FINAL REPORT
2024/2025 Joint Innovation Project

Developing Hybrid Oyster Seeds for Alaska Shellfish Growers

Lead Entity: Pacific Hybreed

Category: Boosting oyster growth at nurseries or farms
Project Location: Juneau and Ketchikan
Project Start Date: September 1, 2025
Project End Date: March 31, 2026
Award Amount: $100,000

Project Team & Partners: NOAA Fisheries, Seagrove Oyster & Hump Island Oyster Co.

PROJECT OVERVIEW

a. **Problem Statement:** Oyster strains optimized for growth in Alaska waters are lacking, presenting a barrier for continued growth of the shellfish aquaculture industry.

b. **Background/Context:** Genetic breeding is a proven strategy for enhancing farm yield. Crop yield is a biological trait, defined by growth and survival, which results from a complex interplay between an organism's genetics and its environment. Given that the Pacific oyster is farmed along the Pacific Coast of North America under diverse environmental conditions, localized breeding efforts are essential to develop oyster strains optimally suited for specific locations.

   Pacific Hybreed researchers initiated a breeding program, involving a series of genetic crosses, to create and evaluate oyster strains for performance in Alaska. For this project, distinct genetic lines of the same species were crossbred to produce hybrid crosses. This approach leverages hybrid vigor, maximizing improvements through both additive and non-additive genetic effects. These resulting hybrid crosses were then planted at two separate sites in Southeast Alaska for replicated yield evaluation.

c. **Proposed Solution:** To optimize the performance of farmed oysters, we proposed to conduct experimental crosses using established genetic lines, combined with fieldwork in Alaska to evaluate the yield for different genetic lines of the Pacific oyster.

d. **Project Objectives, Tasks and Measures of Success:** The main objective of this initiative was to select elite hybrid lines for future commercial production of double-hybrids. A secondary aim was to assess the relative significance of general and specific combining abilities in the genetic lines. This evaluation will inform the optimal breeding strategy for the Alaska shellfish industry.

   Success will be measured by several factors: the hatchery's ability to produce hybrid crosses with enhanced yields, the deployment of these improved hybrids on farms, and rigorous statistical analysis of how the specific hybrid cross and the environment affect the animals' growth and survival.

e. **Project Outcomes:** During the 2024-2025 project period, a total of 42 genetic families were outplanted and measured. This included 23 families from the first joint innovation project (JIP 1), which continued to be monitored, and 19 new hybrid crosses specifically produced for this project (JIP 2). These combined efforts have resulted in a two-year dataset of yield data for various hybrid crosses. Analysis of this data successfully identified the best hybrid crosses (indicating hybrid vigor) and elite genetic lines (demonstrating a general additive effect). The inclusion of repeated crosses across both year-classes provided temporal replication, which was crucial for reliably identifying hybrids with improved performance.

f. **Successes, Challenges, Lessons learned:** Hybrid crosses were successfully evaluated at two locations, demonstrating significant yield differences that will guide future breeding efforts to develop improved strains suitable for the Alaskan oyster growing environment.

   We did not observe a genotype-by-environment (G-by-E) interaction for the hybrid crosses tested in the two Southeast (SE) Alaska sites. This suggests that similar improvements may be achieved by cultivating the best hybrids at other locations within the general SE area. However, the lack of a G-by-E effect might stem from the study sites being geographically close and having comparable environmental conditions. Deploying these improved farm stocks in other Alaskan shellfish-growing areas will be crucial to determine if additional strains are needed to support the industry's growth.

   One of our study sites, in use since 2024, was permanently closed. Our research collaborators at the NOAA Alaska Fisheries Science Center responded efficiently to this unforeseen change, securing permission to relocate the oysters. This relocation caused a delay in data collection. Given that the animal transfer occurred in late fall, when oyster growth naturally slows, we anticipate that most of the yield differences observed were established while the genetic families were under the field conditions of the original deployment site (Little Port Walter Biological Research Station, LPW).

g. **Continuation + Dissemination of Results:** Pacific Hybreed is actively advancing its breeding program for the Alaska shellfish industry, with support from the Alaska Fisheries Development Foundation. The next project will be focused on producing new hybrid crosses and propagating the elite hybrids identified during this project. By deploying these hybrid crosses across a broader range of sites, the project aims to enhance understanding of how Alaska's diverse environmental conditions affect strain performance.

   The research outcomes have been shared at key industry events, including the Alaska Mariculture Conference, the Pacific Coast Shellfish Growers Association Annual Meeting, and the Aquaculture Triennial Conference.

DATA & PROJECT OUTCOMES

a. **General trends:** A longitudinal dataset (2024-2025) was created for this project by outplanting twenty-three families at LPW in 2024 and subsequently measuring them (Cohort 1). Data was collected over six time-points: three in 2024 and three more in 2025. Survivorship proved consistently high across the study. Survivorship during the growing season in 2024 was 94% and 95% in 2025, and overwinter survivorship between 2024 and 2025 was also high at 98%. These high survival rates suggest that differences in growth rate are the primary factor determining yield variation at this field site.

Across the 92 deployed cages, the average individual weight of all families significantly increased over the two-year period, rising from 0.2 ± 0.08 g (standard deviation) to 4.5 ± 1.35 g (Fig. 1). Growth rates varied seasonally, with notably higher growth during the summer months; summer 2025 saw an 85% increase in average individual weight, compared to a 45% increase during spring 2025. Furthermore, substantial variation was observed among the families, particularly at the final measurement (Fig. 1), where the highest-performing family achieved an average weight 3.5 times greater than the slowest-growing family.

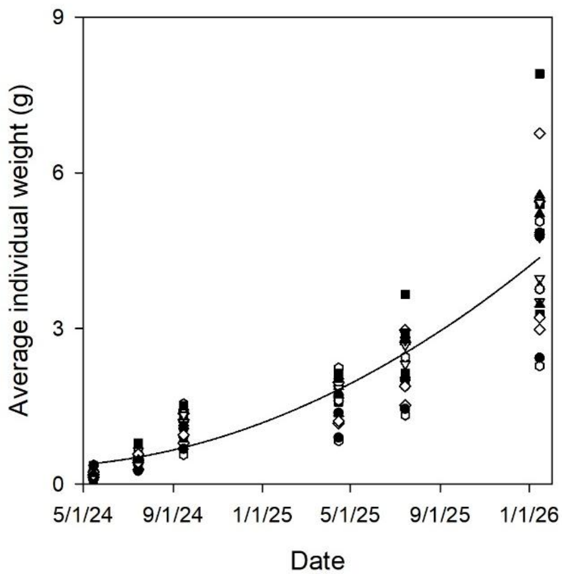


Figure 1. Average individual weight at six different timepoints between 2024-2025. Each individual weight data point was calculated from the group weight and count for the oysters outplanted in a field cage. Different symbols at each timepoint represent different families (n = 3 to 4 field cages per family). The solid regression line shows the general trend of individual growth across all 23 families.

b. **Predictability of growth potential:** An analysis was conducted on the two-year dataset for Cohort 1, encompassing measurements from 23 families across six timepoints, to assess how well early growth trajectories predict ultimate yield potential (Table 1). The analysis involved a series of correlation tests, utilizing variances derived from differences within a family across time intervals and differences between families at each timepoint.

The results demonstrated a decline in the correlation coefficient as the time interval between comparisons increased. Specifically:

- Correlation was strongest when comparing two adjacent time points.
- The strength decreased to moderate ($r < 0.8$) when growth was compared over two time-intervals.
- Correlation became weak ($r \leq 0.5$) for data points separated by three or more time-intervals.

This diminishing correlation over time is likely due to family-dependent differences in growth becoming more pronounced in larger oysters. Consequently, this finding suggests that an oyster's farm performance after the first year of cultivation may not be a reliable predictor of the final farm yield in Alaska, which typically requires 3 to 4 years of cumulative growth and survival.

Table 1. Correlation analysis of average individual weights at different time-points. Values in each cell show the Pearson correlation coefficient and corresponding P value. Emboldened numbers are significant correlation coefficients (α = 0.003, adjusted for multiple comparisons).

	Time 2	Time 3	Time 4	Time 5	Time 6
Time 1	**0.94**	**0.73**	0.58	0.29	0.09
	<0.001	<0.001	0.004	0.181	0.699
Time 2		**0.89**	**0.74**	0.51	0.31
		<0.001	<0.001	0.014	0.157
Time 3			**0.92**	**0.76**	0.58
			<0.001	<0.001	0.004
Time 4				**0.90**	**0.76**
				<0.001	<0.001
Time 5					**0.88**
					<0.001

c. **Yield variation:** Yield data for the hybrid crosses outplanted at LPW during the 2024–2025 growing seasons are presented in Figure 2. Data collection occurred three times each year: at the start, midpoint, and end of the growing season. Yield was determined from the total weight of oysters per bag at the end of the season, adjusted for initial differences in the number of oysters and group weight per bag.

In 2024, yield values ranged 1.5-fold, from a low of 18.0 g (cross 37×30) to a high of 24.5 g (cross 37×26). This variation increased significantly in 2025, showing a 2.2-fold difference, with the lowest yield at 55.7 g (cross 26×37) and the highest at 121.4 g (cross 37×33). The larger spread in the 2025 results emphasizes the necessity of multi-year field testing in Alaska, likely due to the slower growth rates observed compared to other major oyster-producing regions in the U.S.

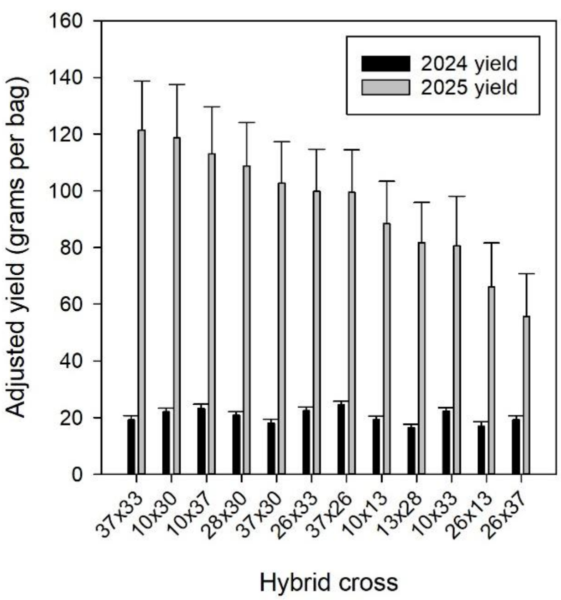


Figure 2. Yield values for 12 hybrid crosses evaluated between 2024 and 2025. Yield was calculated from the final group weight, adjusted for differences in the initial weight and count, using a linear model: yield = cross + initial weight + initial count. Midpoint weights and counts were included in the model when these variables were significant factors affecting the final group weight. N = 3 to 4 field cages per family; error bars show standard errors.

d. **Diallel analysis:** A complete diallel cross conducted in 2025 yielded 25 hybrid crosses (Cohort 2). Of these, 19 and 14 were outplanted at LPW and near Ketchikan, respectively. The overlapping crosses allowed for a diallel analysis using Griffing's random effects model (method 4). This model was used to estimate the general combining ability (GCA) and specific combining ability (SCA) of different genetic lines under varied environmental conditions. GCA estimates the impact of specific lines on yield, whereas SCA measures the effect of specific crosses on yield.

This statistical model was significant, explaining 78% of the total variance ($F_{23,36} = 5.42$, $P < 0.0001$, N = 60, $R^2 = 0.78$). Test sites account for the largest proportion of variation (62%, $P < 0.0001$), followed by hybrid crosses explaining the second highest proportion (22%, P = 0.009). Neither technical replicates (P = 0.44) nor the site-by-cross interaction (P = 0.10) was significantly different. These results show that LPW and the lease area by Hump Island Oyster Co. provide distinct growing environments for the oysters. The relative performance of hybrid crosses, however, did not differ (no site-cross interaction), indicating that high-performing strains are generally robust to the environment within SE Alaska areas.

The analysis of combining ability showed a significant effect of GCA on yield (P = 0.01). The effect of GCA-by-environment interaction on yield was not significant (P = 0.62). In contrast, SCA-by-environment interaction was significant (P = 0.03). Examining the estimated effects of each line and cross on yield, the cross 26×36 (male-by-female) produced significant improvement (P = 0.018) at the Ketchikan farm site. Oyster seed of this specific cross had an approximately 40% increase above the mean. In addition to the cross identified by the diallel analysis, the cross 37×33 also produced large improvements in yield (Fig. 3). This cross was not highlighted by the diallel analysis due to the significant SCA-by-environment effect, which resulted from the differential performances of this specific cross at the two test sites. Importantly, the improvement for the 37×33 cross and the general positive effect of genetic lines 26 and 37 are consistent with the results from Cohort 1, confirming the reproducibility of the breeding approaches.

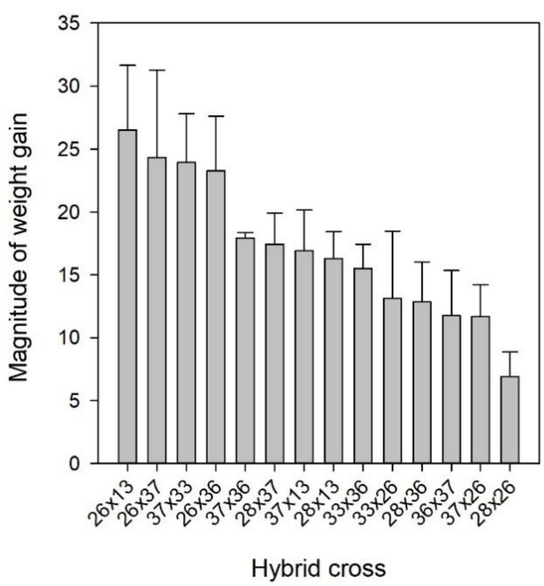


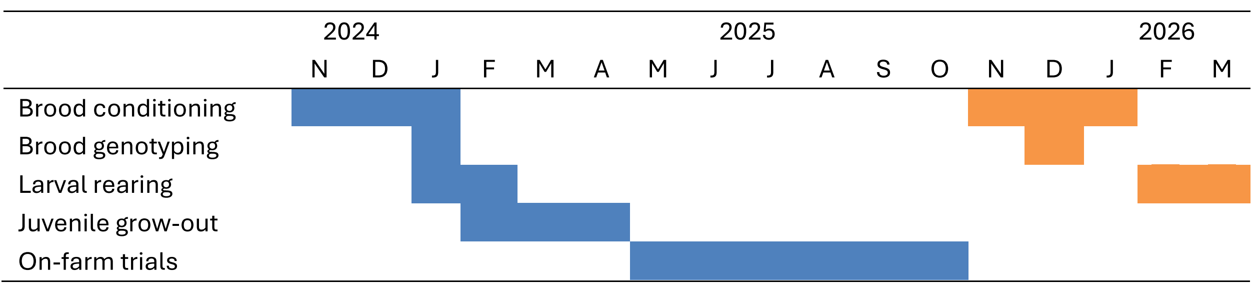
Figure 3. Weight gain for 14 hybrid crosses at Hump Island Oyster Farm during 2025. The magnitude of increase in weight was calculated from the initial and final group weights to account for the difference in initial weights between families at the start of the trial. There was a significant effect of hybrid cross on the magnitude of gain. N = 3 field cages per hybrid cross; mean ± standard error shown.

In summary, the findings from this research collectively demonstrate the significant and quantifiable productivity improvements achievable in commercial shellfish farming operations. These advancements are directly attributable to the implementation of controlled crossbreeding programs, integrated with rigorous on-farm performance trials. Specifically, the data has shown superior growth rates and improved yield metrics in the crossbred lines.

The next phase of this research and development pipeline will involve a substantial, larger-scale outplanting of the most promising crosses identified through the initial trials. This transition to a commercial-scale evaluation is essential. It will allow us to move beyond controlled, small-plot testing and assess the performance, consistency, and robustness of the enhanced seeds under a wider range of variable environmental conditions and typical commercial operating practices. This extensive outplanting is a necessary step to further assess the commercial viability and scalability of introducing these genetically improved shellfish seeds into the broader aquaculture industry. Success in this final phase will pave the way for the full commercialization and adoption of this enhanced broodstock, promising a sustainable boost to global shellfish production.

ADDITIONAL INFORMATION

Actual Project Timeline:



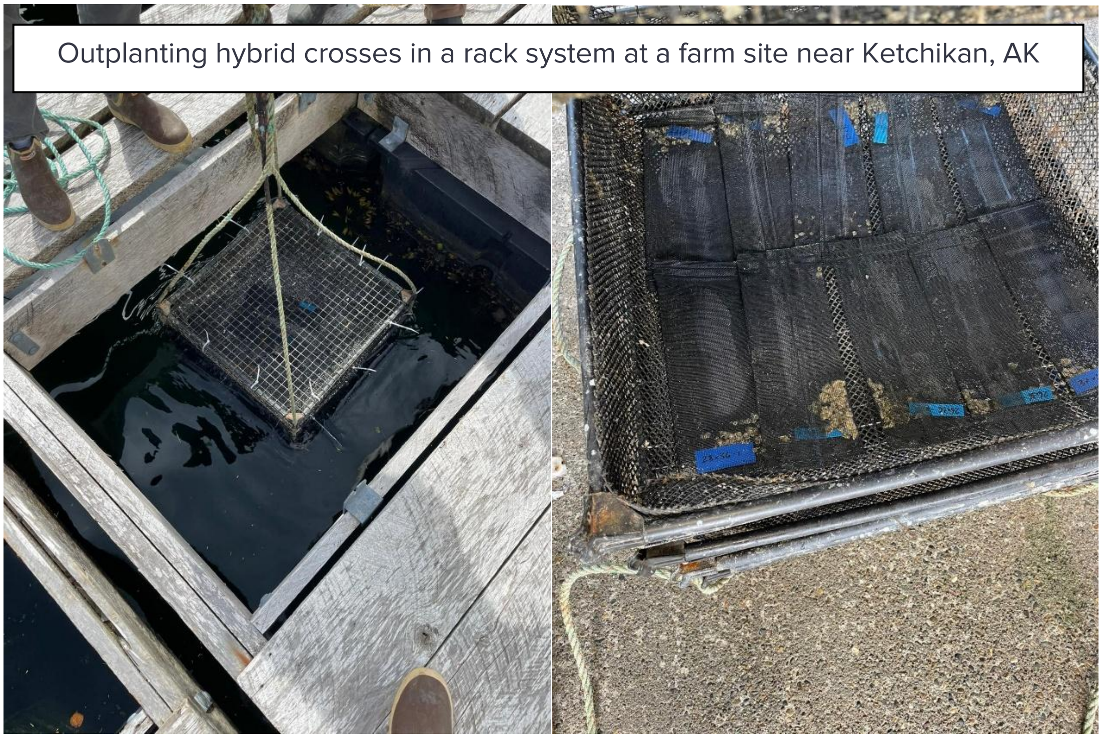
The actual project timeline did not significantly deviate from the proposed timeline. Blue highlighted columns show Cohort 2 animals that were produced and deployed during the 2024-2025 award period. We are currently conducting hatchery work to produce a set of new, experimental hybrid lines and commercial quantities of high-yield strains based on the findings from this project.

BUDGET

Expense	Total Spent
Personnel	$ 52,211
Travel	$ 21,461
Supplies	$ 26,100
Total Direct Charges	$ 99,772
Indirect Charges - NOT ALLOWED	$ 0
Total Budget	$ 99,772

The project was completed within the projected budget, with no expense categories exceeding or falling short of the budgeted amount by more than 10%.

PHOTOS



Outplanting hybrid crosses in a rack system at a farm site near Ketchikan, AK

Outplanting hybrid crosses at the Little Port Walter Biological Research Station

Data collection at the NOAA Alaska Fisheries Science Center

Genetic lines overwintering in Juneau, AK