Photosynthesis and the Green Isopod Pentidotea reseca
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Abstract
The isopod Pentidotea reseca can be found on the eelgrass Zostera marina and Macrocystis spp. along the western coast of the United States. Two separate color morphs can be found, a brown morph which lives on Macrocystis and a green color morph on Zostera marina. Due to the variation in color it was hypothesized that chloroplasts may be taken in with their food. In this study we investigated whether chloroplasts are retained in the gut and maintain some functionality.

Methods
Respirometry was conducted using oxygen spectrometers to measure oxygen levels inside sealed chambers containing an isopod in seawater as measured during the light were not as clear. The mean respiration rate of live individuals in the dark was significantly higher in the dark than in the light. This suggests that some of the respirated oxygen is being replaced via photosynthesis in the light. Over the three week experimental period this effect increased (Fig 4).

Discussion
For live individuals the respiration rate was significantly higher in the dark than it was in the light. This strongly suggests photosynthesis contributing oxygen to the system in the light and lowering the apparent metabolism. It also rules out differences in activity which would have had the opposite effect since isopods showed similar activity or were even slightly more active in the light. Over the three week period the amount of photosynthesis appeared to increase, likely due to increased diatom growth on the eelgrass. Diatoms were brushed off prior to respirometry, however it was impossible to remove them all.

Figure 3. Mean metabolic rate seen in the lights and darks is both live and dead animals. The mean metabolism for live animals in the dark was significantly higher than any of the other groups. There was no other significance found. Letters indicate groups which are significantly different. Two-way ANOVA, p<0.001. Error bars indicate standard deviation.

Figure 4. The mean metabolic rate of live isopods by week. Data normalized to dark metabolism. For every week the apparent metabolism in the light was significantly lower than the dark. Paired means t-test, p<0.001.

The mean respiration rate of live individuals in the dark was significantly higher than the mean respiration rate of live individuals in the light as well as dead individuals in both light and dark conditions (Fig. 3). The difference between light and dark metabolism in dead individuals (with gut removed) was much less pronounced with no significant difference between the two.

Acknowledgements
We would like to thank Walla Walla University and the Walla Walla University Rosario Beach Marine Laboratory for providing the research facilities and the Padilla Bay National Research Reserve for their advice and assistance during the isopod study. A special thanks to Shelene McCarty who helped with many aspects of this research. Finally we would like to express our gratitude to the Crustacean Society for providing a scholarship award which covered many of the materials used in this study.

Differences in apparent metabolism in the light and dark of live animals suggested that substantial photosynthesis is taking place in the light. Some of the photosynthetic activity appeared to be due to diatoms growing on the outer surface of the animals. Our data suggest that at least some of the photosynthesis may have been from viable chloroplasts within the gut of the animal. Whether these cells make any contribution to the animal's metabolism is unclear.

Conclusions:
• Differences in apparent metabolism in the light and dark of live animals suggested that substantial photosynthesis is taking place in the light. Some of the photosynthetic activity appeared to be due to diatoms growing on the outer surface of the animals.
• Our data suggest that at least some of the photosynthesis may have been from viable chloroplasts within the gut of the animal.
• Whether these cells make any contribution to the animal's metabolism is unclear.

Introduction
The isopod Pentidotea reseca is found along the western coast of the United States. Individuals of this species are the same color as their substrate and primary food source with green color morphs found on Macrocystis spp. Due to this variation in color it was hypothesized that chloroplasts may be taken in with their food. In this study we investigated whether chloroplasts are retained in the gut and maintain some functionality.

Results
No significant difference was found in isopod activity between light and dark environments. (Fig. 2) If anything their activity in the light was higher. Both light and dark respirometry were conducted during the day to eliminate interference from any pre-existing circadian cycles.

Figure 1. Pictures showing LED Grow Lights and the experimental setup with respirometry chambers and oxygen optodes.

Figure 2. Activity levels as measured by movement across a grid. No significant difference was found between light and dark activity levels in 20 animals. Paired t-test with 10,000 randomizations, p<0.001. Error bars indicate standard deviation.

Means of rates of respiration for P. reseca in each experimental group

<table>
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<th>Group</th>
<th>Mean metabolic rate of live isopods by week</th>
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<td>Light</td>
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</tr>
<tr>
<td>Dark</td>
<td>987654321</td>
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</tbody>
</table>

The mean metabolic rate of live isopods in the light and dark. Data normalized to dark metabolism. For every week the apparent metabolism in the light was significantly lower than the dark. Paired means t-test, p<0.001.

For live individuals the apparent rate of respiration was significantly higher in the dark than in the light. This suggests that some of the respirated oxygen is being replaced via photosynthesis in the light. Over the three week experimental period this effect increased (Fig 4).

Figure 2. Activity levels as measured by movement across a grid. No significant difference was found between light and dark activity levels in 20 animals. Paired t-test with 10,000 randomizations, p<0.001. Error bars indicate standard deviation.

Figure 3. Mean metabolic rate seen in the lights and darks is both live and dead animals. The mean metabolism for live animals in the dark was significantly higher than any of the other groups. There was no other significance found. Letters indicate groups which are significantly different. Two-way ANOVA, p<0.001. Error bars indicate standard deviation.

For live individuals the respiration rate was significantly higher in the dark than it was in the light. This strongly suggests photosynthesis contributing oxygen to the system in the light and lowering the apparent metabolism.