“Where’s Waldo?”: Unraveling the puzzle of *Idotea wosnesenskii* abundance across San Juan Island

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ABSTRACT

Idotea wosnesenskii are intertidal isopods typically found on kelp, mussel beds, and intertidal rocks. With a relatively large geographical range, *I. wosnesenskii* can be found from Alaska to northern Mexico while also appearing along the coastlines of Siberia. This study examined the influence of rock width, substrate preference, shore crab presence, and intertidal height on the abundance and distribution of *I. wosnesenskii* across San Juan Island. We found that aggregations of *I. wosnesenskii* are likely to be found under rocks with width larger than 25.6 cm ($R^2 = 0.36$, $p = 0.028$). In comparison, singular individuals of *I. wosnesenskii* are more likely to be found under rocks with width smaller than 25.6 cm. *Idotea wosnesenskii* also had a substrate preference of seaweed, cobble, and bedrock ($F = 10.9$, $p = 0.01$). Shore crab presence and intertidal height had no significant effect on the abundance of *I. wosnesenskii* ($p > 0.05$). These findings may support observations from past studies that *Idotea* are primarily mesograzers who can also be omnivorous depending on food availability. However, further research is required to determine the full impact of shore crab presence, and intertidal height on the distribution of *I. wosnesenskii*.

INTRODUCTION

In 1798, Fabricus described a new genus within the order Isopoda: *Idotea*. *Idotea* are small littoral and sublittoral marine crustaceans with flattened, segmented bodies (Salemaa, 1979). Mainly found across the northern hemisphere and in temperate waters, *Idotea* are ecologically important herbivores that graze on algae and seagrass (Jaschinski & Sommer, 2008; Roth et al., 2010; Starko et al., 2016). Within the genus *Idotea*, species are polymorphic - with pigmentation ranging between black, yellow, tan, and pink (Merilaita, 2001). Over the years, polymorphism has been shown to play a crucial role in assisting with mate selection and reducing the likelihood of predation (Merilaita, 2001). Much research has focused on examining these color-inducing mechanisms and how they influence *Idotea* ecology, distribution, and sexual selection (Lee & Gilchrist, 1972; Jormalainen, 1995; Merilaita, 2001).

In comparison to their polymorphic traits however, the distribution of individual species within the genus Idotea remains vastly understudied and primarily focused on species concentrated along the European coast (Gutow, 2003; Panova et al., 2016). Furthermore, the distribution of *Idotea* native to the Pacific is almost nonexistent, with studies mainly focusing on genetic analyses or the influence of water currents on *Idotea* behavior (Gurjanova, 1968; Rafi & Laubitz, 1990).

Within the Pacific Northwest, *Idotea* are known to range between Prince William Sound, Alaska, to Juan de Fuca Strait, Washington (Rafi & Laubitz, 1990). Two of the most extensively studied species indigenous to the Pacific Northwest are *I. resecata* and *I. wosnesenskii*, with many reports examining temporal patterns, attachment strength, and swimming capabilities (Alexander, 1988; Thom et al., 1995; Starko et al., 2016). However, no study currently has analyzed small scale distribution or abundance for either species.

This study aims to survey the distribution and abundance of *I. wosnesenskii* across several sites on San Juan Island, Washington, USA. We hypothesized that *I. wosnesenskii* abundance would be higher under rocks of width over 25.6 cm, and that *I. wosnesenskii* would prefer boulders to other substrates such as seaweed, rocks, and sand. We also hypothesized that *I. wosnesenskii* abundance would be inversely proportional to crab abundance, as well as proportional to intertidal height. We then analyze the findings using a general linearized model, one-way ANOVA, and Tukey tests, and relate our findings and implications to past studies.

METHODS

Study Location

Four sites were surveyed across San Juan Island, Washington: Eagle Cove, Third Lagoon, Cattle Point, and Beaverton Cove. All surveys were conducted during the lowest tide of the day (Table 1).

Data Collection

Three transects were laid parallel to the waterline and spaced five meters apart at each site. Transects were categorized as a low, medium, or high depending on the distance away from the waterline (Fig. 1). Ten 0.5 m2 quadrats were randomly placed along each transect on both sides of the transect tape. Substrates and sediment grain size were recorded for each quadrat and organized into the following: seaweed, pebbles (0.2-6.5cm), cobbles (6.5-25.6cm), boulders (25.6-409.6cm), and bedrock (>409.6cm). The sediment grain size was determined using the Wentworth scale, published by Chester K. Wentworth in 1992 and measured using a caliper, tape, or meter stick. Rock width was calculated by measuring the width of the rock.

Total counts of *I. wosnesenskii* were recorded for each quadrat. Rock width was also measured for all isopods found under rocks. Only the substrate was recorded if the isopod was not located under a rock. The presence or absence of crabs within the quadrat was also noted.

Data Analysis

A generalized linear regression was then performed to analyze the influence of the rock width on the distribution of *I. wosnesenskii*. In addition, a one-way ANOVA was performed to examine the impact of shore crab presence, substrate preference, and tidal height on the abundance of *I. wosnesenskii*.

RESULTS

The influence of rock width on the abundance of *I. wosnesenskii* was statistically significant ($R^2 = 0.36$, $p = 0.028$) (Fig. 1). Aggregations (more than two individuals) of *I. wosnesenskii* were more likely to be found under rocks over 25.6cm width. In contrast, single individuals of *I. wosnesenskii* were more likely to be found under rocks less than 25.6cm in width. *The data also show that there is a strong likelihood that I. wosnesenskii* prefer substrates such as seaweed, cobbles, and bedrock ($F = 10.9$, $p = 0.01$) (Fig. 2).

Furthermore, the presence of shore crabs had no significant effect on the abundance of *I. wosnesenskii* across all sites sampled ($F = 2.84$, $p = 0.09$) (Fig. 3). Finally, we detected no significant influence of tidal height on the distribution of *I. wosnesenskii* (Fig. 4).

DISCUSSION

This study is the first to examine the influence of rock width, substrate preference, crab presence, and intertidal height on the abundance of *I. wosnesenskii*. Furthermore, this study is also the first to examine the influence of intertidal rock width on any species of *Idotea.*

Our finding is that aggregating *I. wosnesenskii* (> 2 individuals) are more likely to inhabit boulders, while solitary *I. wosnesenskii* (< 2 individuals) are more likely to inhabit areas with cobbles and pebbles. This aggregating behavior is not yet well understood, but it may be a form of social aggregation seen in other genera of isopods (Shuster & Wade, 1991; Shuster, 1990). Social aggregation amongst isopods has been found to reduce risks such as predation or desiccation and increase the odds of finding a mate (Salma & Thomson, 2016; Salma & Thomson, 2017). The aggregating behavior observed in *I. wosnesenskii* may also be explained by the findings of Salma & Thomson, 2016, and Salma & Thomson, 2017, but requires further examination to validate this conclusion.

Idotea are also herbivorous crustaceans feeding on filamentous macroalga (Orav-Kotta & Kotta, 2004, Naylor, 1995a). However, depending upon food availability, *Idotea* may be omnivorous (Naylor, 1995b). Our finding that *I. wosnesenskii* preferred seaweed, cobbles, and boulders, supports the likelihood of omnivorous feeding within *I. wosnesenskii*. However, our finding that *I. wosnesenskii* are likely to be found on other substrates besides seaweed directly contradicts a study performed by Starko et al., 2016. Due to morphological constraints, those researchers determined that most *I. wosnesenskii* are limited to habitats with thicker seaweed and higher wave intensity. However, our study found very similar numbers of *I. wosnesenskii* amongst seaweed, cobbles, and bedrock. We believe this may be because researchers did not survey equal amounts of each substrate at all locations.

While macroalgae were present at all locations, only two of the four sites had significant amounts of algae, specifically *Fucus*, or were prone to high wave action. Whether *I. wosnesenskii* directly feeds on *Fucus* rather than inhabiting it is still unknown, but several studies along the European coast suggest that it may be a possibility (Roth et al., 2010; Engkvist

& Tobiasson, 2000; Salemaa, 2012). Therefore, to quantify the true impact of macroalgae on the abundance of *I. wosnesenskii*, we recommend that future research direct attention towards limiting transects to areas strictly covered by macroalgae and areas strictly without macroalgae instead of sampling areas with a combination of both.

This study found no statistically significant influence of shore crab presence on the abundance of *I. wosnesenskii* despite observations of a higher abundance of *I. wosnesenskii* in areas with no crabs present. While common shore crabs and alien crabs can negatively affect other intertidal species via predation or competition, this study, at first glance, suggests that there does not seem to be competition for space or resources with *I. wosnesenskii*. However, this finding requires further research. Therefore, we recommend that future research investigate the behaviors between *I. wosnesenskii* and shore crabs before concluding that there is no impact of shore crabs on the distribution or abundance of *I. wosnesenskii*.

Finally, we found that intertidal height does not influence *I. wosnesenskii* abundance. This finding directly supports observations that the genus *Idotea* are spatially distributed throughout the intertidal shore (Ranta & Salemaa, 1991; Salemaa, 1986; Salemaa, 1997). Furthermore, in a study by Leifsson, 1998, the vertical distribution of *Idotea* were found to be subject to change depending on the season or food availability. These observations may explain why the current study found no significant preference between tidal height and *I. wosnesenskii* abundance. To quantify the influence of seasonality on *I. wosnesenskii* distribution, we recommend that future research repeat this experiment during the summer, fall, and winter.

As an intertidal crustacean, the genus *Idotea are* well adapted to life in the intertidal (Hultgren & Mittelstaedt, 2015; Starko et al., 2019; Wethey & Woodin, 2008). With adaptations such as lipid storage and plastic physiology, these herbivores may be well-equipped to face some of the challenges posed by climate change. However, ocean acidification still poses a threat - reducing survival rates, genetic diversity, and overall immunocompetence (Rugiu et al., 2021; Wood et al., 2014; Roth et al., 2010).

Furthermore, *Idotea* are ecologically important mesograzers that influence the structure of intertidal communities (Jaschinski & Sommer, 2008). A sudden plummet in the abundance of *Idotea* due to increasing effects of climate change may then result in the restructuring of current intertidal communities (Engkvist et al., 2000; Gonzalez & Biddanda, 1990; Boström & Mattila, 1999). Because of the ecological importance of *Idotea*, we must better understand what influences their abundance and distribution not just across San Juan Island but also globally to predict future implications of climate change on the structuring of intertidal communities (Hultgren & Mittelstaedt, 2015).

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TABLES AND FIGURES

Table 1. The time researchers began surveying each transect and the tidal height associated with the transect.

Date	Location	Transect	Time	Tidal Height ('MLLW)
16-May-22	Third Lagoon	Low	9:28 AM	-2
16-May-22	Third Lagoon	Medium	10:16 AM	-2.5
16-May-22	Third Lagoon	High	10:51 AM	-2.5
17-May-22	Cattle Point	Low	10:35 AM	-2.9
17-May-22	Cattle Point	Medium	11:18 AM	-3.2
17-May-22	Cattle Point	High	11:50 AM	-3.1
18-May-22	Beaverton's Cove	Low	12:39 PM	-2.9
18-May-22	Beaverton's Cove	Medium	1:20 PM	-2.8
18-May-22	Beaverton's Cove	High	2:10 PM	-2.5
19-May-22	Eagle Cove	Low	12:15 PM	-2.8
19-May-22	Eagle Cove	Medium	12:53 PM	-3.1
19-May-22	Eagle Cove	High	1:30 PM	-3

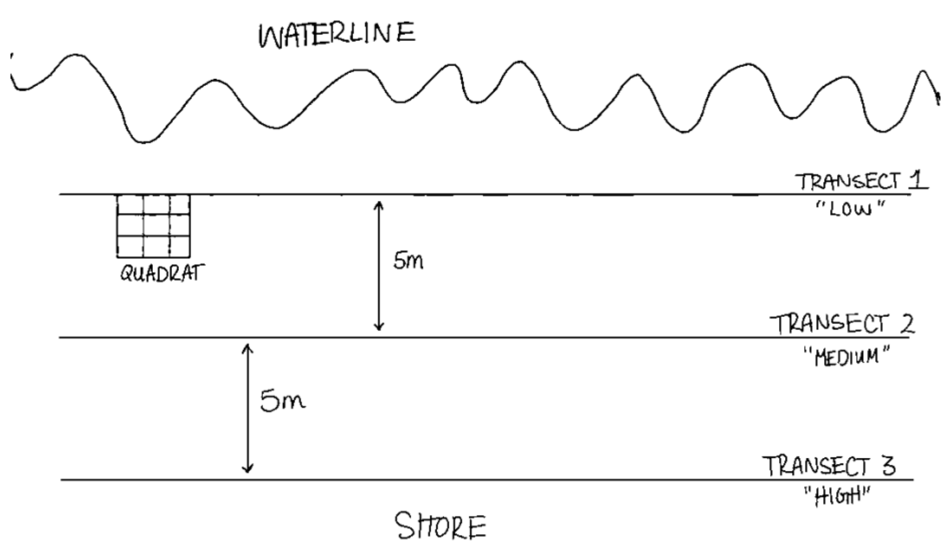

Figure 1. Experimental setup for surveying each location.

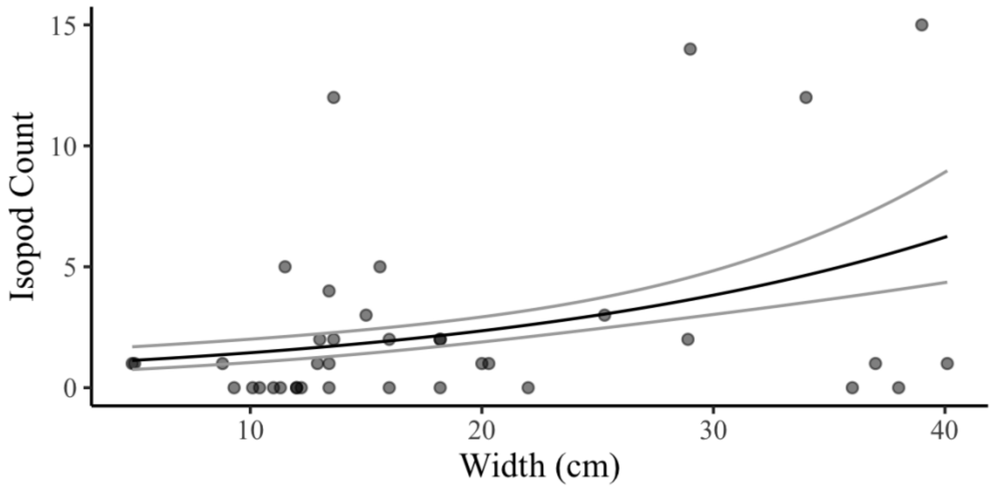

Figure 2. Number of *I. wosnesenskii* versus width of rock ($p < 0.01$).

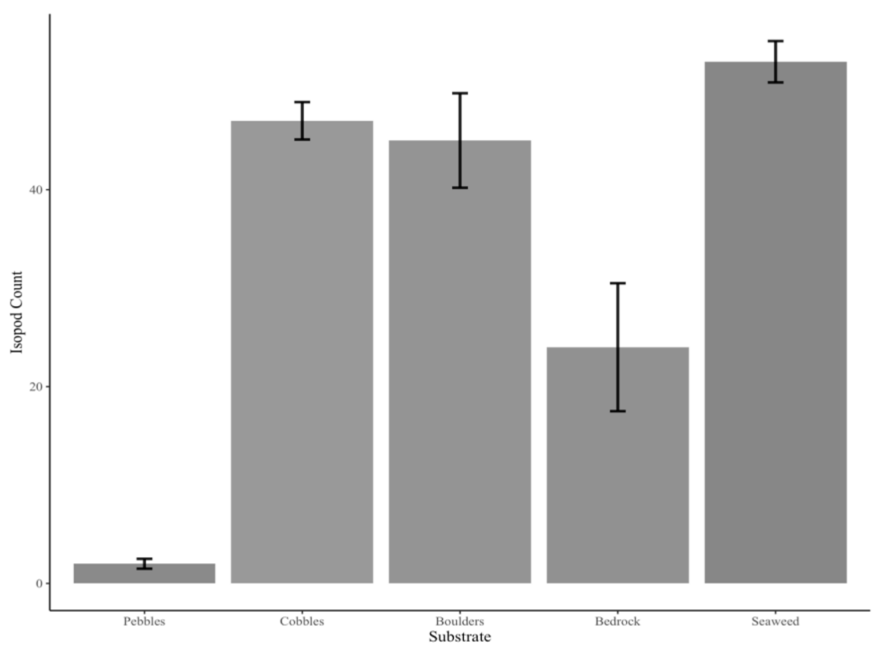

Figure 3. Count of *I. wosnesenskii* present on each substrate. Rock substrates were categorized into the following sizes: seaweed, pebbles (0.2-6.5cm), cobbles (6.5-25.6cm), boulders (25.6-409.6cm), and bedrock (>409.6cm).

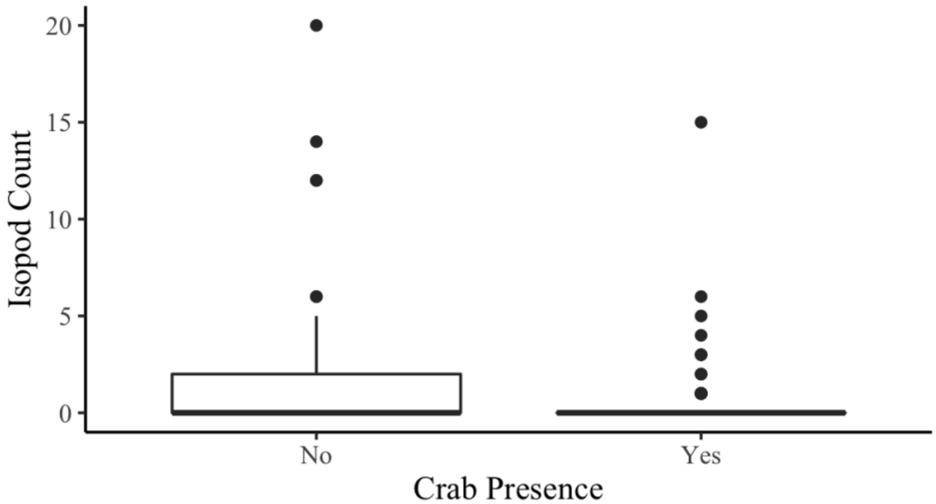

Figure 4. The count of *I. wosnesenskii* present in areas with crabs and areas without crabs present.

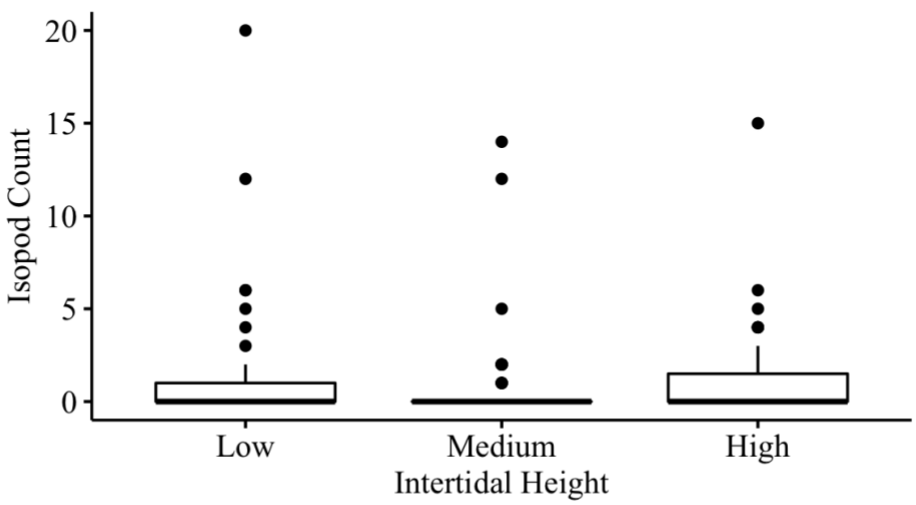

Figure 5. *Idotea wosnesenskii* count for each transect height. Low transects were located 5m away from the waterline.

LITERATURE CITED

Alexander, D. E. (1988). Kinematics of swimming in two species of *idotea* (Isopoda: Valvifera). *Journal of Experimental Biology*, *138*(1), 37–49. https://doi.org/10.1242/jeb.138.1.37

Boström, C., & Mattila, J. (1999). The relative importance of food and shelter for seagrass-associated invertebrates: A latitudinal comparison of habitat choice by isopod grazers. *Oecologia*, *120*(1), 162–170. https://doi.org/10.1007/s004420050845

Engkvist, R., Malm, T., & Tobiasson, S. (2000). Density dependent grazing effects of the isopod Idotea baltica Pallas on Fucus vesiculosus L in the Baltic Sea. *Aquatic Ecology*, *34*(3), 253–260. https://doi.org/10.1023/a:1009919526259

Epifanio, C. E. (2013). Invasion biology of the Asian Shore crab hemigrapsus sanguineus: A Review. *Journal of Experimental Marine Biology and Ecology*, *441*, 33–49. https://doi.org/10.1016/j.jembe.2013.01.010

Gonzalez, H., & Biddanda, B. (1990). Microbial transformation of metazoan (Idotea granulosa) faeces. *Marine Biology*, *106*(2), 285–295. https://doi.org/10.1007/bf01314812

Gurjanova, E. F. (1968). The influence of water movements upon the species composition and distribution of the marine fauna and flora throughout the Arctic and North Pacific Intertidal zones. *Sarsia*, *34*(1), 83–94. https://doi.org/10.1080/00364827.1968.10413373

Gutow, L. (2003). Local population persistence as a pre-condition for large-scale dispersal of Idotea Metallica (crustacea, Isopoda) on drifting habitat patches. *Hydrobiologia*, *503*(1-3), 45–48. https://doi.org/10.1023/b:hydr.0000008482.33369.ec

Hultgren, K. M., & Mittelstaedt, H. (2015). Color change in a marine isopod is adaptive in reducing predation. *Current Zoology*, *61*(4), 739–748. https://doi.org/10.1093/czoolo/61.4.739

Jaschinski, S., & Sommer, U. (2008). Functional diversity of Mesograzers in an eelgrass–epiphyte system. *Marine Biology*, *154*(3), 475–482. https://doi.org/10.1007/s00227-008-0942-y

Jormalainen, V. (1995). Differential predation on sexes affects colour polymorphism of the isopod Idotea Baltica (pallas). *Biological Journal of the Linnean Society*, *55*(1), 45–68. https://doi.org/10.1016/0024-4066(95)90028-4

Kotta, J., Paalme, T., Martin, G., & Mäkinen, A. (2000). Major changes in macroalgae community composition affectthe food and Habitat Preference Ofidotea Baltica. *International Review of Hydrobiology*, *85*(5-6), 697–705. https://doi.org/10.1002/1522-2632(200011)85:5/6<697::aid-iroh697>3.0.co;2-0

Lee, W. L., & Gilchrist, B. M. (1972). Pigmentation, color change and the ecology of the marine isopod Idotea Resecata (Stimpson). *Journal of Experimental Marine Biology and Ecology*, *10*(1), 1–27. https://doi.org/10.1016/0022-0981(72)90089-5

Leifsson, B. R. (1998). Life cycles, breeding periods and vertical distribution of idotea granulosa (crustacea, Isopoda) on Icelandic Shores. *Sarsia*, *83*(1), 1–13. https://doi.org/10.1080/00364827.1998.10413664

Merilaita, S. (2001). Habitat heterogeneity, predation and gene flow: Colour polymorphism in the isopod, Idotea Baltica. *Evolutionary Ecology*, *15*(2), 103–116. https://doi.org/10.1023/a:1013814623311

Naylor, E. (1955a). The diet and feeding mechanism of *idotea*. *Journal of the Marine Biological Association of the United Kingdom*, *34*(2), 347–355. https://doi.org/10.1017/s0025315400027703

Naylor, E. (1955b). The ecological distribution of British species of Idotea (Isopoda). *The Journal of Animal Ecology*, *24*(2), 255. https://doi.org/10.2307/1713

Orav-Kotta, H., & Kotta, J. (2004). Food and habitat choice of the isopod Idotea Baltica in the northeastern Baltic Sea. *Hydrobiologia*, *514*(1-3), 79–85. https://doi.org/10.1023/b:hydr.0000018208.72394.09

Panova, M., Nygren, A., Jonsson, P. R., & Leidenberger, S. (2016). A molecular phylogeny of the north-east Atlantic species of the genus with focus on the Baltic Sea. *Zoologica Scripta*, *46*(2), 188–199. https://doi.org/10.1111/zsc.12200

Rafi, F., & Laubitz, D. R. (1990). The idoteidae (crustacea: Isopoda: Valvifera) of the shallow waters of the northeastern North Pacific Ocean. *Canadian Journal of Zoology*, *68*(12), 2649–2687. https://doi.org/10.1139/z90-370

Ranta, E., & Salemaa, H. (1991). Phenotypic variability of the intertidal isopod idotea granulosa Rathke in the Irish Sea. *Crustaceana*, *61*(2), 155–174. https://doi.org/10.1163/156854091x00650

Roth, O., Kurtz, J., & Reusch, T. B. (2010). A summer heat wave decreases the immunocompetence of the MESOGRAZER, Idotea Baltica. *Marine Biology*, *157*(7), 1605–1611. https://doi.org/10.1007/s00227-010-1433-5

Rugiu, L., de Wit, P., Kostian, I., & Jormalainen, V. (2021). Climate change driven hyposalinity as a selective agent in the littoral mesoherbivore idotea balthica. *Marine Environmental Research*, *163*, 105216. https://doi.org/10.1016/j.marenvres.2020.105216

Salemaa, H. (1979). Ecology of Idotea spp. (Isopoda) in the northern Baltic. *Ophelia*, *18*(1), 133–150. https://doi.org/10.1080/00785326.1979.10425495

Salemaa, H. (1986). Breeding Biology and microhabitat utilization of the intertidal isopod idotea granulosa Rathke, in the Irish Sea. *Estuarine, Coastal and Shelf Science*, *22*(3), 335–355. https://doi.org/10.1016/0272-7714(86)90047-8

Salemaa, H. (2009). Geographical variability in the colour polymorphism of Idotea Baltica (Isopoda) in the northern baltic. *Hereditas*, *88*(2), 165–182. https://doi.org/10.1111/j.1601-5223.1978.tb01619.x

Salma, U., & Thomson, M. (2016). Gregarious aggregative behavior in the marine isopod Icirolana harfordi. *Invertebrate Biology*, *135*(3), 225–234. https://doi.org/10.1111/ivb.12134

Salma, U., & Thomson, M. (2017). Social aggregation of the marine isopod Icirolana harfordii does not rely on the availability of light-reducing shelters. *Physiological Entomology*, *43*(1), 60–68. https://doi.org/10.1111/phen.12229

Shuster, S. M. (1990). Courtship and female mate selection in a Marine Isopod Crustacean Paracerceis sculpta. *Animal Behaviour*, *40*(2), 390–399. https://doi.org/10.1016/s0003-3472(05)80935-2

Shuster, S. M., & Wade, M. J. (1991). Female copying and sexual selection in a marine isopod crustacean, Paracerceis sculpta. *Animal Behaviour*, *41*(6), 1071–1078. https://doi.org/10.1016/s0003-3472(05)80645-1

Starko, S., Smyth, C., & Kucera, H. (2016). Attachment strength of the herbivorous rockweed isopod, Idotea wosnesenskii (Isopoda, Crustaceae, Arthropoda), depends on properties of its seaweed host. *Journal of Experimental Marine Biology and Ecology*, *477*, 1–6. https://doi.org/10.1016/j.jembe.2016.01.006

Thom, R., Miller, B., & Kennedy, M. (1995). Temporal patterns of grazers and vegetation in a temperate seagrass system. *Aquatic Botany*, *50*(2), 201–205. https://doi.org/10.1016/0304-3770(95)00449-a

Wethey, D. S., & Woodin, S. A. (2008). Ecological hindcasting of biogeographic responses to climate change in the European Intertidal Zone. *Challenges to Marine Ecosystems*, 139–151. https://doi.org/10.1007/978-1-4020-8808-7_13

Wood, H. L., Sköld, H. N., & Eriksson, S. P. (2014). Health and population-dependent effects of ocean acidification on the marine isopod Idotea Balthica. *Marine Biology*, *161*(10), 2423–2431. https://doi.org/10.1007/s00227-014-2518-3