3 weeks across the egg laying period, starting in March 2022 to July 2022

Thermal tolerance trials

Larvae were also photographed under the microscope (Axio Lab. A1, 910 magnification, Zeiss, Carl Zeiss Microscopy, LLC, White Plains, NY, USA, University of California, Irvine) using Zeiss Zen 2 program. The average larval size (longest length, mm) for N=10 subsample was calculated from microscope photos using ImageJ.

Capsules collected were transported directly to the lab in a cooler to conduct tolerances assays. We placed 3 larvae per capsule in seawater filled 1.5 mL plastic centrifuge tubes. For each capsule, we had a total of four tubes (subreplicates) which were randomly assigned to each of the following treatments: control, 32°C, 35°C, 38°C, and 40°C. Temperatures represented thermal conditions experienced by egg capsules in the field (Fig. S2) and measured at intertidal sites in the region (Wallingford & Sorte 2019, Pandori & Sorte 2021). Our goal was to use the narrowest range of temperatures that would yield the full range of outcomes (0% to 100% survival) for individuals, allowing us the most sensitivity to estimate LT_{50} (50% survival).

We poked holes in the tube caps and heated tubes to treatment temperatures from room temperature (~21–22°C) using heat blocks at a heating rate of 0.1°C/min. Treatment temperature was recorded every 1 min by Omega HH506RA logging thermometers. Larvae were exposed to treatment temperatures for a ramp up period, 1 h exposure, and followed by a 1 h recovery period at ambient ocean temperature (~10°C) before survival was evaluated. Snail larvae were considered dead if no movement was detected.

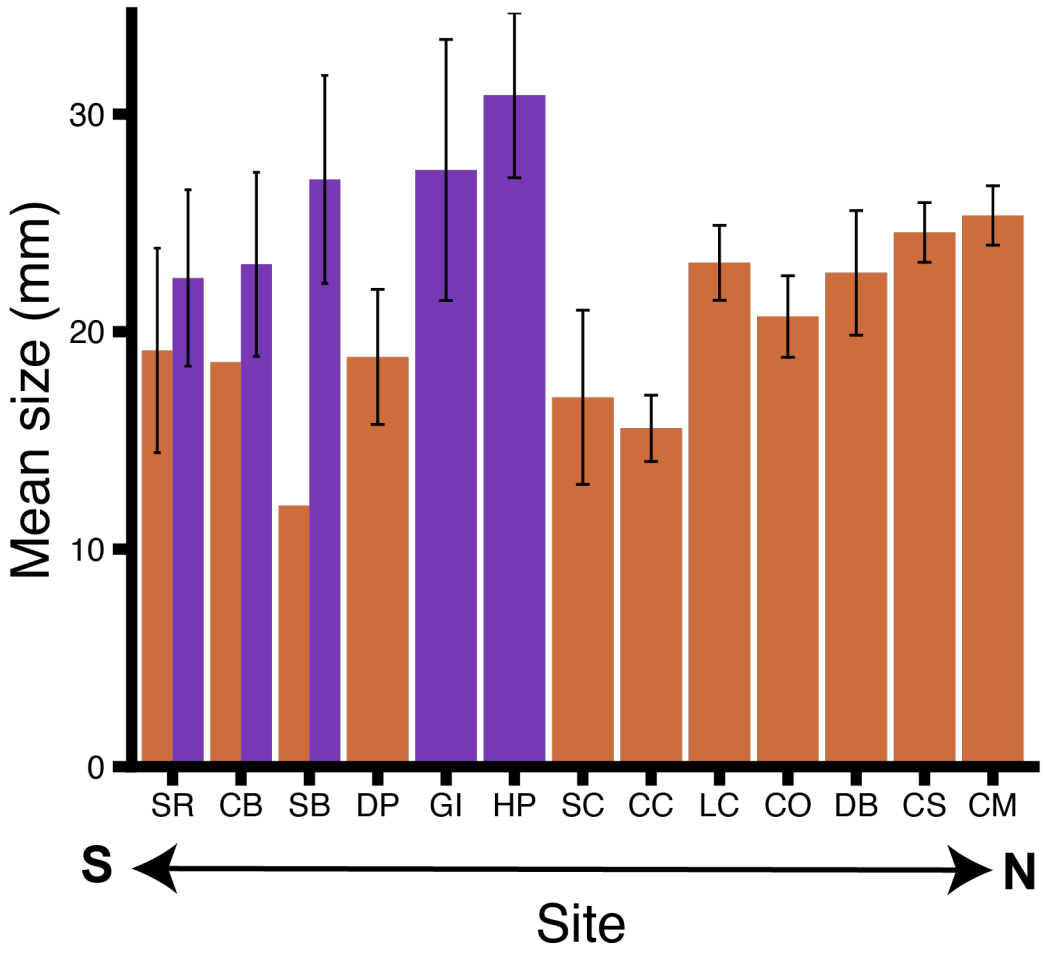

Figure S1. (A) The mean size (mm) ± standard deviat1ion of *A. spirata* (orange) adult whelks and (B) *M. lugubris (*purple) adult whelks at each site found per hour survey (*A. spirata*: GLM t=-14.30, df=326, P<0.0001; *M. lugubris*: GLM t=4.12, df=116, P<0.0001).

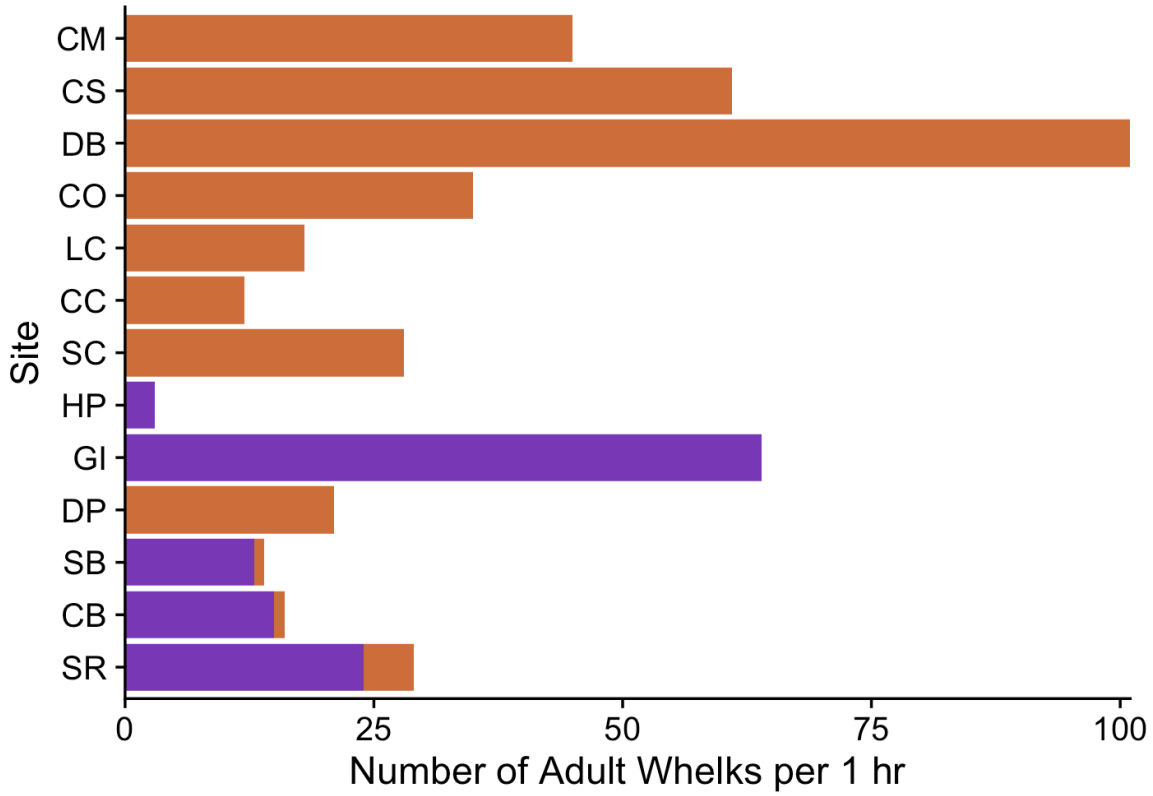

Figure S2. The number of adult whelks per 1 hr across sites south (bottom) to north (top). Adult whelk abundances increased with latitude for *A. spirata* (GLM; t=3.716, df=10, P=0.005) but not *M. lugubris (*t=0.550, df=4, P=0.621). Purple = *M. lugubris,* orange = *A. spirata*.

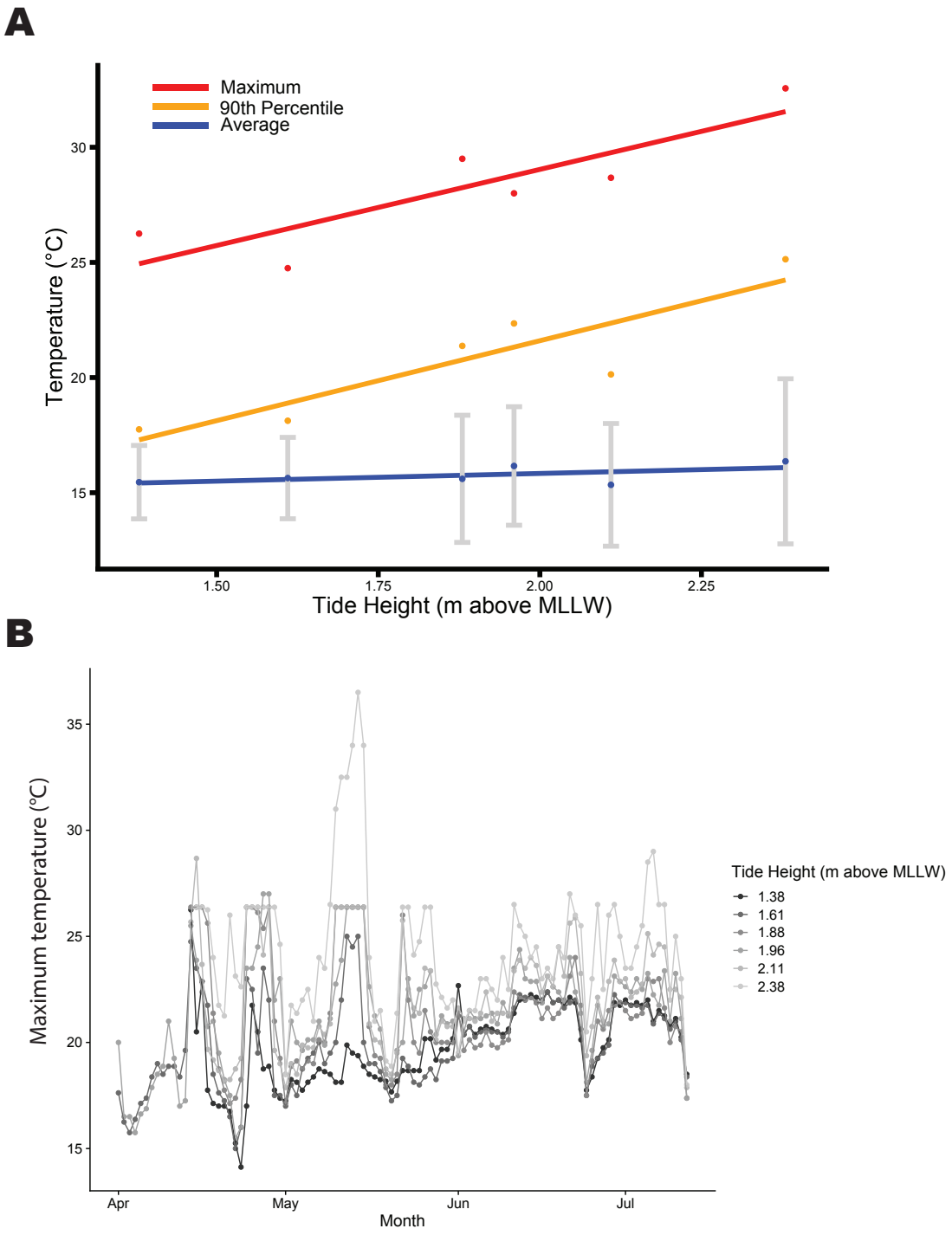

Figure S3. (A) Maximum temperature (red line), 90th percentile temperatures (yellow), and average temperatures (blue ± SD) across tide heights over study period April - July 2022. (B) Daily maximum temperatures from April – July 2022 across tide heights. Daily maximum temperatures vary significantly across tide heights (GLM; t=21.035, df= 23, P<0.001).

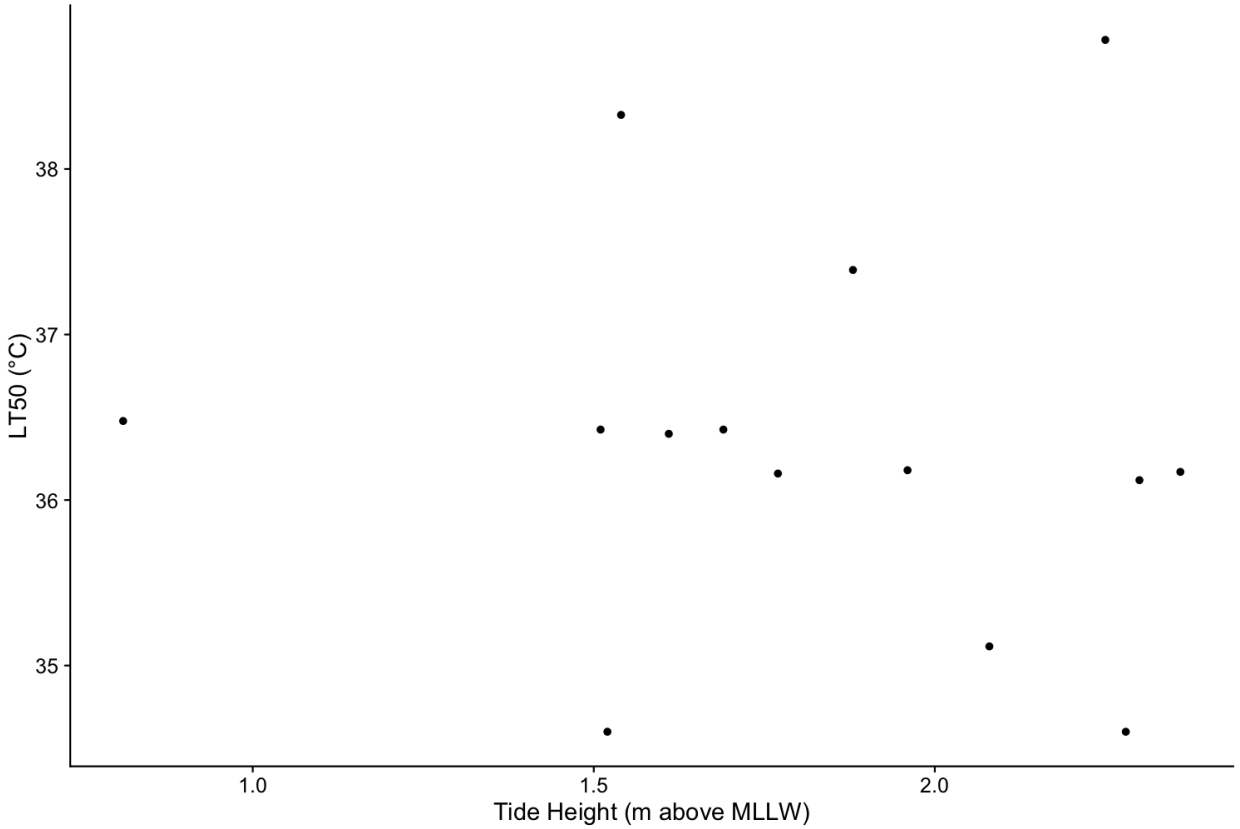

Figure S4. Larval LT_{50} did not significantly vary across tide height (GLM t=-0.232, df=13, P=0.821). Values presented are the LT_{50} (temperature at which 50% of individuals die) values for precompetent whelk larvae at Thousand Steps Beach in Laguna Beach, California, USA.

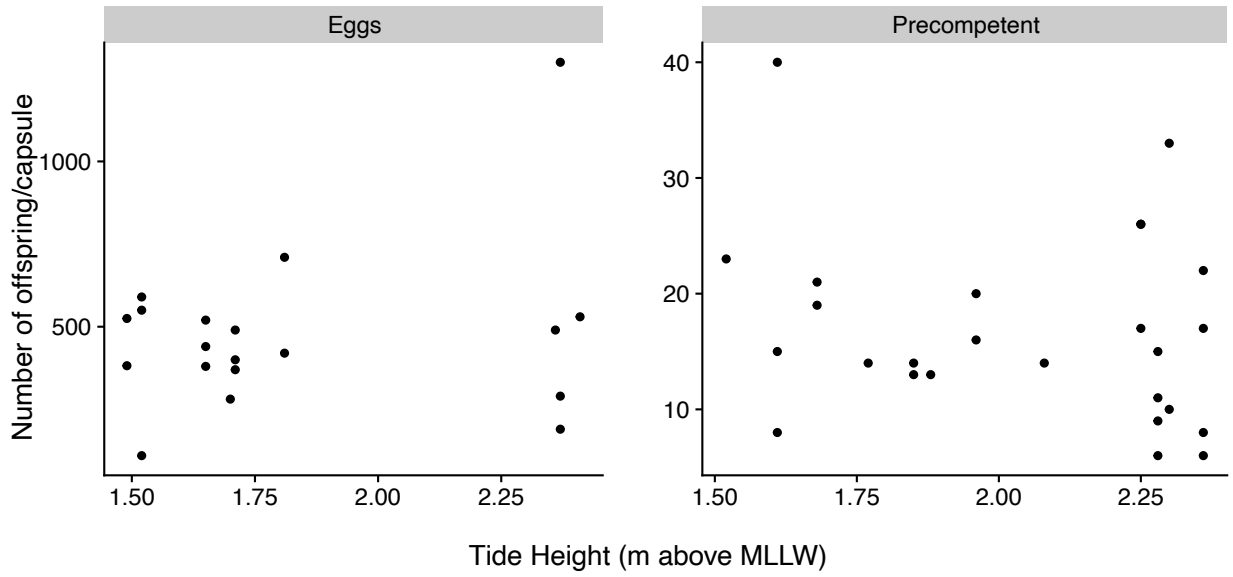

Figure S5. Number of offspring per capsule across tide heights for *Mexacanthina lugubris* at Thousand Steps Beach, Laguna Beach, CA. We did not find significant relationship between number of eggs (GLM using gamma distribution P=0.296, df=17) or precompetent larvae (GLM using gamma distribution P=0.289 df=24) across tide height.

Literature Cited

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