Arsenic Related Human Health Risk from Consumption of *Doryteuthis opalescens* (Market Squid) in Puget Sound, WA

Tyler Hall, Jim Gawel, Eliza Heery
Environmental Science

Introduction

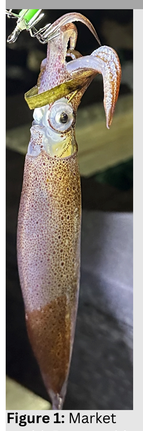

Figure 1: Market squid, Doryteuthis opalescens.

- Market squid or *Doryteuthis opalescens* (Figure 1)
- **Popular urban fishery**
- Live only one year (semelparous)
- **Sustainable, abundant, and easily obtainable source of protein**
- **10lb daily limit and no retention limit**
- Very little research done on Puget Sound population
- Bioaccumulate metals in the mantle tissue
- **Other studies on cephalopods have found high concentrations (8.63 mg/kg of frozen tissue) of arsenic in mantle tissues (Conficoni et al 2018)**
- Need to assess human health risk

Methods

- Squid captured using Jigging Methods (Figure 3)
- Four locations; Port Angeles (PANG), Illahee (ILLA), Waterman (WATR), and Steilacoom (STEIL) (Figure 4)
- A one inch diameter piece of mantle was removed using a fabricated PVC punch (Figure 2)
- Tissue was then dried at 60 °C for 3 days, then ground into a powder and digested in HNO3 (MARS 5)
- Metals were analyzed using ICP-MS
- Calculated metal concentrations for each location using excel (Figure 5)
- Principal component analysis using R (Figure 8)
- Significant correlations were analyzed using R
- Verified metals recovery for method using a control dogfish liver (DOLT-5 2014)
- Calculated both cancer and non-cancer risks using Department of Health's tool (Hull et al 2021)
- Calculated risk for general and at-risk populations (DEQ 2008)

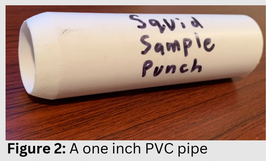

Figure 2: A one inch PVC pipe fabricated into a punch tool. Used to acquire flesh samples from squid mantle tissue.

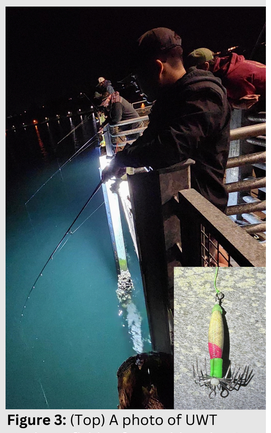

Figure 3: (Top) A photo of UWT students fishing for squid at the Port Angeles Pier. (Bottom Right) A photo of the squid jigs used to capture the squid.

Methods cont...

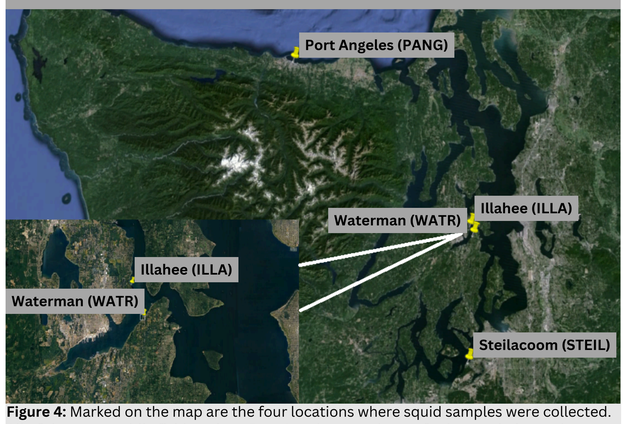

Figure 4: Marked on the map are the four locations where squid samples were collected. All of them are public fishing piers. Port Angeles was chosen for its proximity to the ocean, and Clyde Davidson (Steilacoom) was conversely chosen for its distance from the Pacific. Illahee and Waterman were selected as both a gradient measure and for the proximity to the Naval Base. There is a zoomed in image of them on the bottom left.

Results

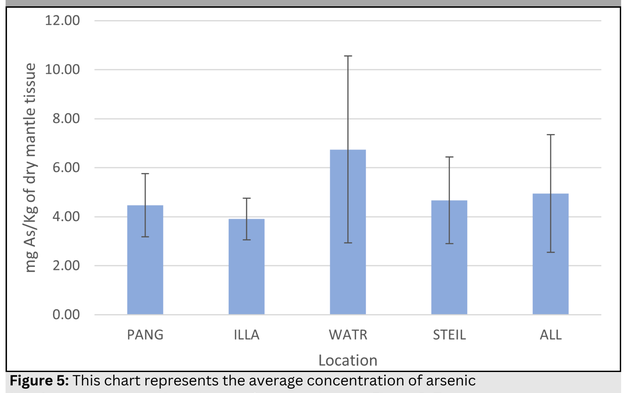

Figure 5: This chart represents the average concentration of arsenic (mg As/kg dry mantle tissue) at the four locations on Figure 3. The error bars represent the standard deviation of As concentration of nine squid captured at each location.

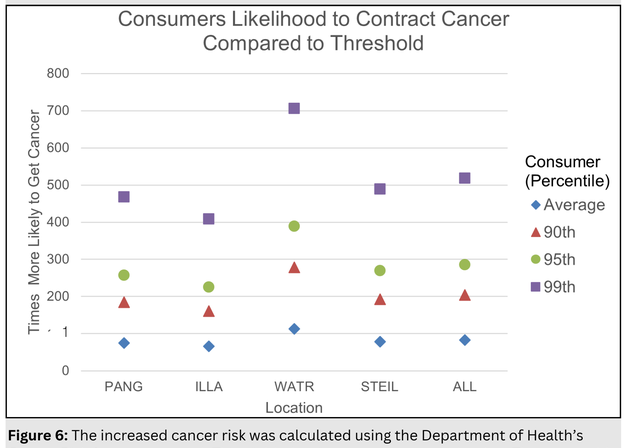

Figure 6: The increased cancer risk was calculated using the Department of Health's Cancer Risk Assessment tool. This yielded an increased cancer risk value. The acceptable lifetime risk is 1 in 100000.

Results cont...

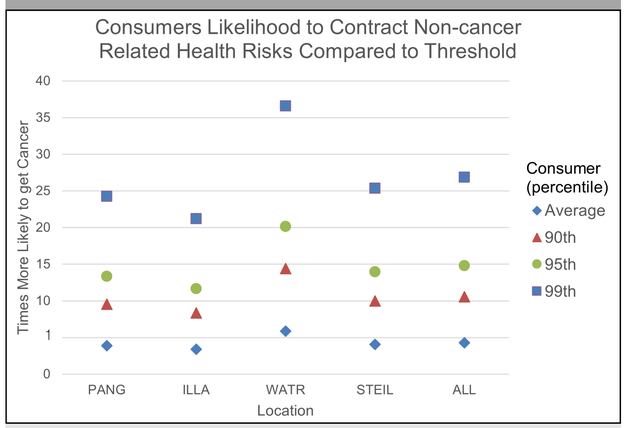

Figure 7: The ingestion dose was calculated using the Department of Health's Non-Cancer Risk Assessment tool. This yielded a recommended daily dose in mg/kg/day. The acceptable daily dose is 0.0003 mg/kg/day.

- **Arsenic (As) levels exceeded the human risk threshold (Figure 6 and 7)**
- **Average consumers are 83 times more likely to get cancer (Figure 6)**
- **Average consumers are 4 times more likely to contract non-cancer related health risks (Figure 7)**
- **Based on DOLT-5 dogfish liver certified reference material there was an 83.7% recovery meaning arsenic levels may be underestimated**
- There were no significant correlations between arsenic levels and measurements such as dorsal mantle length or weight that would skew our findings
- Squid caught from more oceanic locations (PANG and ILLA) had higher concentrations of metals (Figure 8)
- **Cephalopods in Italy had similarly high concentrations of As in mantle tissue (Conficoni et al 2018)**

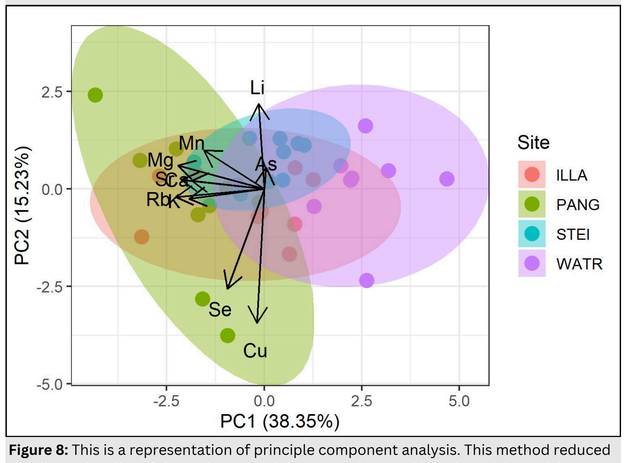

Figure 8: This is a representation of principle component analysis. This method reduced the dimensionality of the various metal concentrations and locations. PC1 explains 38.35% of the variation while PC2 explains 15.23%. The arrows indicate how strongly each variable affects the measured values and separates any patterns.

Discussion

- **All consumers are at significant health risk**
- We don't understand why As concentrations are so high in Puget Sound squid
- Research on As in cephalopod tissue is relatively underrepresented (Conficoni et al 2018)
- **We are working with the Washington Dept. of Fish & Wildlife and the Dept. of Health on the next steps in creating a consumption advisory**
- WATR, that has highest As levels is the closest location to the Bremerton Naval Ship yard (Figure 4) which is a known source of pollution
- Squid caught at each location had similar As concentrations (Figures 5 and 8)

Conclusion

- **The availability and abundance of squid make them a significant risk for pollutant ingestion**
- Arsenic levels in each location is of concern, but there is significantly higher concentrations at the Waterman location
- Arsenic levels in Puget Sound squid had not been reported prior to this study

References

Acknowledgements

We thank the late Mary Cline and her family, whose legacy funded our research. We thank Dr. Bonnie J. Becker, Francesca Marvin, Ashley Benson, Lindsay Overstreet, Jessica Linkemyer, Arthur Weisberg, and everyone else at Becker Lab. We thank Roy Clark, Jack Dudding, Camille Speck, and everyone else at the Washington Department of Fish and Wildlife. We thank Dr. Julie Masura and Dr. Peter Selkin at UWT. This research would not have been possible without all of your help and support.