Supplement

The original data and code for this paper can be accessed at:
https://github.com/GCov/Covernton-and-Harley-2019

Text S1

Experimental Setup: Encapsulated Embryos

We collected the egg capsules for a specific replicate from different naturally occurring clusters to increase genetic diversity within a replicate. For each replicate, we placed five egg capsules into paper tea bags, secured with a paper clip in twenty 600 mL glass beakers. We used a loop of cable tie to separate the inner walls of the tea bags and thus create an incubation space. Four replicates each of five salinity treatments (9, 12, 15, 20, and 25 psu) were prepared by diluting seawater with dechlorinated water and filling the beakers. Gradual change in salinity can reduce short-term physiological stress of encapsulated gastropod embryos, so we dropped salinities stepwise from 31.5 psu to 25, 20, 15, 12, then 9 psu, every 15 minutes, depending on treatment. We then partially submersed the beakers in a seawater table at 12°C in four blocks of five beakers in raised plastic containers with mesh sides to allow flow around the beakers for temperature control. We aerated the beakers by bubbling in ambient air and covered them loosely with parafilm to minimize evaporation. We checked salinity and adjusted it regularly, with weekly seawater changes and rotations of beaker placement within block every two weeks. The salinities in each beaker tended to shift upwards between adjustments due to evaporation, with an average shift between adjustments of ~1 psu in all beakers. We checked the egg capsules for signs of stress for a total of 77 days and regularly replaced their tea bags as they would begin to degrade over time.

Experimental Setup: Adults and Juveniles

For this experiment, we partially submersed four blocks of three 20 L glass tanks in a seawater table system at 12 °C. In each block we randomly assigned treatments of high salinity (20 psu), low salinity (9 psu), and a variable salinity (9 psu with 3-hour exposure to 20 psu every 24 hours) treatment. To prevent clumping of body sizes within replicates, we separately sorted Tower Beach South adults, White Rock adults, and White Rock juveniles (repeated for each population/age class) into 12 groups based on ascending shell length. We then selected one individual from each group at random and placed it into a plastic container. We repeated this procedure to fill 12 containers for each size and population class, generating a total of 36 containers holding *N. lamellosa*. We covered each plastic container with a lid including a mesh-covered hole to allow for water circulation. We assigned a container from each of the three size and population classes to one each of the twelve 20 L tanks. Each tank thus held 8 Tower Beach South adults, 11 White Rock adults, and 12 White Rock juveniles in 3 separate containers. To prevent fouling, we changed the seawater twice a week in all tanks via 8 L (40%) replacement with fresh, appropriately diluted seawater. For the variable salinity treatment, we also held four 20-L glass tanks containing 20 psu seawater in the seawater system for the duration of the experiment. 21 hours following initiation of the experiment and every 24 hours thereafter, we randomly transferred all three containers from each of the variable salinity treatment replicates to one of the four 20 psu tanks, left them for 3 hours, and then returned them to their original tank. During the 3-hour period, we briefly removed all other containers from their tanks and checked them for mortality, thus standardizing handling. Before returning the containers to their home tanks, we also checked the *N. lamellosa* in the variable salinity treatment for mortality.

High-resolution field salinity data

To better understand temporal patterns of salinity in the field, we mounted a salinity logger (Star Oddi) in the very low intertidal zone on the wooden breakwater enclosing the Royal Vancouver Yacht Club, Jericho, located ~300 m west of the Dunbar Street survey location. The logger recorded salinity at 30-minute intervals for approximately one full lunar cycle from 12 May 2009 through 5 June 2009. The Fraser River freshet in 2009 peaked at 7,490 m^3s^{-1} on June 20th; this peak was lower than the long-term 1912-2016 median peak of 8,470 (data from Environment Canada, https://wateroffice.ec.gc.ca).

We plotted the high-resolution salinity data in Fig. S2, along with predicted tide data from Point Atkinson (Xtide, available from tbone.biol.sc.edu/tide). Note that the salinity logger, when emersed during extreme low tides, recorded a salinity of zero. We trimmed these false zeros from the data. Brief spikes of high salinity were associated with higher high tides when the freshwater lens lifted above the fixed position of the logger. This general pattern formed the basis for our salinity rescue treatment in the *Nucella* survival trials (see main text). Note that the salinity values used in that experiment (20 and 9 psu) are lower than the values recorded at Jericho in 2009 (a high of ~28 and a low of ~11). Nevertheless, we feel that the experimental values are realistic, especially for sites nearer to the Fraser River mouth or years with higher outflow values. We also note that our rescue salinity of 20 is conservative; higher salinities may apply during natural high tide 'rescue', which may further enhance *Nucella* survival.

Historical Salinity at Tower Beach South

To determine changes in annual and interannual salinity fluctuations near the mouth of the Fraser River, we predicted daily salinities from 1986 to 2016 using the site-level salinity model and historical Fraser River outflow data. A number of characteristics were then tested in relation to year to determine what long-term changes in salinity have occurred, including number of days in a year where salinity dropped below 15 psu, number of days below 9 psu, the minimum salinity reached in a year, the salinity mean in a given year, the number of days into a year at which the minimum salinity occurred, the variance in yearly salinity, and the salinity stress metric. We used linear models were to test these relationships for all variables. Minimum salinity data were natural log plus one-transformed to increase normality. None of the variables changed significantly with year (Fig. S3).

Table S1: Lat/long coordinates for all sites.

Site	Salinity	Lat	Lon
Tower Beach South	Low	49° 16' 18" N	123° 15' 41" W
Tower Beach North	Low	49° 16' 28" N	123° 15' 26" W
Dunbar	Low	49° 16' 24" N	123° 11' 00" W
Waterloo	Low	49° 16' 22" N	123° 10' 40" W
Kitsilano Point	Low	49° 16' 40" N	123° 09' 10" W
Point Atkinson	Low	49° 19' 49" N	123° 15' 55" W
Weston Park	Low	49° 19' 44" N	123° 10' 22" W
Navvy Jack Point	High	49° 19' 37" N	123° 10' 08" W
Figurehead Point	High	49° 18' 12" N	123° 07' 35" W
White Rock	High	49° 01' 53" N	122° 52' 33" W
Yellow Point	High	49° 02' 36" N	123° 45' 07" W

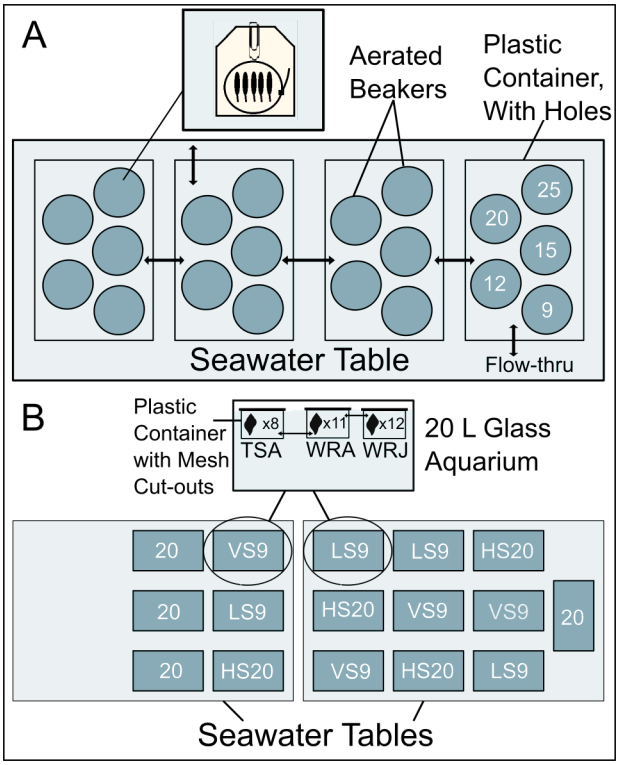

Figure S1: Experimental setup for the *Nucella lamellosa* salinity tolerance experiments conducted on A) encapsulated embryos and B) adults and juveniles. In A, the five salinity treatments (9, 12, 15, 20, and 25 psu) were replicated in beakers (circles) across four 'blocks' of plastic containers, which were in turn placed in a recirculating seawater table. The plastic containers had holes in their sides to allow circulating seawater to keep consistent temperatures within the beakers. Within each beaker and using a paperclip, we secured a teabag holding 5 *N. lamellosa* egg capsules and held open with a loop of cable tie. In B, 20-L glass aquaria were used to replicate the three treatments; LS9 = low salinity at 9 psu, HS20 = high salinity at 20 psu, and VS9 = variable salinity at 9 psu with daily 3-hour placement in to the 20 psu tanks (labelled '20'). The aquaria were placed into 4 'blocks', seen as columns here, with the 3 treatments randomly distributed within each block. We placed the aquaria within two adjoining recirculating seawater tables to support consistent temperatures within. Within each experimental tank, three floating plastic containers, with mesh-covered holes in their sides and tops to allow for water flow, containing each of 8 Tower South adults (TSA), 11 White Rock adults (WRA), or 12 White Rock juveniles (WRJ).

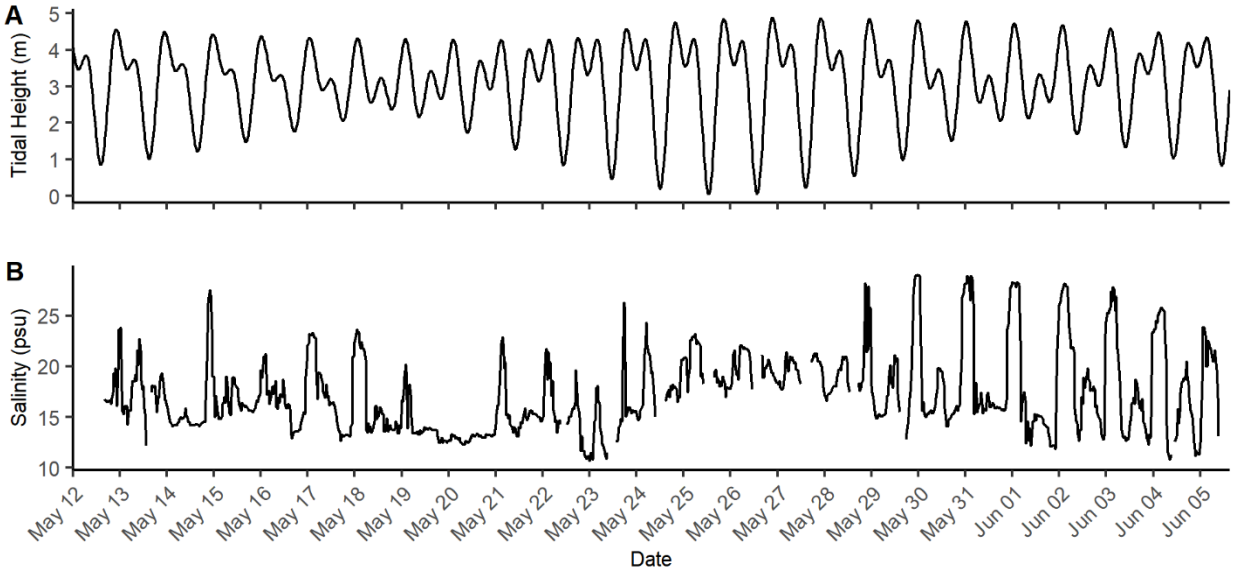

Figure S2: Plots showing A) tidal height as recorded at Point Atkinson, and B) salinity as recorded at Jericho via salinity logger during the period of May 12-June 5, 2009. Breaks in salinity represent points where the logger was exposed to the air during an exceptionally low tide.

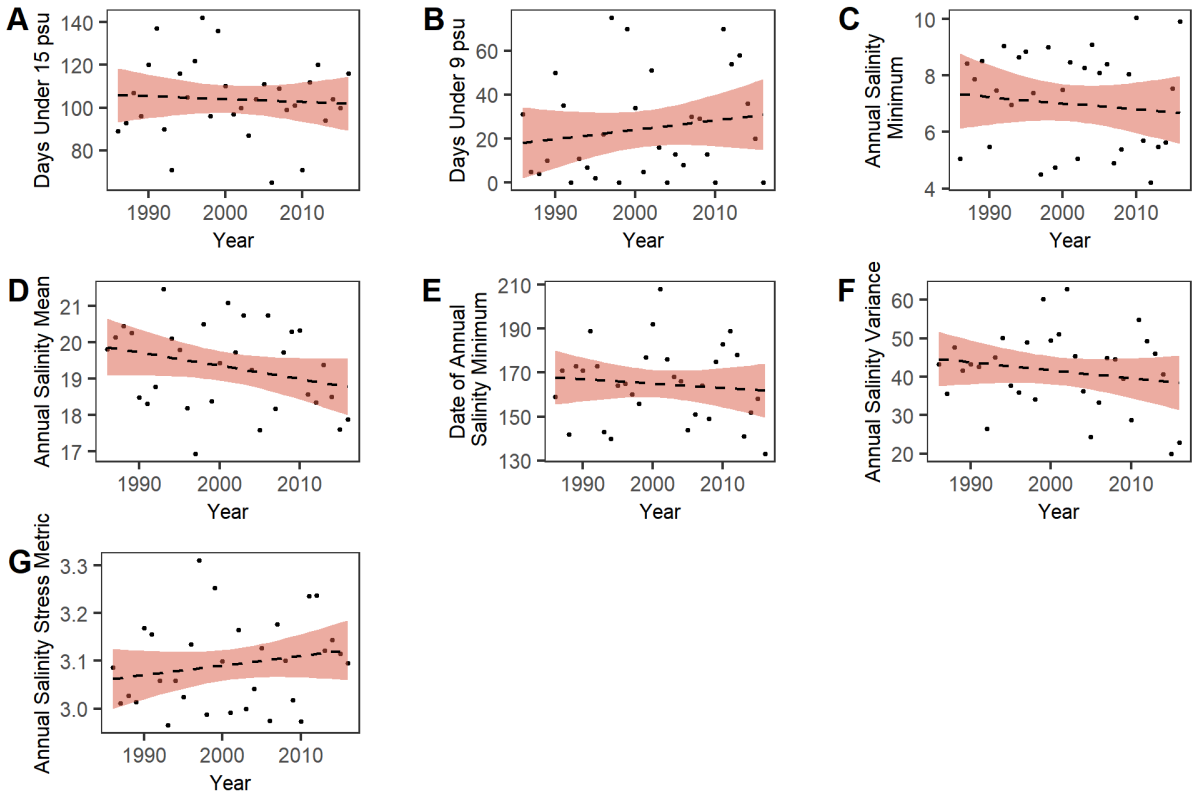

Figure S3: Plots showing A) annual days under 15 psu, B) annual days under 9 psu, C) Annual salinity minimum, D) annual salinity mean, E) date of annual salinity minimum, F) annual salinity variance, and G) annual salinity stress metric as predicted at Tower Beach South using historical Fraser River outflow data. The ribbons show 95% confidence intervals of the model predictions.