Essential Fish Habitat project status report

Reporting date: 10/22/2012

Project number: 2012-1

Title: The role of benthic habitat in larval rock sole settlement dynamics – Yr 2 of 2

PIs: B.J. Laurel and A.W. Stoner

Funding year: 2012

Funding amount: $42,740

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: This is the 2nd year of a proposed a 2-yr project that initially received HEPR funding in 2011. In 2012, both lab and field components were added to complement 2011observations and experiments. All proposed milestones were met. These included:

1. Strip spawn N. rock sole broodstock Apr 12
2. Laboratory experiments using reared rock sole May-Jun 12
3. Field survey #1 May 12
5. Field survey #2 Jul 12
7. Field survey #3 Aug 12
8. Analysis (video, lab and field catch data) and write-up Sept 12-

Field data processing (baited camera, fish IDs and lengths from net samples) have all been processed, but the data are still being compiled. All laboratory experiments were conducted by two NSF-REU students (Tara Zimmerman and Mary Kate Swenarton) during the summer of 2012. Students completed all proposed experiments related to the 2012 HEPR projects in addition to several complementary experiments examining oceanographic processes controlling settlement in the nursery. These included examinations on the effects of temperature and thermoclines on dispersal and settlement rates using large flume tanks and the Newport laboratory 'Big Tank' (2.5m x 2.5m x 2.5 m) where vertical position, behavior, and settlement rates could be observed. Results from 2012 were reported to the HMSC REU chair and HMSC community in the form of oral presentations on the final day of the internship. Two manuscripts are anticipated from these experiments by FY14.

Results: What is the most important result of the study?

H1: Movement into favorable, deepwater habitats is restricted by limited dispersal capabilities beyond the initial settlement location.

Several experiments were conducted to test this hypothesis. We specifically examined the effects of pigmentation, temperature and predator risk on post-settlement movement into the nursery area. These experiments were conducted in the laboratory using larvae and juveniles reared from broodstock held at the Newport laboratory.

For newly settled larvae/juvenile rocks sole, two flume tanks apparatuses were used to examine post-settlement dispersal. Flume were set up alongside each other to run simultaneous trials. Dimensions of the apparatus were 4.80 m long, 0.41 m wide, and 0.30 m deep. Tanks were equally sectioned into 10 chambers that were 0.40 m in length. Approximately 45 kg of fine sand was placed as substrate and raked until the substrate level was even throughout the apparatus. Newly settled rock sole (n=8) were placed in a perforated transparent starting chamber consisting of a cylinder with an open bottom that allowed fish to be in contact with the substrate. They remained in this chamber for 6 hours to acclimate. After 6 hours, the chamber would be carefully raised so as to not disturb larvae. Inflow was placed at the furthest point from the starting chamber and outflow drained from a pvp pipe nearest the starting chamber, separated by a perforated acrylic partition to keep the larvae from that area of the apparatus. Control treatments had the water starting temperature of approximately 7 °C and an ending temperature of approximately 9°C. Flow was allowed during the acclimation portion of the trial, and turned off during the trials. Cold water treatments had a water starting, and ending, temperature of approximately 3 °C. In order to maintain the cold water treatment, flow was constant throughout the trials. Each trial for each treatment ran for 18 hours. After the end of the trial, 10 beakers labeled with the section number of the apparatus were used to collect larvae at the end of the trial. A 100 ml pipet was utilized to collect the larvae. This method at collecting fish did not appear to disturb other larvae still in the apparatus. Rock sole were placed into their corresponding beakers and taken for imaging analysis. Image Pro software was used to record pigmentation (fully pigmented vs. non-fully pigmented) and total length. A total of 10 replicates of each treatment (warm and cold temperatures) were performed.

For older rock sole juveniles, a larger (single) flume was used (10 m in length, 1.52 m wide, with water depth of 1.09 m). Trial lengths in the larger flume were identical to the trials in the smaller flumes (6 hours acclimation, 18 hours trial). The large flume tank was divided into a series of even sections (n= 9, 1.09 m in length each), with an equal sized acclimation chamber at the west end of the tank. Upon trial start, a large partition was raised to allow the juvenile rock sole (n=8) access to the full dimensions of the tank. Each section of the tank was partitioned with a weighted net that was lowered at the end of the trial. Netting was attached to pvc pipe which allowed the netting to be lowered smoothly into the apparatus for minimal disturbance. Control treatments utilized ~454 kg of fine sand dispersed evenly throughout the tank bottom. In the gravel habitat treatment, 340 kg of medium sand (section 0 – 7) with ~50 kg of fine sand was placed at the furthest point of the apparatus from the starting chamber (section 8).

Gravel to sand ratio of the gap crossing treatment was kept during the predator trial. ~1 hour prior to treatment start 2 walleye pollock were placed in the center of the apparatus.

At the end of the trial when the partitions were lowered, Pollock were the first collected in order to minimize disturbance of the NRS.

Total length of fish was recorded and weight was recorded after blot drying.

1.1 Dispersal behavior as a function of temperature in newly settled larvae Figure 1 shows the distance newly settled rock sole larvae travelled in a flume tank after 20 hrs in two temperature treatments. Highest dispersal occurred in the warm treatment as indicated by a one way ANOVA analysis was performed at position 0 (ANOVA $F_{1,14}$=48.18, p-value <0.001).

1.2 Dispersal behavior as a function of size in newly settled larva There was no observable interactive effect of temperature and fish size on dispersal distance in flume tanks (Figure 2; ANOVA $F_{1,40}$ 1.265, p-value = 0.267). However, using combined treatment data suggests there was an overall effect of size on dispersal distance although the regression was not statistically significant (R^2=0.54, p = 0.0617)

1.3 Dispersal behavior as a function of pigmentation in newly settled larvae Figure 3 expresses the effect of pigmentation on dispersal distance under varying temperature conditions. No interactive effect between temperature and pigmentation was found (Figure 3; ANOVA $F_{1,40}$ 0.765, p-value = 0.467). However, a linear regression analysis on combined treatmeant data indicated that unpigmented, settled larvae dispersed further than pigmented, settled larvae (R^2=0.71, p =0.0035).

1.4 The effect of habitat on dispersal distance of Age-1 post settled rock sole. Figure 4 graphically expresses the effect of habitat, size, and predator presence on the dispersal behavior of Age-1 post-settled NRS. NRS were separated into two size classes (small rock sole≤ 45 mm TL, 46 mm TL ≤ big rock sole ≥ 70 mm TL) to determine if there is a size effect on dispersal distance. As shown on the graph the two size classes had similar dispersal patterns throughout both habitat treatments.

H2: Initial settlement into the nursery area is determined by water column characteristics

This was a value-added, complementary component to what was originally proposed to HEPR in 2012. The hypothesis was that thermoclines in deeper regions of the nursery prevent access to favorable substrates during settlement. Temperature data from the

Kodiak nursery sites show 2-3 ˚C of stratification in deeper parts of the nursery whereas shallow regions remain unstratified throughout the settlement period. In addition, a recent AFSC study of juvenile rock sole distributions along the Inner Front of the Bering Sea suggests that changing thermal regimes control rock sole larval distribution and supply to nursery sites. To test this hypothesis, rock sole larvae were reared to 90 days of development, and individually introduced to a series of 2 m water columns nested in a large tank (2.5m x 2.5m x 2.5 m) where vertical position, behavior, and settlement was recorded over a 3-hr period (Fig. 2). Water column treatments ranged from isothermic (4 or 9˚C throughout) to thermally stratified conditions with either 4˚C temperature change over 20 cm (strong thermocline: ST) or 100 cm (weak thermocline (WT) across the water column. A total of 136 independent trials were conducted. Results indicated that the larvae are highly variable in the size they settled across treatment, but that all larvae settled regardless of water column conditions at a certain size threshold (Fig. 5). Rock sole larvae concentrated at the thermocline break but demonstrate more spatial variation in the water column when conditions are isothermic (Fig. 6). Rates of settlement were highest in the isothermal treatment at 4˚C, suggesting thermoclines do restrict competent larvae from settling. These data partially explain the narrow depth range occupied by newly settled rock sole in Kodiak nurseries and support observations of annual changes in the spatial distribution of juvenile rock sole in the Bering Sea. Ongoing research is examining the consequences of settlement in poor quality habitat and whether post-settlement dispersal limits occupation of more favorable areas of the nursery.

Figures

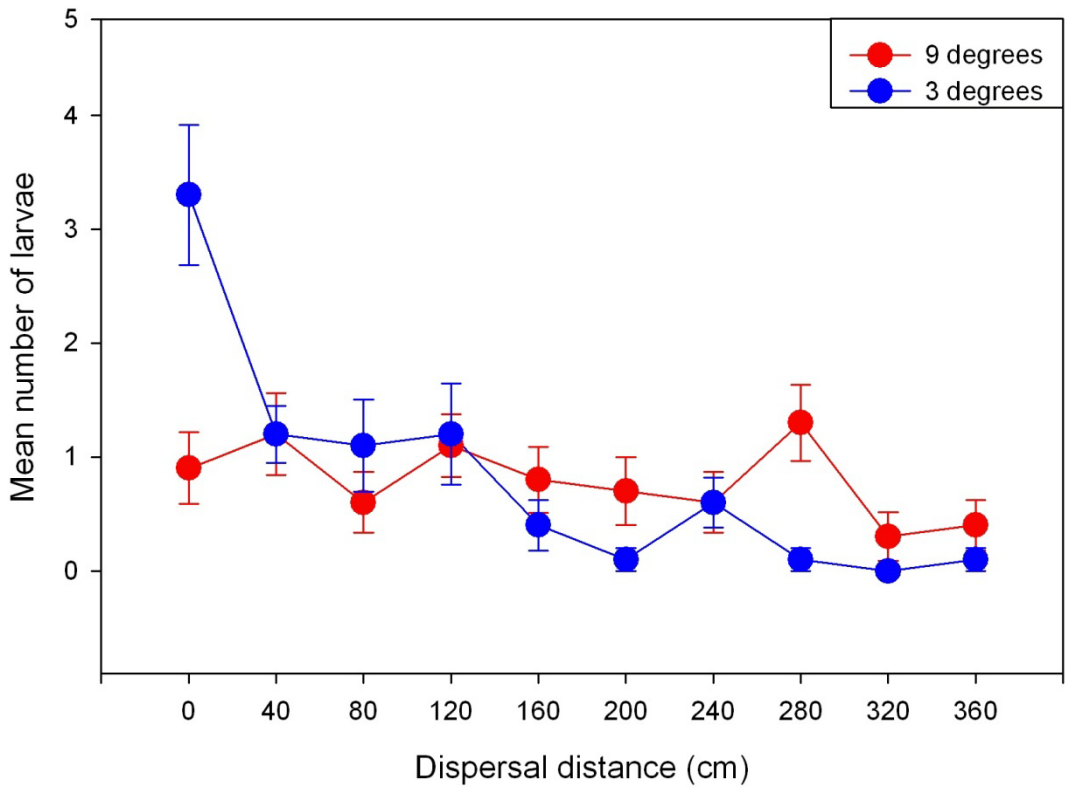

Figure 1. Effect of temperature on dispersal distance in settling rock sole larvae. One way ANOVA performed at position 0 shows a significant effect of temperature on dispersal behavior.

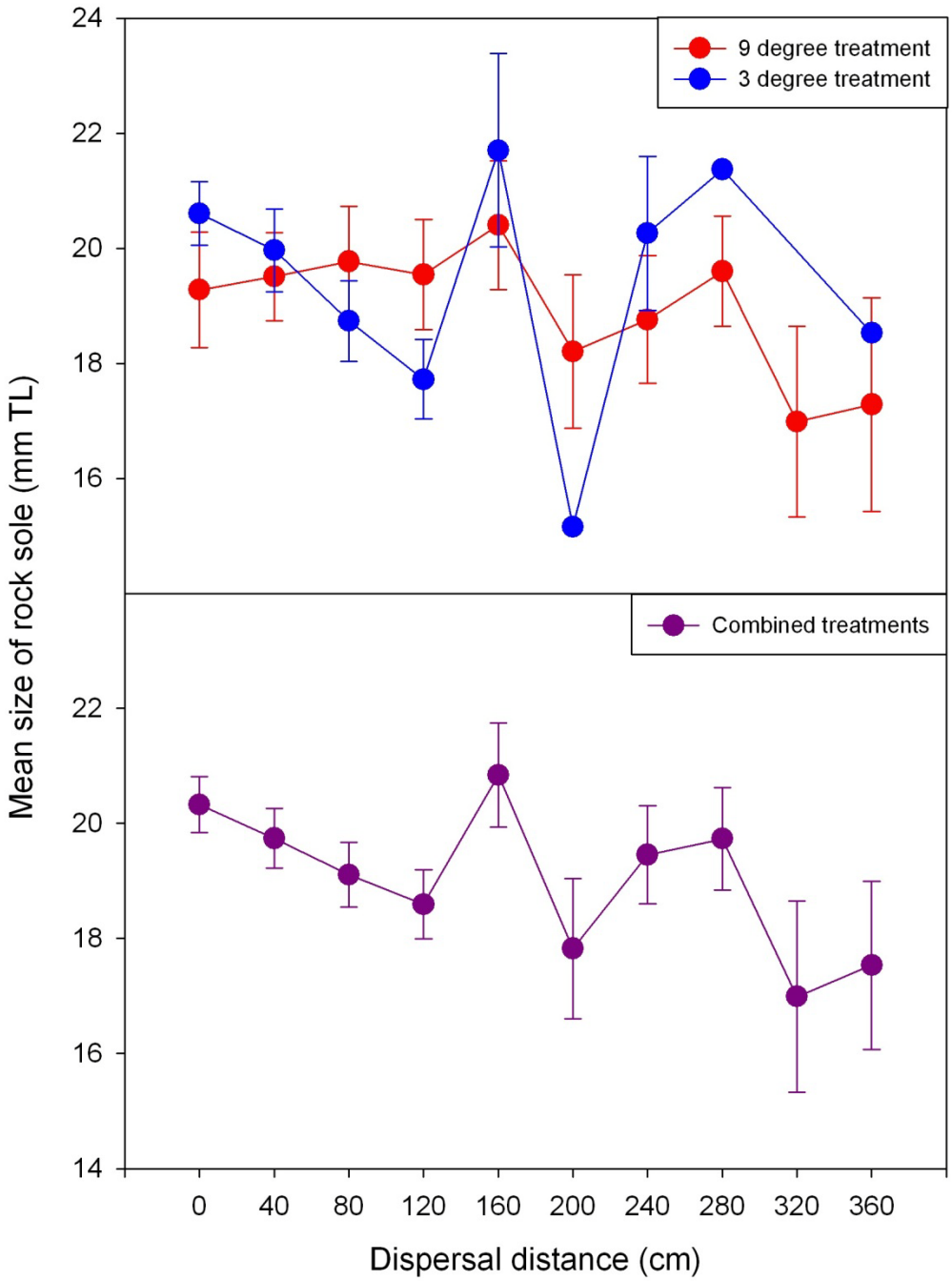

Figure 2. No interactive effect shown of temperature and fish size on dispersal distance. No interactive effect of temperature and fish size on dispersal distance so data was combined. Linear regression analysis shows size does not have a significant effect on dispersal distance in combined data.

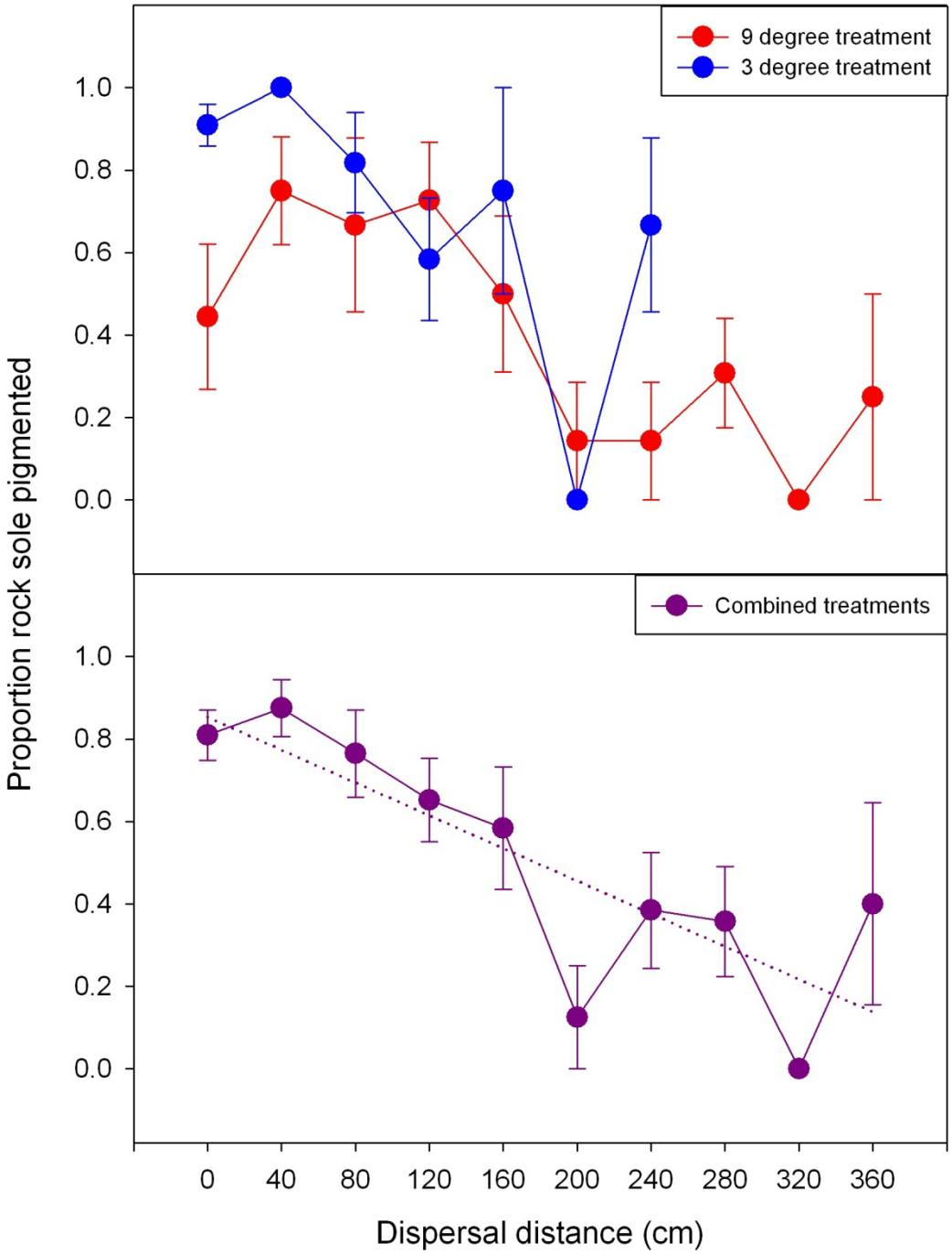

Figure 3: No interactive effect of pigmentation and temperature was found on dispersal distance in newly settled northern rock sole (top panel) but overall pigmented, settled rock sole larvae tended to disperse less than pigmented larvae (bottom panel).

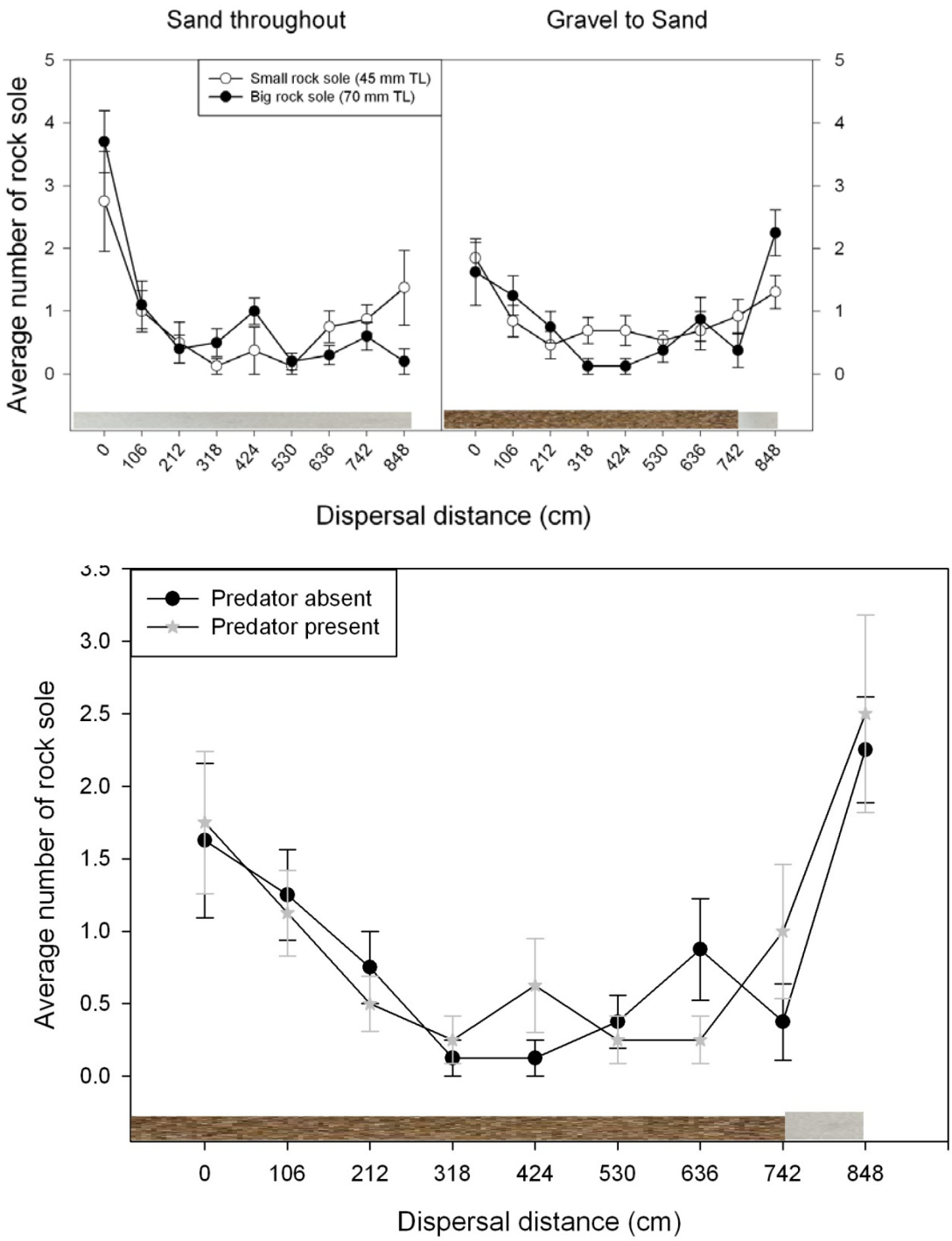

Figure 4. Settled northern rock sole juveniles tended to disperse further on unfavorable habitat (gravel) (top panels) and this pattern was not affected by the presence of predators (lower panel).

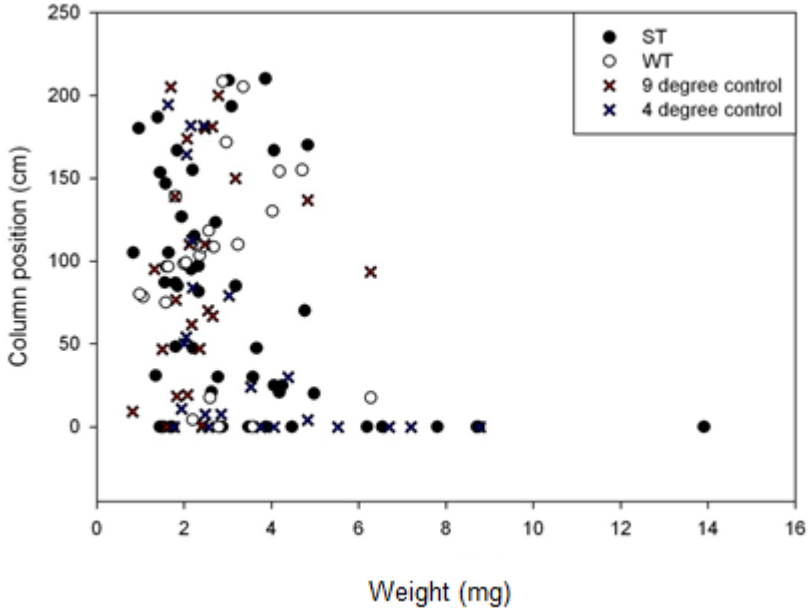

Figure 5. Mean column position of each rock sole larvae in all of 4 different temperature treatments by their weight in mg. Position of 0 is correlated with settlement. At ~6mg, fish settle despite temperature treatments.

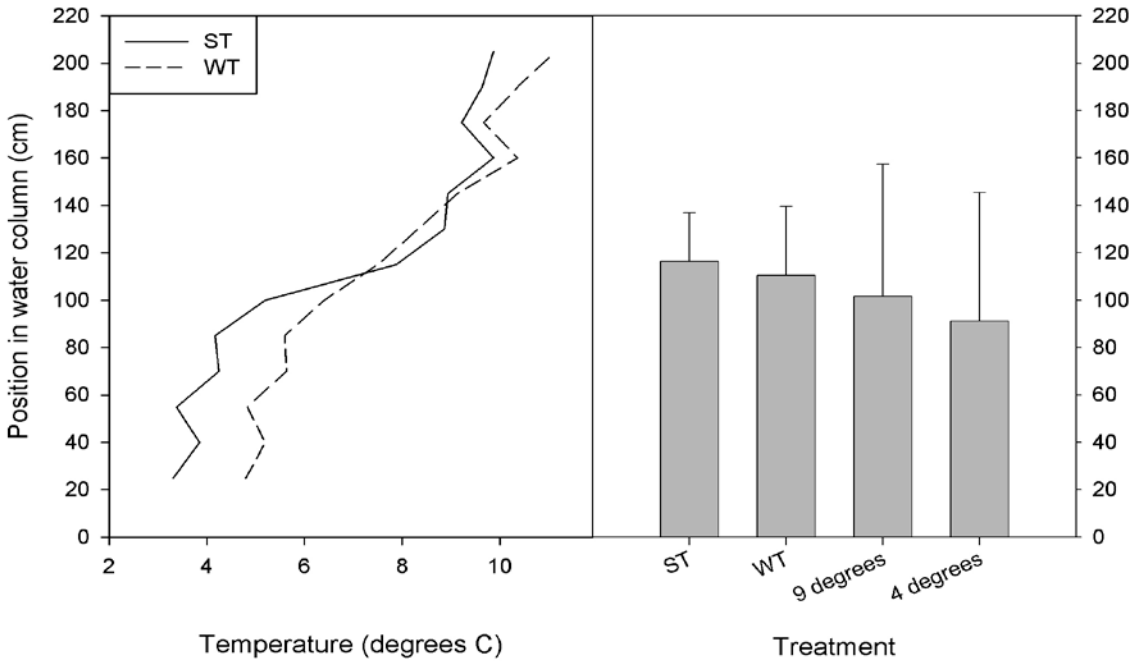

Figure 6. The left panel is the mean temperature profile of all the strong (ST) and weak thermocline (WT) treatments. The right panel is the mean position of rock sole larvae over all observations in each of 4 temperature treatments. Settled larvae were removed from the analysis. Data is based on means ± 1 standard error.