NPRB1616 Summary Report for the Communities of Old Harbor, Ouzinkie and Kodiak

Project Title: Implementation of Community-Based PSP Testing for Subsistence and Recreational Shellfish Harvesting in Southcentral and Southwestern Alaska
Short Title: 1616 Community Based PSP Testing for Shellfish

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Project Overview:
Paralytic Shellfish Poisoning (PSP) remains a serious health risk for Alaskan residents. Seasonal blooms of the biotoxin producing dinoflagellate, *Alexandrium*, are responsible for PSP toxins in Alaskan waters. Subsistence shellfish harvesters in southwest Alaska are exposed to high PSP risks due to their dependency on shellfish resources, strong cultural traditions, and limited accessibility to medical care. The State of Alaska does not conduct routine testing of recreational/subsistence-harvested shellfish so regional and statewide networks have formed to address the problem. Community based monitoring has proven to be an effective strategy to reduce PSP risks.

This NPRB-funded study leveraged existing PSP monitoring networks in southwest Alaska with previous NPRB-funded technologies to continue subsistence shellfish testing and develop improved toxin testing tools.

The objectives of the study were:

1. To build on existing PSP toxin monitoring efforts in the communities of Kodiak, Old Harbor and Ouzinkie;
2. To use shellfish tissues collected in the Kodiak region to further develop the toxin testing methodologies with the goal of producing a field test kit;
3. Secondary objective: to investigate the toxicity of different anatomical tissue in butter clams.

Background:
While the State of Alaska directs financial resources to the commercial shellfish industry, there are no dedicated funds addressing toxin monitoring of subsistence-harvested shellfish. A recreational shellfish monitoring pilot study, funded by the Alaska Department of Environmental Conservation (ADEC), was implemented in 2012-2015. This pilot study has been the only effort by the State of Alaska to conduct toxin monitoring in support of shellfish harvesting for personal use.

The communities of Old Harbor and Ouzinkie began monitoring PSP toxins in butter clams in 2013 as part of this ADEC pilot study. Kodiak was one of four communities that participated in this 3-year statewide effort. The project in Kodiak was administered through the Kodiak Island Borough School District (KIBSD), with support from Kodiak Alaska Sea Grant (ASG) Marine Advisory Program (MAP) agent Julie Matweyou.

Shellfish monitoring was conducted in Ouzinkie by the Ouzinkie School, with support of an Ouzinkie resident (then City Mayor); and in Old Harbor by the Alutiiq Tribe of Old Harbor. An important aspect of the project was that communities determine the shellfish species and the location to be monitored. Butter clams were identified as the preferred species in both communities, and the subsistence shellfish sites were selected as Shipwreck Beach in Old Harbor and Sourdough Beach in Ouzinkie. Monthly shellfish toxin results were disseminated to the communities via outreach fliers and word of mouth, and educational activities and youth involvement were a primary component of the project. A full project report can be referenced for the project results and thorough discussion of the program successes and challenges (Matweyou, J. and Bartz, K. 2015. Recreational Shellfish Project FINAL REPORT).

A powerful data set emerged from the state-wide monitoring effort. Samples under this program were tested using High Performance Liquid Chromatography (HPLC), a method that provides insight into the different toxin compounds (congeners) that make up the collective PSP toxins referred to as saxitoxins (STXs).

The NPRB1616 project team came together in 2016 to continue collection of this useful information through community-based monitoring and to use this detailed data to inform development of toxin testing methods (i.e. to develop a field test kit). The NPRB project continued butter clam monitoring at Old Harbor and Ouzinkie and established a third monitoring site in Kodiak through partnership with the Sun'aq Tribe of Kodiak. The Agdaagux Tribe of King Cove and the Qagan Tayagungin Tribe of Sand Point also contributed butter clam data, contributing to our understanding of butter clam toxicity in Western Alaska.

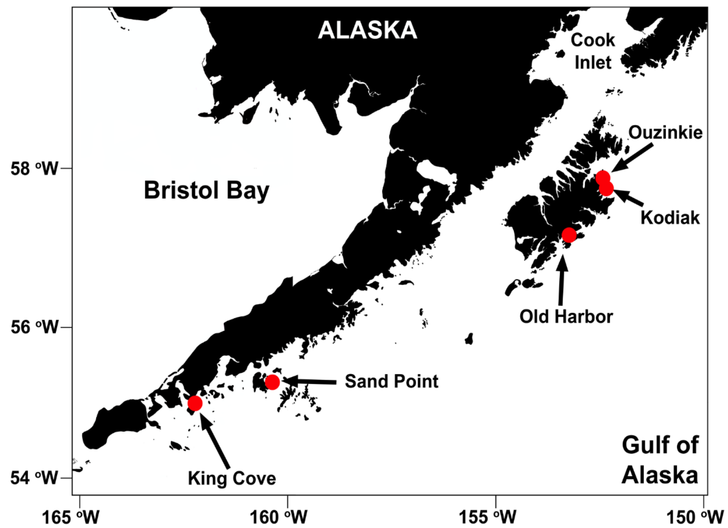


Figure 1. NPRB1616 study sites.

Monthly Toxin Monitoring:

Monthly toxin monitoring under NPRB 1616 began in October 2016 and continued through February 2020 in the Kodiak region. Additional samples collected in 2015-2016 by volunteers after the ADEC funding expired and before this project began, were also analyzed as a component of the NPRB project. Monthly butter clam samples were collected by community samplers and processed according to the ADEC Environmental Health Laboratory sample protocol, and stored frozen until they could be shipped or carried into Kodiak. Samples were then shipped to Beaufort, NC for analysis by HPLC at the NOAA Beaufort Laboratory. [Note: analysis of project samples collected between August 2019 and February 2020 is delayed due to laboratory closures related to COVID-19; results will be provided upon completion]. A combined data set was established that included the ADEC and NPRB projects, as well as results from a six-month study in Old Harbor funded by the Alaska Native Tribal Health Consortium (ANTHC). Results from these studies are presented graphically in Figure 2, and in tabular form in Appendix A. Table 1.

Butter clam toxicity data from the three monitoring sites exhibited clear seasonal patterns with toxins increasing during summer months and declining in the winter. Distinct peaks in clam toxicity were evident at all three sites in June - July, consistent with the annual occurrence of *Alexandrium* blooms. Lower levels were generally evident during the winter months as toxicity declined after the blooms subsided. However even in winter, toxicity regularly exceeded FDA regulatory limit of 80 µg STX/100 g.

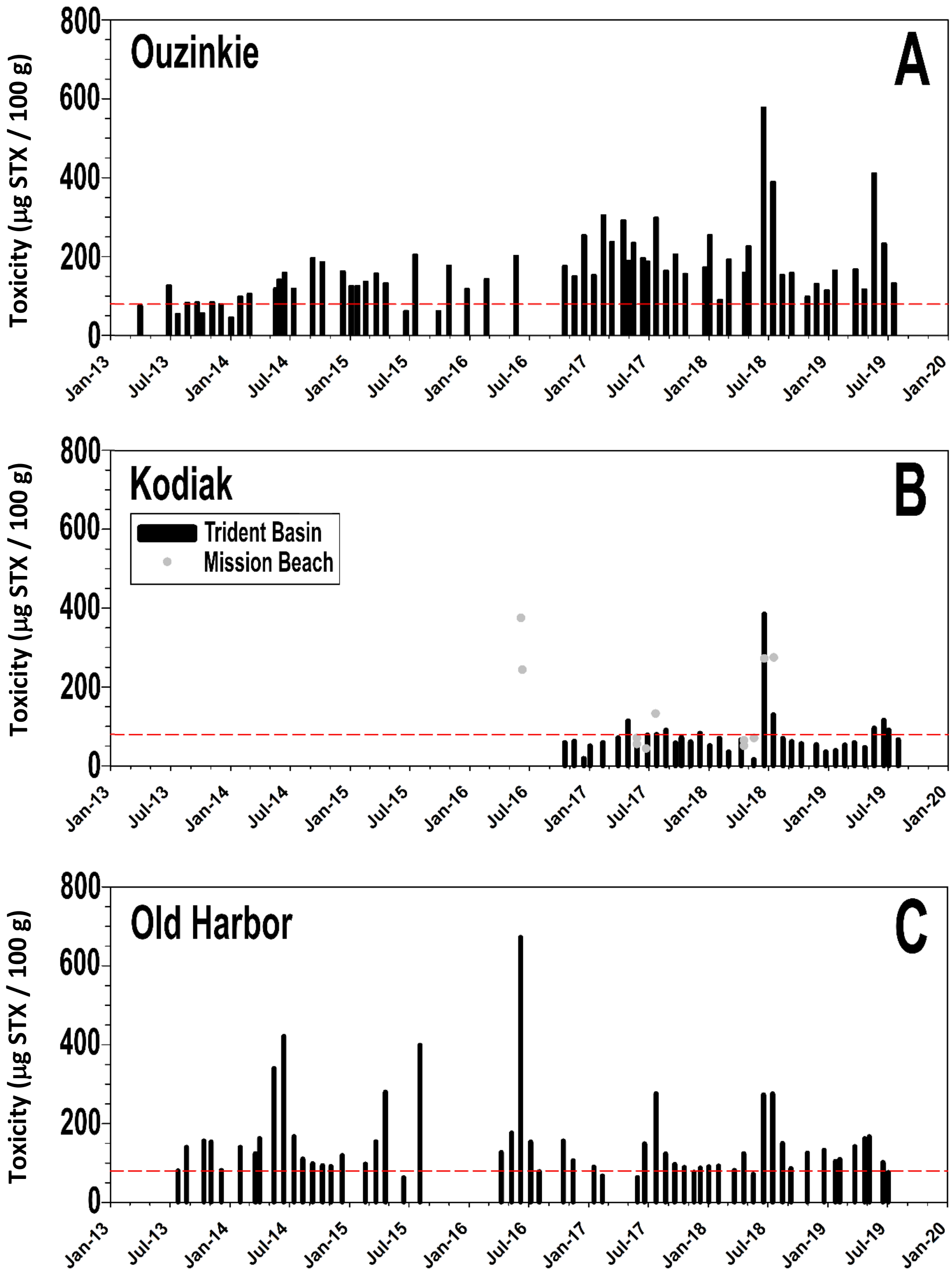


Figure 2. Butter clam toxicity during 2013-2020 at (A) Sourdough Beach, Ouzinkie, (B) Trident Basin (bars) and Mission Beach (gray dots), Kodiak, and (C) Shipwreck Beach, Old Harbor. Toxicity is presented as µg STX Eq. 100 g^{-1} which is the same as µg STX / 100 g. The red dashed line denotes the FDA regulatory limit of 80 µg STX / 100 g shellfish tissue.

Toxicity data from Sourdough Flats, Ouzinkie and Shipwreck Beach, Old Harbor showed toxin concentrations in butter clams consistently above the FDA regulatory limit. Only nine of the 67 Ouzinkie samples, and seven of the 56 Old Harbor samples, tested below the regulatory limit. Toxin levels ranged from 46 to 578 µg STX / 100 g in Ouzinkie and 63 to 672 µg STX / 100 g in Old Harbor. In contrast, data from Near Island, Kodiak indicated butter clam toxicity was primarily below the regulatory level. Toxin levels ranged from 16 to 385 µg STX / 100 g at the Trident Basin site, with only eight of the 35 samples testing above regulatory level. The minimal level in May 2018 of 16 µg STX / 100 g was followed by an abrupt increase in toxicity to 385 µg STX / 100 g in June. This apparent early summer *Alexandrium* bloom was short lived, as Near Island clam toxicity declined in July and remained relatively low for the rest of the study.

Alexandrium blooms are seasonal and can be highly variable and patchy in distribution. We see this variability between regional collection sites, and between sites in close proximity (data not shown). Toxins can increase to lethal levels without warning depending on the concentration and toxicity of the *Alexandrium* cells, factors governing these blooms are ultimately determined by oceanographic conditions. Because it is impossible to predict toxin blooms at this time, we recommend routine monthly sampling and harvest/hold/test practices. It is also important to remember that shellfish monitoring results only reflect the conditions on the designated beach and cannot be interpreted for other areas. It is also important to note that the highest toxin concentration reported here (672 µg STX / 100 g in Old Harbor) is just $1/10^{th}$ of the butter clam toxicity reported previously in the Kodiak region. A drastic increase in shellfish toxicity could happen unexpectedly any year.

To help describe seasonal trends in toxicity, the 2013-2019 butter clam monitoring data at the three Kodiak sites were binned into monthly means (Figure 3A.). The data again illustrate a distinct peak in clam toxicity in May-July at all sites.

Saxitoxin , the potent neurotoxin associated with PSP, refers to an entire suite of structurally related neurotoxins known collectively as "saxitoxins". The collective term saxitoxin includes over 20 chemical variants, each with a specific name and level of toxicity. We are able to identify these toxins with the HPLC analytical method used in this project. This level of detail informs our understanding of seasonal trends in the environment. The relative contribution of the major saxitoxin congeners are presented in Figures 3B-D as percent toxicity (% toxicity) of the total toxin. The data indicate saxitoxin (STX) was the most important toxin overall, with a lesser contribution by neosaxitoxin (neoSTX) and gonyautoxins (GTXs). The GTXs were identified as important components of the spring and summer toxicity profiles (May through July) when *Alexandrium* cells are in high numbers (Kibler et al., in progress). The Kodiak data are being combined with other Western Alaska data and evaluated for statewide trends. Understanding the toxin profiles found in Alaska shellfish is important to the development of a PSP test kit that detects all toxins. The manuscripts resulting from this study will be shared with participating communities when finalized.

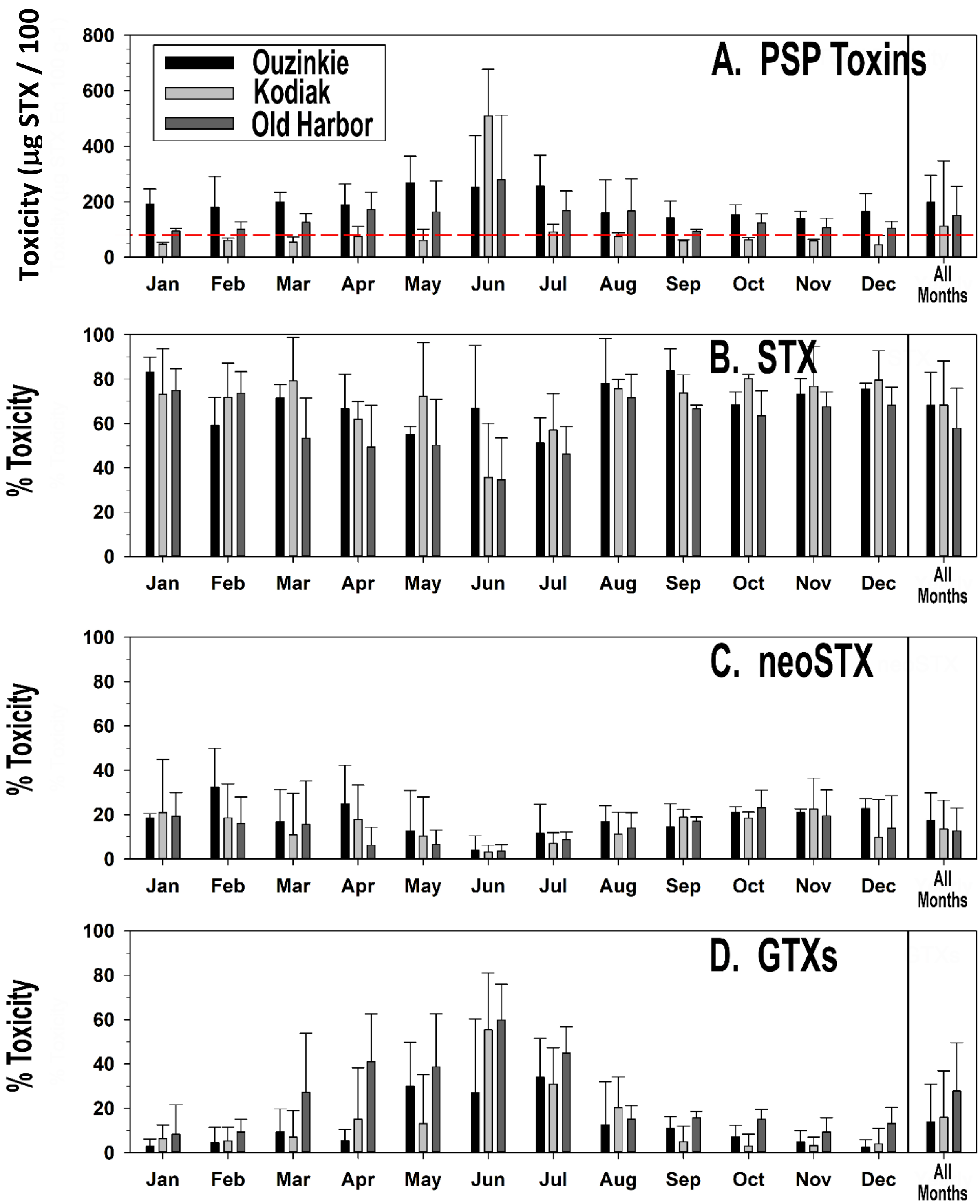
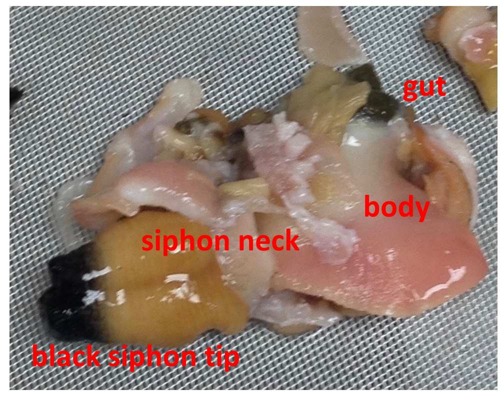


Fig. 3. Average monthly butter clam toxicity (± Standard deviation) and contributions (% toxicity) from the dominant congeners STX, neoSTX and GTX from the three Kodiak sites. A. Monthly butter clam toxicity from all PSP toxins (µg STX / 100 g), B. Percent toxicity due to saxitoxin (STX), C. Percent toxicity due to neosaxitoxin (neoSTX), D. Percent toxicity due to gonyautoxins (GTX1, 2, 3, 4, 5). The red dashed line denotes the FDA regulatory limit of 80 µg STX / 100 g shellfish tissue.

Butter Clam Tissue and Cleaning Study:
Bivalve shellfish species differ in how they process saxitoxins (STXs) and in which tissues these compounds concentrate. This knowledge has led to numerous inquiries by Kodiak shellfish harvesters regarding how shellfish cleaning methods might affect the amount of STXs consumed. Old Harbor samplers requested their "cleaned" samples be tested as part of the ADEC pilot study. However, we were unable to conduct these investigations at that time because the shellfish testing protocol required the whole shucked tissue be included for testing. NPRB project 1616 was developed with input from local harvesters and addressed the effect of cleaning methods through a clam tissue dissection study and a clam cleaning study.

<u>Clam Tissue Dissection Study:</u>
Butter clams are known to accumulate high levels of toxins and retain them for long periods. Previous research has shown that butter clams store large amounts of toxins in the siphon. We explored the distribution of toxins in the butter clam tissues by separating tissues into four categories: 1) black siphon tip, 2) siphon neck, 3) gut content and 4) body (remaining tissue). The experiment was repeated using clams from two different locations (Shipwreck Beach, Old Harbor and Mission Beach, Kodiak) and during different dates/years. For each sample, a group of 12 butter clams were dissected and the tissues were combined for a composite sample for each tissue type.



The resulting data showed distribution of PSP toxins among butter clam tissues was highly variable among sampling sites and different times of year. But toxin concentrations generally followed the monthly trends in toxicity in Figure 2, with overall toxin levels increasing in the summer months. We were also able to see a seasonal shift in the toxin congeners as the dominant compounds in each tissue type changed. In the summer, the toxins were first observed to increase in the gut when *Alexandrium* cells are present in high numbers. The prevalent forms of toxin found in the gut are gonyautoxins (GTXs), which are quickly distributed throughout other parts of the clam. Over time, butter clams chemically modify the GTXs in their tissues to produce saxitoxin (STX) and neosaxitoxin (neoSTX), which are more toxic variants. During the winter, the STX and neoSTX continue to concentrate in the black siphon tip and the siphon neck.

The 2018 Mission data shown below (Fig. 4) is just one set of data that demonstrates this pattern. In April, the majority of toxin was found in the black tip and neck, in the forms of neoSTX and STX. This represents pre-bloom period. By summer, the majority of the toxin was found in the gut in the form of GTXs. The presence of GTX is indicative of an *Alexandrium* bloom. The GTX will move into the body meat and over time convert to STX and neoSTX.

This tissue study provided useful information pertaining to the removal of tissue for the cleaning study (see below). We evaluated the effectiveness of removing the black siphon tip and determined that the resulting decrease in toxicity is highly variable, and because of the small amount of tissue the reduction in toxicity is often slight.

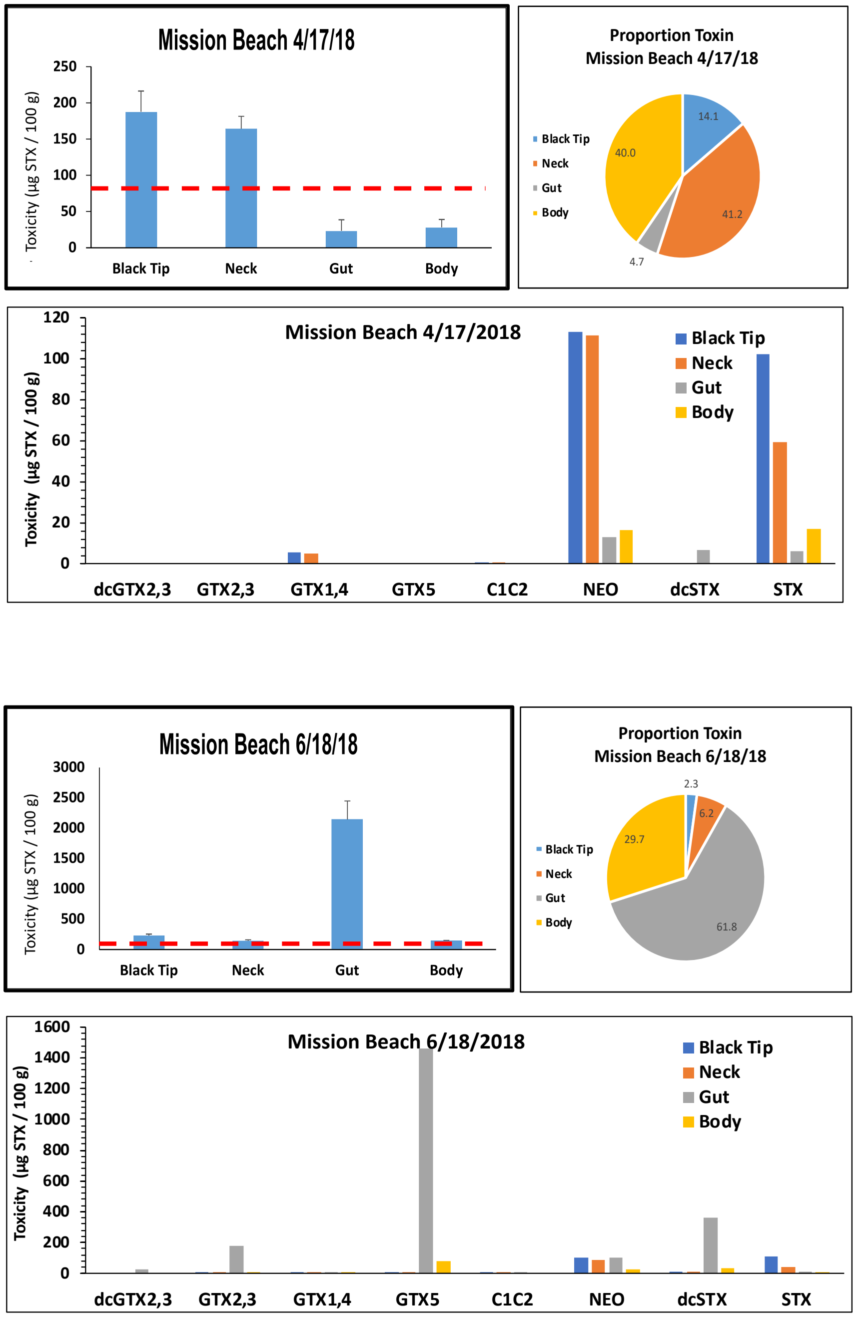


Figure 4. Example of season shift in congeners detected in butter clam tissue types at Mission Beach in April and June 2018. The toxicity of each tissue type is given as concentration of saxitoxins (top left panes) and as relative proportion of the total clam toxicity (top right panes).The toxin dominant toxin congeners are presented by tissue type (lower panes) Toxicity is expressed as µg STX / 100 g. Error bars = Standard Deviation. Red line denotes the FDA Action Limit for shellfish closure.

Clam Cleaning Study:

In another component of this project, we examined traditional preparation methods used by Kodiak subsistence butter clam harvesters, and the effect on PSP risks. For these comparisons, butter clam tissues were separated into "edible" and "non-edible" fractions according to different methods.

Three residents demonstrated their preferred butter clam cleaning techniques to Project Lead Julie Matweyou, who then used two of the methods. An Old Harbor resident performed the third cleaning method on groups of clams collected each month for five months. Twelve clams were processed for each group. Method 1 included minimal processing with the black siphon tip removed. Method 2 involved moderate processing with removal of the black siphon tip, brown tissues and gills; the gut content was gently squeezed out. Method 3 was maximum processing with the black siphon tip and brown tissues removed, and the gut cut away fully.

Results from the study are included in Appendix A. Table 2. The study showed a reduction of butter clam toxin levels of 7–18% using cleaning Method 1, reduction of 12–76% with Method 2, and 9–89% reduction using Method 3. The wide ranges in toxicity reduction reflect changes in the seasonal distribution of STXs in the butter clam tissues (as seen in the tissue study) and the variability in toxin concentrations among individual butter clams. While toxicity exposure can be reduced by removal of certain tissues, particularly the black tip and the gut, the effectiveness of this toxin removal varies and is dependent. **Even with maximum processing, where about 50% of the clam tissue was discarded, there was not a 100% removal of toxins and in many samples the remaining edible tissues still contained toxin levels unsafe for consumption.**

The cleaning study results are summarized in an informational pamphlet for distribution to harvesters (see attached document). The primary information in the pamphlet includes:

- PSP toxins increase dramatically during the summer months due to the seasonal increase of toxic *Alexandrium* cells. In Kodiak, toxins begin to increase in April and can remain elevated through September or longer.
- Risk of PSP exists year-round because toxins can be retained in some bivalve shellfish.
- Butter clams can accumulate very high levels of toxins and retain toxins for long periods.
- PSP toxin distribution in butter clam tissues changes seasonally, as do the forms of toxins (STX, neoSTX, GTXs).
- Removing the gut contents, the black siphon tip and at least half of the siphon neck in butter clams is recommended if harvesters choose to eat untested clams; a percentage of toxin is reduced. However, the effectiveness of the toxin removal varies and is not predictable.
- **Removal of these tissues does not guarantee processed butter clams will be toxin-free. Toxin levels can remain above recommended limits in the "cleaned" meat.**
- Where extreme toxin concentrations are common, such as Kodiak, it can be assumed that the STXs will be present in all edible tissues.
- **The practice of harvest and hold is recommended.** Harvest the clams, sacrifice some of the clams for testing, and wait for test results before consuming. Only testing ensures safe consumption.

Improved Toxin Testing Methodology:
Existing commercially available field test kits for detecting paralytic shellfish (PSP) fail to detect many of the PSP toxins found in Alaskan shellfish and provide only pass/fail results. Shellfish harvesters seek a test that can provide more detail. This project set out to develop a field test that could detect all the toxin variants associated with PSP in Alaska and provide numerical results to help guide harvesters. We began with an Electrochemical Test (ECtest) prototype and had hoped to provide a working test by the end of the project. However, saxitoxin is a complex molecule and the biochemistry of test development is challenging.

Our project team succeeded in developing an improved enzyme-linked immunosorbent assay (ELISA) for PSP toxins. The new antibody combined with a chemical reduction step to convert GTXs to STX and neoSTX. This conversion dramatically increased the performance of the test. It is currently the most accurate ELISA test on the market and is now commercially available.

However, the chemical conversion step is not easily accomplished in the field, which prevented converting the test into a rapid field test kit. There are ongoing efforts to streamline the method towards continued development of a field test. The laboratory version of the ELISA was commercialized by SEATox Research, Inc., and is being used in ongoing field studies to measure PSP toxin levels throughout the Alaskan coastal food webs and with climate studies. Laboratory equipment has been purchased to establish the new ELISA capacity at the Kodiak Seafood and Marine Science Center (Matweyou's lab) with the goal of setting up a Kodiak regional PSP monitoring lab.

Summary
Regional shellfish monitoring: Community-based shellfish monitoring demonstrates the importance of site differences, seasonal variation and regional climate changes on shellfish toxicity and PSP risks. We recommend continued monitoring to inform subsistence harvesters about toxicity risks.

Butter clam tissues & cleaning methods: Study results show toxicity of butter clams can often be reduced by removal of the siphon tip and the gut with contents, as well as other tissues. But the effectiveness of this removal depends on harvest time and location, the intensity of *Alexandrium* blooms, and ultimately, the preferences of the individual harvester. We recommend the practice of harvest/hold/test.

Improved toxin detection: The SEATox , Inc. ELISA test coupled with the reduction method dramatically improved quantification of GTXs, PSP toxins that regularly reach high concentrations in shellfish during spring and summer *Alexandrium* blooms. These toxins are nearly undetectable with other antibody-based tests that are commercially available.

Report attachments include:
Appendix A. Data Tables
Appendix B. Outreach publication *Paralytic shellfish toxins in butter clam tissues*
Appendix C. Project poster that is being printed for each participating community

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References

Kibler et al. In progress. Occurrence of Paralytic Shellfish Poisoning Toxins in the Tissues of Butter Clams (*Saxidomus gigantea*) from Three Communities in the Kodiak Islands, Alaska.
Matweyou J., Bartz, K. 2015. Recreational shellfish project final report. Anchorage, AK: Recreational Shellfish Beach Monitoring Pilot Program, Alaska Dept. of Environmental Conservation.

Appendix A

Table 1. Record of butter clam sample collection and PSP toxin levels per study site.

Ouzinkie Data

Location	Species	Month	Site	Collection Date	Toxin level (ug/100g)	Project
Ouzinkie						
Ouzinkie	Butter clam	Jan	Sourdough Beach, S.	1/14/13	81	ADEC
Ouzinkie	Butter clam	Feb	Sourdough Beach, S.	2/11/13	69	ADEC
Ouzinkie	Butter clam	Mar	Sourdough Beach, S.	3/30/13	75.6	ADEC
Ouzinkie		Apr			n/a	ADEC
Ouzinkie		May			n/a	ADEC
Ouzinkie	Butter clam	June	Sourdough Beach, S.	6/26/13	127	ADEC
Ouzinkie	Butter clam	Jul	Sourdough Beach, S	7/23/13	55	ADEC
Ouzinkie	Butter clam	Aug	Sourdough Beach, S.	8/21/13	82.9	ADEC
Ouzinkie	Butter clam	Sept	Sourdough Beach, S.	9/20/13	84	ADEC
Ouzinkie	Butter clam	Oct	Sourdough Beach, S.	10/6/13	56.4	ADEC
Ouzinkie	Butter clam	Nov	Sourdough Beach, S.	11/5/13	84.4	ADEC
Ouzinkie	Butter clam	Dec	Sourdough Beach, S.	12/2/13	79.4	ADEC
Ouzinkie	Butter clam	Jan	Sourdough Beach, S.	1/2/14	46.3	ADEC
Ouzinkie	Butter clam	Feb	Sourdough Beach, S.	1/30/14	99.1	ADEC
Ouzinkie	Butter clam	(Mar)	Sourdough Beach, S.	2/27/14	106	ADEC
Ouzinkie	Butter clam	(Apr)	Sourdough Beach, S.	3/31/14	73.2	ADEC
Ouzinkie	Butter clam	(May)	Sourdough Beach, S.	4/29/14	n/a	ADEC
Ouzinkie	Butter clam	(May)	Sourdough Beach, S.	5/19/14	120	ADEC
Ouzinkie	Butter clam	(May-Jun)	Sourdough Beach, S.	5/29/14	142	ADEC
Ouzinkie	Butter clam	Jun	Sourdough Beach, S.	6/14/14	158	ADEC
Ouzinkie	Butter clam	Jul	Sourdough Beach, S.	7/12/14	119	ADEC
Ouzinkie		Aug			n/a	ADEC
Ouzinkie	Butter clam	Sept	Sourdough Beach, S.	9/8/14	196	ADEC
Ouzinkie	Butter clam	Oct	Sourdough Beach, S.	10/8/14	186	ADEC
Ouzinkie	Butter clam	Nov	Sourdough Beach, S.	11/5/14	138	ADEC
Ouzinkie	Butter clam	Dec	Sourdough Beach, S.	12/9/14	163	ADEC
Ouzinkie	Butter clam	Jan	Sourdough Beach, S.	1/4/15	126	ADEC
Ouzinkie	Butter clam	Jan	Sourdough Beach, S.	1/23/15	126	ADEC
Ouzinkie	Butter clam	Feb	Sourdough Beach, S.	2/17/15	136	ADEC
Ouzinkie	Butter clam	Mar	Sourdough Beach, S.	3/21/15	157	ADEC
Ouzinkie	Butter clam	Apr	Sourdough Beach, S.	4/19/15	133	ADEC
		May			n/a	volunteer
Ouzinkie	Butter clam	Jun	Sourdough Beach, S.	6/20/15	62.3	volunteer

Ouzinkie	Butter clam	Jul	Sourdough Beach, S.	7/18/15	204.9	volunteer
Ouzinkie	Butter clam	Sep	Sourdough Beach, S.	9/27/15	61.8	volunteer
Ouzinkie	Butter clam	Oct	Sourdough Beach, S.	10/29/15	177.3	volunteer
		Nov			n/a	volunteer
Ouzinkie	Butter clam	Dec	Sourdough Beach, S.	12/23/15	117.9	volunteer
		Jan			n/a	volunteer
Ouzinkie	Butter clam	Feb	Sourdough Beach, S.	2/21/16	143.6	volunteer
		Mar			n/a	volunteer
		Apr			n/a	volunteer
Ouzinkie	Butter clam	May	Sourdough Beach, S.	5/21/16	202.1	volunteer
		Jun			n/a	volunteer
		Jul			n/a	volunteer
		Aug			n/a	volunteer
		Sep			n/a	volunteer
Ouzinkie	Butter clam	Oct	Sourdough Beach, S.	10/17/16	176.3	NPRB
Ouzinkie	Butter clam	Nov	Sourdough Beach, S.	11/16/16	150.4	NPRB
Ouzinkie	Butter clam	Dec	Sourdough Beach, S.	12/15/16	254.3	NPRB
Ouzinkie	Butter clam	Jan	Sourdough Beach, S.	1/14/17	153.2	NPRB
Ouzinkie	Butter clam	Feb	Sourdough Beach, S.	2/12/17	305.1	NPRB
Ouzinkie	Butter clam	Mar	Sourdough Beach, S.	3/10/17	237.1	NPRB
Ouzinkie	Butter clam	Apr	Sourdough Beach, S.	4/14/17	292.1	NPRB
Ouzinkie	Butter clam	Apr	Sourdough Beach, S.	4/29/17	189.3	NPRB
Ouzinkie	Butter clam	May	Sourdough Beach, S.	5/15/17	234.7	NPRB
Ouzinkie	Butter clam	Jun	Sourdough Beach, S.	6/13/17	196.5	NPRB
Ouzinkie	Butter clam	Jun	Sourdough Beach, S.	6/26/17	188.0	NPRB
Ouzinkie	Butter clam	Jul	Sourdough Beach, S.	7/23/17	298.5	NPRB
Ouzinkie	Butter clam	Aug	Sourdough Beach, S.	8/22/17	164.7	NPRB
Ouzinkie	Butter clam	Sep	Sourdough Beach, S.	9/20/17	205.9	NPRB
Ouzinkie	Butter clam	Oct	Sourdough Beach, S.	10/20/17	156.1	NPRB
Ouzinkie	Butter clam	Dec	Sourdough Beach, S.	12/19/17	172.7	NPRB
Ouzinkie	Butter clam	Jan	Sourdough Beach, S.	1/3/18	254.8	NPRB
Ouzinkie	Butter clam	Feb	Sourdough Beach, S.	2/3/18	90.8	NPRB
Ouzinkie	Butter clam	Mar	Sourdough Beach, S.	3/2/18	192.6	NPRB
Ouzinkie	Butter clam	Apr	Sourdough Beach, S.	4/19/18	158.9	NPRB
Ouzinkie	Butter clam	May	Sourdough Beach, S.	5/1/18	226.4	NPRB
Ouzinkie	Butter clam	Jun	Sourdough Beach, S.	6/16/18	577.7	NPRB
Ouzinkie	Butter clam	Jul	Sourdough Beach, S.	7/15/18	389.2	NPRB
Ouzinkie	Butter clam	Aug	Sourdough Beach, S.	8/12/18	153.5	NPRB
Ouzinkie	Butter clam	Sep	Sourdough Beach, S.	9/10/18	158.6	NPRB
Ouzinkie	Butter clam	Oct	Sourdough Beach, S.	10/28/18	98.7	NPRB

Ouzinkie	Butter clam	Nov	Sourdough Beach, S.	11/25/18	130.7	NPRB
Ouzinkie	Butter clam	Dec	Sourdough Beach, S.	12/26/18	115.0	NPRB
Ouzinkie	Butter clam	Jan	Sourdough Beach, S.	1/20/19	164.9	NPRB
		Feb			n/a	NPRB
Ouzinkie	Butter clam	Mar	Sourdough Beach, S.	3/24/19	168.01	NPRB
Ouzinkie	Butter clam	Apr	Sourdough Beach, S.	4/20/19	117.10	NPRB
Ouzinkie	Butter clam	May	Sourdough Beach, S.	5/20/19	411.09	NPRB
Ouzinkie	Butter clam	Jun	Sourdough Beach, S.	6/19/19	233.32	NPRB
Ouzinkie	Butter clam	Jul	Sourdough Beach, S.	7/19/19	132.94	NPRB
Ouzinkie	Butter clam	Aug	Sourdough Beach, S.	8/3/19	pending	NPRB
Ouzinkie	Butter clam	Sep	Sourdough Beach, S.	9/29/19	pending	NPRB
Ouzinkie	Butter clam	Oct	Sourdough Beach, S.	10/28/18	pending	NPRB
Ouzinkie	Butter clam	Nov	Sourdough Beach, S.	11/26/19	pending	NPRB
Ouzinkie	Butter clam	Dec	Sourdough Beach, S.	12/27/19	pending	NPRB
Ouzinkie	Butter clam	Jan	Sourdough Beach, S.	1/24/20	pending	NPRB
Ouzinkie	Butter clam	Feb	Sourdough Beach, S.	2/24/20	pending	NPRB

Old Harbor Data

Location	Species	Month	Site	Collection Date	Toxin level (ug/100g)	Project
Old Harbor						
Old Harbor	Butter clam	July	Shipwreck	7/26/13	80	ADEC
Old Harbor	Butter clam	Aug	Shipwreck	8/21/13	140	ADEC
Old Harbor	Butter clam	Sept	Shipwreck	9/21/13	156	ADEC
Old Harbor		Oct			n/a	ADEC
Old Harbor	Butter clam	Nov	Shipwreck	11/4/13	153	ADEC
Old Harbor	Butter clam	Dec	Shipwreck	12/5/13	81.3	ADEC
Old Harbor		Jan			n/a	ADEC
Old Harbor	Butter clam	Feb	Shipwreck	2/1/14	140	ADEC
Old Harbor	Butter clam	Mar	Shipwreck	3/19/14	124	ADEC
Old Harbor	Butter clam	Apr	Shipwreck	4/1/14	162	ADEC
Old Harbor	Butter clam	May	Shipwreck	5/15/14	340	ADEC
Old Harbor	Butter clam	June	Shipwreck	6/14/14	421	ADEC
Old Harbor	Butter clam	July	Shipwreck	7/15/14	167	ADEC
Old Harbor	Butter clam	Aug	Shipwreck	8/11/14	110	ADEC
Old Harbor	Butter clam	Sept	Shipwreck	9/10/14	98.6	ADEC
Old Harbor	Butter clam	Oct	Shipwreck	10/10/14	93.5	ADEC
Old Harbor	Butter clam	Nov	Shipwreck	11/5/14	91.2	ADEC
Old Harbor	Butter clam	Dec	Shipwreck	12/9/14	119	ADEC
Old Harbor		Jan	Shipwreck		n/a	ADEC
Old Harbor	Butter clam	Feb	Shipwreck	2/18/15	97.3	ADEC
Old Harbor	Butter clam	Mar	Shipwreck	3/22/15	154	ADEC
Old Harbor	Butter clam	Apr	Shipwreck	4/20/15	280	ADEC
Old Harbor	Butter clam	May	Shipwreck		n/a	volunteer
Old Harbor	Butter clam	Jun	Shipwreck	6/15/15	62.8	volunteer
Old Harbor	Butter clam	Jul	Shipwreck		n/a	volunteer
Old Harbor	Butter clam	Aug	Shipwreck	8/4/15	398.9	volunteer
Old Harbor	Butter clam	Sep	Shipwreck		n/a	volunteer
Old Harbor	Butter clam	Oct	Shipwreck		n/a	volunteer
Old Harbor	Butter clam	Nov	Shipwreck		n/a	volunteer
Old Harbor	Butter clam	Dec	Shipwreck		n/a	volunteer
Old Harbor	Butter clam	Jan	Shipwreck		n/a	volunteer
Old Harbor	Butter clam	Feb	Shipwreck		n/a	volunteer
Old Harbor	Butter clam	Mar	Shipwreck		n/a	volunteer
Old Harbor	Butter clam	Apr	Shipwreck	4/8/16	127	ANTHC
Old Harbor	Butter clam	May	Shipwreck	5/10/16	176	ANTHC
Old Harbor	Butter clam	Jun	Shipwreck	6/6/16	672	ANTHC

Old Harbor	Butter clam	Jul	Shipwreck	7/7/16	153	ANTHC
Old Harbor	Butter clam	Aug	Shipwreck	8/2/16	78.05	ANTHC
Old Harbor	Butter clam	Sep	Shipwreck		n/a	ANTHC
Old Harbor	Butter clam	Oct	Shipwreck	10/15/16	156	ANTHC
Old Harbor	Butter clam	Nov	Shipwreck	11/14/16	106.1	NPRB
Old Harbor	Butter clam	Dec	Shipwreck		n/a	NPRB
Old Harbor	Butter clam	Jan	Shipwreck	1/16/17	89.6	NPRB
Old Harbor	Butter clam	Feb	Shipwreck	2/11/17	67.1	NPRB
Old Harbor	Butter clam	Mar	Shipwreck		n/a	NPRB
Old Harbor	Butter clam	Apr	Shipwreck		n/a	NPRB
Old Harbor	Butter clam	May	Shipwreck	5/29/17	63.2	NPRB
Old Harbor	Butter clam	Jun	Shipwreck	6/20/17	148.9	NPRB
Old Harbor	Butter clam	Jul	Shipwreck	7/25/17	276.0	NPRB
Old Harbor	Butter clam	Aug	Shipwreck	8/23/17	123.5	NPRB
Old Harbor	Butter clam	Sep	Shipwreck	9/20/17	96.5	NPRB
Old Harbor	Butter clam	Oct	Shipwreck	10/19/17	88.9	NPRB
Old Harbor	Butter clam	Nov	Shipwreck	11/18/17	76.4	NPRB
Old Harbor	Butter clam	Dec	Shipwreck	12/7/17	87.2	NPRB
Old Harbor	Butter clam	Jan	Shipwreck	1/2/18	90.4	NPRB
Old Harbor	Butter clam	Feb	Shipwreck	2/1/18	92.3	NPRB
Old Harbor	Butter clam	Mar	Shipwreck	3/21/18	81.2	NPRB
Old Harbor	Butter clam	Apr	Shipwreck	4/19/18	123.9	NPRB
Old Harbor	Butter clam	May	Shipwreck	5/18/18	71.2	NPRB
Old Harbor	Butter clam	Jun	Shipwreck	6/18/18	273.1	NPRB
Old Harbor	Butter clam	Jul	Shipwreck	7/16/18	275.5	NPRB
Old Harbor	Butter clam	Aug	Shipwreck	8/15/18	149.76	NPRB
Old Harbor	Butter clam	Sep	Shipwreck	9/10/18	86.10	NPRB
Old Harbor	Butter clam	Oct	Shipwreck	10/30/18	124.95	NPRB
Old Harbor	Butter clam	Nov	Shipwreck		n/a	NPRB
Old Harbor	Butter clam	Dec	Shipwreck	12/20/18	132.12	NPRB
Old Harbor	Butter clam	Jan	Shipwreck	1/24/19	104.26	NPRB
Old Harbor	Butter clam	Feb	Shipwreck	2/6/19	109.41	NPRB
Old Harbor	Butter clam	Mar	Shipwreck	3/24/19	141.78	NPRB
Old Harbor	Butter clam	Apr	Shipwreck	4/23/19	161.84	NPRB
Old Harbor	Butter clam	May	Shipwreck	5/7/19	166.61	NPRB
Old Harbor	Butter clam	Jun	Shipwreck	6/18/19	101.28	NPRB
Old Harbor	Butter clam	Jul	Shipwreck	7/4/19	76.16	NPRB
Old Harbor	Butter clam	Aug	Shipwreck		n/a	NPRB
Old Harbor	Butter clam	Sep	Shipwreck		n/a	NPRB
Old Harbor	Butter clam	Oct	Shipwreck	10/1/19	pending	NPRB

Old Harbor	Butter clam	Nov	Shipwreck	11/15/19	pending	NPRB
Old Harbor	Butter clam	Dec	Shipwreck	12/12/19	pending	NPRB
Old Harbor	Butter clam	Jan	Shipwreck	1/13/20	pending	NPRB
Old Harbor	Butter clam	Feb	Shipwreck	2/13/20	pending	NPRB

Kodiak Data (Trident Basin only)

Location	Species	Month	Site	Collection Date	Toxin level (ug/100g)	Project
Kodiak - Near Island, Trident Basin						
Kodiak	Butter clam	Oct	Trident Basin, N.	10/17/16	58.9	NPRB
Kodiak	Butter clam	Nov	Trident Basin, N.	11/15/16	62.5	NPRB
Kodiak	Butter clam	Dec	Trident Basin, N.	12/14/16	18.6	NPRB
Kodiak	Butter clam	Jan	Trident Basin, N.	1/2/17	50.7	NPRB
Kodiak	Butter clam	Feb	Trident Basin, N.	2/10/17	59.2	NPRB
Kodiak	Butter clam	Mar	Trident Basin, N.	3/29/17	70.9	NPRB
Kodiak	Butter clam	Apr	Trident Basin, N.	4/28/17	114.0	NPRB
Kodiak	Butter clam	May	Trident Basin, N.	5/25/17	70.2	NPRB
Kodiak	Butter clam	Jun	Trident Basin, N.	6/26/17	78.4	NPRB
Kodiak	Butter clam	Jul	Trident Basin, N.	7/24/17	79.4	NPRB
Kodiak	Butter clam	Aug	Trident Basin, N.	8/22/17	90.4	NPRB
Kodiak	Butter clam	Sep	Trident Basin, N.	9/20/17	58.0	NPRB
Kodiak	Butter clam	Oct	Trident Basin, N.	10/8/17	72.7	NPRB
Kodiak	Butter clam	Nov	Trident Basin, N.	11/5/17	61.3	NPRB
Kodiak	Butter clam	Dec	Trident Basin, N.	12/4/17	82.5	NPRB
Kodiak	Butter clam	Jan	Trident Basin, N.	1/3/18	51.2	NPRB
Kodiak	Butter clam	Feb	Trident Basin, N.	2/1/18	69.9	NPRB
Kodiak	Butter clam	Mar	Trident Basin, N.	3/1/18	35.2	NPRB
Kodiak	Butter clam	Apr	Trident Basin, N.	4/8/18	65.9	NPRB
Kodiak	Butter clam	May	Trident Basin, N.	5/17/18	16.3	NPRB
Kodiak	Butter clam	Jun	Trident Basin, N.	6/18/18	385.3	NPRB
Kodiak	Butter clam	Jul	Trident Basin, N.	7/16/18	129.4	NPRB
Kodiak	Butter clam	Aug	Trident Basin, N.	8/14/18	69.65	NPRB
Kodiak	Butter clam	Sep	Trident Basin, N.	9/10/18	61.62	NPRB
Kodiak	Butter clam	Oct	Trident Basin, N.	10/9/18	56.01	NPRB
Kodiak	Butter clam	Nov	Trident Basin, N.	11/24/18	53.90	NPRB
Kodiak	Butter clam	Dec	Trident Basin, N.	12/23/18	35.53	NPRB
Kodiak	Butter clam	Jan	Trident Basin, N.	1/22/19	38.79	NPRB
Kodiak	Butter clam	Feb	Trident Basin, N.	2/19/19	52.83	NPRB
Kodiak	Butter clam	Mar	Trident Basin, N.	3/20/19	58.96	NPRB
Kodiak	Butter clam	Apr	Trident Basin, N.	4/21/19	46.76	NPRB
Kodiak	Butter clam	May	Trident Basin, N.	5/20/19	95.71	NPRB
Kodiak	Butter clam	Jun	Trident Basin, N.	6/18/19	115.83	NPRB
Kodiak	Butter clam	Jul	Trident Basin, N.	7/3/19	90.95	NPRB
Kodiak	Butter clam	Aug	Trident Basin, N.	8/1/19	66.42	NPRB
Kodiak	Butter clam	Sep	Trident Basin, N.	9/1/19	pending	NPRB

Kodiak	Butter clam	Oct	Trident Basin, N.	10/28/19	pending	NPRB
Kodiak	Butter clam	Nov	Trident Basin, N.	11/26/19	pending	NPRB
Kodiak	Butter clam	Dec	Trident Basin, N.	12/26/19	pending	NPRB
Kodiak	Butter clam	Jan	Trident Basin, N.	1/12/20	pending	NPRB
Kodiak	Butter clam	Feb	Trident Basin, N.	2/7/20	pending	NPRB

Table 2. Details of the Individual tissue separation investigations. Composite clam samples (n=12) were separated into “cleaned” and “discarded’ tissues. Toxin concentrations were measured in each fraction; toxin levels are presented for the cleaned meats and the whole clams. The percent toxicity by weight was calculated to compare the contribution of each tissue type to the overall toxicity of the clam and the percent toxin reduction after discarding tissues is reported.

Method 1 Trident / Mission

Date	Group	Toxin in Cleaned Meat (ug STX / 100g)	Toxin in Whole clam (ug STX / 100g)	% Toxin Reduction with cleaning
5/18/18	1	45	49	-10
	2	43	47	-9
	3	47	50	-7
	4	23.4	28.6725	-18

Method 2 Mission Beach

Date	Group	Toxin in Cleaned Meat (ug STX / 100g)	Toxin in Whole clam (ug STX / 100g)	% Toxin Reduction with cleaning
4/17/18	1	55	78	-29
	2	50	61	-19
	3	52	59	-12
5/18/18	1	12	28	-56
	2	14	26	-48
	3	15	28	-45
6/18/18	1	118	434	-73
	2	98	400	-76
	3	91	326	-72
7/18/18	1	43	120	-64
	2	67	141	-53
	3	54	115	-53

Method 3 Shipwreck Beach

Date	Group	Toxin in Cleaned Meat (ug STX / 100g)	Toxin in Whole clam (ug STX / 100g)	% Toxin Reduction with cleaning
4/19/18	1	89	106	-16
	2	66	92	-28
	3	88	103	-14
5/18/18	1	13	62	-79
	2	39	76	-49
	3	63	80	-21
6/18/18	1	101	300	-66
	2	349	506	-31
	3	126	476	-74
7/16/18	1	50	434	-89
	2	43	278	-85
	3	151	484	-69
8/15/18	1	106	149	-29
	2	154	217	-29
	3	117	152	-23
9/10/18	1	100	113	-11
	2	67	94	-29
	3	76	110	-31
10/30/18	1	65	88	-26
	2	98	123	-20
	3	103	113	-9

Paralytic Shellfish Toxins in Butter Clam Tissues

Background

Paralytic Shellfish Poisoning (PSP) is a persistent problem that affects Alaska subsistence and recreational shellfish harvesting. PSP is caused by consumption of shellfish that have accumulated saxitoxins (STXs), potent neurotoxins produced by the marine dinoflagellate *Alexandrium*. STXs disrupt normal nerve function and can result in respiratory paralysis. The collective term STXs refers to over 20 chemical variants, each with a specific name and level of toxicity. Bivalve shellfish species differ in how they process the STXs, and STXs can concentrate in different shellfish tissues. This knowledge has led to numerous inquiries by shellfish harvesters regarding how shellfish cleaning methods might affect the amount of STXs consumed. Accordingly, this document focuses on one of the most commonly sought-after subsistence bivalves, butter clams.

Butter clams, *Saxidomus giganteus*

Kodiak shellfish are known to have very high levels of PSP toxins that have caused severe illness and deaths. The regulatory limit for safe shellfish consumption is 80 micrograms of toxin per 100 grams of shellfish tissue **(80 µg STX / 100 g shellfish tissue)**. In the Kodiak region, toxin levels have measured as high as 8,532 µg STX / 100 g in butter clams, and 20,606 µg STX / 100 g in blue mussels. Efforts are ongoing to address the problem through research, monitoring and education. Toxin monitoring in butter clams has been conducted in the Kodiak region since 2013. During this time, butter clam toxicity was consistently too high for safe harvesting (Figure 1).

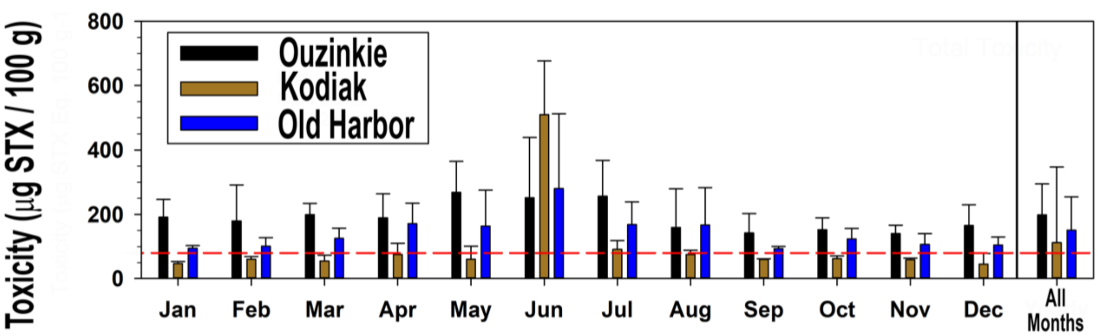
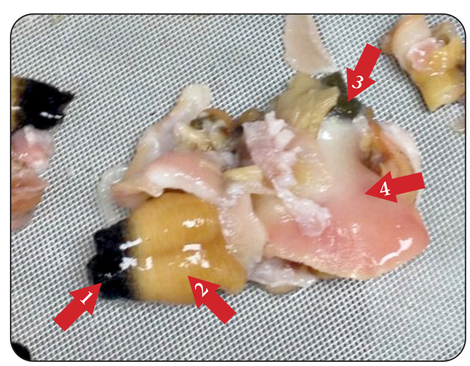


Figure 1. Average monthly butter clam toxicity (µg STX / 100 g) ± standard deviation in butter clams collected in 2013–2019 from Sourdough Flats, Ouzinkie; Near Island, Kodiak; and Shipwreck Beach, Old Harbor. The red dashed line is the FDA regulatory limit.

Toxins in butter clam tissues

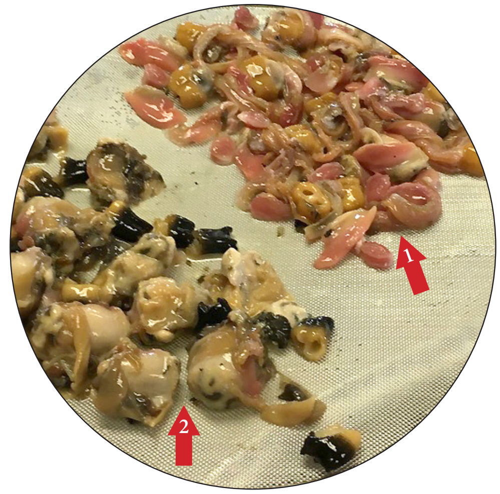
In response to harvester-specific questions, **this study addressed the difference in toxicity between whole and cleaned butter clams.** We looked at the distribution of STXs in butter clam tissues on a seasonal basis and evaluated cleaning methods used by harvesters.

Butter clams are known to accumulate high levels of toxins and retain them for long periods. Previous research has shown that butter clams store large amounts of toxins in the siphon. Our data agreed with these results, and further showed toxin levels to be present in different tissues seasonally. In the summer, STXs are first observed to increase in the gut when *Alexandrium* cells are present in high numbers. The prevalent forms of toxin found in the gut are gonyautoxins (GTXs), which are quickly distributed throughout other parts of the clam. Over time, butter clams chemically modify the GTXs in their tissues to produce saxitoxin (STX) and neosaxitoxin (neoSTX), which are more toxic variants. During the winter, the STX and neoSTX continue to concentrate in the black siphon tip and the siphon neck.



Butter clam tissue preparation. (1) black siphon tip, (2) siphon neck, (3) gut content, (4) body meat.

Effect of cleaning butter clams



Harvester cleaning Method 3, separation of (1) edible and (2) discarded tissue.

In an attempt to reduce PSP risk, some harvesters "clean" butter clams by removing tissues with known or suspected toxins. We examined three different cleaning methods used by Kodiak harvesters. Tissues were segregated into edible and discarded tissues according to judgment by the harvester. Toxin concentrations were measured in each fraction and the percent toxicity by weight was calculated to compare the contribution of each tissue type to the overall toxicity of the clam. Method 1 included minimal processing with the black siphon tip removed. Method 2 involved moderate processing with removal of the black siphon tip, brown tissues and gills; the gut content was gently squeezed out. Method 3 was maximum processing with the black siphon tip and brown tissues removed, and the gut fully cut away.

The study showed a reduction of butter clam toxin levels of 7–18% using cleaning Method 1, reduction of 12–76% with Method 2, and 9–89% reduction using Method 3. The wide ranges in toxicity reduction reflect changes in the seasonal distribution of STXs in the butter clam tissues and the variability in toxin concentrations among individual butter clams. Because the distribution and abundance of toxic *Alexandrium* cells is patchy, and varies seasonally, it is very difficult to predict when or where particular shellfish will be toxic.

Even with maximum processing, where about 50% of the clam tissue was discarded, **there was not a 100% removal of toxins. And in many samples the remaining edible tissues still contained toxin levels unsafe for consumption.** While toxicity exposure can be reduced by removal of certain tissues, particularly the black siphon tip and the gut, **the effectiveness of the cleaning strategies to remove toxins varies greatly and is not predictable.** The toxicity of the "cleaned" meat is dependent on the time of harvest, location of harvest and variation in the toxicity of individual clams.

Summary

- PSP toxins increase dramatically during the summer months due to the seasonal increase of the toxic *Alexandrium* cells. In Kodiak, toxins begin to increase in April and can remain elevated through September.
- Risk of PSP exists year-round because toxins can be retained in some bivalve shellfish.
- Butter clams can accumulate very high levels of toxins and retain toxins for long periods.
- PSP toxin distribution in butter clam tissues changes seasonally, as do the forms of toxins (STX, neoSTX, GTXs).
- Removing the black siphon tip, at least half of the siphon neck and the gut content in butter clams is recommended if harvesters choose to eat untested clams; a percentage of toxin is reduced. However, the effectiveness of the toxin removal varies and is not predictable.
- **Removal of these tissues does not guarantee processed butter clams will be toxin-free. Toxin levels can remain above recommended limits in the "cleaned" meat.**
- Where extreme toxin concentrations are common, such as Kodiak, it can be assumed that the STXs will be present in all edible tissues.
- **The practice of harvest and hold is recommended.** Harvest the clams, sacrifice some of the clams for testing, and wait for test results before consuming. Only testing ensures safe consumption.

Authors

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Acknowledgments

We thank the North Pacific Research Board for funding to complete this study, and our project partners in Kodiak, including the Alutiiq Tribe of Old Harbor, the City of Ouzinkie and the Sun'aq Tribe of Kodiak.

Community-based PSP Testing for Shellfish - Kodiak Region Summary

Project Community Partners: Alutiiq Tribe of Old Harbor, City of Ouzinkie, Sun'aq Tribe of Kodiak

Science Team: Julie A. Matweyou[1], R. Wayne Litaker[2], Steven R. Kibler[2], Bruce A. Wright[3], D. Ransom Hardison[2], Patricia A. Tester[4]

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Background and Need

Paralytic Shellfish Poisoning (PSP) is caused by the consumption of shellfish that have accumulated saxitoxins, potent neurotoxins produced by the marine dinoflagellate *Alexandrium*. Subsistence shellfish harvesters in southwest Alaska are exposed to high PSP risks due to their dependency on shellfish resources, strong cultural traditions, and limited accessibility to medical care.

Kodiak shellfish are known to have very high levels of PSP toxins that have caused severe illness and deaths. The regulatory level for safe shellfish consumption is 80 micrograms of toxin per 100 grams of shellfish tissue (**80 µg STX / 100 g**). In the Kodiak region, toxin levels have measured as high as 8,532 µg STX / 100 g in butter clams, and 20,606 µg STX / 100 g in blue mussels.

Communities in the Kodiak region have been monitoring shellfish since 2013. This NPRB-funded study (#1616) expanded shellfish testing in the Kodiak region, addressed harvester-specific questions and developed improved toxin testing.

The project incorporates monitoring data from Western Alaska to better understand PSP dynamics statewide.

This study involves community preference for investigating PSP toxicity in butter clams, the most commonly harvested shellfish.

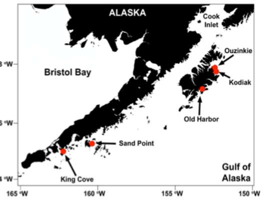
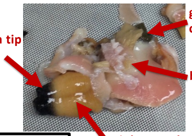


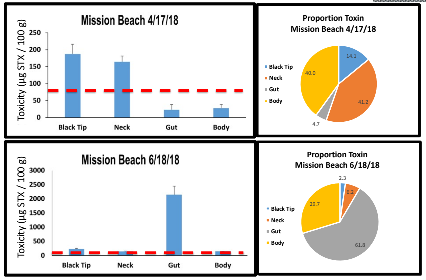
Figure 1. Study locations.

Toxins in Butter Clam Tissues

Saxitoxins (STXs) refers to over 20 chemical congeners, each with a specific name and toxicity. Bivalve shellfish species differ in how they process the STXs, and STXs can concentrate in different tissues. Butter clams are known to accumulate high levels of toxins and retain them for long periods. We looked at the seasonal distribution of SXTs in butter clam tissues.

Tissue study: Butter clam tissues were separated into four components: the black siphon tip, siphon neck, gut content, and body.





Figures 2 &3. Mean toxicity of each tissue type per test date is given as concentration of saxitoxins (left panes) and as relative proportion of the total clam toxicity (right panel). Error bars = Standard Deviation. Red line is FDA regulatory limit.

Prevalent toxins in winter are saxitoxin (SXT) & neosaxitoxin (neoSTX) found in the siphon tip and neck; gonyautoxins (GTXs) are dominant in the gut in summer.

Community Engagement

This project is a celebration of community! The study was designed in response to feedback from subsistence shellfish harvesters in SW Alaska. There has been much individual and community effort addressing safe and sustainable shellfish harvest in the Kodiak region. We have collected data, investigated questions, and shared stories and practices. We thank each and every member of our communities in supporting these efforts.

Sample collection: The community samplers are the backbone of the project. Butter clam samples were collected monthly and processed; frozen tissues were shipped to the Beaufort, NC NOAA Lab for analysis by High Performance Liquid Chromatography (HPLC), a technique that detects the different toxin congeners.

Youth engagement: Education has been a primary focus of these PSP projects. Toxin monitoring was initiated in 2013 through the Kodiak School District under the ADEC funded monitoring project and educational activities were built into field, classroom and summer camp activities.

Effect of Cleaning Butter Clams

In an attempt to reduce PSP risk, some harvesters "clean" butter clams by removing tissues with known or suspected toxins. We investigated the effectiveness of this.

Harvester cleaning methods: Three methods were compared. Tissues were separated into "edible" and "discarded" tissues and percent toxicity by tissue weight was calculated.

Method 1 – removal of black siphon tip
- ❖ reduction of 7-18%

Method 2 – removal of black siphon tip, brown tissues and gills, and gut gently squeezed
- ❖ Reduction of 12-76%

Method 3 – removal of black siphon tip, brown tissues and gills, and gut fully cut away
- ❖ Reduction of 9-89%

Method 3: Even with maximum processing (approximately 50% of the clam tissue discarded), **there was not a 100% removal of toxins.**

Toxicity exposure can be reduced by removal of certain tissues, particularly the black siphon tip and gut. **But the effectiveness of the cleaning strategies to remove toxins varies greatly and is not predictable.** The toxicity of the "cleaned" meat is dependent on the season, location of harvest and variation in individual clams.

Kodiak Regional Monitoring

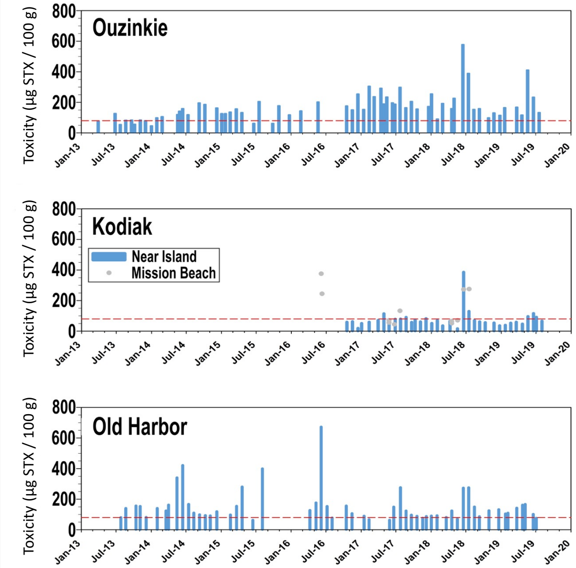


Figure 4. Butter clam toxicity (µg STX / 100 g) in shellfish collected by community samplers at (A) Sourdough Flats, Ouzinkie; (B) Trident Basin, Kodiak; and (C) Shipwreck Beach, Old Harbor. The red line is the FDA regulatory limit (80 µg STX / 100 g).

Summary

Regional shellfish monitoring:
PSP toxins increase dramatically during the summer months, but risk exists year round because toxins are retained in butter clams. Community monitoring data demonstrate toxin levels are routinely above the FDA regulatory limit. Monitoring is an effective solution to provide critical information about PSP risk to coastal residents in Alaska, and we recommend continuing monitoring.

Toxins in Butter clam tissues:
Distribution of toxins within butter clam tissue varied seasonally, with high GTXs in the gut during *Alexandrium* blooms and high STX & neoSTX in the siphons after the bloom season. Cleaning studies show toxicity of butter clams can be reduced by removal of the siphon tip and the gut, as well as other tissues. **But removal of these tissues does not guarantee processed butter clams will be toxin-free**. Toxin levels can remain above recommended limits in the "cleaned" meat. **The practice of harvesting and holding the shellfish until they have been tested and shown safe is recommended.**

Acknowledgments

We thank: ❖The North Pacific Research Board, Project #1616 ❖The Alaska Department of Environmental Conservation Environmental Health Lab ❖Alutiiq Tribe of Old Harbor ❖City of Ouzinkie ❖Sun'aq Tribe of Kodiak ❖Agdaagux Tribe of King Cove ❖Qagan Tayagungin Tribe of Sand Point ❖Jennifer McCall with SeaTox Research Inc.