FINAL REPORT

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Scallop Research Set Aside Project 05-SCA-005

Continued Investigation of Marine Biotoxins in the Atlantic Sea Scallop Resource Increasing the Economic Return from the US Atlantic Sea Scallop Fishery

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National Marine Fisheries Service
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U.S. Department of Commerce

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Table of Contents

1. Project Summary

2. Opportunity, constraints and project approach
2.1 Background on the market opportunity for roe-on scallops
2.2 Background of the U.S. Atlantic sea scallop resource
2.3 Background on marine biotoxins
2.4 Project approach

3. Project Team

4. Description of how the work was accomplished
4.1 Sample collection
4.2 Sample handling and initial processing
4.3 Testing market acceptance of roe-on scallops with local restaurants
4.4 Conducting the workshop
4.5 Unanticipated factors affecting data collection

5. Methods of testing for marine biotoxins
5.1 Overview
5.2 PSP – Jellett Rapid Test (JRT)
5.3 PSP – Receptor Binding Assay (RBA), NOS and FDA
5.4 PSP – Mouse Bioassay (MBA), Massachusetts DMF
5.5 PSP – High Performance Liquid Chromatography (HPLC), WHOI
5.6 ASP – Jellett Rapid Test (JRTA)
5.7 ASP – Receptor Binding Assay (RBAA) and LC-MS for Domoic Acid
5.8 R / M (Roe to Meat ratio) and GSI (Gonadalsomatic Index)

6. Results and discussion
6.1 PSP – Maps, Receptor Binding Assay, Mouse Bio Assay, roe and viscera, NOS, FDA, DMF
6.2 PSP – Maps, Jellett Rapid Test, roe and viscera
6.3 ASP - Map, Liquid Chromatography – Mass Spectrometer
6.4 Scallop roe to meat ratio (R /M) – plot over time and map
6.5 Discussion
6.6 Utility of Jellett Rapid Test
6.7 Dockside Protocol
6.8 USFDA CFSAN offshore shellfish testing

7. Conclusions

8. Contribution to management

9. Acknowledgements

10. Presentations and meetings

11. References

12. Appendices

Glossary of terms used throughout this report

ASP – Amnesiac Shellfish Poison – federal standard for closure is 20μg/g tissue domoic acid.

AOAC – Association of Official Analytical Chemists – standardizing body for chemical testing.

CCEHBR – Coastal Center for Environmental Health and Biomolecular Research

CFSAN / FDA – Center for Food Safety and Applied Nutrition, U S Food and Drug Administration

DMF – Massachusetts Division of Marine Fisheries

FDA - U.S. Food and Drug Administration

GSI - Gonadalsomatic Index

HPLC – High Performance Liquid Chromatography

ISSC / NSSP – Interstate Shellfish Sanitation Conference / National Shellfish Sanitation Program

JRT / JRTL – Jellett Rapid Test / Jellett Rapid Testing Limited, Nova Scotia, Canada

JRTA_G and JRTA_V - Jellett Rapid Test for ASP on the gonad or viscera

JRTP_G and JRTP_V – Jellett Rapid Test for PSP on the gonad or viscera

LC - MS - Liquid Chromatography – Mass Spectrometer

R / M – Roe to Meat ratio

MBA – Mouse Bioassay

NEFMC – New England Fishery Management Council

NOAA – National Oceanic and Atmospheric Administration

NOS – National Ocean Service, Charleston, S.C.

NMFS – National Marine Fisheries Service

PSP – Paralytic Shellfish Poison – federal regulatory standard is 80μg/100g STX equivalents

RBA – Receptor Binding Assay

Roe – scallop gonads, female ovaries (red-orange) and male testes (white-beige)

RSA – Research Set Aside program and source of funding

STX equiv. – Saxitoxin equivalents, expressed in μg/100g tissue, with 80μg as the federal standard

WHOI – Woods Hole Oceanographic Institution

1. Project Summary

Project partners conducted testing of Atlantic sea scallop tissues for marine biotoxins responsible for Paralytic and Amnesic Shellfish Poisoning (PSP and ASP) to provide toxin distribution data critical to the development of a roe-on scallop fishery. This project continued sampling and testing efforts conducted from mid 2004 through the end of 2005 in NOAA Grant NA05NMF4540010. During this project, in 2006 and 2007, almost 12,000 animals were collected from 873 sample locations across the U.S. range of the fishery, using both commercial scallop industry vessels and the NOAA R/V Albatross IV as vessels of opportunity. Testing for biotoxins was again accomplished using two newly developed methods, Jellett Rapid Test (JRT) and Receptor Binding Assay (RBA), with a subset of samples crosschecked with the ISSC approved Mouse Bioassay (MBA). Scallop adductor meats do not retain biotoxin to any significant degree and were not tested. Roes were tested separately from the remaining viscera (eye-rings, vellum, hepatopancreas).

Only very low concentrations of PSP toxins were found in roes taken from all areas in the Mid-Atlantic region in all years. All quantitative RBA and MBA test results in the Mid-Atlantic roes were well below federal regulatory action level of 80µg STX equiv / 100g of shellfish tissue. West of the western boundary of the 2005 PSP Emergency Closure Area (71° W) near Block Island, all roes tested below detection levels in 2006, and in 2007 toxin results were below 10µg. In 2004 toxin results were found in the single digits and in 2005 roe toxins were found in the low teens.

Accordingly the strongest finding from the combined three year effort is that there are no public health reasons that scallop roes from the Mid-Atlantic resource cannot immediately be brought to market. There are, however, significant fisheries management regulations, including poundage possession limits for both Limited Access and General Category fleets, that will require action by the New England Fishery Management Council in order to facilitate this opportunity.

In 2006, the year following the largest harmful algal bloom in New England in 30 years, many viscera samples collected within the combined PSP Closure Areas exhibited values above federal action levels of 80µg, however out of the 115 samples tested throughout the study area no roe samples had test results measured or inferred to be > 80µg. In 2007 only 2 roe samples were found above the federal standard during the widespread and intense *Alexandrium fundyense* bloom on Georges Bank. Combining results from all years for both projects (2004 through 2007) 973 sample groups were obtained from the two PSP Closure Areas, and 679 quantitative RBA or MBA tests conducted. Of these only 14 roe samples of the 563 tested had results testing above or inferred to be above federal action level of 80µg, and 9 of those were in 2005.

All ASP results using the quantitative LC-MS method were less than half of the 20µg/g federal action levels in all areas from 2005 on, with testing discontinued in early 2007.

Several problems were overcome during the course of the project. We had envisioned that the Jellett Rapid Test (JRT) would be useful as an at-sea test for use during fishing operations, however significant issues were encountered after quantitative shore based test results demonstrated the JRT to be “inconsistently hypersensitive” for both roe and viscera. Additional testing with the Jellett kits was suspended for the remainder of the project in early 2007. A major reorganization of project partners was encountered in the early stages when the fish house supporting the processing closed, and the NOS partners ceased RBA and LC-MS testing due to funding issues. A new processing facility was established with Bergies Seafood in New Bedford. In 2007 the USFDA Center for Food Safety and Applied Nutrition (CFSAN) personnel undertook RBA testing for the 2007 NOAA R/V Albatross portion of the sampling.

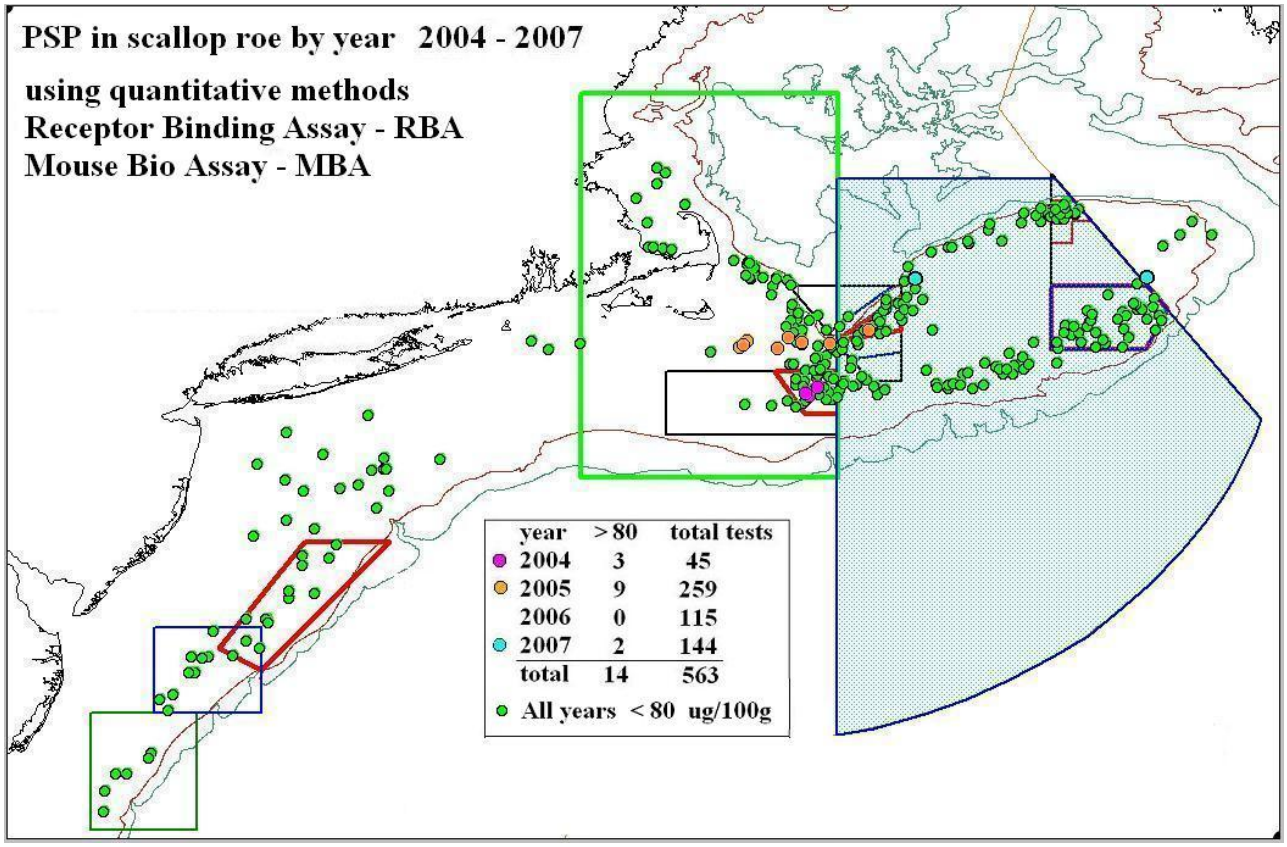


Figure 1. RBA and MBA results by year, for roe samples tested or inferred >80 µg/100g STX equiv

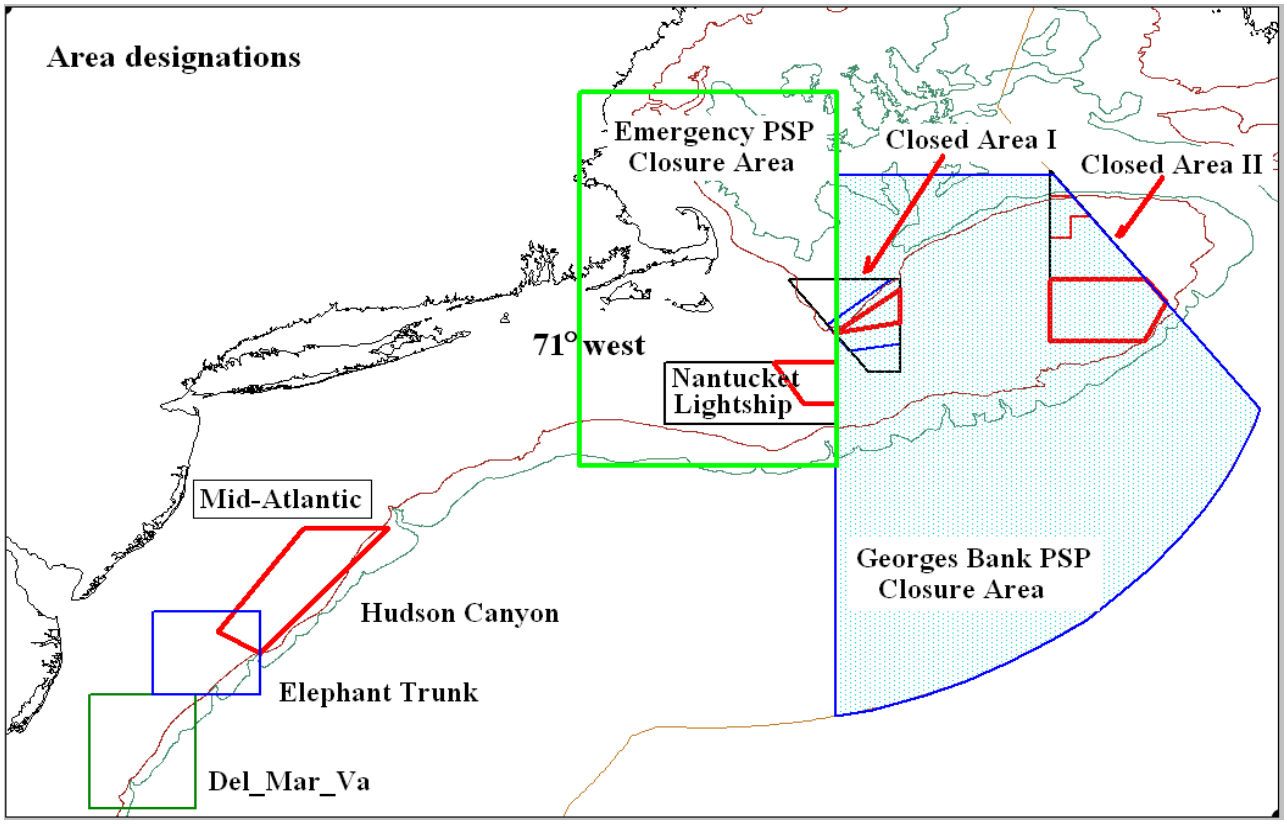


Figure 2. Area Designations

2. The opportunity, the constraints, and the project approach

2.1 Background on market opportunity for roe-on scallop product

Historically, there has been a thriving demand for roe-on scallops within the European Union yet the U.S. Atlantic sea scallop (*Placopecten magellanicus*) fishery currently discards the roe portion of the animal, partially due to the potential for retention of biotoxins in the roe and viscera, and partially due to scallop fishery management regulations regarding trip limits that to date have not been crafted to address the retention of roe. US scallop vessels produce approximately 25,000 metric tons annually of scallop meats, approximately half from the Mid-Atlantic portion of the fishery with the other half coming from the Georges Bank and the Great South Channel. We feel there is a strong opportunity to develop a market for roe-on scallops from the toxin free waters of the Mid-Atlantic.

Roe-on scallops, as traditionally preferred by European consumers, consist of the adductor muscle with gonad (roe) attached. France is the largest consumer of roe-on scallops with smaller markets in Belgium, Spain, Italy and the UK. Monfort (Appendix B) estimates the French market for roe-on scallops at 7,000 metric tons, 20% provided locally with the remaining 80% imported from the UK, Chile, Peru, Japan and New Zealand. Other EU roe-on consumption adds up to 10,000 metric tons indicating a possible EU market size of 17,000 metric tons. Shumway (2006) reports Canadian exports beginning in 1987 range between 10 and 100 metric tons of shell-off / roe-on scallops, proving a small but promising E.U. acceptance of *Placopecten magellanicus* roe.

Both the traditional EU markets for a roe-on scallop and the success of the initial Canadian efforts indicate an opportunity for the development of the US roe resource. However Monfort also reports demand for roe-on scallops is falling in France due to increased availability of and preference for American roe-off product. Cheap Chilean roe-on imports also make it harder for a relatively higher cost US product to enter European markets. Further, French consumers pay a premium for live, locally produced, King and Queen scallops with orange, bicolor roes. *P. magellanicus* scallop roe, while similar in flavor, has red female roe and beige colored male roes. Additionally *P. magellanicus* cannot be imported into to France as a live product. While consumer tastes may change, it appears that when spending for a premium product, French consumers may tend to the traditional rather than a new product.

Roe size and market acceptability of roe-on scallops varies seasonally, with about half the available U.S. resource currently restricted from harvest due to PSP closures and with the other half market ready for a short period of the year, only a portion of the available resource can produce market ready roes. We estimate that a roe-on product could immediately increase the saleable poundage of the US sea scallop industry by 15%. Vessels wishing to specifically target this market could potentially double this through trip trading allowing increased access to the Mid-Atlantic Access Areas in the spring of the year. Sale of live scallops, of interest to US Asian markets, would increase utilization up to 100%, however scallops are difficult to keep alive, their shelf-life is short, and the total current volume is small. Most importantly, any additional saleable weight from roes or whole scallops can be realized without increasing mortality on the scallop stock.

Additional market opportunities are more difficult to quantify and deserve further exploration. Initial market testing during this project confirmed that strong demand exists for fresh roe-on scallops with a half dozen local Massachusetts white tablecloth seafood restaurants.

2.2 Background on U.S. Atlantic sea scallop resource

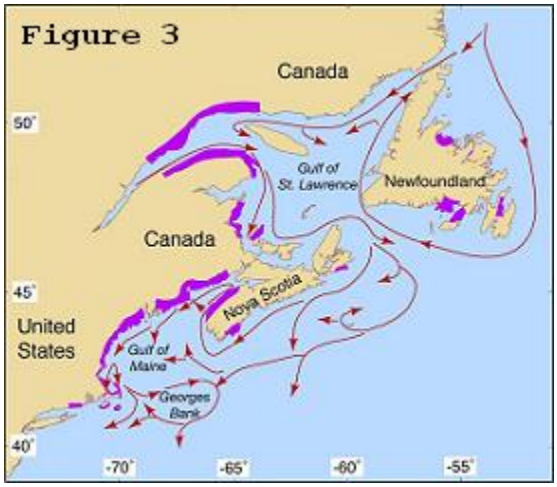
Amendment 10 to the Scallop Fishery Management Plan (FMP) institutionalized the process of identifying and closing areas where large sets of juvenile scallop are found, allowing them to grow significantly beyond the ring size of the fishing gear before the areas are reopened. Whether due to fortuitous environmental conditions for spawning, or to the success of the closure method, the Mid-Atlantic scallop growout areas currently contain more than half of the harvestable scallop resource (Hart 2008). The scallop access areas on Georges Bank also contain large numbers of larger scallops, however ~40% are not accessible due to groundfish regulations. What we see in the Mid-Atlantic is large sets of new animals settling directly down current from the densely populated growout areas: Hudson Canyon, Elephant Trunk, and Del Mar Va with the latter two Access Areas established in these last few years (Figures 1 and 2).

While the Mid-Atlantic area has been considered to be free of biotoxins, testing of scallops has been limited, with the primary concern being the large surf clam fishery. No toxins have been found there, so the area is open for the harvest of whole molluscan shellfish, including whole or roe-on scallops. There has been no significant commercial-scale effort to develop markets for live or whole scallops, or other value added scallop products, in part because large parts of the Mid-Atlantic areas have been rotationally closed and warm temperatures make it difficult to hold and land live scallops during much of the year.

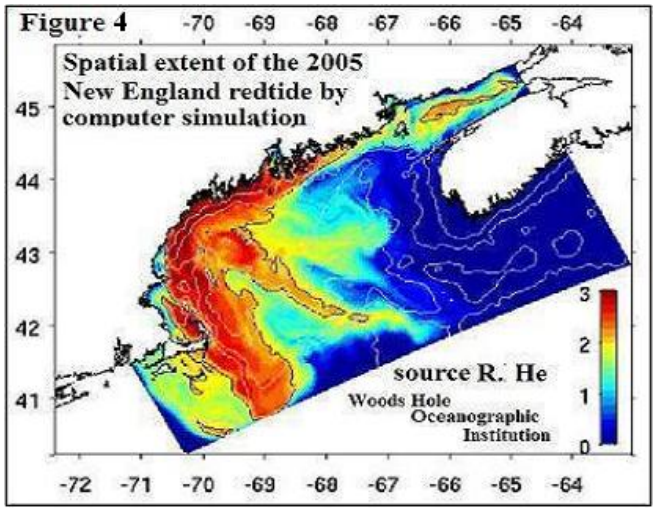
In 2007 and 2008 the Elephant Trunk Access area off New Jersey has been reopened with total landings over 30 million pounds. A spring roe-on fishery could begin there immediately as roes are market sized and water temperatures should not be a problem. In the other half of the northeast region's scallop resource, Georges Bank and Great South Channel, the landing or sale of whole scallops or scallop roe is currently prohibited as a result of federal offshore closures due to PSP established in 1989, and more recently for the more inshore waters in 2005.

2.3 Background on marine biotoxins

High concentrations of toxic marine algae, known as harmful algal blooms or HABs, are often referred to as "red tides" as concentrations of algae can sometimes become so dense they can cause waters to appear red. In many cases, however, water can be clear and uncolored, yet shellfish can still be toxic due to the potent toxins they have concentrated while filter feeding. The term "red tide" can thus be misleading. Nevertheless, given the popular use of the term in the context of regional PSP issues studied here, this term will be used hereafter.

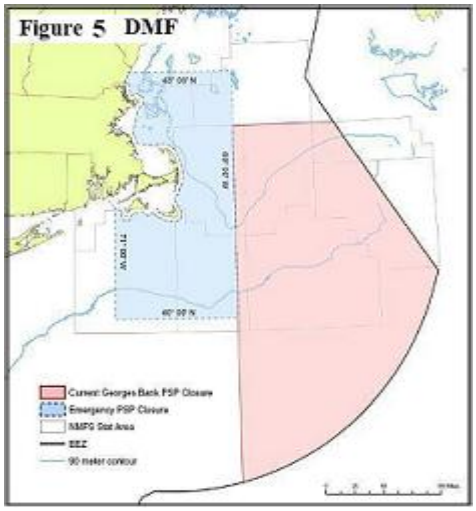


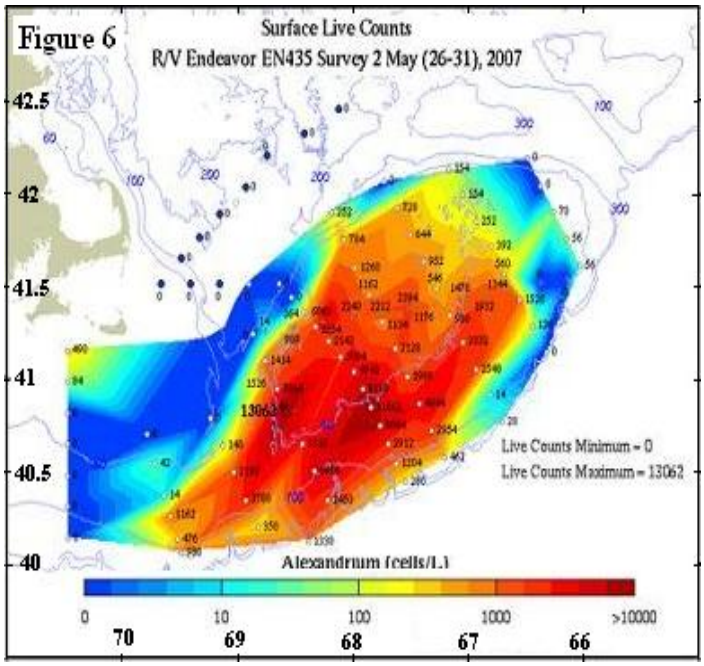
Alexandrium fundyense, a single celled marine algae, is the causative organism for PSP in the study region. A second group of algae, *Pseudo-nitzschia (spp)* are the causative organisms for ASP. When sufficient quantities of *Alexandrium* or *Psudeo-nitzschia* are consumed by shellfish, toxins build up in shellfish roe and viscera, which if consumed by humans, can cause illness or death. Safe harvest of valuable nearshore species, such as clams, mussels, and oysters, both wild and cultured, has been made possible through routine monitoring and periodic closures by state and federal regulatory programs.



In the spring of 2005 the largest red tide bloom in over 30 years developed in the western Gulf of Maine (Figure 4; Anderson et al 2005). By June, shellfish toxicity had increased sharply causing the FDA to close shellfisheries from New Hampshire to Martha's Vineyard and out to 69º W, about 40 miles east of Cape Cod. While the inshore areas were subsequently reopened as shellfish toxicity fell below federal action levels in many species, the landing of whole or roe-on sea scallops from this 16,000 square mile emergency closure area remains prohibited. East of 69º W is similarly closed due to toxins found there in 1989 and 1991.

The well-documented events of PSP poisoning of fishermen (CDC, 1991) leading to the 1991 Georges Bank closure, and the bloom that led to the 2005 PSP Emergency closure (Figure 5), are a result of the long distance movement of algal blooms from the northerly inshore waters southward along the coast, and the subsequent retention and growth of these cells on Georges Bank (Figures 3 and 4). Movement of these blooms appears to be forced by a combination of events: fresh water runoff, the strong currents in the Gulf of Maine, and the variable influence of wind direction and intensity (Anderson et al, 2005). Notably, the 2005 bloom also closed Cape Cod bay to the harvest of whole and roe-on scallops, however that closure was lifted in November 2006, with the eastern half of Cape Cod bay closing again in May 2008 (DMF 2008).





Scientists at WHOI and other institutions including NOAA, EPA, FDA, and Mass DMF, are working together in a collaboration known as GOMTOX to advance the science regarding harmful algal blooms. By developing new methodologies and making sampling cruises in key areas as funding and weather allow, GOMTOX crews collect water or sediment samples that may contain concentrations of *Alexandrium* cells. Cells are identified and counted to produce cell count maps which when combined with meteorological and oceanographic information create computer models to forecast or backcast how harmful algal blooms might affect coastal and deep water shellfish toxicity.

Anderson (2005) found *Alexandrium* cells in "high abundance" at 10,000 – 20,000 cells per liter during the harmful algal bloom of that year. In 2006 offshore survey efforts identified 1,000 to 3,000 cells per liter range on one cruise in June 2006 in the eastern Gulf of Maine which may have contributed to keeping Cape Cod Bay closed for whole molluscan shellfish and whole and roe-on scallops through November of that year. On Georges Bank, 2007 cell counts in May as high as 13,062 and June of 9,898 (Figure 6) may have been predictive of shellfish toxicity found in the spring and summer of 2007 in that area. Cell count cruises to the east and south found very low cell counts.

While no direct correlation has been made between high surface cell counts and scallop roe toxicity in this project we begin to tie the data from GOMTOX and scallop toxicity together, and emphasize that due to oceanographic, meteorological and biological factors this relationship is very complex. Additional new method development and data from future cell count and tissue toxicity cruises will be necessary to more fully understand the cause and effect of harmful algal blooms and shellfish toxicity in off-shore waters.

Although there have been many studies of marine biotoxins in scallop tissue (Nassif, et al 1993, Shumway 1993, 2006), prior to this study little was known about the presence or absence of harmful algal toxins in offshore scallop tissues throughout the U.S. range of the Atlantic scallop resource, i.e. there has been no effort to produce an annual, synoptic view. The presence and uptake of these toxic algae is the critical issue to development of markets for scallop tissues other than the adductor muscle. Unlike the meats, the sea scallop viscera and roe are known to retain harmful PSP or ASP toxins, often for an extended period of time after a bloom.

Worldwide, toxin-free harvest and export of roe-on scallops is permitted by public health officials using a combination of methods: water monitoring, tissue screening, lot testing, and source control each implemented to meet internationally recognized and standardized shellfish sanitation protocols. However, U.S. producers cannot meet E.U. health and quality standards as sufficient protocols necessary to allow safe harvest are not fully in place.

We believe the key factors limiting development of U.S. roe-on scallop products are:

1). Worldwide, whole or roe-on scallops are classified as "whole molluscan shellfish", as they are capable of retaining marine biotoxins which could put the consumer at risk for shellfish poisoning. Whole molluscan shellfish taken from open areas do not require tissue testing provided that open areas are certified by local shellfish authorities, however this classification calls for tissue testing to insure roe-on scallops taken from PSP closure areas are non-toxic (CFSAN 2001).

2). Protocols and tissue testing necessary to meet shellfish safety and import requirements required by other countries are only partially in place. A critical factor is the AOAC mouse bioassay used to certify that whole molluscan shellfish taken from PSP closure areas are safe, and that any toxins found are below federal action levels. This test is available only on an extremely limited "pilot project" basis to vessels participating in the Dockside Protocol pilot program and carrying an Exempted Fishery Permit.

3). The NEFMC Scallop Fisheries Management Plan does not currently allow for the extra crew in the open areas, or extra weight beyond trip limits in the closed areas, and in the General Category fishery necessary to process and land roe-on scallops in a cost competitive manner.

2.4 Project Approach

In the initial effort (NA05NMF4540010) during 2004 and 2005, project partners sought to address the first issue above by collecting and testing sea scallops over the U.S. Atlantic range in order to document the presence or absence of biotoxins that cause shellfish poisoning, and the location of market-acceptable roe-on scallops. We sought to accomplish these primary goals while evaluating new technologies to test for the presence of the two major biotoxins found in the region.

This 2006 – 2007 project was to continue the previously established procedures with the added opportunity of documenting the longevity of the effects of the massive *Alexandrium fundyenses* bloom of 2005, the "largest in at least 30 years". Beyond the project deliverables, we conducted a limited market test selling roe-on scallops landed within public safety regulations in order to explore product production and market acceptance. Lastly we planned to bring industry and regulatory stakeholders together in a meeting to explore the opportunities and problems related to the development of a roe-on scallop fishery.

To continue our investigation, this project set out to meet our original objectives, with the addition of some initial market testing.

1). Document the distribution and abundance of the two known marine biotoxins in the region (PSP and ASP) found in scallop tissues using samples from vessels of opportunity.

2). Explore the utility of and results from newly available biotoxin testing methods.

3). Monitor roe and meat condition over the course of the year in various fishing areas to identify where and when market-ready roe-on harvest might occur.

4). (New Objective) Introduce roe-on scallops to local restaurants to determine product production issues and market acceptance.

5). Conduct a workshop with scientific, regulatory and industry partners to present project findings, and explore the next steps for the development of a safe roe-on scallop fishery.

During the initial project, June 2004 through December 2005, over 6,600 animals from 534 sample locations were collected across much of the U.S. range of the species, from the waters off Virginia to the Canadian end of Georges Bank. In this second phase of the project, January 2006 through August 2007, almost 12,000 animals were collected from 874 sample locations. All samples were collected by commercial scallop industry vessels and the NOAA R/V Albatross IV as vessels of opportunity.

Testing of samples for marine biotoxins was accomplished using two newly developed methods, Jellett Rapid Test (JRT) and Receptor Binding Assay (RBA), with portions crosschecked with the ISSC approved Mouse Bioassay (MBA). Roe and meat weights were recorded and plotted by area and season to estimate when and where a market-ready roe-on product was available. From January 2006 until early 2007 the CCEHBR laboratory conducted the RBA testing. Beginning in 2007 the majority of testing was provided by FDA CFSAN using the RBA and JRT on scallop roe and viscera samples collected during the R/V Albatross IV scallop survey cruises.

3. Project Team

Donald M. Anderson, Ph.D., Senior Scientist, Woods Hole Oceanographic Institution. Anderson provided guidance for the proposal, testing and reporting phases, along with insight into Harmful Algal Blooms in the region. Associates D. McGillicuddy, B. Keafer and R. He provided results from offshore biotoxin sampling and modeling efforts.

Geoffrey Day, Seafood Research Associates, Cambridge, Mass., led the project with Taylor. Day gathered initial research, recruited team members, collaborated on the proposal, worked with state and federal agencies to acquire / renew Letters of Authorization necessary to land potentially toxic product from federally closed waters, worked with General Category vessels and partners to collect, process and analyze tissue, conducted the Jellett tests, coordinated testing with MA DMF, NOS and FDA, and co-wrote interim and final reports.

Richard Taylor, www.seascallop.com, Gloucester, Mass., collaborated on the proposal and reporting, and arranged sample collection with the limited access scallop vessels and R/V Albatross IV. Taylor also arranged the funding trips, processed samples, mapped and analyzed the data and co-wrote interim and final reports.

Frances Van Dolah, Ph.D., Research Biochemist and Algal Biochemistry Project Leader, Marine Biotoxins Program, Center for Coastal Environmental Health and Biomolecular Research, NOAA/NOS, Charleston, S.C. Van Dolah provided the lab and staff that conducted the Receptor Binding Assay and LC-MS testing as well as providing guidance and insight into marine biotoxins.

Mike Hickey, Dave Whittaker, Florence Pettengill, Massachusetts Division of Marine Fisheries provided Mouse BioAssay testing for samples, along with critical suggestions throughout the project.

Marie Christine Monfort, Consultant, www.marketing-seafood.com wrote "The French Market for Roe-On Scallops" under contract with this project (Appendix B).

Vessels Kathy Marie, Atlantic, Westport, Christian & Alexa, Kayla Rose, Kathy and Jackie, Jillian, and Santa Barbara conducted RSA funding trips and brought in offshore scallop samples throughout the year. Six other Limited Access and nine General Category scallop vessels also contributed samples during the project.

NOAA R/V Albatross contributed samples from the 2006 and 2007 scallop survey trips.

Bergies Seafoods New Bedford, Mass provided storage and processing workspace, transportation, and ongoing support throughout the project.

Mike Hopper, TransOceanic Seafoods, Cambridge, Mass, ongoing support for the project with additional market data provided from his customers in Europe.

Stacey Etheridge, CFSAN USFDA, Frederick, Maryland conducted sampling and testing of scallop samples during the NEFSC annual summer scallop survey in 2007.

Participating restaurants: The East Coast Grill, Cambridge MA, The Back Eddy, Westport MA, Naked Oyster, Hyannis MA, The Brewster Fish House, Brewster MA, Bleu, Marstons Mills, MA, The Red Pheasant Inn, Dennis MA, and The Sesuit Harbor Café, Dennis MA

4. Description of how the work was accomplished

4.1 Sample collection

From January 2006 through September 2007 samples were collected by 14 Limited Access scallop vessels, 9 inshore General Category vessels, and the NOAA R/V Albatross IV. Eight of the Limited Access vessels received RSA compensation trips, the remaining 6, and all General Category vessels contributed voluntarily. Additional samples were collected by the NEFSC survey crews during the annual scallop surveys in 2006 and 2007, providing an opportunity to obtain samples from areas that were not open to commercial vessels.

4.2 Sample handling and initial processing

Samples were fresh frozen at sea aboard participating vessels or delivered directly to the freezer at Bergies Seafood, New Bedford, for storage. As the vessels had highly variable schedules, groups of samples were accumulated until sufficient samples were on hand to provide a full day of work. Samples were then processed at the Bergies facility. Scallops were thawed, shucked, with shell heights measured and recorded. Soft parts were separated, rinsed, weighed, mascerated, labeled and refrozen in 100 ml replicate sample tubs for local testing, shipping to project partners, and archiving. Meat, roe and viscera weights were recorded to calculate gonadalsomatic index and roe to meat ratios. To insure there was no possibility of mixing potentially toxic tissues with product going into the food supply from the plant, processing was done in a Mass Dept of Public Health inspected area, normally during weekends when the plant was not in use.

4.3 Testing market acceptance of roe-on scallops with local restaurants

A brief and geographically limited market test was conducted in 2007 using roe-on scallops landed from areas known to be free of marine biotoxins, and approved by both state and federal public safety regulations. All market ready product was handled in a separate facility appropriately licensed for processing and selling whole molluscan shellfish, insuring full certification of the product, and that there would be no chance for intermixing with scallops landed for biotoxin testing. Some market ready product was entered for testing for biotoxins as a routine matter. Free samples were given away to interested restaurants and later fresh product was successfully sold, given away at cooking demonstrations, and served as hors d'overes at the 2007 Harmful Algal Bloom Conference at WHOI.

Figure 8. Roe-On Scallops

4.4 Conducting the workshop

A workshop for industry and regulators was conducted at Woods Hole Oceanographic Institution on November 14, 2008 to present findings.

4.5 Unanticipated factors affecting data collection

In October 2005, new enforcement of a longstanding but previously overlooked Multispecies Fishery Management Plan gear closure area in the Great South Channel caused many of the General Category scallop vessel captains to move into different waters, or switch over to a different fishery. The area reopened in August 2006. In November 2005, project partner New England Shellfin, Inc. ceased operations, in great part because of the inability to land whole scallop from the Emergency Closure Area. These factors affected data collection after that time as each contributed substantially to our efforts. Significantly fewer samples were obtained from the inshore areas most affected by the bloom of 2005. Project processing operations were relocated to the Bergies Seafood plant in New Bedford. Inconsistent results from JRT caused abandonment of this method in 2007. NOS RBA testing was suspended due to budgetary limitations in early 2007 leaving a backlog of untested samples. RBA testing by the CFSAN FDA laboratory became available to supplement testing not conducted by NOS.

5. Methods of testing for marine biotoxins

5.1 Overview

Initial proof of concept of at-sea testing for PSP using the Jellett Rapid Test was conducted by Taylor aboard F/V Westport in 2004. The key questions were: did the Jellet test kits work as described in their product literature, and were the testing methods suitable for use aboard a commercial scallop vessel while fishing. While the initial tests were concluded successfully, all further Jellett testing was conducted ashore as a method of achieving a more time-efficient and standardized testing procedure. Day tested both tissue compartments separately, roes and remaining viscera (eye rings, vellum, and hepatopancreas combined), when using the Jellett Rapid Test.

Selected replicates of samples were shipped to the NOS Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) facility in Charleston for Receptor Binding Assay (RBA) tests. Additional testing using High Performance Liquid Chromatography (HPLC), conducted at the Woods Hole Oceanographic Institution during the first effort, was dropped from the project as the higher throughput of the RBA, and close agreement with the MBA results, was repeatedly demonstrated. Sample groups from the two PSP Closure Areas were tested using the Mouse Bioassay (MBA) at the Massachusetts Division of Marine Fisheries Lab in Gloucester by Florence Pettengill.

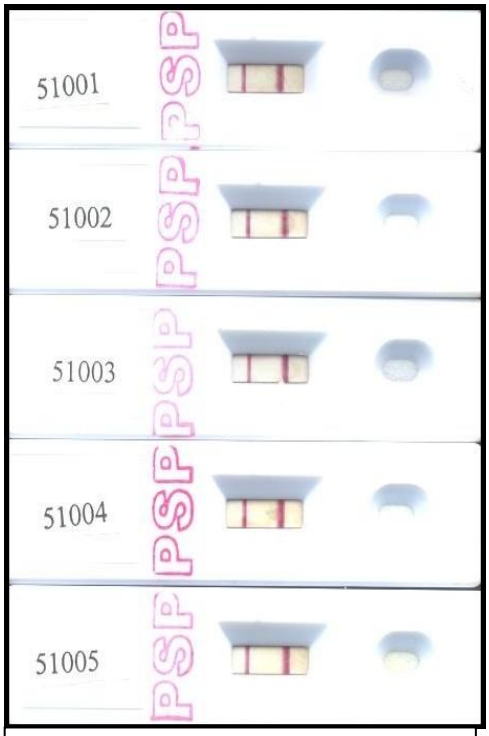


Figure 9. Sample Jellett kit results

5.2 PSP - Jellett Rapid Test (JRT)

Selected replicates were tested for PSP with the JRT using the JRT vinegar and alcohol extraction method. Selections were based on three initial factors: time of the year, location, and history of PSP in an area. Tests were spread out through the year and across the range of areas represented in an effort to observe temporal and spatial trends. Roes were selected for testing more frequently than viscera. Our initial project identified a high incidence of "false positives" where the JRT showed positive in the roe at > 40µg/100g STX equivalents (half of the federal standard) yet the RBA showed toxins as low as 10µg/100g.

For 2006 and 2007 testing, Jellett Rapid Testing Limited provided a custom buffer to reduce "false positives" when testing the roe. Since our prior project identified a theoretical relationship between roe and viscera toxicity, and since initial data indicated a low false positive rate in the viscera results using JRT, dilutions were experimentally used to test viscera samples in an attempt to increase utility of the JRT.

5.3 PSP - Receptor Binding Assay (RBA), NOS and FDA

Scallop tissues were extracted for PSP analysis using the standard AOAC procedure for regulatory testing. Extracted scallop tissues were analyzed using the RBA following the procedures established in our initial project. (Appendix B, Final Report NA05NMF4540010, 2007). All tissues were available to NOS, however not all samples were shipped, and not all shipped samples were tested. Staffing and time constraints limited testing to representative areas and periods and simple methods were devised to infer the roe toxicity from visceral toxicity when there was no test done for roe tissue. A limited number of samples were also tested using the LCMS for ASP. Due to limited funding, NOS stopped from all testing in early 2007 leaving a backlog of tissues collected by industry vessels in 2007 untested.

Alternatively we reached out to FDA CFSAN (Center for Food Safety and Nutrition) to request continuing the testing of the 2007 backlog samples as FDA RBA methods are similar to NOS RBA methods. Technical problems prevented the FDA from completing these tests by the project end date, however the FDA did successfully test R/V Albatross samples from that year and toxicity data and results comparing the RBA and JRT are presented and combined with our results here.

5.4 PSP - Mouse Bioassay (MBA), Massachusetts DMF

The Mouse Bioassay was conducted using the AOAC standard method (AOAC 1990) by Florence Pettengill at the Massachusetts Division of Marine Fisheries facility in Gloucester.

5.5 PSP - High Performance Liquid Chromatography (HPLC), WHOI

HPLC testing proved problematical during the effort in 2004 and 2005 (NA05NMF4540010) due to the sporadic nature of sample testing and the time involved in setting up the machine for alternating tasks. Given the utility of the RBA and MBA testing efforts this segment of the project was discontinued. Alternate arrangements with a laboratory in New York were discussed at some length but were not undertaken.

5.6 ASP - Jellett Rapid Test (JRTA)

Georges Bank was of particular interest because domoic acid (the toxin that causes ASP) was identified in 23 whales found dead off the coast of New England (NOS 2003). However test results for ASP during the previous project using all methods had found only very low levels of toxins with none more than half the federal action level. After NOS partners ceased testing in early 2007, JRT testing for ASP was also suspended as no comparative quantitative test was available.

5.7 ASP – Receptor Binding Assay (RBAA) and LC-MS for Domoic Acid

Initially, ASP toxins were to be analyzed by NOS using the RBA, but early results were unreliable and in 2005 NOS substituted LC-MS (Liquid Chromatography - Mass Spectrometer) as their chosen method for ASP testing. Initial random samples from Georges Bank were selected, and later samples testing positive with the JRT for ASP were identified and tested. LC-MS testing was available on a limited basis. Methods are fully described in Appendix B of NA05NMF4540010.

5.8 R / M (roe to meat ratio) and GSI (gonadalsomatic index)

All samples were dissected with meats, roes, and viscera weighed, and shell heights measured to establish time and place specific relationships. The gonadalsomatic index or GSI is commonly used to determine the reproductive state of shellfish, and consists of the weight of the roe as a fraction of whole animal soft tissue weight. While this ratio is useful to gauge overall reproductive status, we found it more useful to consider the ratio of roe to meat weight (R / M). This ratio gives a direct estimate of the increase in saleable poundage possible in a specific area at a given time of the year, and could be used to forecast both where and when harvest is optimal.

6. Results and discussion

Though this project focused on scallop samples collected from January 2006 through September 2007, because of the uniformity of the results with our initial project (NA05NMF4540010), this section will present the broadscale findings of the data from both projects.

Over 18,000 individual scallops in over 1400 sample groups were collected during the course of the two projects from the fishing grounds off Del Mar Va in the south to Georges Bank in the east and Stellwagen Bank to the north. No samples were obtained from areas south of the Del Mar Va Peninsula, however all other Mid-Atlantic samples were negative for biotoxins. Of these samples the 2004 –2005 project collected 534 sample groups with over 6,600 animals, and the 2006-2007 project collected 873 sample groups containing almost 12,000 animals.

Primary results are presented from all data collected during these two projects, 2004 - 2007:

Testing for marine biotoxins

All samples of scallop roe or the remaining viscera tested by LC-MS anywhere within the study area exhibited a concentration of Domoic Acid (ASP) well below the federal action levels.

All sample groups tested with the quantitative methods RBA and MBA, originating from west and south of the eastern end of Long Island were found to be well below the federal action level (80 µg/100g STX equivalents) for PSP for both roe and the remaining viscera.

Individual sample groups in the PSP Emergency Federal Closure Area and Georges Bank Shellfish Closure area exhibited widely differing levels of PSP toxins in both roes and remaining viscera when tested with the quantitative RBA and MBA methods, with the few high values interspersed within many low values. When samples were tested using both the RBA and MBA method results were uniformly consistent. While the vast majority of roe samples tested throughout area were well below federal action level, 14 of the roe samples (of 563) either tested above 80µg, or could be inferred to be above 80µg from very high values in the viscera when only the viscera was tested. In all cases samples with results below 414µg in the viscera had results below 80µg for the roe alone.

Looking at it by year, of the 14 roe samples testing (or implied) > 80µg in the roe, 3 were in 2004, 9 occurred in 2005, none were found in 2006, and 2 in 2007. Notably, all roe results above federal action levels for toxicity were collected by General Category scallop vessels or the R/V Albatross.

Gauging the utility of new test methods

The RBA test method proved to be highly sensitive and consistent, providing quantitative data that generally matched results provided by the Mouse Bioassay tests provided by the Mass Division of Marine Fisheries Lab in Gloucester. FDA partners indicated radio-labeled standards necessary for the RBA test became difficult to procure and limited testing in the latter part of the project. The Jellett Rapid Test continued to generate “false positives” in both roe and viscera tests and was discontinued. Note the difference between the maps in sections 6.1 and 6.2.

Monitoring scallop condition over time
Roe weight varied both by area and season with Mid-Atlantic areas highest in the spring, ~50% of meat weight, with Great South Channel samples highest in late summer with roes often equal to meat weights in the larger animals. The differences in seasonality could allow a vessel targeting roe to trade trips from the northern access areas where areas are closed to roe or whole animal harvest due to PSP for Mid-Atlantic trips in the spring where no PSP is found.

Roe-on market testing
In the spring of 2007 whole scallops were landed from the Elephant Trunk and processed as roe-on scallops in a licensed Shucker Packer facility. Frozen samples were given away to a variety of restaurants identified through prior research as having a strong interest yet no restaurants reordered. Later product was sold fresh as all respondents reported they would not purchase frozen and preferred fresh.

Figure 10. Roe-Scallops Provencal at the Naked Oyster Hyannis 2007

In summer of 2007 fresh product landed from Cape Cod Bay and packed following food safety guidelines was successfully sold to 7 high end restaurants in the area, all with repeat orders averaging 1 – 2 gallons per week at prices between $ 11 – 13 / pound until the season ended and roes fell to less than 30% of meat weight in September. Product was also briefly offered through one retail location which reported they sold out immediately. Tests were limited to these few restaurants as this was the maximum volume available from the small fishery in Cape Cod Bay.

The captain of the single General Category vessel used to produce roe for the market testing in this project quickly learned how to shuck high quality roe-on product through video and hands-on training and immediately saw additional value as a result of roe-on sales. Additional vessels approached failed to produce consistent quality product. Notably this supply was made available due to an unusual situation where the captain preferred to fish close to home and routinely landed no more than 12 – 15 bushels of live, whole scallops for use by US Asian restaurants. As a result, the captain could shuck a small amount of scallops roe-on without exceeding the 50 bushel / 400 pound per day limit.

Conducting a Workshop
A workshop entitled ***Increasing the Economic Return from the US Atlantic Sea Scallop Fishery*** was held at Woods Hole Oceanographic Institution, Woods Hole, Mass. on 14 November 2008. 625 invitations were sent out to license holders, resource managers, regulators, and the scientific community. 32 individuals attended to explore project findings and discuss regulatory and management issues (Appendix A). State and Federal regulators were well represented, and four individuals from industry were present.

6.1 Combined plot of PSP test results using quantitative methods - Receptor Binding Assay and Mouse BioAssay - NOS, FDA, and Mass DMF

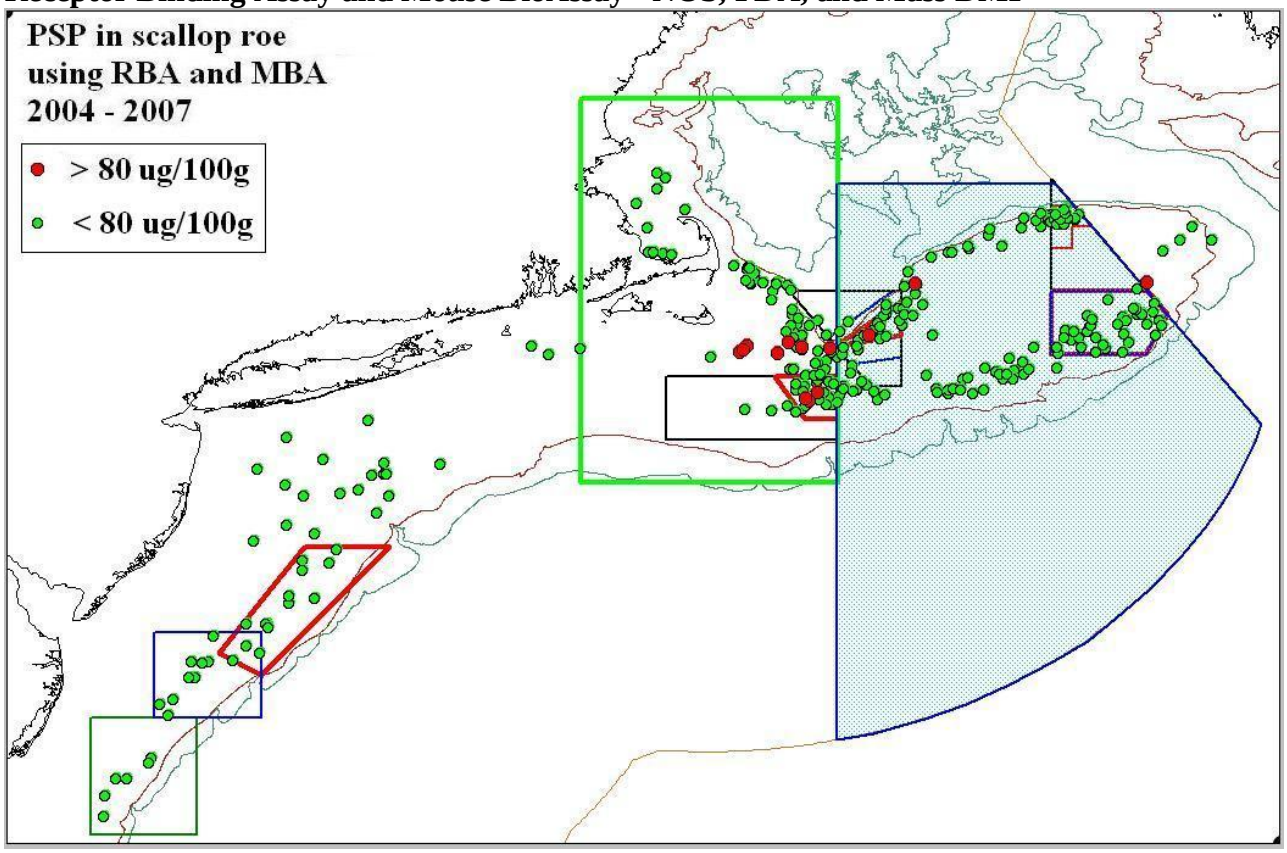


Figure 11. PSP in scallop roe – NOS and FDA RBA, Massachusetts DMF MBA, 2004 -2007

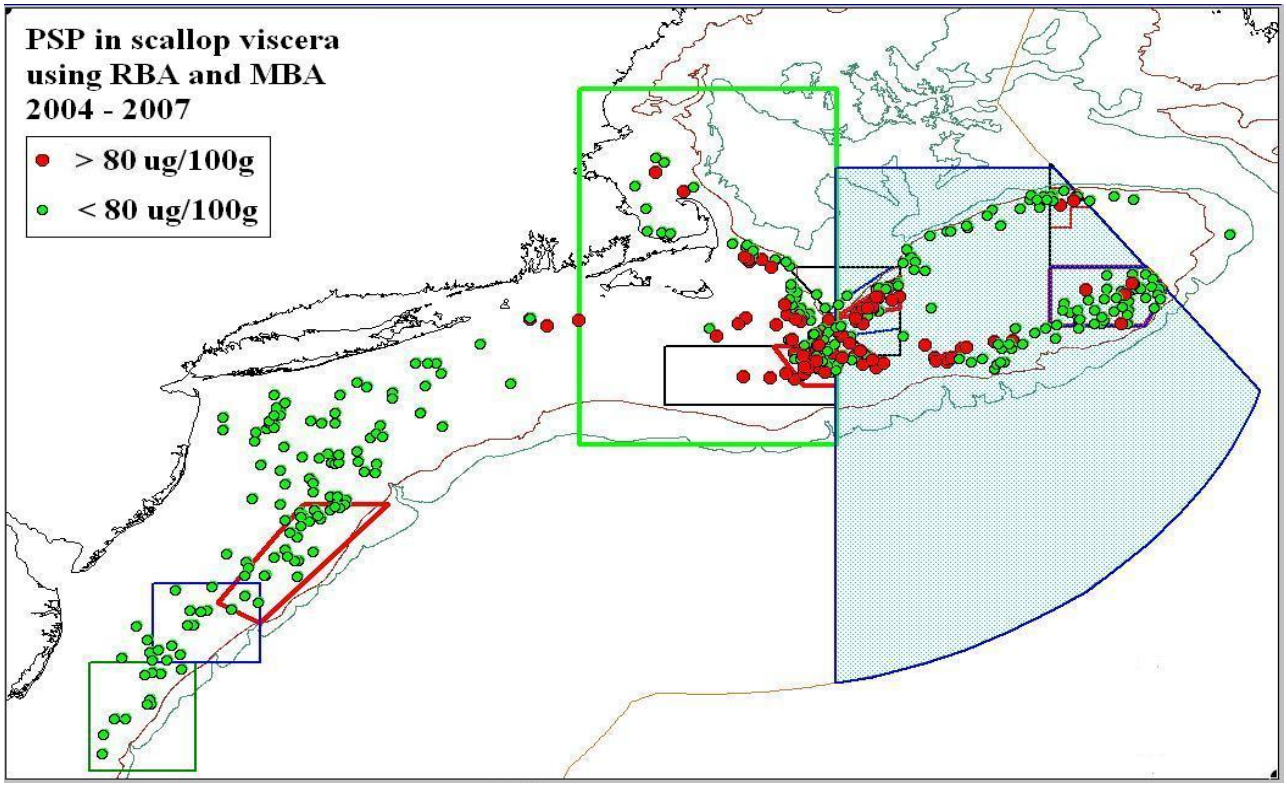


Figure 12. PSP in scallop viscera - NOS and FDA RBA, Massachusetts DMF MBA, 2004 - 2007

6.2 PSP Jellett Rapid Test – note differences from quantitative results using RBA and MBA

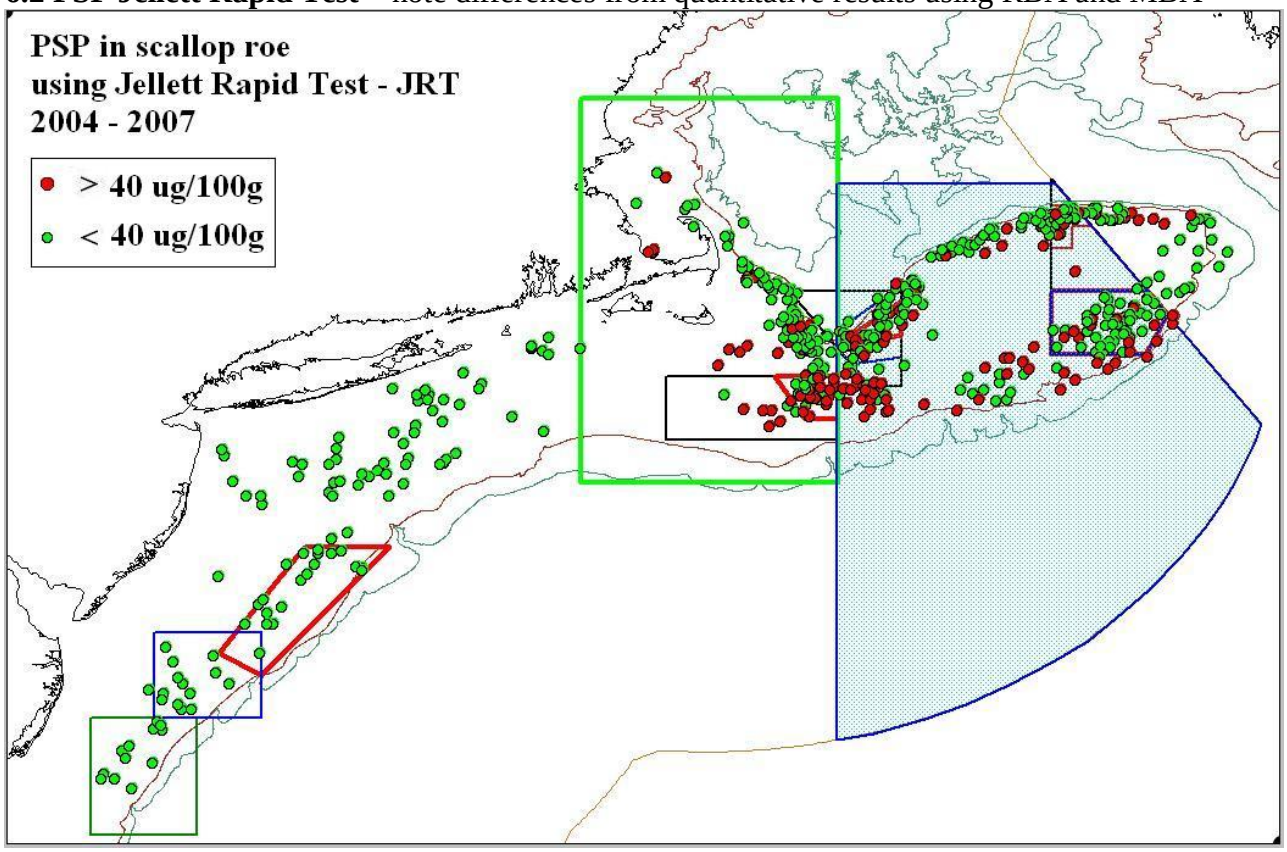


Figure 13. Jellett Rapid Test – JRT - scallop roe, 2004 - 2007

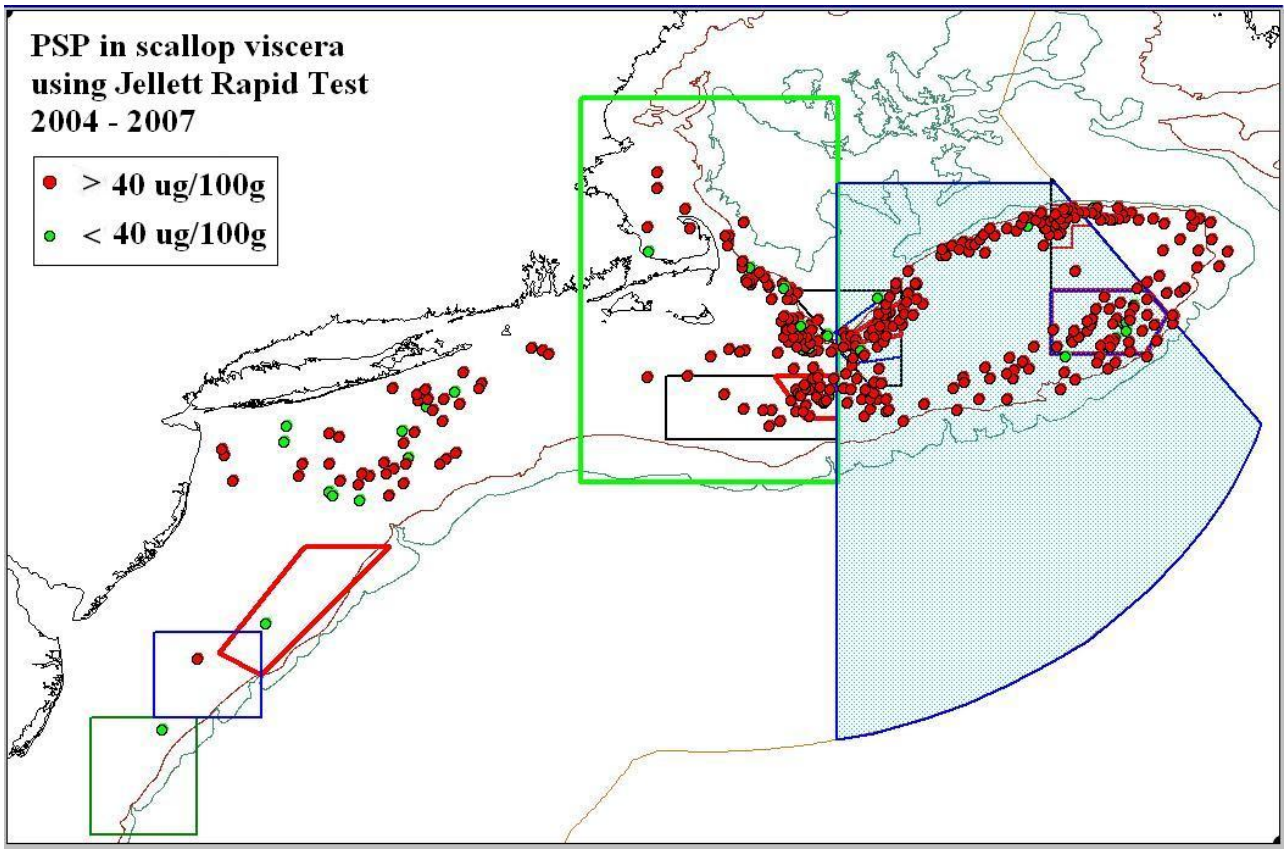


Figure 14. Jellett Rapid Test – JRT – scallop viscera, 2004 - 2007

6.3 ASP – Liquid Chromatography – Mass Spectrometer (LC-MS)

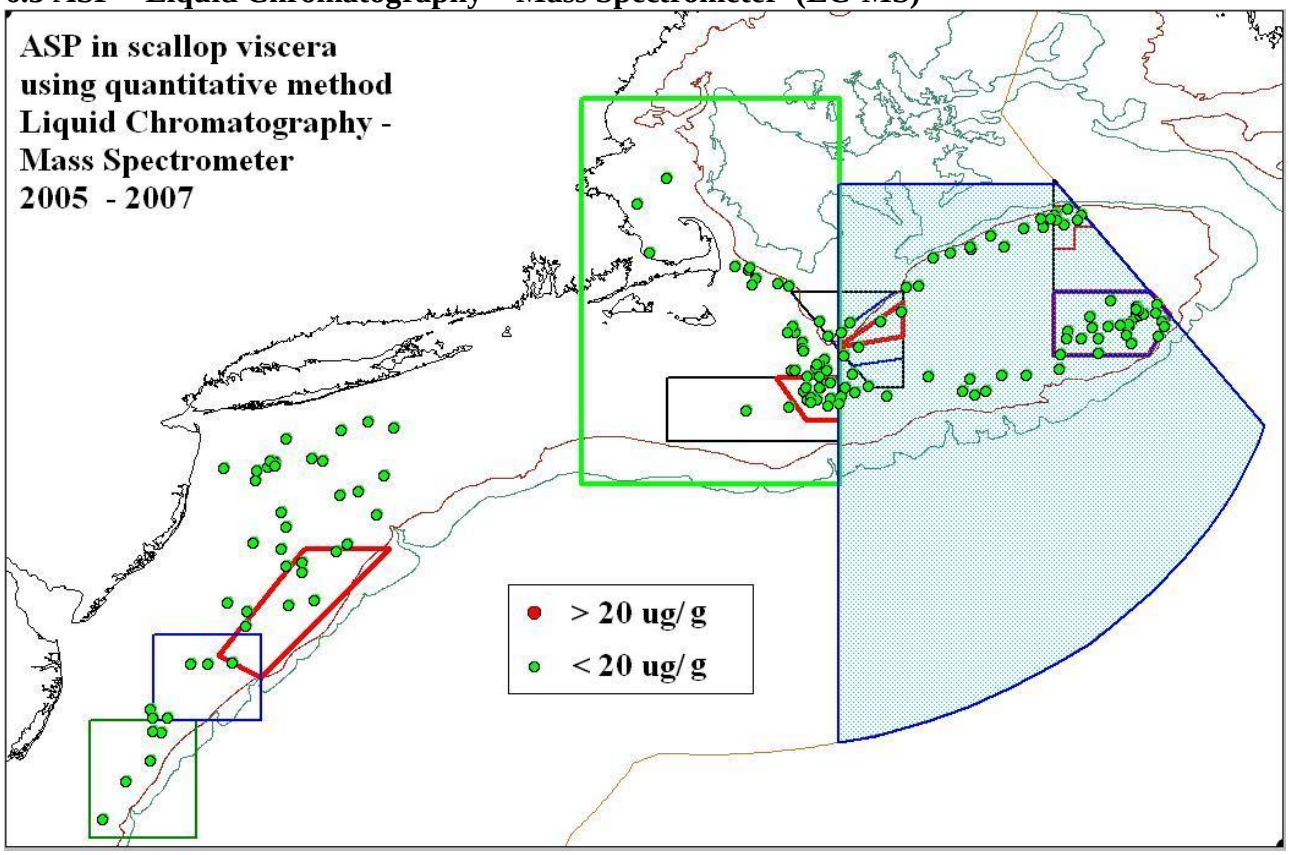


Figure 15. ASP LC-MS, scallop viscera, 2004 – 2006. 161 tests were conducted using LC-MS.

6.4 Scallop Roe to Meat ratio

Over the course of the two efforts ~18,000 scallops from 1390 sample groups were dissected with meats, roes, and viscera weighed, and shell heights measured to establish seasonal variation over the geographic range of samples collected. Condition of the roes varied markedly over the year from near zero (< 1 g) to as high as 160% of meat weight. Note that the high numbers of samples in July and August is explained by the numerous samples collected during those months by the NOAA Albatross IV survey cruises.

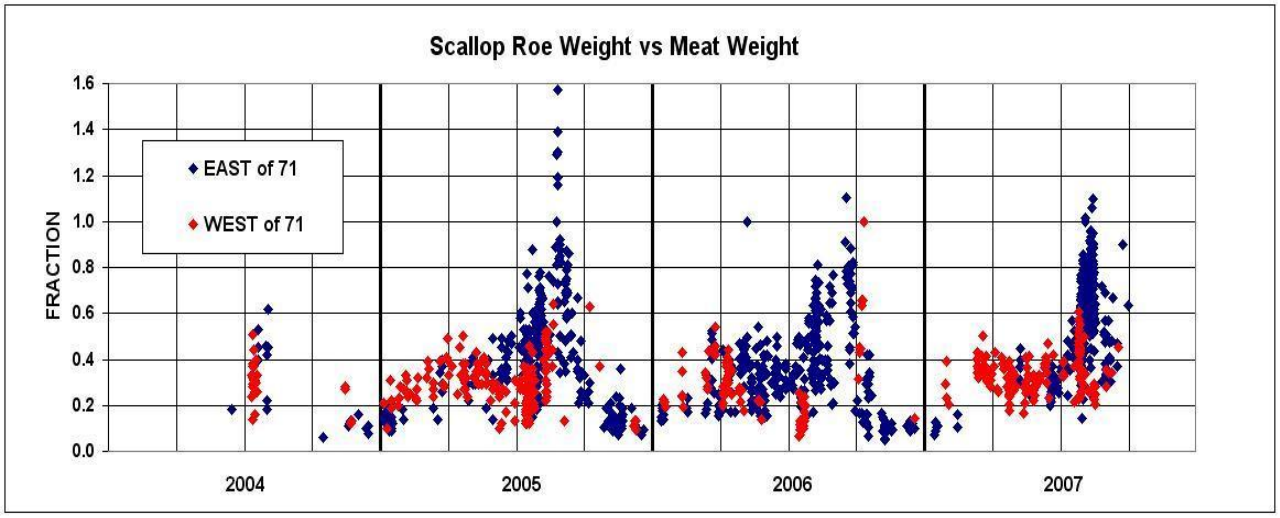


Figure 16. Scallop Roe to Meat ratio over time

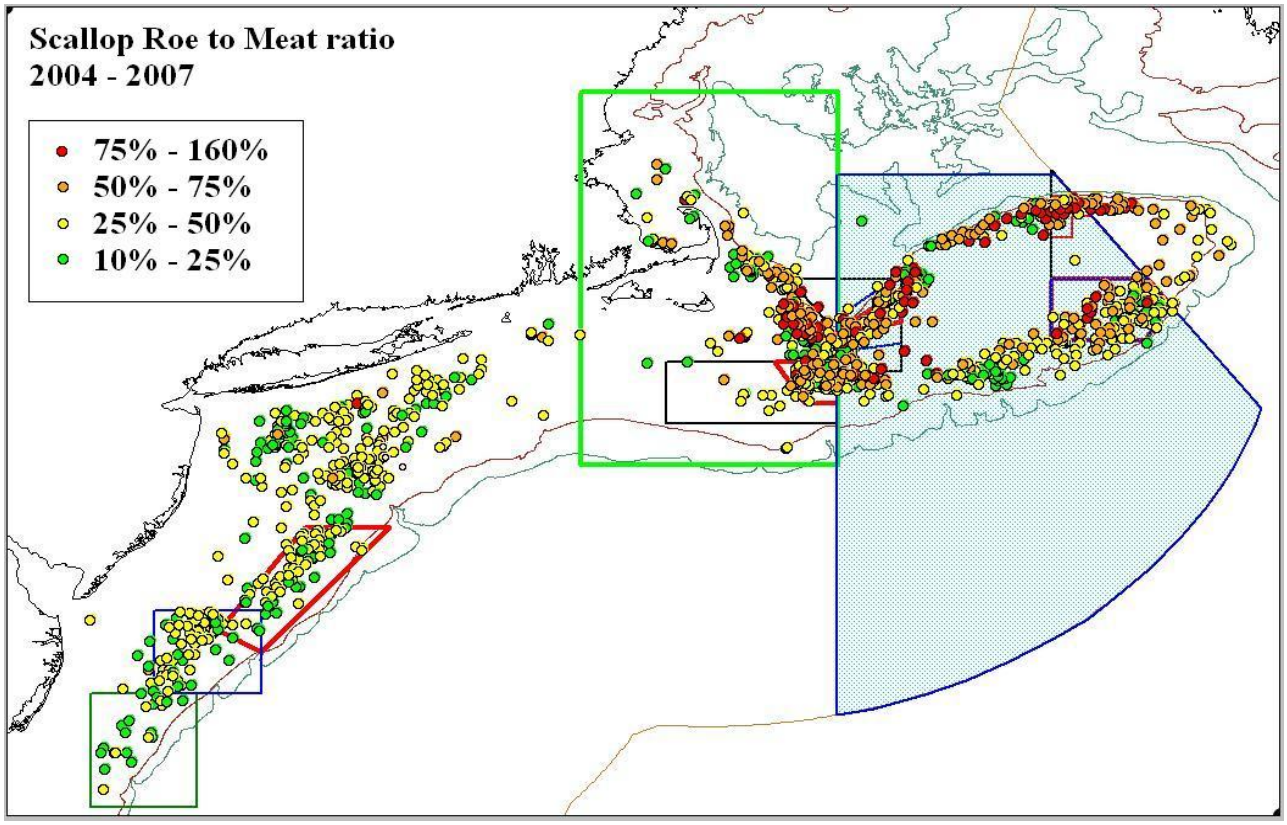


Figure 17. Scallop Roe to Meat ratio by area, 2004- 2007

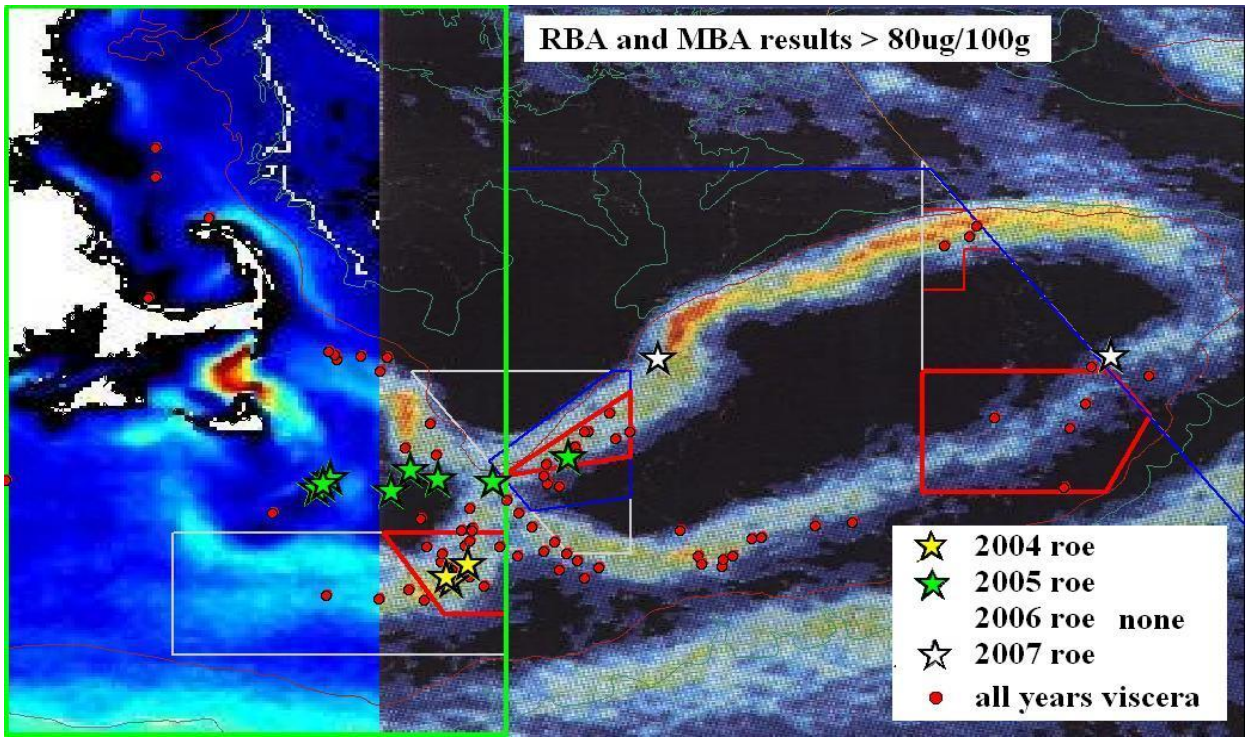


Figure 18. Map of all samples testing > 80µg plotted over the strong frontal boundaries for July as described in GLOBEC 1985-1996 (Mavor, Bisagni 2001). We feel it significant that the most toxic samples are directly on these persistent fronts that serve to concentrate drifting particles (cells) and deliver them to the bottom. The exception is the line of samples across the Great South Channel and Nantucket Shoals (green stars) that appears to mark the southern extent of the bloom in 2005.

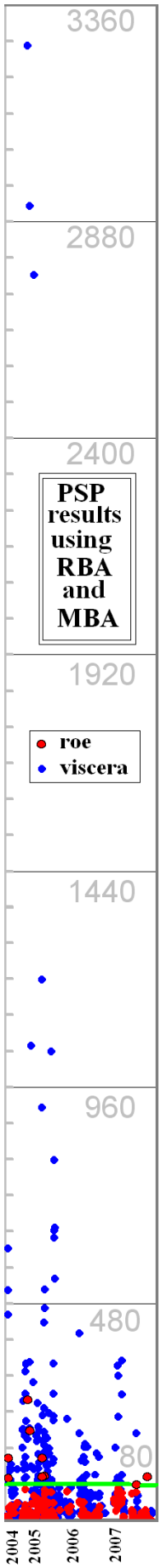


Figure 19.

6.5 Discussion

The overarching goal of this project was to determine if roe-on scallops could be harvested and marketed without risk to public health. Findings in both projects indicate unambiguously that roe-on scallops harvested from the Mid-Atlantic, where no toxicity was found, can be marketed without risk to public health. A secondary goal was to learn if new biotoxin testing methods were practical, and to cross-test tissues using multiple methods to determine if newer methods, the Jellett Rapid Test and RBA, correlated with the ISSC accepted MBA test. The implication of this secondary goal becomes increasingly important if future demand for roe-on scallops is sufficient to cause fishermen to want to harvest scallop roe from areas outside of the Mid-Atlantic, in areas closed for PSP, particularly in light of the low incidence of toxins found in roe over multiple years in those areas despite the widespread blooms of toxic algae.

Harvest of approximately half of the potential roe-on resource, that located within the PSP closure areas west of 71° W, hinges on the application of these newer methods, specifically the JRT, effectively a required component of the "Dockside Protocol" now under development and specifically designed to allow safe harvest from areas closed for PSP. Both projects found the JRT inconsistently showing "positive" for PSP toxins in viscera and roe samples at well below 40µg – results dissimilar to early JRTL product literature indicating a positive result meant the sample contained at least 40µg of PSP toxins. These so called "false positives" aren't truly false as they identify the presence of toxins, they just identify them at extremely low levels as measured by the RBA and with lesser frequency the MBA quantitative methods. While "false positives" err in the direction of protecting public safety, current JRT test results would unreasonably limit the potential harvestable area by half or more, yet public safety risk from toxicity above the federal action limit of 80µg may not be a problem in those areas. (Compare maps in Sections 6.1 and 6.2)

Findings in both phases of this project indicate general agreement between the RBA test method and the traditional, "gold standard" MBA. Minimal discrepancies result from the increased sensitivity of the RBA method and our use of single samples rather than replicate samples used in formal public safety testing.

Regulatory officials confirm general agreement between the MBA and RBA and indicate ongoing official validation studies of the RBA method indicate it is good enough to be considered as a method for submission for approval by the ISSC / NSSP. While ISSC approval can take years, this means it is almost official that results from the RBA are considered to be as accurate as the MBA when testing for PSP shellfish toxicity. The RBA becomes increasingly important if large volumes of shellfish samples need testing as it provides higher throughput, more accuracy, and greater sensitivity over a greater range, when compared with the MBA.

The maps in Section 6.1 plot the location of sample results for PSP toxins within the region. In Figure 19 the strength of these toxins is plotted in time for both tissue fractions over the four summers of the projects, clearly indicating the differences between years. This plot illustrates 1) the low and decreasing number of roes testing above 80µg, 2) the high number of roe samples testing below 80µg, 3) the decreasing number of viscera samples testing between 80µg and 414µg.

Count	Sample #	Date	Roe µg/100g	Viscera µg/100g	Test	By	Notes	
1	840008	20050714	266	3207	RBA	NOS		= < 80
2	840010	20050716	197	2916	RBA	NOS		= not tested
3	840017	20050721	54	2762	RBA	NOS		= duplicate
4	860001	20050801	137	1199	RBA	FDA		
5	870023	20050803	NT	1051	RBA	NOS	YEAR	ROES > 79
6	812007	20050912	61	1038	RBA	NOS		
4	860001	20050801	98	915	MBA	DMF	2004	3
7	812008	20050912	NT	799	RBA	NOS	2005	9
8	813014	20050920	NT	648	RBA	NOS	2006	0
9	812010	20050909	NT	642	RBA	NOS	2007	2
10	812006	20050912	NT	627	RBA	NOS		
11	ALBA04_281	20040719	96	602	RBA	NOS		
12	813013	20050920	NT	536	RBA	NOS		
13	811009	20050904	58	511	MBA	DMF		
14	ALBA04_282	20040719	137	510	RBA	NOS		
13	811009	20050904	67	470	RBA	FDA		
15	ALBA04_283	20040719	90	456	RBA	NOS		
16	811007	20050904	99	439	RBA	FDA		
17	52490	20070811	97	NT	RBA	FDA		
18	52375	20070731	79	NT	RBA	FDA		

Figure 20. Summary table of highest toxicity in viscera and roes.

In all cases the viscera had significantly higher values than the roes when using the quantitative RBA and MBA tests. However, all samples did not have both the roes and the remaining viscera tested. Highest test values for viscera and roes are presented in Figure 20. Note that 2005 had the most, and most toxic, samples, although four samples with high values in the viscera tested below 80µg in the roe. All other samples for all years had viscera results < 414µg with roe results below 80µg.

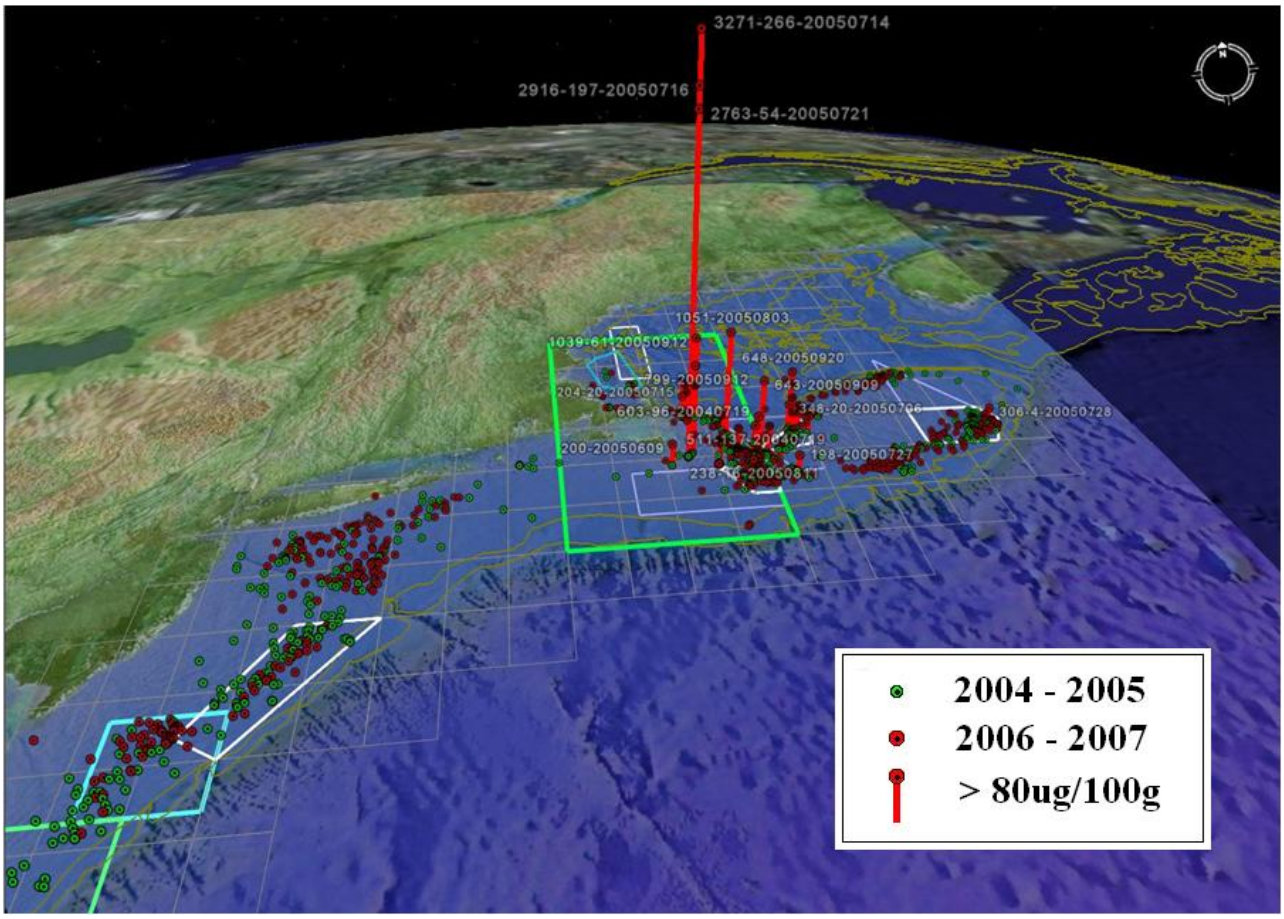


Figure 21. 3 Dimensional plot of sample locations with RBA and MBA results > 80µg/100g tissue clearly indicating that the highest toxicity was found in the Great South Channel area.

6.6 Utility of Jellett Rapid Test

At the first level, the JRT has great utility: this easy to use method can be used to screen shellfish samples as an at-sea or shore based test for PSP toxins by non-certified technicians. The JRT is

straightforward to operate, requiring the test kit (including test strip and matching buffer) and paper filters, plastic bottles, 5% acetic acid (common white vinegar) and 70% isopropyl alcohol (common rubbing alcohol) for the extraction, and a pipette for diluting the shellfish extract with the buffer and loading the test strip. While this procedure can be done at-sea, any potentially toxic tissue samples need to be well separated from any possible contact with food; this may be difficult unless vessels have a separate area designated for lab use. At the second level, results often but not always show this test is too sensitive, i.e. showing positive when actual toxins measured by quantitative methods are well below 50% of the federal standard. While this may be viewed favorably by public health officials as a conservative and useful evaluation that errs in the right direction, industry needs a test that can be both used easily at sea and can consistently and correctly distinguish low toxin levels from high toxin levels.

Preliminary test results from the Jellett Rapid test (Final Report NA05NMF4540010) when compared with quantitative tests indicated high "false positives" (53%) where the test strip indicated toxins were present at > 40µg in scallop roe yet RBA tests indicated toxins at much lower levels in those samples. For tissue collected in 2006 and 2007, JRTL provided custom buffer solutions to reduce "false positives" however the high rate of false positives continued and testing was suspended. Further use of the JRT on scallop tissue compartments in 2007 by the FDA confirmed high rates of "false positives" (16% in roe and 65% in viscera) although custom buffer solutions were not used.

Through ongoing discussions with JRTL we learned that what we were calling "false positives" were truly positive results indicating low levels of toxins; and the JRT is best used as a Yes / No screening test to identify the presence of any toxins. Positive results should be considered preliminary positives and need to be followed up by other quantitative testing such as the MBA. Negatives are truly negative and require no further testing. JRTL clearly says the test was not designed for quantitative use despite the fact that literature shipped with early test kits clearly stated that a positive result meant that the sample tested contained at least 40µg/100g of PSP toxins. Current test kit literature refers only to positive and negative results. Later in 2008 JRTL admitted that the test may have been "oversold" in earlier years by previous management and offered there may be numerous additional approaches to reducing true false positives. JRTL strongly suggested that the test, with special calibration, might be able to accurately screen tissue at specific concentration of toxins.

An improved JRT is critical to future harvest of roe-scallops from within the PSP Closure Areas where landings are only possible through following the Dockside Protocol which names the JRT as the method used for at-sea screening. It is conceivable that the Dockside Protocol may be modified to allow for other testing methods as they are developed. Clearly these newer methods for testing are evolving and each requires refinement through experimentation, application, time and regular revisions to improve. The JRT is evolving and we wish to encourage further evolution.

It is beyond the scope of this project to improve the utility or fully validate this test against other methods; calibration and validation must be done under controlled conditions by certified lab technicians following procedures far more rigorous than those used in this preliminary investigation. Ideally, conversations begun at our 2008 workshop between JRTL and the FDA will provide the opportunity for the calibration necessary to improve the Jellett test in such a way that it can truly show positive for toxins at the specific concentration needed by the Dockside Protocol.

6.7 Dockside Protocol

Coincident to this study industry and regulators have continued to refine a Dockside Protocol to allow for safe harvest of roe-on and whole scallops, surf clams and ocean quahogs from areas closed for PSP (Final Report NA05NMF4540010, Appendix E, and URLs in References).

This ISSC member designed Dockside Protocol is more formally known as the Protocol for Onboard Screening and Dockside Testing for PSP Toxins in Molluscan Shellfish in Federally Closed Waters. The protocol allows trained individuals fishing on vessels operating under special Exempted Fishery Permits to target and land roe-on and whole scallops and/or other whole molluscan shellfish such as the Atlantic Sea Clam and Ocean Quahog provided the shellfish tests negative using the Jellett Rapid Test or other approved methods. Shellfish can only then be sold after statistically significant lot samples are tested for PSP and do not exceed the federal action level of 80µg/100g STX equivalents when further tested by the ISSC approved Mouse BioAssay.

Under the current Protocol revision any single positive JRT result prohibits harvest from within a single 3 square mile box. Since each box requires 5 tests per box, and with a false positive rate from 10% up to 30%, inconsistent test hypersensitivity renders harvest unlikely anywhere that low levels of PSP toxins might be found. For example, where the MBA and RBA found no toxins in the Nantucket Lightship Access Area above federal action levels, 3 JRT roe tests out of the 11 used in that area in 2006 clearly show positive results, what we are calling "false positive". In 2007 the single JRT strip used in that area where we had corroborating data from the RBA, where no toxicity was found by any quantitative methods, was also a "false positive". With these numerous "false positives", it is likely that the whole area would be declared off limits in one if not both years by the Dockside Protocol, yet scallop roe harvested from that area in both years might well meet public safety standards.

6.8 US FDA CFSAN offshore shellfish testing

Also coincident to this study, the US FDA has begun PSP testing on a broad array of shellfish including scallop roe and viscera while aboard the NEFSC annual scallop survey. This expands on the findings of this project and will provide a continuing view of toxicity in scallop roe and viscera and other shellfish in federal waters. Dr. Stacey Etheridge and members of her lab used the JRT and RBA to document shellfish toxicity, with most of the 2007 data from the Albatross in this report coming from Etheridge's lab. This decision to investigate shellfish toxicity at this level is a decidedly good turn of events which will more rigorously explore shellfish toxicity in federal waters and contribute findings to GOMTOX to help tie shellfish toxicity to biological, oceanographic and atmospheric factors. While this is excellent, this work aboard the R/V Albatross and later R/V Sharp only covers a few weeks in July and August. To get a more synoptic view of the presence or absence of toxins from other locations and times of the year, shellfish samples might have to continue to come from industry efforts such as this one.

6.9 RBA Technology Transfer

As an indirect result of this study NOS offered "technology transfer" of an RBA system to project partners to allow for additional tissue testing. Due to the cost and infrastructure necessary to license, house and manage technology depending on radioactive material, this option was put on hold. If the RBA becomes ISSC approved, this technology, in the hands of a state shellfish testing lab, could greatly facilitate the future harvest of roe-on scallops and other whole molluscan shellfish from within areas closed for biotoxins.

7. Conclusions

Broadscale findings of our project include:

1) Commercial harvest of roes in the Mid-Atlantic is safe and could begin immediately. Although limited by management regulations, biotoxins of any type are not a limiting factor west of 71° W longitude. The Mid-Atlantic currently represents approximately 50% of the scallop fishery and the extra weight available to this potential roe-on fishery could expand revenues by 15% or more. All workshop participants agreed that biotoxins were not a problem in this area and this was a reasonable finding.

2) ASP toxicity is not a problem in any part of the scallop fishery as ASP toxins were not found in scallop viscera samples above federal action levels in any areas.

3) In 2004 – 2007 PSP biotoxins were found in scallop roe at differing levels east of 71° W longitude, however they were infrequently found. When found above the federal action levels they appear in relatively small areas.

4) Toxicity findings here are "preliminary" and cannot be considered definitive. As a preliminary investigation, no single area was sampled systematically throughout any entire year. The use of vessels of opportunity did not allow a preplanned more comprehensive sampling strategy. Yet this 40 month study across 4 summer seasons gives clear indication of infrequent roe toxicity > 80μg found in relatively small areas, and the fact that this can be stated for several years following the 2005 red tide lends greater credence to these findings.

5) The Jellett Rapid Test strips generated frequent false positives and few false negatives. The JRT shows significant need for improvement – specifically if the JRT is to be relied upon for at-sea screening within the Dockside Protocol.

6) The RBA method of testing for PSP shows good agreement with the MBA.

7) Roe / Meat Ratio studies indicate roes in the 30 – 50% of meat weight are available in the Mid-Atlantic area in the spring, with higher percentages in the more problematic eastern areas in the late summer.

8) Limited market testing shows positive acceptance for fresh over frozen product.

9) Despite consistent findings of low to no PSP toxins present in scallop roes west of the PSP closure areas, and infrequent but high toxicity found in the PSP closed areas, we conclude that continuing testing is necessary in all areas – both to increase the understanding of shellfish toxicity and to increase scientific and practical methods for testing of both PSP and ASP toxicity

Development of a safe roe-on product

From a public health perspective, product from an area with no history of toxins in scallop gives the highest certainty of safety. Individual results from areas with a mixed history of toxicity, when backed up by shoreside testing seem possible but unlikely in the near future. More importantly, and outside the scope of this project, resource management limitations need to be changed to allow vessels landing roe-on scallops to be able to land the additional weight, or take extra crew or time necessary to land a quality product.

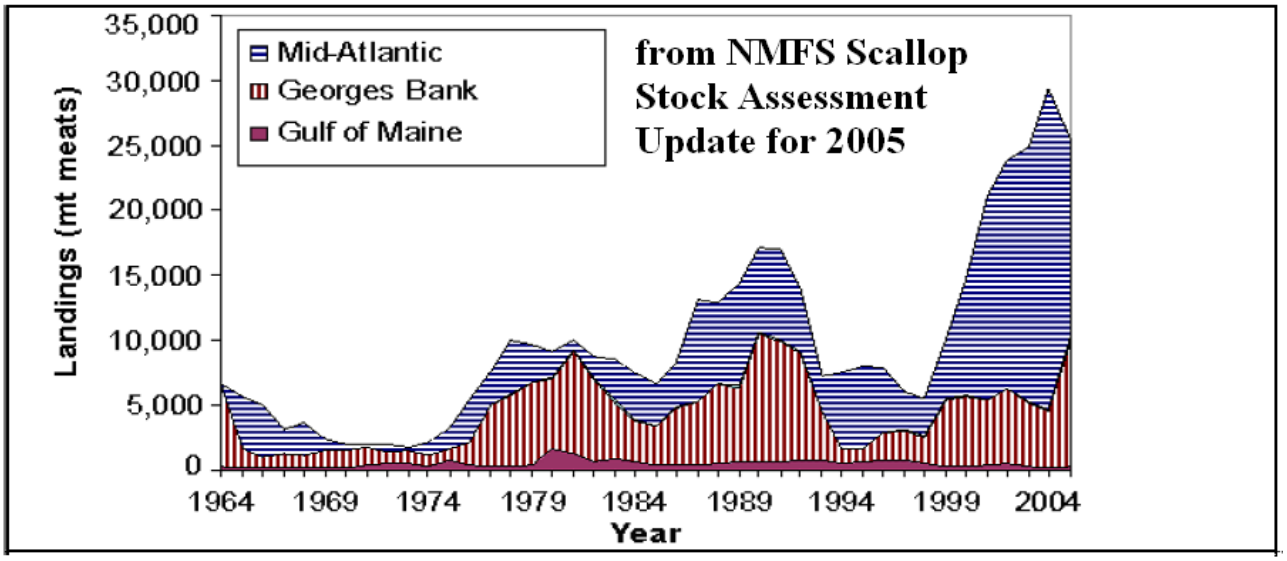


Figure 22. Source: modified from NEFSC Stock Assessment Update Report for 2005 (Hart 2006).

This opportunity is especially evident given the high proportion of scallop biomass in the mid-Atlantic resource areas, recently over 50% of total landings (Framework 18, NEFMC). Additionally there is the favorable spring timing of roe maturation, and a prime market acceptable roe fraction and size relative to the other US sources of this product. Given the scale of the landings from the Mid-Atlantic scallop fishery and the portion of the year where the roe is within the sizes deemed acceptable to the market, Mid-Atlantic production could supply a significant fraction of scallop production as roe-on scallops for US or European markets.

8. Contribution to decision making and management

This project contributed by providing background information useful in two specific areas: public health, and fishery management.

The overarching intent of this work was to explore the opportunities and constraints of having vessels retain whole scallops or portions of the scallop that are currently discarded, primarily the roe. This opportunity was described by examining the scale of the three largest markets for scallop roe, export, local US whole or live, and roe-on products to restaurants. The primary constraint, that of public health concerns with regard to marine biotoxins potentially found in the region, was addressed by the collection and testing of scallop samples by the project partners.

Test results from samples collected early in the initial effort (2004) indicated that the area previously thought adequate for preventative protection, the Georges Bank Shellfish Closure Area, did not fully address the extent of PSP in the scallop resource. The area west of the Georges Bank PSP Closure had been considered free of toxins and was open until the 2005 bloom, and the subsequent PSP Emergency Closure. It was in this area, specifically in a small part of the Nantucket Lightship Groundfish Closed Area, where toxicity > 80μg was found in samples collected in July 2004, well before the 2005 bloom.

Quantitative results from PSP and ASP testing verified that the Mid-Atlantic scallop resource was free of significant public health concerns with regard to marine biotoxins for all years of testing, and that there is currently no reason that scallops in this area, whole or in part, cannot be marketed.

While the New England Fishery Management Council has no direct input into the testing or safety of seafood or seafood products, it does have the ability to modify existing fishery regulations to

expand the economic yield per recruit by adjusting the trip limits for the scallop growout areas to allow the additional poundage of roe for both the Limited Access Closed Area and General Category fleets. This would serve to encourage development of the roe-on fishery. For example, if a vessel is allowed 18,000 pounds of scallop meats, and the roe-to-meat ratio is a determined to be 33%, then the allowance for vessels landing a mixed product could be 24,000 pounds total, 18,000 of scallop meats and 6,000 pounds of roe. The same concept concerning poundage limits that reflect only meat weight would apply to a General Category scallop vessel regarding the existing 400 pound trip landing limit extending their roe-on yield to 533 lbs.

This situation would require no more individual animals, thus no increase in the fishing mortality, number of tows or swept area. Conversion for whole animal landing are more complex with all concerned aware that the current ratio of 50 bushels of shell to 400 pounds of meats is rarely even close to correct. The benefits of more complete utilization are more difficult to realize in the open areas within the current management approach of Days At Sea as participating vessels would likely require additional time or crew to cut out the product, a near certainty at startup.

Beyond public health issues and necessary changes in the current iteration of fishery regulations concerning landings, such a scenario would present other regulatory issues, with the primary concern being enforcement. While this aspect of the problem is critically important, it is beyond the scope of this project to address this specific issue.

Overall the situation emphasizes the need for continued collection of samples by industry, continued testing, continued close collaboration with regulators, and a modification of regulations to encourage new product development.

9. Acknowledgements

This project results from the efforts of many who helped in the years before the RSA funding. Those include Paul Anderson, (Maine SeaGrant), Sherwood Hall (FDA CFSAN), Paul Tierney (MA DPH), Sean Cone (F/V Lady Luck), and Paul Rosonina (F/V Kathy Marie).

This project was an extension of an initial RSA project administered as NOAA Grant number NA05NMF4540010, and was funded by the hard work of the Captains and crews of commercial scallop fishing vessels Kathy Marie, Kayla Rose, Westport, Atlantic, Kathy and Jackie, Christian and Alexa, Guidance, Silver Sea, and Elizabeth and Niki. These men caught the scallops allocated to fund both projects contributing a good portion of the proceeds of sale in order to accomplish the project objectives.

Susan Olsen for her outstanding ability to navigate to workable solutions getting the first project started, and for her patience with us in seeing it through. Catherine Tadema-Wielandt and Pete Christopher of NMFS NERO for timely responses to the many questions and for the rapid turnaround on the funding trip LOAs. Ryan Silva for timely assistance with getting the second project funded. Rich Maney for his assistance and patience in this repeatedly extended process.

Special thanks go to Bergies Seafoods in New Bedford for processing workspace.

Special thanks go to the NMFS scientists and science crews of the NOAA R/V Albatross IV for providing samples from the annual scallop survey cruises during 2004, 2005, 2006 and 2007.

Many samples were contributed by the General Category scallop fleet without compensation, especially important for the inshore areas most affected by the “Red Tide” event in 2005.

Special thanks goes to Captains Lee Jackson, Bruce Gibbs, Joe Smith, Lenny Michaud, Bob Keese and many others out of Gloucester, Chatham, Harwich, Hyannis, Provincetown, and Woods Hole.

The NMFS Regional Office and the Massachusetts Division of Marine Fisheries provided timely support in permitting for the sample collection program, especially Kevin Chu and Brian Hooker from NMFS, and Melanie Griffin from DMF who helped by writing the LOAs to allow sample collection from PSP closure areas.

Considerable unfunded effort in testing samples was provided by the NOS CCEHBR lab in Charleston, S.C., the FDA CFSAN Lab in Silver Spring, Md., and the Massachusetts Division of Marine Fisheries lab in Gloucester, Mass. Particular thanks go to Tod Leighfield and Spencer Fire at CCEHBR, Florence Pettengill, Dave Whittaker, and Mike Hickey at Mass DMF, and Lisa Horn and Maurice Laycock at Jellett Rapid Testing Ltd.

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F/V Kathy Marie owner Arnie DeMello, and Captain Paul Rosonina for bringing in samples for 5 years before this project began.

Over the course of the projects it became clear that each of these participants served an absolutely necessary function within the larger team, and that no combination of fewer partners could have produced these results.

10. Presentations and meetings

3rd International Symposium on GIS/Spatial Analyses in Fisheries and Aquatic Sciences, Shanghai Fisheries University, Shanghai, China, 25-28 August 2005

Geographic Information Systems and Ocean Mapping in Support of Fisheries Research and Management, Massachusetts Institute of Technology, Cambridge, Mass., 10 April 2006

2006 MIT SeaGrant Workshop on Red Tide of 2005 (Poster)

2006 Workshop on improving Dockside Protocol (participation)

2007 WOMR Radio Interview about Roe-On Scallops

2007 GomTox, Portland, Maine (presentation)

2007 CLASH (Cape Land and Sea Harvest Presentation, Cape Cod Community College)(presentation and roe-on preparation and tasting)

2007 Harmful Algal Bloom Conference (poster and roe-on tasting)

2008 Pectnid Workshop, Halifax, N.S. (poster)

2008 GomTox, Portland Maine (presentation)

2008 National Shellfisheries Association, Providence, RI (presentation)

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Internet Resources

WHOI Northeast PSP website
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http://www.nero.noaa.gov/sfd/clams/

Federal Registry Notice: Application for Exempted Fishery Permit
http://edocket.access.gpo.gov/2006/pdf/E6-19190.pdf

11. Appendices

A. List of Workshop Attendees

Don Anderson	**Woods Hole Oceanographic Institution**
Bill Bomster	**Stonington Seafoods, Stonington CT**
Sean Bowen	**Mass Department of Agricultural Resources**
John Brawley	**Saquish Scientific LLC**
Monica Bricelj	**Institute of Marine and Coastal Sciences**
Mike Celona	**Mass Department of Public Health**
Susan Congdon	**Mass Department of Public Health**
Darcie Couture	**Biotoxin Monitoring, State of Maine**
Geoffrey Day	**RSA Project Coordinator**
Candace Dolan	**Phytoplankton Coordinator, Mass DMF**
Martin Dowgert	**Northeast Region Shellfish Specialist**
Stacey Etheridge	**Center for Food Safety and Applied Nutrition, USFDA**
Bob Fisher	**SeaGrant / Virginia Institue of Marine Science**
Michael Hickey	**Mass Division of Marine Fisheries**
Eric Hickey	**Mass Department of Public Health**
Karen Hines	**RSA Project Technician**
Michael Hopper	**TransOceanic Seafoods**
Jeff Kennedy	**Mass Division of Marine Fisheries**
Judy Kleindenst	**Woods Hole Oceanographic Institution**
Maurice Laycock	**Jellett Rapid Testing Ltd**
Alan Lewitus	**Center for Sponsored Coastal Ocean Research**
Florence Lowell	**Naked Oyster Restaurant, Owner**
Julianne Nassif	**Division of Analytical Chemistry,** MA DPH
Pricilla Neves	**Mass Food Protection Program, MA DPH**
Patricia Perry	**NOAA Seafood Inspection**
Florence Pettengill	**Mass Division of Marine Fisheries**
Mark Poli	**Medical Research Institute of Infectious Diseases**
Meri Ratzel	**Phytoplankton Monitoring Volunteer**
Richard Taylor	**RSA Project Coordinator**
Dave Whittaker	**Mass Division of Marine Fisheries**
Gary Wolf	**Central Region Shellfish Specialist, USFDA**
Vanessa Yandell	**Mass Department of Public Health**