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Pelago-benthic Coupling in a High Arctic Fjord

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1. INTRODUCTION

Meroplankton—pelagic larvae of benthic invertebrates—plays a key role in Arctic coastal ecosystems by linking pelagic and benthic processes through dispersal and settlement (Pineda-Metz 2020). However, in shallow hard-bottom environments, factors driving this pelago-benthic coupling remain poorly understood. We investigated these processes through a year-round study in Isfjorden, Svalbard (>78 °N), combining seasonal plankton sampling with an in situ colonization experiment using settlement plates at two stations (site S and site N).

2. MATERIAL AND METHODS

The study took place in Isfjorden, the largest fjord on the western coast of Spitsbergen (Svalbard), characterized by varied hydrological conditions and underwater landscapes. Salinity in shallow zones ranges from 28 to 34 PSU, and temperatures from −1.4 to 7 °C (Nilsen et al. 2008). Inner bays are seasonally ice-covered (Nov–July), and the region experiences a 112-day polar night. Two stations were surveyed: a northern site (N) with colder, more Arctic-like conditions and greater glacier influence, and a southern site (S), warmer and less impacted by freshwater input. Environmental differences are shaped by fjord circulation, glacier proximity, and bathymetry.

Plankton samples were collected every three months using a vertically hauled WP2 net and two SCUBA diver-operated methods (horizontal net tow and suction pump). To investigate the relationship between larval supply and benthic colonization, we carried out a year-round settlement experiment using a metal frame structure equipped with two sets of triplicate plates oriented upward and downward and exchanged at three-month intervals.

3. RESULTS AND DISCUSSION

Regardless of the method, seasonality was the strongest predictor of meroplankton composition (PERMANOVA, 31.8% variation explained), with spring peaks in Polychaeta larvae and Cirripedia nauplii, summer peaks in Bivalvia veligers, Echinodermata ophioplutei, and Cirripedia cypris, and autumn peaks in Bryozoa cyphonautes. Environmental variables including temperature, chlorophyll *a*, and photoperiod, jointly explained 36.7% of variability (DistLM), supporting the view that planktotrophic larval development is an effective strategy in high-latitude taxa like Bivalvia and Cirripedia.

The southern station (S), influenced by warm Atlantic waters, showed greater productivity, while the northern station (N), affected by winter sea ice drift, exhibited higher overall meroplankton abundance. Method comparison indicated that the WP2 net was most effective for deeper sampling, but the suction pump proved valuable in shallow, kelp-dense zones where standard nets are impossible to use. Combining both methods maximized multivariate dispersion, highlighting their complementary value in shallow Arctic ecosystems.

To investigate the relationship between larval supply and benthic colonization, we carried out a year-round settlement experiment using a metal frame structure equipped with two sets of triplicate plates oriented upward and downward and exchanged at three-month intervals. The results revealed that light and temperature were the main drivers of early epibenthic colonization. These physical factors—together with depth, plate orientation, and station location—explained 46% of the variability in settlement patterns, while biotic variables, such as the presence of meroplanktonic larvae and phyto- and zooplanktonic communities, explained an additional 24% (Fig. 1).

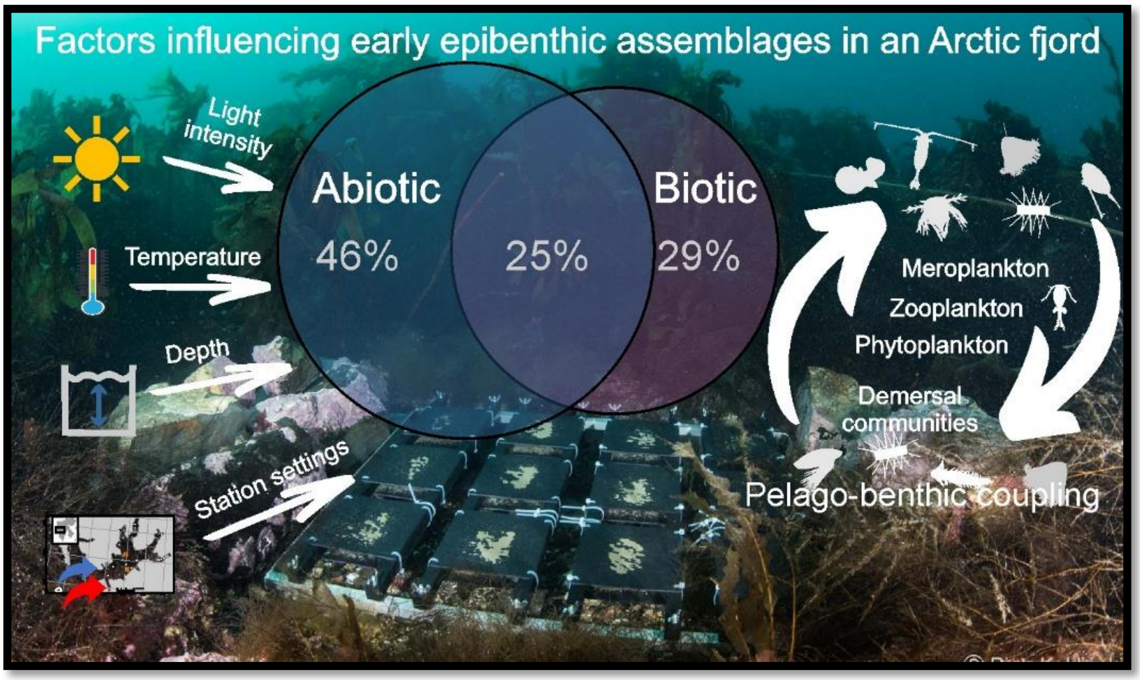

Fig. 1. Venn diagram of partition of explained variation in epiobenthic taxa composition shared between abiotic and biotic explanatory variables (modified after Ronowicz et al. 2024).

Sessile taxa displayed strong orientation-dependent settlement: coralline red algae (*Lithothamnion* sp.) dominated upward-facing plates, while polychaetes and bryozoans were more abundant on downward-facing surfaces. However, during summer, juvenile individuals of the cirriped *Semibalanus balanoides* aoutcompeted other recruits on both plate sides due to a massive larval influx triggered by phytoplankton blooms. Seasonal trends were particularly pronounced on downward-facing plates: autumn and winter were dominated by polychaetes belonging to Spirorbinae and by bryozoans; spring by *Lithothamnion* sp. and bryozoans (at station N) or Spirorbinae and bryozoans (at station S); and summer by *S. balanoides*, irrespective of site. Notably, high numbers of *Lithothamnion* sp. on upward-facing plates deployed during the polar night provide the first evidence that coralline algae at high latitudes can settle in complete darkness, suggesting that solar radiation is not a prerequisite for spore release or settlement. The connectivity between pelagic larvae and benthic recruitment was clearly visible in the seasonal sequence of cirriped life stages, and to a lesser extent in cyphonautes larvae, which may correspond to currently unidentified juvenile cheilostomatid bryozoan settling on plates.

4. CONCLUSIONS

In conclusion, this study provides novel insight into the mechanisms of pelago-benthic coupling and settlement dynamics in typically poorly explored shallow Arctic rocky habitats. Our results demonstrate that seasonality, environmental conditions, and larval dispersal patterns jointly structure meroplankton communities and influence settlement success, highlighting the complex nature of coastal habitats. These findings suggest that climate-driven changes in light and temperature regimes may alter recruitment patterns and disrupt the functioning of polar ecosystem.

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