Alaska Mariculture Alliance: Tracking the fate of farmed kelp dissolved organic carbon

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Project objective: 1) quantify rates of dissolved organic carbon (DOC) release and primary production by the farmed kelp *Alaria marginata* under controlled laboratory conditions; 2) determine whether DOC release differed between kelp sourced from distinct Alaskan mariculture sites, reflecting site-specific local adaptation; 3) evaluate how DOC production and associated carbon and nutrient fluxes varied across ecologically relevant temperature and light regimes; and 4) use these empirical data to improve kelp farm carbon budget estimates and inform blue carbon and mariculture management in Alaska.

Project update: We are currently carrying out various laboratory analyses following experimental trials at the Alutiiq Pride Marine Institute in Seward, AK. DOC incubation water samples are currently undergoing analytical processing for total organic carbon/DOC concentrations. In addition, kelp tissue samples are being processed via oven-drying and muffle furnace combustion to determine ash-free dry weight (AFDW), which is a necessary step to normalize changes in DOC concentration by kelp tissue mass, which can vary significantly when wet. This process results in a standardized, biomass-normalized rate of DOC production, photosynthetic carbon fixation (O_2 evolution / DIC drawdown), and inorganic nutrient fluxes across temperature, light, and population treatments. While this aspect of the project is ongoing, several other components have been completed and are reviewed below.

Scope of Growth ~mass (g) (6-week growth trial at ambient temperature ~7˚C)

To evaluate growth, daily specific growth rates, change in mass (SGR, % day^{-1}), were measured at weekly intervals for six weeks (T1-T6) for *A. marginata* sporophytes sourced from Kodiak Island Sustainable Seaweed (KOD) and Royal Ocean Kelp Co. in Cordova (CDV). A Linear Mixed-Effects Model found significant effects for time (Fig. 1, $p < 0.0001$) and site--population origin ($p = 0.0003$). Growth rates slowed over time, declining from initial rates in Week 1 (17.31 +/- 3.99% day^{-1} for KOD; 14.78 +/- 3.83% day^{-1} for CDV) to near-zero by Week 6 (0.74 +/- 1.51% day^{-1} for KOD; -0.35 +/- 2.42% day^{-1} for CDV). Across all weeks, KOD sporophytes sustained higher mean SGR than CDV sporophytes ($p < 0.001$). We included tank as a random effect in our model, which revealed a small but significant tank effect (ICC = 0.121, Likelihood Ratio Test Chi-square = 25.24, $p < 0.0001$). This resulted in 12.1% variability in growth attributable to

differences in the individual tank environment.

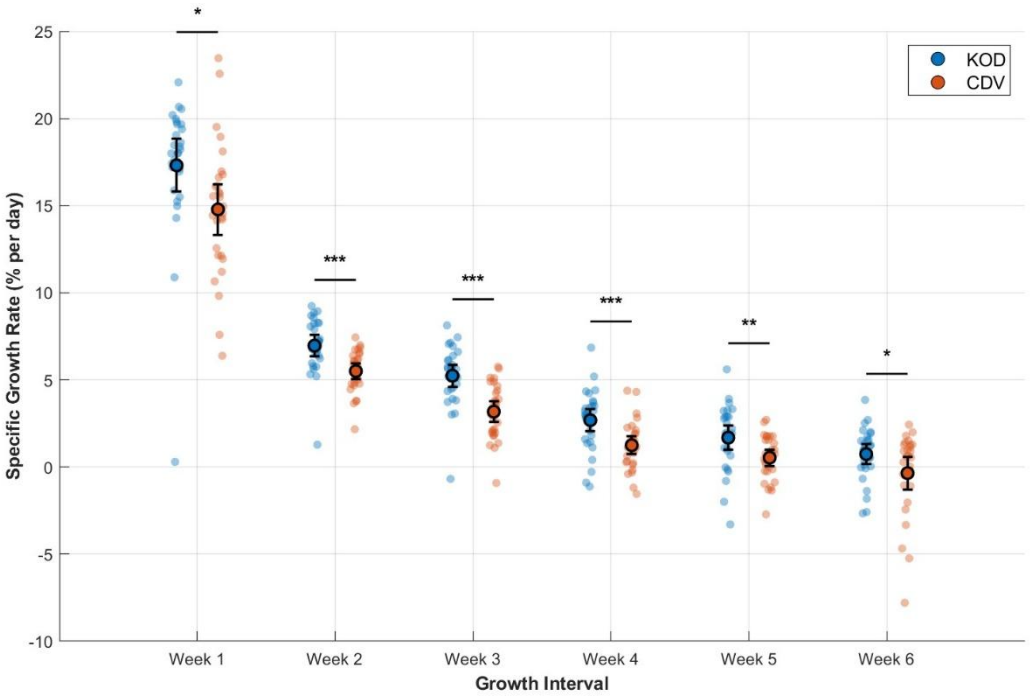

Figure 1 Specific growth rate of Kodiak (KOD) and Cordova (CDV) populations across weekly intervals. Specific growth rate (% per day) measured over six consecutive weeks (Week 1–Week 6). Points represent individual measurements, bold circles with error bars represent mean ± 95% confidence intervals. Asterisks indicate significant differences between populations within each week (p < 0.05, p < 0.01, *** p < 0.001).*

Tissue Nutrient Composition & Stoichiometry

Tissue nutrient parameters (nitrogen % mass, carbon % mass, C:N ratios, dC13 and dN15) were measured for the Scope of Growth endpoints (T0 vs. T6) using Two-Way ANOVA (Site x Time) and across thermal treatments (10°C and 14°C), using two-sample t-tests between KOD and CDV populations. There were significant changes over time (T0 to T6) in both nitrogen and carbon (Fig. 2, $p < 0.05$), reflecting likely nitrogen depletion. We are currently analyzing the seawater nutrient data, which will either confirm or reject this preliminary assessment. Population contrasts at 10°C thermal exposures suggest site-specific physiological divergence in tissue stoichiometry (Fig. 2 C:N), potentially highlighting baseline metabolic differences between Kodiak and Cordova populations under mild thermal stress. At 14°C, both populations elicit similar responses with respect to tissue nutrient concentrations. Stable isotope signatures (dC13 and dN15) revealed baseline differences between populations at time zero (Fig. 3 T0; $p < 0.001$), reflecting distinct regional field nutrient values. However, tissue isotope values converged by T6 and remained statistically indistinguishable across both 10°C and 14°C thermal exposures ($p > 0.05$), indicating that Kodiak and Cordova

sporophytes are similar with respect to their carbon fixation and nitrogen turnover dynamics once acclimatized.

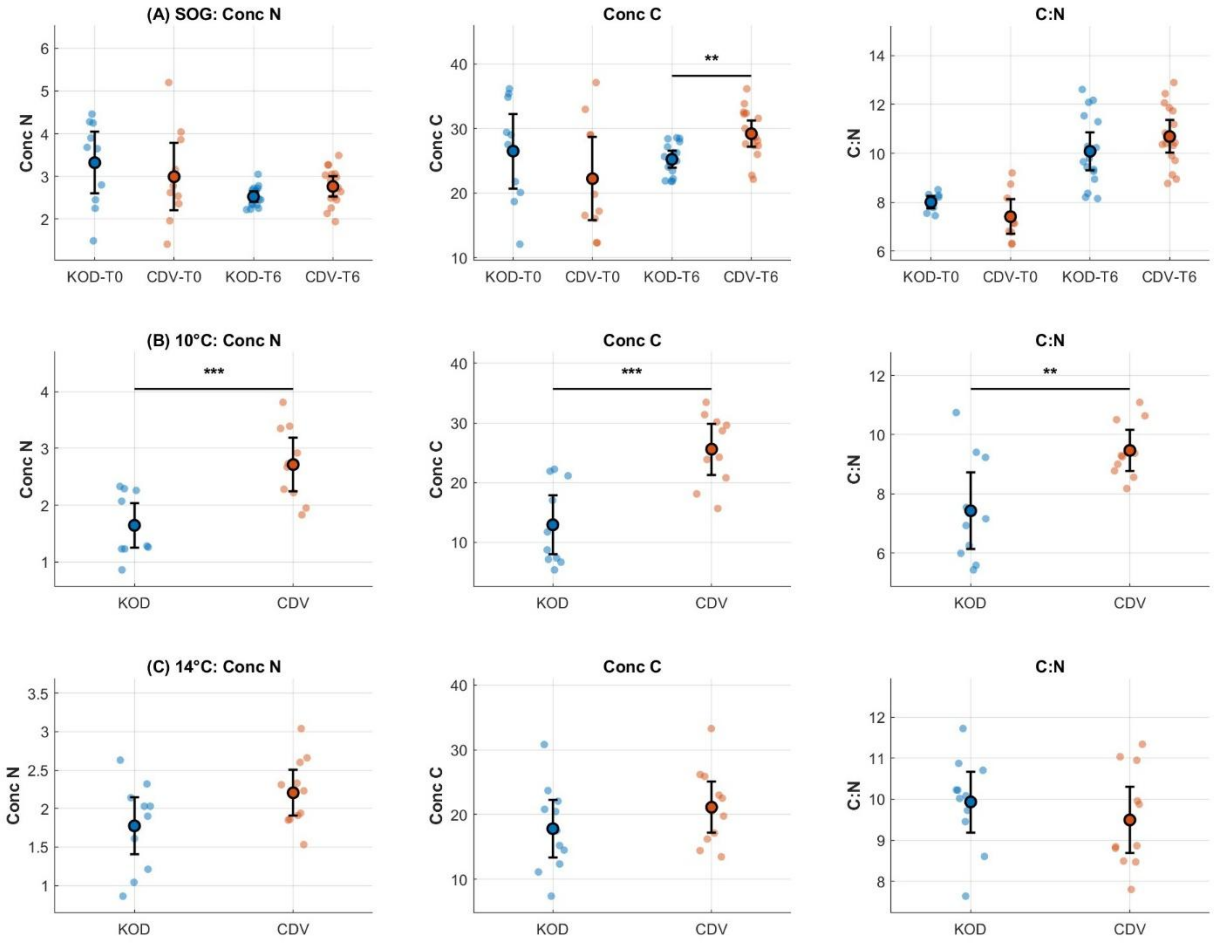

*Figure 2 Tissue nutrient parameters and C:N stoichiometry for Kodiak (KOD) and Cordova (CDV) populations across treatments. Tissue nitrogen concentration (Conc N), carbon concentration (Conc C), and C:N ratio measured under (A) Scope of Growth endpoints (T0 vs. T6), (B) 10°C thermal exposure, and (C) 14°C thermal exposure. Points represent individual sample, circles with error bars represent mean ± 95% confidence intervals. Significance brackets indicate statistical differences between populations ($p < 0.01$, *** $p < 0.001$).*

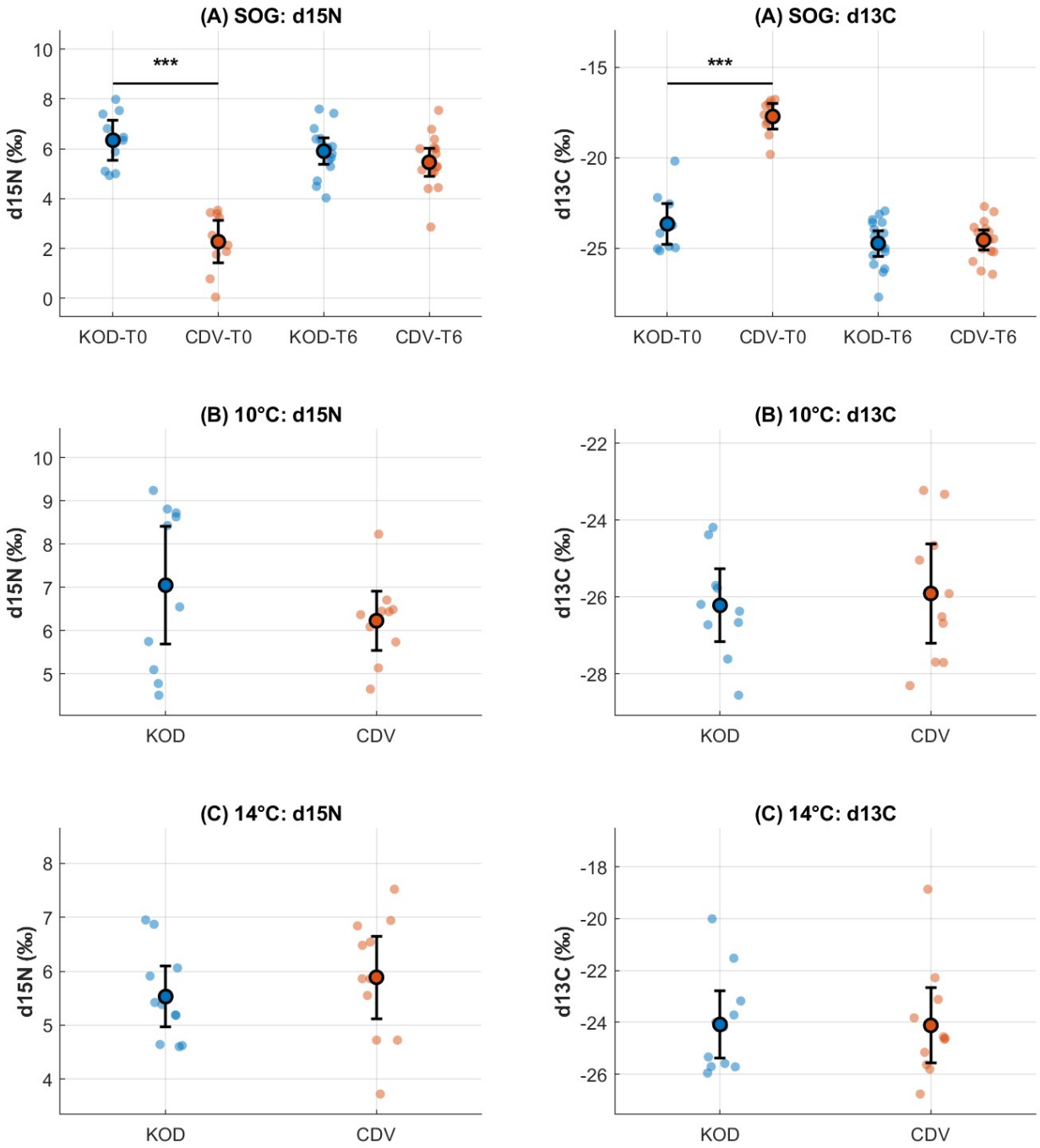

*Figure 3 Stable isotope signatures (d15N and d13C) for Kodiak (KOD) and Cordova (CDV) populations across treatments. Tissue d15N and d13C values measured under (A) Scope of Growth endpoints (T0 vs. T6), (B) 10°C thermal exposure, and (C) 14°C thermal exposure. Points represent individual sample values, bold circles with error bars represent mean ± 95% confidence intervals. Significance brackets indicate statistical differences between populations (*** p < 0.001).*

Next steps: We will finalize the DOC measurements, and then determine the rate of DOC production, photosynthetic carbon fixation (O_2 evolution / DIC drawdown), and inorganic nutrient fluxes across temperature, light, and population treatments.