# Effects of depth on diet of *Chlamys hastata* and *Chlamys rubida*

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**Abstract**

Scallops are semi-mobile filter feeding bivalves; an important member of their ecosystems due to their ecological contributions and importance as bioindicators. Despite their importance, little is known about their diet and feeding habits. It is accepted that suspension feeding bivalves have the ability to select particles by size (Riisgård 1988), and perhaps by chemical/nutritional properties (Ward et al. 1998). In this study we aimed to answer the question as to whether scallop individuals, *Chlamys rubida* and *Chlamys hastata,* consumed different diets across depths and species, displayed through gut contents. This was done by capturing *C. rubida* and *C. hastata* individuals from two different depths and analyzing their diets via a random survey of the gut contents. An overall ANOSIM test of gut content assemblage showed no significant difference between species or depths (p-value= 0.35). This confirmed our null hypothesis that there would be no significant difference between diets of scallop individuals across species or depth. The same-diet phenomenon could be due to multiple reasons, including but not limited to the abundance of food at each depth or to the scallops' ability to select food.

**Keywords**

*Chlamys rubida*, *Chlamys hastata*, *Pectinidae*, Diet Analysis, Gut Contents

**Introduction**

Molluscs are an important phylum ecologically, commercially and as bioindicators (Rittschof & McClellan-Green, 2005). They have been proven to improve water quality in Chesapeake Bay when feeding in large numbers (Gottlieb and Schweighofer 1996). Oysters from Chesapeake Bay and Willapa Bay, WA, as well as Sea Scallops (*Placopecten magellanicus*) in the Northeast Atlantic have been harvested commercially, supporting large fisheries. The *P. magellanicus* fishery in the Northeast Atlantic (primarily MA and NJ) is the largest wild scallop fishery in the world. In 2009, U.S. fishermen harvested 58 million pounds of sea scallop meats worth over $382 million (NOAA, 2011). Many filter feeding molluscs are also considered good bio indicators because they feed on what is in the water column and are therefore sensitive to anthropogenic inputs (Rittschof & McClellan-Green, 2005).

Scallops are semi-mobile filter feeding bivalves. Scallops have the unique ability to swim through the water column by opening and closing the valves of their shells, whereas most bivalves are cemented to a substrate via byssal threads or a foot and are therefore limited to local food sources (Brand 2006). The swimming movement of scallops also allows them to stir up benthic sediment; as a result they can access suspended materials in the near-bottom water as well as newly deposited materials (Shumway et al. 1987). Since scallops are dependent on suspended organic matter for food (Shumway et al. 1987), they bioaccumulate human-derived particles and other harmful organic matter. As opportunistic filter feeders, scallops can take advantage of a variety of food sources including phytoplankton, diatoms and other particulate organic matter (Shumway et al. 1987).

It has been assumed that a suspension feeder's diet is restricted to material that passes their gills, but recent evidence suggests that scallops are capable of selective feeding. At least some scallop species have the ability to select food after it has been ingested. Sea scallops collected from Deer Island, Canada, can sort organic from inorganic particles before and after ingestion (Brillant and MacDonald 2002). Laboratory studies have shown that scallops can retain protein-coated micro beads longer than uncoated ones by postingestive selection based on chemical properties (Brillant and MacDonald 2002). This coincides with a study where Cranford (1995) fed varying concentrations of organic and inorganic matter to scallops to look for relationships between food quality, quantity, and efficiency/absorption rates of dietary constituents. The absorption efficiencies of particulate organic matter decreased as dietary inorganic content increased (Cranford 1995), suggesting that additional time and energy is being spent sorting organic and inorganic material. Less is known about whether scallops have the ability to select among organic particles. However, suspension feeding bivalves have the ability to select particles by size (Riisgård 1988), and perhaps by chemical/nutritional properties (Ward et al. 1998).

Since scallops are important commercially and ecologically, it would be beneficial to determine where their nutrients come from and what they are eating in their natural habitat. Lehane and

Davenport (2002) compared gut contents of the Queen Scallop, *Aequipecten opercularis*, taken directly from their natural benthic habitat with other *A. opercularis* that were suspended in cages in the water column. Both groups of scallops consumed many zooplankton species, but suspended scallops consumed food items of longer length (Lehane and Davenport 2002).

When analyzing the diet of scallops at different depths, one might expect scallops from shallower waters to consume more planktonic organisms which tend to concentrate near the surface because they are reliant on the sun as a source of energy. Scallops in deeper water below the euphotic zone might rely more on detritus since plankton are less readily available. Detritus, or particulate organic matter, floating down to deeper dwelling scallops would have large amounts of dead planktonic organisms and decaying macroalgae molecules. The specific nutritional value of particulate macroalgae as well as its overall contribution to food web dynamics is not fully understood. However, Duggins and Eckman (1997) suggested that a common suspension feeding bivalve, *Mytilus trossulus*, feed and grew on both fresh and aged particulate macroalgae. Additionally, a diet analysis of deep water scallops (Patinopecten yessoenesis) found that detritus constituted the bulk of the diet with varying amounts of algae throughout the seasons (Mikulich and Tsikhon-Lukanina, 1981). This suggests that particulate macroalgae may be a significant source of food for many suspension feeders.

*C. rubida* and *C. hastata* were used in this study because they are distinct species which occupy the same depth range in the same location (5m-100m+). In this study the question was raised as to whether the diets of scallop individuals of different species varied while living at the same depth. Additionally, the question was raised as to whether the diets of scallop individuals of the same and different species varied across depths. The null hypothesis is that there will be no significant difference between the diets of individuals across species or depth.

**Methods**

The scallops used in this experiment, *Chlamys hastata* and *Chlamys rubida*, were collected at two different depths around San Juan Island, WA. The first scallops were collected at approximately 50 fathoms via a dredge. The remaining *C. hastata* and *C. rubida* were collected four days later from approximately 25 m via scuba. After each respective collection, 20 *C. rubida* and 20 *C. hastata* individuals from the deep and shallow depths were immediately dissected to remove the stomach. The stomachs were preserved in 1 ml of 1.6% paraformaldehyde to prevent further digestion of contents. During the dissection, the length, sponge cover, and sex of the individuals were recorded.

After the dissections were completed, the gut content of each individual was analyzed. To evenly distribute the gut contents, the stomachs were cut open and swirled in the 1 ml of 1.6% paraformaldehyde in which they were stored. Then, a sample of the preserved gut contents was taken and looked at it under a compound microscope at 100x magnification. For each sample, five semi-random points were selected to prevent biased observation (Figure 2). The points were semi-random in the sense that they all fell in the same general area (corners and middle), but placement in each respective area was random (Figure 2). At each random point a transect was established along the ocular micrometer, recording what fell under five predetermined spots on the micrometer (Figure 2). This procedure was repeated three times for each scallop so that a total of seventy-five data points were accrued for each individual (Figure 2). Common diatoms were identified to genera, where as uncommon ones were recorded as centric, pennate, or chain forming along with a note. The 16 categories used to classify the stomach contents are as follows: Thalassiosira, Other Centric, Pennate, Chaetoceros, CF Melosira, Other Chain, Other Diatoms, Biogenic Inorganic (pieces of diatoms), Micro algae, Macro algae, Stomach Tissue, Inorganic Detritus, Other (Unidentifiable), Empty, Ovate, and Dinoflagellate. The remaining contents were identified to the best of our abilities. Statistics were compiled using Primer6™ software.

**Results**

The average count of biogenic inorganic structures observed in *C. rubida* deep, *C. hastata* deep, *C. rubida* shallow and *C. hastata* shallow were 9.10, 6.60, 9.95 and 9.62 respectively (Figure 1, Table 1). The average count of Thalassiosira observed in *C. rubida* deep, *C. hastata* deep, *C. rubida* shallow and *C.*

*hastata* shallow were 1.05, 1.80, 1.55 and 1.15 respectively(Figure 1, Table 1). The average count of micro algae items observed in *C. rubida* deep, *C. hastata* deep, *C. rubida* shallow and *C. hastata* shallow were 20.20, 22.00, 23.40, and 29.92 respectively (Figure 1, Table 1). A similarity percentage analysis (SIMPER) of *C. rubida* deep, *C. hastata* deep, *C. rubida* shallow and *C. hastata* shallow gut contents within each group, the average similarity was 69.15%, 70.42%, 73.29% and 74.30% respectively. A multivariate plot suggested that the scallops were ingesting similar items regardless of depth or species (high overlap of groups of points) (Figure 3). An analysis of the overall gut content assemblage items showed no significant differences in an overall ANOSIM test (p-value= 0.35) or between any of the species or depths (Table 2). For each of the tests performed above, the empty category of gut contents was removed prior to data analysis.

**Discussion**

*C. rubida* and *C. hastata* have the same diet in both shallow water, (which is in the euphotic zone), and the deep water which is out of the euphotic zone. Additionally, the diets of *C. rubida* and *C. hastata* were shown to be the same at similar and different depths. This same-diet phenomenon could be due to multiple reasons, including but not limited to the abundance of food at each depth or to the scallops' ability to select food. This same-diet phenomenon confirmed the null hypothesis that there would be no significant difference between diets of scallop individuals across species or depths.

For each of the tests performed on the scallop gut contents, the "empty" category was removed prior to data analysis. The spots counted as "empty" were points across the transect which contained no gut contents under them. They were removed from data analysis as they provided no significance to the questions raised. If the stomach contents were diluted in regards to the size of the stomach, an analysis of how full the stomach was could have been done. However, due to time constraints this was not undertaken and should be an area of further study.

As mentioned, previous studies have shown that scallops have the ability to sort organic from inorganic particles before and after ingestion (Brillant and MacDonald 2002), select particles by size

(Riisgård 1988), and perhaps by chemical/nutritional properties (Ward et al. 1998). These factors could be reasons why there is no significant difference in diets among either of the *Chlamys* species or depths. Both *C. hastata* and *C. rubida* could be selectively feeding for the same particles based on their nutritional value, which would explain their same diets.

The confirmed null hypothesis could also be explained by the simple availability of food in the system. It is possible that at both depths, the only food available to a filter feeding bivalve is particulate organic matter. If this particulate organic matter were of the same composition at both depths, the similarity in diets would be explained without selective feeding by the scallops.

Further research should be conducted in the diet composition of scallops in an attempt to understand why no differences were seen. This project had a category of gut contents titled “Micro Algae” which should be investigated further. The composition of the micro algae was uncertain, it seemed to contain bits of diatom frustules as well as a “goo” (may be partially digested algae or diatoms). It is possible that this “goo” is partially digested particulate macroalgae which clumped on to other particles in the gut. This would be consistent with previous literature stating that detritus constituted a bulk of deep water scallop diets (Mikulich and Tsikhon-Lukanina, 1981). However, its composition is not determinable from this experiment. This issue is important for a better understanding of the scallop diets and further studies should attempt to determine what this “Micro Algae” was. Additionally, further investigation into the composition of particulate organic matter in the same area of scallop diet experiments should be undertaken. The particulate organic matter could also provide clues to what the “Micro Algae” consisted of, if in fact it was a mix of detritus.

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**Figures**

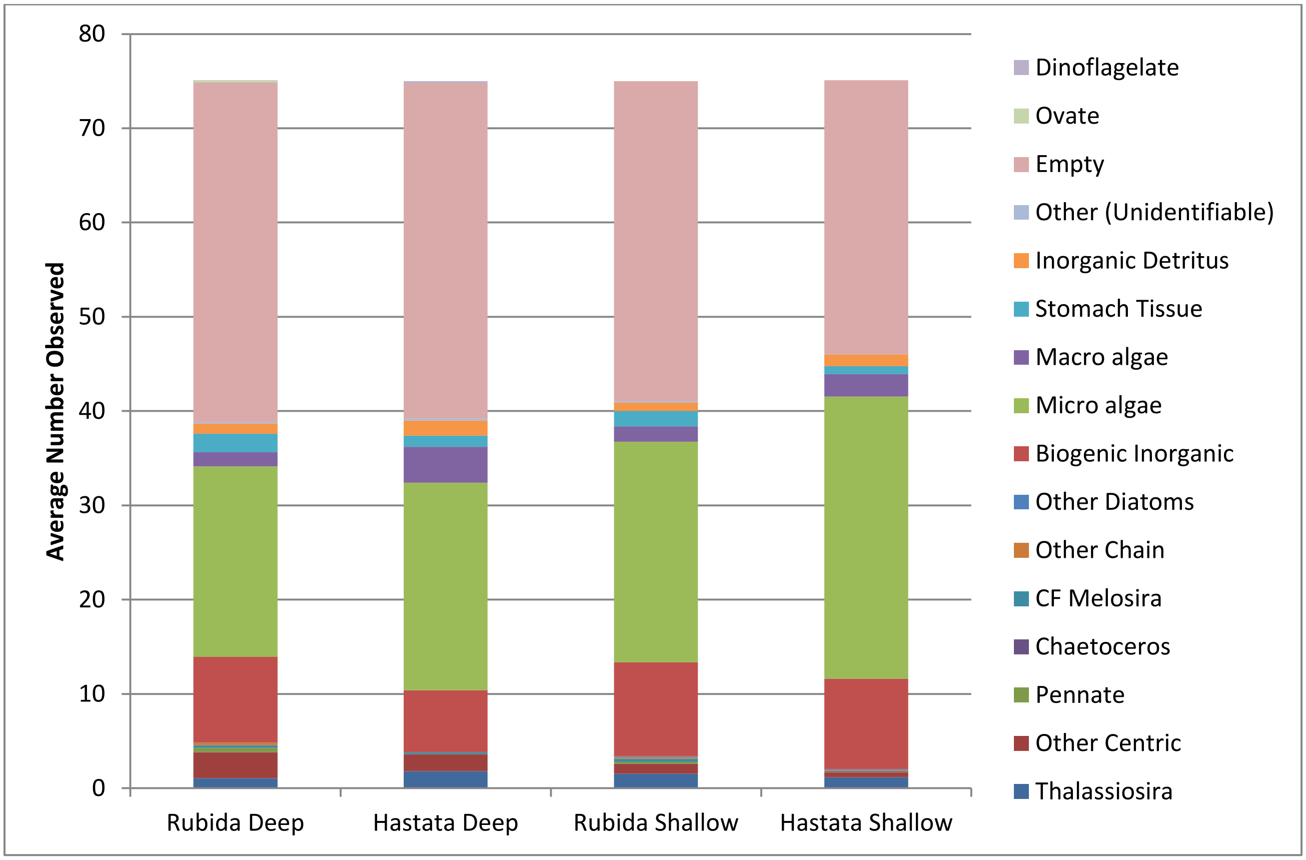


**Figure 1. Average number of observed food items for *C. rubida* deep, *C. hastata* deep, *C. rubida* shallow and *C. hastata* shallow.**

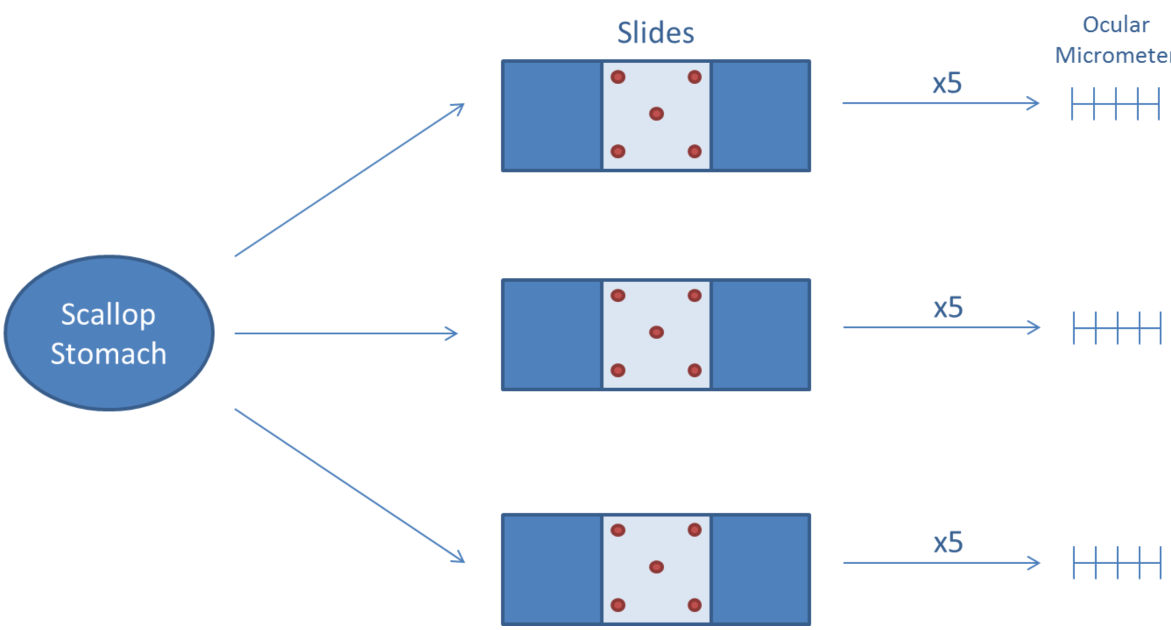


**Figure 2. Diagram of scallop gut sampling methods**

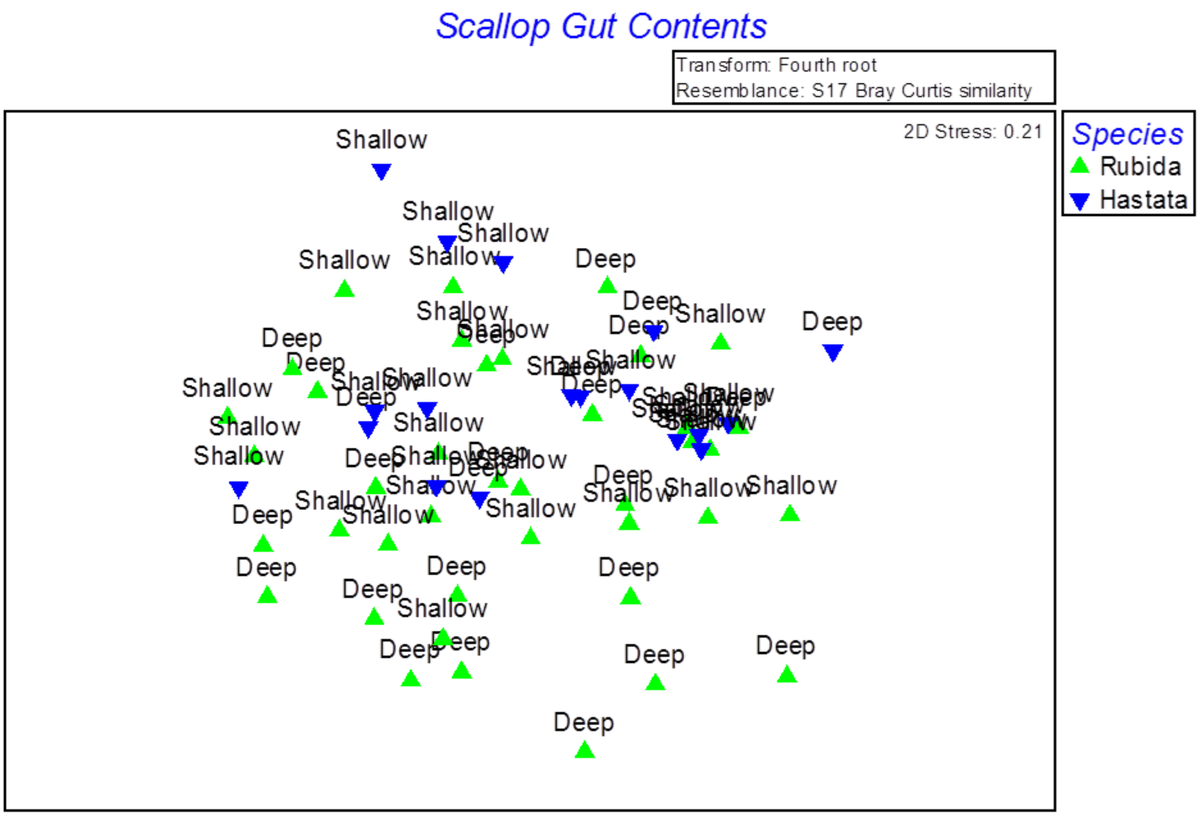


**Figure 3. Multidimensional scaling of all gut contents of *C. rubida* deep, *C. hastata* deep, *C. rubida* shallow and *C. hastata* shallow. Each point represents the gut contents of one scallop in multidimensional space; points closer together are scallops with more similar gut contents (type and abundance of foods).**

**Table 1. Average number of observed food items for *C. rubida* deep, *C. hastata* deep, *C. rubida* shallow and *C. hastata* shallow.**

| | Thalassiosira | Other Centric | Pennate | Chaetoceros | CF Melosira | Other Chain | Other Diatoms | Biogenic Inorganic |
|---|---|---|---|---|---|---|---|---|
| RD | 1.05 | 2.75 | 0.45 | 0.05 | 0.25 | 0.30 | 0.00 | 9.10 |
| HD | 1.80 | 1.80 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 | 6.60 |
| RS | 1.55 | 1.05 | 0.20 | 0.00 | 0.35 | 0.15 | 0.10 | 9.95 |
| HS | 1.15 | 0.54 | 0.08 | 0.08 | 0.00 | 0.08 | 0.08 | 9.62 |

| | Micro algae | Macro algae | Stom. Tissue | Inorganic Detritus | Other | Empty | Ovate | Dinoflag. |
|---|---|---|---|---|---|---|---|---|
| RD | 20.20 | 1.50 | 1.95 | 1.10 | 0.15 | 36.00 | 0.20 | 0.05 |
| HD | 22.00 | 3.80 | 1.20 | 1.60 | 0.20 | 35.60 | 0.00 | 0.20 |
| RS | 23.40 | 1.65 | 1.60 | 0.90 | 0.15 | 33.95 | 0.00 | 0.00 |
| HS | 29.92 | 2.38 | 0.85 | 1.23 | 0.00 | 29.08 | 0.00 | 0.00 |

| | HD | HS | RD |
|---|---|---|---|
| HS | 0.235 | - | - |
| RD | 0.667 | 0.141 | - |
| RS | 0.300 | 0.519 | 0.427 |

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