2014 Interstate Shellfish Sanitation Conference
Techniques and Practices for Vibrio Reduction Proposal
State of Connecticut Department of Agriculture Bureau of Aquaculture

1. Executive Summary

During the summers of 2012 and 2013, *V. parahaemolyticus* infections of a strain previously traced only to the Pacific Northwest were associated with consumption of oysters and other shellfish from several Atlantic Coast harvest areas[i]. These outbreaks were caused by elevated levels of the naturally occurring bacteria *Vibrio parahaemolyticus* in shellfish. This marine bacterium occurs naturally in brackish and salt-water environments, and may be found in higher concentrations from April through October when coastal waters are warm. Consumers may be exposed to these pathogenic, or disease-causing, bacteria by eating raw or undercooked shellfish, including oysters, clams, lobster, and crab.

Connecticut growing waters were the source of at least 23 confirmed cases of *Vibrio parahaemolyticus* during the summer of 2013, with another additional 15 cases potentially linked to Connecticut waters.

Environmental monitoring for *Vibrio parahaemolyticus* bacteria in Connecticut shellfish has been limited in previous years by federal and state laboratory and resource constraints. In 2013, the Connecticut Department of Agriculture Bureau of Aquaculture (DA/BA) acquired qPCR technology (Life Technologies 7500 Fast Real Time PCR System) which will allow the DA/BA in their role as the State Shellfish Authority to conduct environmental monitoring for total Vp, tdh+ and trh+ indicators at a statewide scale.

In order to gain a better understanding of *Vibrio parahaemolyticus* levels and their relevance to implementing meaningful Vibrio controls in Connecticut growing waters, the 2014 DA/BA monitoring plan includes the collection of environmental parameters such as water temperature, air temperature, salinity and depth that may correlate to levels of Vibrio bacteria in shellfish. In addition, post-harvest time and temperature controls currently in place as required by the Connecticut 2014 *Vibrio parahaemolyticus* Control Plans will be evaluated by using continuous temperature data loggers (ACR Smart Button) to determine the effectiveness of post-harvest temperature controls and correlate these controls to quantifiable impacts on Vibrio levels.

Real time Vibrio monitoring and continuous environmental observations will be used to inform our understanding of the temporal variability and spatial distribution of Vp in LIS growing areas. This data may provide an early warning system and allow the DA/BA to proactively manage risk of illness by limiting harvest from specific locations or requiring more stringent controls under certain environmental conditions.

In addition, with the assistance of collaborating research partners at the University of Connecticut's Department of Marine Sciences, this proposed ISSC project will analyze previously collected and ongoing observations to establish how Vp levels vary with LIS environmental conditions. The existing FDA model, "Quantitative Risk Assessment on the Public Health Impact of Pathogenic *Vibrio parahaemolyticus* in Raw Oysters" (4) will be used to tailor the pre-harvest component of the model to the LIS using the analyzed observations and apply it for retrospective analysis and forecasts.

As requested by the ISSC RFP, this study will evaluate the effectiveness of a variety of post-harvest practices that could potentially reduce the risk of Vibrio illnesses. One of the major components of this work will be the field evaluation of control options for the shellfish industry that would reduce risk of Vibrio illnesses. Proactive pre-harvest controls, such as identification of lower risk harvest areas, limiting harvest under specific environmental conditions, or applying specific controls under certain environmental controls will also be evaluated in terms of the effectiveness of the actions on limiting Vibrio growth.

This research team has the ability to initiate data gathering by August 2014 as the DA/BA has been actively involved in data collection and Vibrio monitoring since June of 2014.

This work will complement research being proposed by Co-PIs Whitney (UCONN), Ward (UCONN), and DeRosia-Banick (DA/BA) for Connecticut Sea Grant RFP for the 2014-2016 funding cycle *Modeling Vibrio parahaemolyticus Outbreaks in*

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Commercial Shellfish Areas in Western Long Island Sound: Research Linking Local Environmental Factors and Uptake by Oyster.

The chief project **objectives** are to:

- Evaluate post-harvest time and temperature controls currently in place as required by the Connecticut 2014 *Vibrio parahaemolyticus* Control Plans using continuous temperature data loggers (ACR Smart Button) to determine the effectiveness of post-harvest temperature controls and quantify how these controls impact Vibrio levels
- Collect and analyze Vibrio bacteria levels (total Vp, tdh+ and trh+) from growing areas throughout Long Island Sound, with a focus on the Norwalk/Westport outbreak areas
- Collect and analyze environmental data including water temperatures, air temperatures, salinity, depth in order to apply FDA Vibrio Risk Assessment model to Connecticut environmental data and Vibrio monitoring data
- Work with stakeholders, managers, and scientists at the state, regional, and national level to:
  1) translate this research into viable harvest and control options for the shellfish industry that would reduce risk of Vibrio illnesses;
  2) to assess regional and environmental differences that may better define the combination(s) of post-harvest time and temperature controls that will be most effective for a given region or state and;
  3) ensure that the results of these research efforts will be fully considered by the membership of the ISSC.

2. Approach and Methodology

The research will test the following **hypotheses**:

- Shellfish in deeper offshore growing areas have consistently lower Vp levels than nearshore areas due to lower near-bottom temperatures. These are less like to require Vp-related closures.
- Post-harvest controls, such as rapid cooling of oysters to 50°F within 1 hour of harvest, will reduce the proliferation of Vibrio bacteria and associated risk of illness associated with Connecticut oysters
- A linear regression model (following FDA methods) linking the logarithm of Vp counts in shellfish to water temperature and salinity values supplied by a hydrodynamic model will show statistically significant agreement with observations in LIS growing areas.

The project will combine observations, models, and laboratory experiments to answer the research question for the 2014-2015 period and inform *Vp* management efforts.

The specific tasks for the observational and laboratory efforts are described in the Methodological Approach section.

Field Observations:

Long Island Sound Environmental Data:

Beginning in June of 2014, DA/BA deployed 16 HOBO Water Temp Pro v2 temperature data loggers at near-bottom depth (Onset Corp) and six DST conductivity, temperature, and depth (CTD) data loggers have been deployed at near-surface and near-bottom depth at 3 locations in Westport and Milford (Star-Oddi) (Figure 1). Vantage Pro 2 remote weather stations (Davis) have been purchased and will be deployed in Norwalk and in Milford to collect meteorological conditions, including rainfall and air temperature as close to the growing area as possible.

Additional environmental data to be collected via the ISSC funding will include near-surface temperature data at locations where near-bottom temperatures are being collected (16 additional Hobo Water Temp Pro v2), conductivity/temperature loggers for additional continuous salinity measurements (6 Hobo Temperature and Conductivity Data Loggers), and GPS located temperature, salinity and depth profiles at the time of oyster

sample collection (YSI CastAway). See attached budget for equipment being requested in support of this proposal.

Station locations have been identified to provide spatial coverage throughout Connecticut growing waters that are actively in use for oyster cultivation. A higher intensity of data collection is focused on the waters of Norwalk and Westport, where the majority of oysters associated with the 2013 *Vibrio parahaemolyticus* outbreak were harvested.

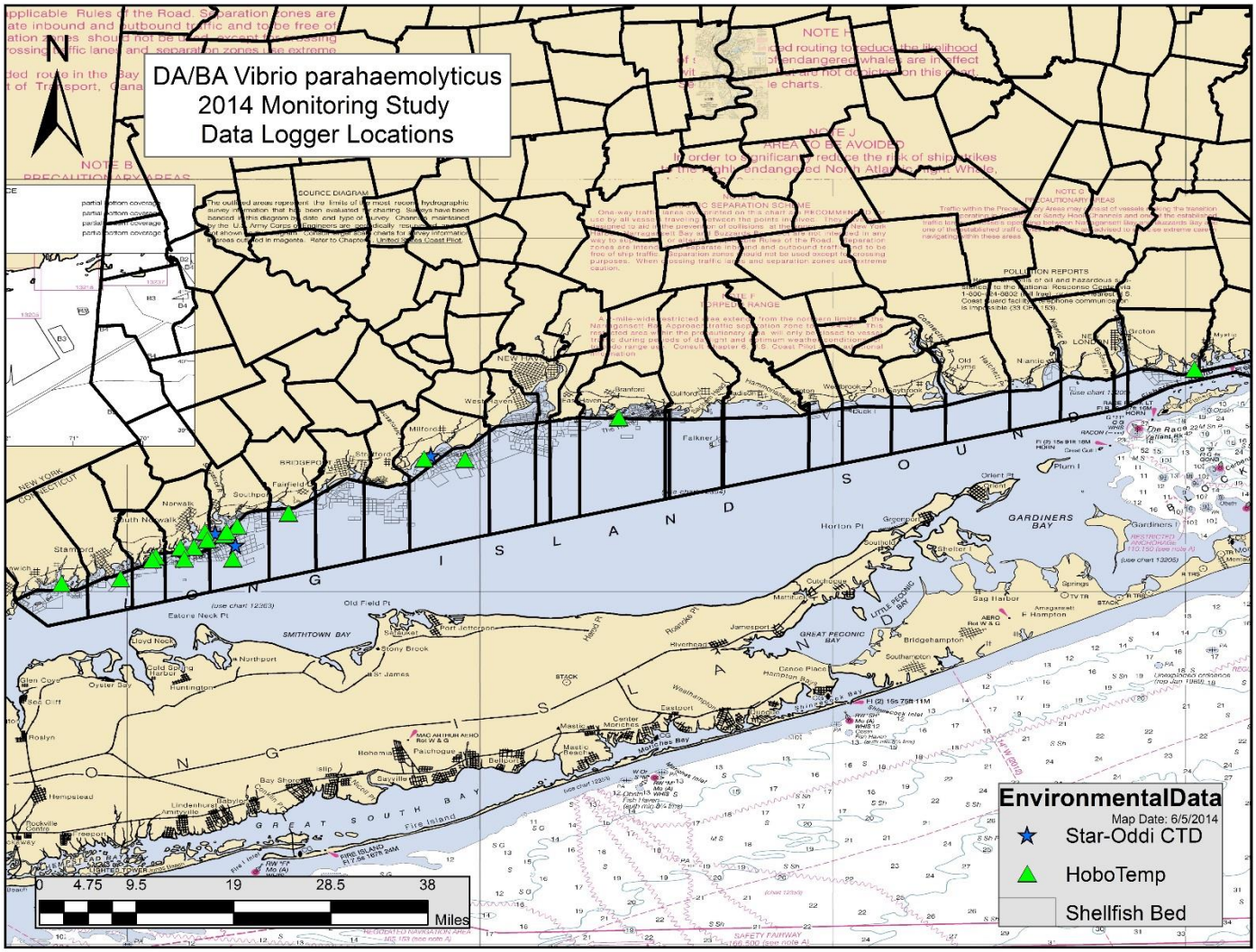

Figure 1. 2014 Vibrio parahemolyticus environmental data monitoring locations.

In addition, SmartButton (ACR Systems) continuous temperature data loggers are being deployed to collect data and evaluate the effectiveness of post-harvest controls on shellfish temperatures and Vibrio levels.

Funding to purchase an additional 25 SmartButton loggers is being requested via this ISSC proposal to support expanded data collection to evaluate post-harvest controls.

***Vibrio parahaemolyticus* Monitoring Data:**

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From June 15 to October 31, 2014, and June 1 through October 31, 2015, 16 shellstock samples will be collected on a bi-weekly basis by DA/BA staff and analyzed using a for total Vp, tdh+, and trh+ levels (Figure 2. 2014 Vibrio parahaemolyticus sample collection locations. Samples will be analyzed for Total Vibrio parahaemolyticus, tdh+, and trh+ levels.). More intensive sampling will be focused on the Westport/Norwalk inner island waters that were associated with the 2013 outbreak, as well as the offshore waters in these towns.

Shellfish samples will be analyzed for total *Vibrio* parahaemoloyticus using MPN-real-time PCR (MPN-Rti-PCR) as previously described by Jones et al (5). A second multiplex Rti-PCR method targeting the *tdh* and *trh* genes, with an internal amplification control (IAC) will be used for identification of pathogenic *V. parahaemolyticus as described by* Jones and Lüdeke (6).

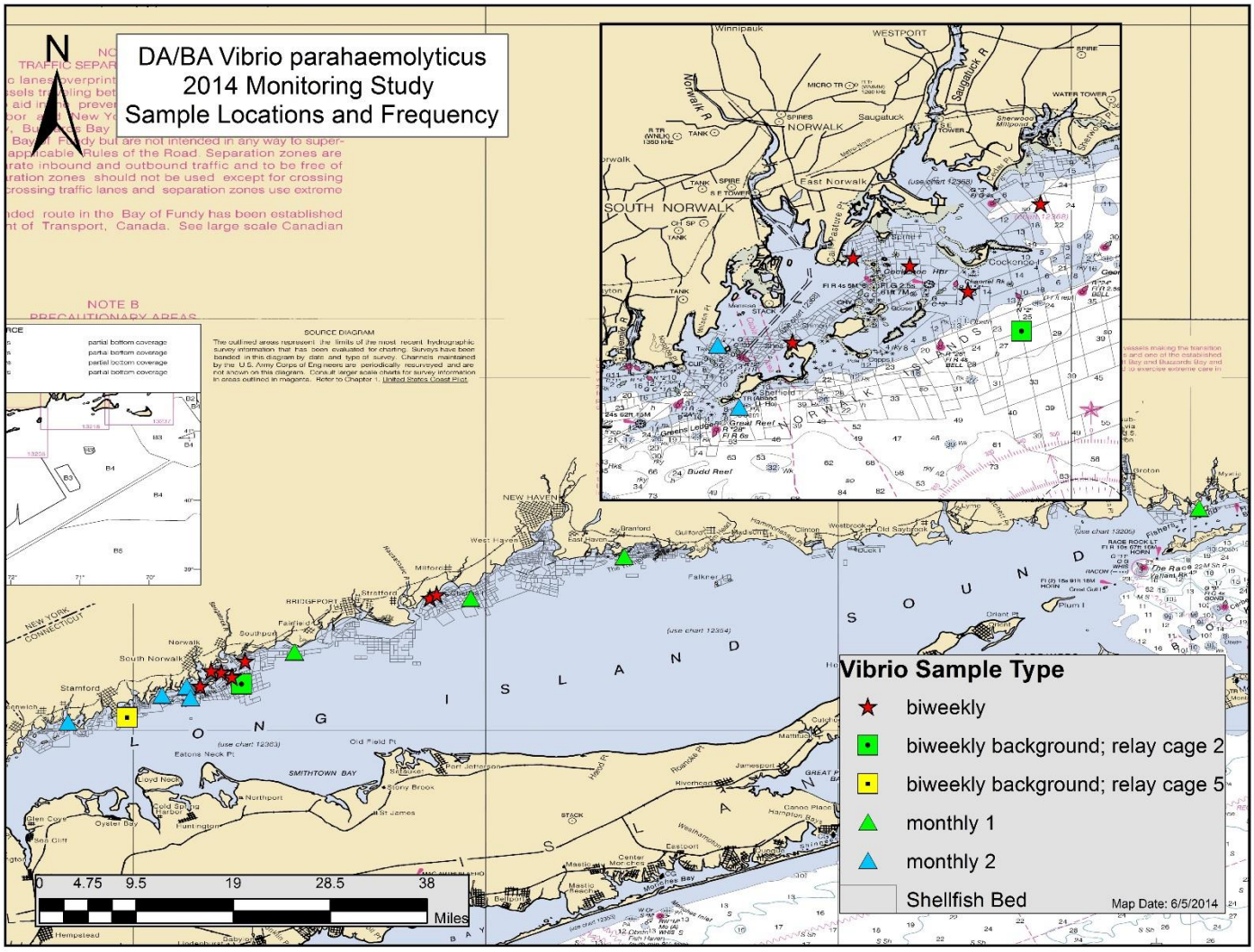

Figure 2. 2014 Vibrio parahaemolyticus sample collection locations. Samples will be analyzed for Total Vibrio parahaemolyticus, tdh+, and trh+ levels.

On a rotating basis, 2 of the 16 samples biweekly will be dedicated to investigating the impacts of the various post-harvest temperature controls on Vibrio levels. Connecticut will have several different Vibrio control plans in place during 2014; the general CT VPCP which allows 5 hours from harvest to refrigeration and 5 hours to an internal temperature of 50°F, as well as rapid cooling to internal temperature of 50°F using either ice or mechanical refrigeration. As this research is implemented during 2014 and 2015, a number of different Vp controls may be in effect depending on how the season progresses, and this portion of the study will be conducted in order to gain the most

useful information in terms of how successful these various controls are in terms of limiting the proliferation of Vibrio bacteria.

Modeling:
Vp modeling follows the approach described in Appendix 5 of the FDA Risk & Safety Assessment (ref???) (**Administration**, 2005) relating the base-10 logarithm of Vp count per gram sample tissue (Vpcount) to water temperature in Celsius (T) and salinity in psu (S) and an error term (ε):

$$log_{10}(Vpcount) = \alpha + \beta T + \gamma_1 S + \gamma_2 S^2 + \varepsilon$$

The coefficients in the preceding equation (α, β, γ_1, γ_2) and the standard deviation (σ) of the random normal error from the fit are estimated using a Tobit regression model. Table YYY includes regression coefficients and errors based on three studies including in the FDA Risk & Safety Assessment.

Table 1. Regression coefficients and error standard deviation for Vp model equation

Study	α	β	γ_1	γ_2	σ
DePaola et al, 1990	-2.63	0.12	0.18	-0.0042	1.00
FDA/ISSC, 2001	-2.05	0.10	0.20	-0.0055	0.73
Washington DOH, 2000, 2001	-1.02	0.30	-0.39	0.0084	0.87

Even though the salinity coefficient is larger than the temperature coefficient, the FDA operational Vp model currently excludes the salinity dependence. For the proposed project the salinity dependence will be included because the data are available and freshwater plumes entering western LIS (e.g Housatonic and Norwalk) create salinity variations in time and space.

3. Project Deliverables

Key Project Deliverables include:

- Informing improved regional understanding of how environmental factors such as water temperature, air temperature, depth, and salinity correlate to total Vp, tdh+, and trh+ levels and making these results available to regional and national partners via a webinar presentation sharing the Connecticut findings;
- Determining the impact of post-harvest time and temperature controls on the proliferation of total and pathogenic Vp and using this data to identify controls that are most effective for Connecticut and the Northeast Region and making these results available to regional and national partners via a webinar presentation sharing the Connecticut findings;
- Translating this research into viable harvest and control options for the shellfish industry that would reduce risk of Vibrio illnesses and sharing this information with industry via a webinar or in-person presentation.

4. Project Management Approach

Project results will be translated into state, regional and national management tools through cooperation with the Connecticut Department of Agriculture Bureau of Aquaculture, National Oceanic and Atmospheric Administration, US Food and Drug Administration, Interstate Shellfish Sanitation Conference, and State Shellfish Authorities and shellfish industry members in the Northeast Region. This task will be conducted with the target audience of state shellfish authorities, FDA regional shellfish specialists, environmental managers and scientists via conference calls and meetings discussing research plans and results throughout the project on a quarterly basis.

An initial conference call occurred during 2014 and guided this proposal development as well as the Connecticut Sea Grant proposal.

Environmental and vibrio data collected and generated by DeRosia-Banick and DeCrescenzo will be shared with collaborating researchers via email updates of data in Excel spreadsheet form along with GIS shapefiles or latitiude and longitude correlating to data collection locations to facilitate modeling.

Conference calls between collaborative partners FDA, and the appropriate committees of the ISSC will be scheduled on a quarterly basis in order update interested parties on research progress. Deliverables generated may be disseminated amongst managers and stakeholders prior to the end of project as deemed appropriate by the group.

5. Detailed and Itemized Pricing

Total Match CT Department of Agriculture Commitment: $32,560

Analyst Hourly Rate (includes benefits):
Salary: $45.00/hour
Time match: 272 hours* $45/hour = $ 12,240 over the 2 year period
Boat Captain Hourly Rate (includes benefits):
Salary: $55.00/hour
Time match: 192 hours* $55/hour = $10,560 over the 2 year period
Microbiologist Hourly Rate (includes benefits):
Salary: $45.00/hour
Time match: 80 hours* $45/hour = $3600 over the 2 year period
Boat Fuel: 7 gal/hr * $5/gal = $35/hour fuel
176 hours * $35 per hour = $6160

Funding Requested:

Item	Supplier	Item #	Quantity	Unit Price	Total Price
PCR Freezer Paks	Fisher Scientific	5115-0032	2	152.02	304.04
Mini-Centrifuge	Fisher Scientific	S67601B	1	276.25	276.25
Dry Block Heater	Fisher Scientific	07-201-839	1	689.85	689.85
Pipet tips 0.1-10	Fisher Scientific	02-707-439	1 pack	41.66	41.66
Pipet tips 2-10	Fisher Scientific	02-707-432	1 pack	41.66	41.66
Pipet tips 20-200	Fisher Scientific	02-707-430	1 pack	41.66	41.66
Tube racks 1.5ml	Fisher Scientific	14-810-31	4 cases	98.67	394.68
Tube racks 2.0ml	Fisher Scientific	05-541	1 cases	119.92	119.92
Rnase away	Fisher Scientific	14-375-35	1	71.84	71.84
2 ml Tubes	Fisher Scientific	02-682-558	1 pack	43.68	43.68
Block well 24 (1.5ml)	Fisher Scientific	07-201-842	2	84.50	169.00
Block well 24 (2ml)	Fisher Scientific	07-201-840	2	84.71	169.42
Pipet tips 100-1000	Fisher Scientific	02-707-404	1	41.66	41.66
Micro tubes black	Fisher Scientific	03-391-161	1	32.09	32.09
Micro tubes 1.5ml	Fisher Scientific	05-408-131	4	24.16	96.64

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Item	Supplier	Item #	Quantity	Unit Price	Total Price
Hobo Temperature and Conductivity Data Logger	Onset	U24-002-C	6	750.00	4,500.00
HOBO Water Temperature Pro v2 Data Logger	Onset	U22-001	20	129.00	2,580.00
SmartButton (25-Pack)	ACR Systems	01-0185	2	1,245.00	2,490.00
CastAway CTD-YSI	Interactive Oceanographics	400000	1	5,515.00	5,515.00
ultra-pure	life tech	500 ml	1	29.00	29.00
ROX Dye	life tech	500ul	1	41.60	41.60
platinum DNA Polymerse	life tech	120 reactions	2	99.00	198.00
HAC	IDT	100 Nm	1	315.00	315.00
TL-1043	IDT	250 NM	1	420.00	420.00
TL-884F	IDT	100 NM	1	13.75	13.75
TL-1091R	IDT	100NM	1	11.55	11.55
TRH 20 F	IDT	100 NM	1	12.65	12.65
iac-186r	IDT	100NM	1	10.45	10.45
trh292r	IDT	100 nm	1	12.65	12.65
tdh 89f	IDT	100 nm	1	9.35	9.35
tdh 321r	IDT	100 nm	1	13.20	13.20
iac46f	IDT	100nm	1	10.45	10.45
PCR Nuc Mix	Roche		1	328.00	328.00
VP-IAC	BioGX		1	500.00	500.00
Custom TAQMAN	Life Tech	vic	1	153.00	153.00
Custom TAQMAN	Life Tech	Fam	1	153.00	153.00
platinum Tac	Life Tech	600 reactiuons	1	459.00	459.00
T Buffer	Fisher	4 liters	1	244.38	244.38
Micro 8 tube strip	Life Tech	1000 tubes	2	102.00	204.00
adhesive film	Life Tech	100 covers	2	219.00	438.00
96 well plate	Life Tech	20 plates	2	134.00	268.00
8 cap strips	Life Tech	300 strips	2	106.00	212.00
				Total Funding Requested	21,676.08

6. Appendix: References

1. Scallan E, Hoekstra RM, Angulo FJ, et al. Foodborne illness acquired in the United States—major pathogens. Emerg Infect Dis 2011;17:7–15.
2. Martinez-Urtaza J, Baker-Austin C, Jones JL, Newton AE, Gonzalez-Aviles GD, DePaola A. Spread of Pacific Northwest *Vibrio parahaemolyticus* strain. N Engl J Med 2013;369:1573–4.
3. CDC. Increase in *Vibrio parahaemolyticus* illnesses associated with consumption of shellfish from several Atlantic coast harvest areas, United States, 2013. Atlanta, GA: US Department of Health and Human Services, CDC; 2013. Available at http://www.cdc.gov/vibrio/investigations/index.html
4. USFDA. Quantitative Risk Assessment on the Public Health Impact of Pathogenic Vibrio parahaemolyticus in Raw Oysters, Unites States, 2005.
5. Jones, J. L., Y. Hara-Kudo, J. A. Krantz, R. A. Benner, Jr., A. B. Smith, T. R. Dambaugh, J. C. Bowers, and A. DePaola. 2012. Comparison of molecular detection methods for *Vibrio parahaemolyticus* and *Vibrio vulnificus*. Food Microbiol. 30:105-111.

6. Jones, J. L. and Lüdeke, C. H. M. 2012. Improved Detection of Pathogenic *Vibrio parahaemolyticus* from Oyster, Water, and Sediment Using Real-Time PCR. Final Program 112th Gen. Meet. Am. Soc. Microbiol. American Society for Microbiology, Washington, DC.

7. Appendix: Project Team Staffing

Kristin DeRosia-Banick (Co-PI) Environmental Analyst II Connecticut Department of Agriculture Bureau of Aquaculture	190 Rogers Avenue Milford, CT 06460 Kristin.DeRosia-Banick@ct.gov 203-874-0696 ext 112
Joseph DeCrescenzo (Co-PI) Microbiologist II Connecticut Department of Agriculture Bureau of Aquaculture	190 Rogers Avenue Milford, CT 06460 Joseph.DeCrescenzo@ct.gov 203-874-0696 ext 112
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Evan Ward (collaborating researcher) Professor Department of Marine Sciences University of Connecticut	1080 Shennecossett Road Groton, CT Evan.Ward@uconn.edu 860-405-9073

See attached Curriculum vitae for investigators and collaborators on this proposal.

8. Appendix: Company Overview

9. Appendix: Background

ISSC Proposal 13-204

Proposal 13-204 was recommended for adoption by the 2013 Task Force II. FDA concurred with Conference action on Proposal 13-204 with the following comments and recommendations.

- FDA urges the ISSC to consider that the evidence most needed for determining the public health benefit of various control strategies would be to compare Vibrio levels at harvest to levels achieved with currently implemented time to temperature control measures and levels achieved using various other control strategies, including immediate cooling.
- To expand further, a more comprehensive approach could examine changes in Vibrio levels as half shell product moves from harvest through processing and distribution.
- These data could inform allocation of regulatory resources to achieve the greatest public health benefit.

Efforts outlined above are intended to help improve existing Vibrio controls, identify additional approaches for reducing risk and improve the effectiveness of the National Shellfish Sanitation Program (NSSP).

ISSC has been allocated $75,000 by the FDA and is seeking to fund multiple studies to identify and evaluate the effectiveness of techniques and practices that could potentially reduce the risk of Vibrio illnesses. The purpose of the RFP is to invite qualified entities to propose studies that could offer viable control options for the shellfish industry that would reduce risk of Vibrio illnesses.

***Vibrio parahaemolyticus* Illnesses in Connecticut**

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(excerpted from FDA's FY 2013 *Vibrio* Risk Management Plan Implementation Program Element Evaluation Report (PEER) for Connecticut)

1. In 2013, Connecticut experienced their first *V.p.* outbreak. That outbreak was associated with oysters harvested from Westport and Norwalk and resulted in a recall of those species harvested from specific lots between July 3 and August 2, 2013. The recall also included clams on a precautionary basis because some of the 2013 illnesses involved both clam and oyster consumption. Thus a mandatory *V.p.* Control Plan for Connecticut will be required to be implemented through the 2018 season unless another *V.p.* outbreak pushes the cut-off date further into the future. No *Vibrio vulnificus* illnesses have been documented as a result of individuals consuming shellstock from the waters of Connecticut.

2. There were no *Vibrio* illness outbreaks associated with CT shellfish in FY12. The DA/BA has investigated or participated in investigations in seven single illness cases of *V.p.* and one single illness case of *Vibrio fluvialis* in FY12 (Table 2). Three *V.p.* illnesses were linked to the Oyster Bay, NY outbreak. Three *V.p.* cases implicated CT oysters; one case was epidemiologically confirmed to be associated with CT oysters. The *V.f.* illness had a multi-state shellstock exposure.

3. As illustrated in Table 2, the number of cases attributed to *Vibrio* has remained steady 2009-2012. The number of cases epidemiologically linked to CT shellstock remained steady through 2012 when mandatory *V.p.* controls were instituted for oysters in late July and voluntary controls were instituted for clams. However, in 2013 the number of *V.p.* cases numbers jumped significantly.

Table 2. *Vibrio* Illness Investigations in Connecticut 2009 through 2012

Year	Number of Cases	Source States
2009	7 (5 involving CT)	1 MA (clams August) 1 CT or RI (oysters August) 1 CT or NY (clams August) 1 Unknown (oysters September) 3 definitely CT (1 oysters, 1 clams, 1 unknown)
2010	5 (3 involving CT)	1 ME, MD or VA (mussels or oyster August) 1 CT, ME, or WA (oysters August) 1 NY, WA, ME, MA (oysters) 2 definitely CT (1 clams July, 1 clams June)
2011	6 (5 involving CT)	1 CT, PE, NY (clams and oysters August) 1 Unknown (clams August) 3 definitely CT (1 *V.f.* oysters July, 1 *V.f.* and *V.p.* oysters August, 1 clams September) 1 CT or WA
2012	7 (4 involving CT)	1 definitely CT (oysters June) 1 NY or CT (oysters June) 1 MA (oysters May) 1 case NY (clams July) 1 case NY or CT (oysters late May/early June) 1 (CT, NY, ME, MA, PE) *V.f.* confirmed (clams and oysters July) 1 case RI (clams August)

Table 3. Connecticut *Vibrio* Illness Investigations 2013

Traceback Code	Traceback Investigation Conclusion	Number of Cases
1	CT Confirmed to Outbreak/Closure Area	11
2	CT Confirmed (Outbreak/Closure plus other CT)	8
3	CT Confirmed (single source outside of outbreak area)	2
4	Out-of-State Confirmed	7
5	CT Outbreak Plus Out-of-State (with PFGE Match)	4
6	CT Plus Out-of-State (Unconfirmed/NO PFGE Match)	6
7	Unconfirmed case, CT Product	2
8	Recreational Case	3
0	Traceback Pending	0
9	CT Confirmed Multiple Possible Sources Outside Outbreak Area	2
	Total CT Confirmed Cases (Traceback Code 1, 2, 3, 9)	**23**
	CT Outbreak Area (Traceback Code 1 & 2)	**19**
	Total Vp Related	45

4. In general, the CT Department of Public Health (DPH) receives an average of 20 – 25 reports of *Vibrio* infections annually. These reports typically increase in mid-summer and cases are most often related to shellfish consumption or recreational water exposure. When cases are reported to the DPH, the Department of Public Health, Epidemiology and Emerging Infections Program (EEIP) works closely with local health departments (LHDs) to conduct case investigations, utilizing the Cholera and other Vibrio Illness Surveillance Report (COVIS) form issued by the Centers for Disease Control and Prevention (CDC). When seafood consumption is reported by the case, the EEIP notifies the Department of Public Health, Food Protection Program (FPP) for further seafood investigation, as warranted. The FPP will need to follow up with the DA/BA, if warranted. Because Connecticut is a FoodNet site, the EEIP is expected to forward the COVIS report to the CDC within 30 days of the specimen collection date for the case. Therefore, when feasible the DA/BA makes every attempt to complete page 4 of the COVIS form within this 30-day period so it can be included with the initial COVIS form submission to CDC. When this is not feasible, the DA/BA will forward an updated COVIS report to the FPP and/or EEIP for submission to CDC once available.

5. The occurrence of continuing sporadic *Vibrio* illnesses compounded by the 2013 *V.p.* outbreak affects Connecticut's *Vibrio* Management Plan. The occurrence of an outbreak on the New York shore of Long Island Sound, and a single epidemiologically confirmed illness associated with Connecticut oysters, precipitated the precautionary closure of growing area waters, and the implementation of the first mandatory *Vibrio* controls at the harvester/dealer level for oysters in 2012. Additionally, the DA/BA began conducting routine testing of oysters and clams for total and pathogenic *V.p.* levels, instituted voluntary controls at the harvester/dealer level for clams, and increased harvester/dealer education efforts. The *Vibrio* MOAs between the CT DA/BA and oyster harvester/dealers were modified to reflect actual aquaculture operations. In many instances, the modified MOAs were more restrictive than the mandatory 5 hours from harvest to refrigeration requirement established by the DA/BA. The DA/BA collaborated with the harvester/dealers operations on a case-by-case basis and made recommendations that reflected best practices for the individual operation.

Connecticut's 2014 *Vibrio parahaemolyticus* Control Plan (VPCP)

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In response to the 2013 illness outbreak of *Vibrio parahaemolyticus* illnesses related to Connecticut shellfish harvested from the waters of Norwalk, Westport, and Darien, the DA/BA recommended several different options for mandatory VPCP to be implemented at the harvester/dealer level during the 2014 season. Because all illnesses during the 2013 season were associated with these waters, and other harvest areas in Connecticut were not implicated, a more stringent control plan was required for the waters of Norwalk, Westport and Darien. The VPCP for these waters requires rapid cooling of oysters on-board the harvest vessel to an internal tissue temperature of 50°F within 1 hour of harvest. The 2014 Connecticut VPCP for growing areas outside of the outbreak area requires 5 hours from harvest to refrigeration, and 5 hours to achieve an internal temperature of 50°F.

The DA/BA held an industry meeting on December 13th, 2013 to educate harvesters on the 2013 outbreak and to present the results of the 2014 Vibrio Risk Assessment and the 2014 VPCP requirements. The following recommendations were made in a January 15th, 2014 letter to the industry which were mailed to all shellfish harvesters licensed in Connecticut along with copies of the two 2014 Vibrio parahaemolyticus Control Plans.

1. The Department is strongly recommending that ***all Connecticut oyster producers*** use an on-board ice slurry method of rapid cooling during the 2014 VPCP control plan months (June 1 through August 31). This method has been proven by FDA to effectively limit the post-harvest growth of Vibrio bacteria, and is our best chance of reducing the risk of illness associated with oysters produced in Connecticut.
2. The Department is **requiring that all oysters harvested from ALL WATERS of Darien, Norwalk, and Westport** be rapidly cooled using an on-board ice slurry method capable of cooling oysters to an internal temperature of 50°F within 1 hour of harvest or time of first exposure. This requirement has been implemented due to the large number of illnesses associated with oysters produced in Darien, Norwalk and Westport. Several illnesses were associated with oysters produced outside of the closure area, and hence this requirement is for all waters in Darien, Norwalk and Westport, rather than limited to the 2013 closure area.

DA/BA followed this letter up with calls to each individual oyster harvest working in the Norwalk, Westport, and Darien growing areas reminding them that they should make an appointment with DA/BA to present their plans for a rapid cooling process, if they planned on harvesting oysters from these waters. The DA/BA collaborated with the harvester/dealers operations on a case-by-case basis and made recommendations that reflected best practices for the individual operation in terms of the rapid cooling process implemented by each of the companies and that were appropriate for the volume and practices of each company. DA/BA expanded rapid cooling approvals to allow direct ice and mechanical refrigeration in addition to ice slurry, if the process was found to be capable of achieving internal temperatures of 50°F within 1 hour of harvest.

During 2014, a number of different rapid cooling processes were approved by the DA/BA in order to reduce oyster temperatures to an internal temperature of 50°F within 1 hour of harvest:

1) Ice slurry processes using large insulated totes into which dredge loads of loose oysters could be placed for large-scale harvest operations
2) Ice slurry processes using large insulated totes into which sorted and bags oysters are placed for cooling and then transferred onto ice for holding
3) Direct ice system into which loose rough sorted oysters are placed for transport back to land-based refrigerated facility for final sorting and bagging
4) On-board mechanical refrigeration into which oysters are placed in totes for rapid cooling and holding for transport back to land-based refrigerated facility for final sorting and bagging.

In addition, in growing areas not required to rapidly cool oysters, the general Connecticut VPCP was also in place which requires harvesters to place oysters under temperature control within 5 hours of harvest, and to reduce internal temperatures to 50°F with 5 hours of harvest.

BIOGRAPHICAL SKETCH

J. Evan Ward
University of Connecticut

Professional Preparation:

Memorial University of Newfoundland, Ocean Sciences Center, Canada	Invertebrate Physiology	Post-Doc, 1990-1992
University of Delaware, Delaware	Marine Biology/Biochem.	Ph.D., Dec., 1989
University of Delaware, Delaware	Marine Biology/Biochem.	M.S., June, 1985
Stockton State College, New Jersey	Marine Science/Biology	B.S., June, 1981

Appointments:

Professor, University of Connecticut, Department of Marine Sciences, Groton, CT, 2009 - present

Visiting Scholar, University of Exeter, Department of Biosciences, Exeter, UK, August 2011 - January 2012.

Associate Professor, University of Connecticut, Department of Marine Sciences, Groton, CT, 2003 - 2009 (promoted)

Visiting Professor, University of Panama, Department of Marine Science and Limnology, Republic of Panama, July 2004 - January 2005

Assistant Professor, University of Connecticut, Department of Marine Sciences, Groton, CT, 1997 - 2003 (promoted & awarded tenure)

Assistant Professor, Salisbury State University, Department of Biological Sciences, Environmental Marine Studies Program, Salisbury, MD, 1994 - 1997

Adjunct Research Associate, University of New Brunswick, Department of Biology, Saint John, New Brunswick, Canada, 1992 - 1994

Five Products Relevant to Proposal:

* Pierce , M.L., **J.E. Ward** & F.C. Dobbs, 2014. False positives in Biolog EcoPlates™ and MT2 MicroPlates™ caused by calcium. *J. Microbiolog. Meth.* 97: 20–24.

Allam, B., W.E. Carden, **J.E. Ward**, G. Ralph, S. Winnicki & E. Pales Espinosa, 2013. Early host pathogen interactions in marine bivalves: Evidence that the alveolate parasite *Perkinsus marinus* infects through the oyster mantle during rejection of pseudofeces. J. Invert. Path. 113: 26-34.

* Lyons, M. M., **J. E. Ward**, H. Gaff, R. Hicks, J. Drake & F.C. Dobbs, 2010. Theory of island biogeography on a microscopic scale: Are organic aggregates islands for aquatic pathogens? Aquatic Microbial Ecology, 60: 1–13.

* Lyons, M.M., Y.T. Lau, W.E. Carden, **J.E. Ward**, S.B. Roberts, R.S. Smolowitz, J. Vallino & B. Allam, 2007. Characteristics of marine aggregates in shallow-water ecosystems: Implications for disease ecology. EcoHealth. 4: 406-420.

* Lyons, M.M., **J.E. Ward**, R. Smolowitz, K.R. Uhlinger & R.J. Gast, 2005. Lethal marine snow: Pathogen of bivalve mollusc concealed in marine aggregates. Limnol. & Oceanogr. 50: 1983-1988.

* - students trained in the Ward lab & funded by external grants

Five Other Products:

Shumway, S.E., **J.E. Ward**, E. Heupel, B.A. Holohan, J. Heupel, T. Heupel & D.K. Padilla, 2014. Observations of feeding in the common Atlantic slippersnail *Crepidula fornicata* L., with special reference to the "mucus net." J. Shellfish Res. 33: 1–13.

Wall, C.C., C.J. Gobler, B.J. Peterson & **J.E. Ward**, 2013. Contrasting growth patterns of suspension feeding molluscs (*Mercenaria mercenaria, Crassostrea virginica, Argopecten irradians, Crepidula fornicata*) across a eutrophication gradient in the Peconic Estuary, NY, USA. Estuaries & Coasts . 36: 1274-1291.

* Rosa, M., **J.E. Ward**, S.E. Shumway, G.H. Wikfors, E. Pales Espinosa & B. Allam, 2013. Effects of particle surface properties on feeding selectivity in the eastern oyster *Crassostrea virginica* and the blue mussel *Mytilus edulis*. J. Exp. Mar. Biol. Ecol. 446: 320-327.

Cranford, P.J., **J.E. Ward** & S. Shumway, 2011. Bivalve filter feeding: variability and limits of the aquaculture biofilter. In: S.E. Shumway (ed.), Shellfish Aquaculture and the Environment, John Wiley & Sons Publ., 81-124.

* Kach, D. & **J.E. Ward**, 2008. The role of marine aggregates in the ingestion of picoplankton-size particles by suspension-feeding molluscs. Mar. Biol. 153: 797-805.

* - students trained in the Ward lab & funded by external grants

Five Synergistic Activities and Achievements:

- Elected member of the Connecticut Academy of Science and Engineering, 2013 to present
- Elected co-Chair of the 2014 Gordon Research Conference on Oceans and Human Health, 2012-2014
- Awarded Fulbright Foreign Scholarship, CIES, International studies and research: **1**) University of Exeter, Exeter, United Kingdom, 2011; and **2**) University of Panama, Republic of Panama, 2004
- Director / Lead PI, Interdisciplinary Research & training Initiative on Coastal ecosystems & Human Health (I-RICH), Graduate Training Consortium, NOAA, Oceans and Human Health Initiative, 2008-2013 (completed)
- Awarded NSF, Faculty Early Career Development Grant (CAREER), 1999-2004

Recent Collaborators:

Bassem Allam, Stony Brook Univ.; Ivar Babb, NURTEC, Univ. of Connecticut; Monica Bricelj, Rutgers Univ.; Celia Chen, Dartmouth Coll.; Peter Cranford, Fisheries and Oceans Canada; Hans Dam, Univ. of Connecticut; Lewis Deaton, Univ. of Louisiana; Sylvain DeGuise, Univ. of Connecticut; Fred Dobbs, Old Dominion Univ.; John Drake, Univ. of Georgia; Emanuelle Pales Espinosa, Stony Brook Univ.; Salvatore Frasca, Univ. of Connecticut; Holly Gaff, Old Dominion Univ.; Tamara Galloway, Univ. of Exeter, UK; Randall Hicks, Univ. of Minnesota Duluth; Brian Huey, Univ. of Connecticut; Brian Jackson, Dartmouth Coll.; Milton Levin, Univ. of Connecticut; Bruce MacDonald, Univ. of New Brunswick, St. John, NB, Canada; Robert Mason, Univ. of Conn.; Dianna Padilla, Stony Brook Univ., Stony Brook, NY; Tracy Romano, Mystic Aquarium & Institute for Exploration; Sandra Shumway, Univ. of Connecticut; Charles Wall, Stony Brook Univ.; Gary Wikfors, National Marine Fisheries Service, Milford, CT

Graduate/Post-graduate Advisors:

Melbourne Carriker, Deceased, University of Delaware (MS advisor)
Nancy Targett, University of Delaware (PhD advisor)
Bruce MacDonald, University of New Brunswick, Saint John, Canada (Post-doc advisor)
Ray Thompson, Memorial University, St John's, Canada (Post-doc advisor)

Advisees in Last Five Years: (total graduate students = 11, total post-docs = 2)

Students

Dustin Kach (MS - graduated), University of Connecticut, Groton, CT
Maille Lyons (PhD - graduated), University of Connecticut, Groton, CT
Dana Frank (MS, PhD - graduated), University of Connecticut, Groton, CT
John Doyle (PhD - graduated), University of Connecticut, Groton, CT
Maria Rosa (MS - graduated, PhD), University of Connecticut, Groton, CT
Melissa Pierce (PhD), University of Connecticut, Groton, CT
Vena Haynes (PhD), University of Connecticut, Groton, CT

Post-docs

Maille Lyons (completed), University of Connecticut, Groton, CT & ODU, Norfolk, VA

KRISTIN DEROSIA-BANICK

CONNECTICUT DEPARTMENT OF AGRICULTURE
BUREAU OF AQUACULTURE
190 ROGERS AVE.
MILFORD, CT 06460

EMAIL: KRISTIN.DBANICK@SNET.NET
OFFICE: 203-874-0696 EXT 112
CELL: 203-231-8662

Environmental Analyst with over ten years of experience in environmental program implementation, shellfish resource management, environmental health and food protection, and geographic information systems

Education:

CONNECTICUT COLLEGE, 09/1989 through 05/1991

Major: Liberal Arts, 60 credits completed

SOUTHERN CONNECTICUT STATE UNIVERSITY**,** May 2003, B.S. in Biology

Major: B.S. in Biology, Concentration in Marine Biology

Honors: Graduated *magna cum laude;* Dean's List, Alumni Association Scholarship

UNIVERSITY OF NEW HAVEN, 11/2004 through 5/2006

M.S. in Environmental Health and Environmental Ecology, 19 credit hours completed

Professional Experience:

CONNECTICUT DEPARTMENT OF AGRICULTURE, BUREAU OF AQUACULTURE

Environmental Analyst III *June 2013 - present*

Shellfish Sanitation Program: Acting lead analyst for illness investigations and shellfish recalls; Lead analyst for Connecticut's *Vibrio parahaemolyticus* Control Plan and statewide Vibrio monitoring program; Investigate and make recommendations during illness outbreaks and recalls in order to protect public health and minimize additional illnesses; Design environmental quality studies or comprehensive shoreline assessments; research and evaluate aquaculture programs for hazards and define new policy; serve as department representative on state, regional and national advisory boards, in legislative hearings, on state councils and Interstate Shellfish Sanitation Conference (ISSC) committees; Design environmental quality studies or comprehensive shoreline assessments which involve conducting a site investigation of each property on the shoreline of the town being studied, conducting and evaluating hydrographic studies, pollution source sampling, assessing water pollution control authority (WPCA) treatment quality, and growing area water quality monitoring; Develop GIS data, provide technical assistance, technical analysis and program data to bureau staff and Director, local and state agencies, state legislature, and federal programs; Write and review legislation and assess and formulate policy for existing and emerging industries;

Environmental Analyst II *December 2006 – June 2013*

Design and conduct shoreline survey pollution source assessments as required by National Shellfish Sanitation Program (NSSP); develop new programs and regulations to implement environmental policy regarding shellfish and aquaculture; prepare informational materials regarding shellfish program policy for state and federal agencies and stakeholders; develop GIS data and provide technical analysis to staff, state and federal agencies; lead analyst for illness investigations; research and evaluate aquaculture programs for hazards and define new policy; serve as department representative on advisory boards, legislative hearings, state councils, environmental committees, etc.

Environmental Analyst I *April 2004 - December 2006*

Conduct site investigation of shoreline properties which included conducting and evaluating hydrographic studies, pollution source sampling, assessing Water Pollution Control Authority (WPCA) treatment quality, and growing area

water quality monitoring; analyze sanitary survey and water quality monitoring data to classify growing areas according to federal standards; statistical analysis of data and preparation of comprehensive assessments for each growing area; evaluate applications for shellfishing activities and inspection of shellfish operations for compliance with NSSP guidelines for sanitation, records and HACCP.

YALE UNIVERSITY, MOLECULAR BIOPHYSICS AND BIOCHEMISTRY

Research Assistant *August 2003 – April 2004-*

Utilize molecular and biochemical techniques in support of RNA structural research in academic setting; responsible for radiation and chemical safety inspections of laboratory.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, WEST NILE VIRUS SURVEILLANCE PROGRAM

Research Assistant *May 2003 – August 2003*

Enumerate and identify mosquitoes to species level for virus surveillance and public health protection; establish and maintain colonies; set traps and collect mosquitoes in field.

CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION, BUREAU OF WATER MANAGEMENT

Research Assistant *May 2002 – November 2002*

Collect water, sediment, benthic invertebrate, and plankton samples from Long Island Sound and tributaries; prepare and analyze samples and deliver to laboratory; prepare charts and graphs for analysis of environmental data

Recent Publications and Presentations

February 2014: Northeast Shellfish Sanitation Association Presentation
Overview of Connecticut's 2013 *Vibrio parahaemolyticus* Season

February 2014: Milford Aquaculture Seminar/NESSA Joint Session on Vibrio Presentation
Regional Overview of the 2013 *Vibrio Parahaemolyticus* Season
Panel Discussion Member

February 2014: Connecticut Shellfish Initiative Presentation
Clean Waters, Safe Shellfish, Christopher Sullivan and Kristin DeRosia-Banick

Spring/Summer 2014: Wracklines Volume 14, Number 1.
Clean Waters, Safe Shellfish, Christopher Sullivan and Kristin DeRosia-Banick

December 2013: Industry Meeting: 2014 *Vibrio parahaemolyticus* Control Plan for CT

January 2013: Connecticut Sea Grant, Municipal Shellfish Gathering
Vibrio Bacteria Guidance for Recreational Shellfishing Programs Presentation

December 2012: Seaweed Regulatory Workgroup Presentation
Seaweed Cultivation in Long Island Sound: An Analysis of Species and Process Specific Hazards

September 2012: 50th Annual Yankee Conference on Environmental Health Presentation
Conducting *Vibrio* Illness Investigations

DeRosia-Banick, K. 2012. Naturally-occurring bacteria threat in the Sound. Long Island Sound Study Sound Update Fall 2012.

DeRosia-Banick, K. 2012. State Responds to the Threat of Naturally Occurring Bacteria in Long Island Sound. The Dredge Volume 5(1): Fall 2012.

March 2012: Connecticut Department of Agriculture Bureau of Aquaculture Shellstock Shipper Owner/Operator Training Seminar
Presentation on Changes to Federal Regulatory Guidance for Shellfish Handling

Certificates/Training:

NOAA Remote Sensing for Spatial Analysts 07/18/2008
Introduction to ArcGIS II 03/28/2008
Shellfish Growing Areas (FD242) 05/10/2007
State of CT Department of Public Health Phase I Subsurface Sewage Disposal 03/2006
State of CT Department of Public Health Food Inspector Certification 02/2006
State of CT Department of Public Health Procedures to Investigate Food borne Illness 2005
Seafood HACCP Regulator Training Program (FD249) 05/04/2005
Basic Shellfish Plant Sanitation (FD 140) 01/13/2005
FDA Training Curriculum for State, Local, and Tribal Regulators ***(****Shellfish Curriculum)* 2004-2005
Interstate Shellfish Sanitation Conference Certificate of Hazard Analysis and Critical Control Point (HACCP) Course Completion 10/21/2004
AFDO Seafood Education Alliance Seafood HACCP Training Course 10/12/2004

Committees and Advisory Boards:

Interstate Shellfish Sanitation Conference, Vibrio Research Committee
Interstate Shellfish Sanitation Conference, Recall Guidance Committee
Connecticut Sea Grant Extension Advisory Board
Connecticut Geospatial Information Council
Connecticut Coastal Health Officials
Sasco Brook Pollution Abatement Committee

Department Of Agriculture, Bureau Of Aquaculture
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Phone (203) 874-0696 ext.125
E-mail joseph.decrescenzo@ct.gov

Joseph August DeCrescenzo

Objective

To learn and grow as a Microbiologist in the shellfish and Dairy community.

Professional experience

2002-Present State of Connecticut Milford, Connecticut

Microbiologist 2

- Perform Bacteriological analyses of seawater, sewage effluent, and shellfish, Prepare media reagents for bacteriological examination, Maintain records, Perform qPCR for total and pathogenic *Vibrio parahaemolyticus* in oyster meats, Perform histopathological examination on shellfish, Prepare reports, Laboratory Evaluation Officer for both Dairy and Shellfish labs in Connecticut, Evaluate 12 dairy Laboratories and 2 Shellfish Laboratories in Connecticut, Supervise a Microbiologist 1.

1999-2001 State of Connecticut Milford, Connecticu

Microbiologist 1

- Perform Bacteriological analyses of seawater, sewage effluent, and seafood, Process shellfish for histopathological examination, Perform histopathological examination, Prepare media reagents for bacteriological examination, Use a bioassay for the detection of Paralytic Shellfish Poisoning, Maintain equipment and laboratory.

1998 State of Connecticut Milford, Connecticut

Internship

- Performed independent research project utilizing histopathogical techniques. Upon completion of project, reported and published data gathered at annual conference.

Patents and publications

* THE PRESENCE OF VIBRIO PARAMAEMOLYTICUS IN CRASSOSTREA AT SPECIFIC LOCATIONS ALONG THE CONNECTICUT AND LONG ISLAND SHORE – FDA SURVEY FOR JUNE 1999 TO JUNE 2000. Leonora Porter and Eugene Zamojcin, State of New York, Department of Enviromental Conservation, 205 North Belle Mead Rd., East Setaucket, NY 11733; Joseph DeCrescenzo, Inke Sunila, and John Karolus, State of Connecticut, Department of Agriculture, Bureau of Aquaculture, P.O. Box 97, Milford, CT 06460

* PRINCIPAL DISEASE OF CONNECTICUT'S OYSTERS. Inke Sunila, Josep DeCrescenzo, John Karolus, and John Volk. State of Connecticut, Department of Agriculture, Bureau of Aquaculture, P.O. Box 97, Milford, Connecticut 06460

* HISTOPATHOGICAL SURVEY OF THE QUAHOG, *MERCENARIA MERCENARIA,* ALONG THE CONNECTICUT COASTLINE. Joseph DeCrescenzo, Inke Sunila, John Karolus, and John Volk. State of Connecticut, Department of Agriculture, Bureau of Aquaculture, P.O. Box 97, Milford, Connecticut 06460

Education

1994-1999 **Unity College** **Unity, Maine**

Bachelor Degree in Science, Emphasis in Biology

2004-2006 **Southern Connecticut University** **New Haven, CT**

9 credits in Graduate level Microbiology Courses

References

References given upon request

MICHAEL M. WHITNEY **CURRICULUM VITAE** **MICHAEL.WHITNEY@UCONN.EDU**

EDUCATION

University of Delaware, College of Marine Studies *Fall 1998*
- Ph.D. 2003, Physical Ocean Science & Engineering (GPA: 4.00) *to Spring 2003*
- Advisor: Dr. Richard Garvine, Harrington Professor of Marine Studies

Yale University *Fall 1992*
- B.S. 1996, *cum laude* (GPA: 3.72) *to Spring 1996*
- Majors: Geology and Geophysics (Atmosphere and Ocean Track), Environmental Studies

EMPLOYMENT

University of Connecticut, Department of Marine Sciences *Summer 2005*
- Associate Professor (promoted in 2012) *to Present*

Yale University, Geology and Geophysics, Department *Fall 2012*
- Visiting Fellow (while on sabbatical from University of Connecticut)

Oregon State University, College of Oceanic and Atmospheric Sciences *Fall 2003*
- Postdoctoral research associate for Dr. J. S. Allen *to Summer 2005*

University of Delaware, College of Marine Studies *Summer 2003*
- Postdoctoral researcher for Dr. Richard Garvine *to Fall 2003*

University of Delaware, College of Marine Studies *Fall 1998*
- Research Assistant and Graduate Fellow *to Spring 2003*

Ocean Surveys, Inc., Old Saybrook, CT *Summer 1996*
- Project scientist in the oceanography department *to Fall 1998*

CURRENT FUNDING

- M. M. Whitney, CAREER: The Influence of Distributed River Inputs and Coastal Embayments on Dynamics of Large Estuaries, National Science Foundation, 6/1/2010-5/31/2015.
- M. M. Whitney (Uconn PI), D. Codiga (URI PI), D. Ullman (URI Co-PI), Collaborative Research: Investigating Tidal Influences on Subtidal Estuary-Coast Exchange Using Observations and Numerical Simulations, National Science Foundation, 9/1/2008-8/31/2013.
- M. M. Whitney (Uconn PI), F. Bryan (NCAR PI), J. Dennis (NCAR Co-PI), P. MacCready (UW PI), Collaborative Project: Improving the representation of coastal and estuarine processes in earth system models, Department of Energy, 9/1/2011-8/31/2014.
- M. M. Whitney and J. Edson, Sea Breezes and Estuary-Shelf Response in Areas with Spatial Sea Surface Temperature Variability and Complex Coastal Geometry, National Aeronautics and Space Administration, 1/1/2013-12/31/2015.
- M. M. Whitney and P. Vlahos, Measuring and Predicting the Fate and Transport of Perfluorinated Contaminants Entering the Long Island Sound from Municipal Wastewater in the Housatonic Watershed, Connecticut Sea Grant, 2/1/2012-1/31/2015.

TEACHING AND ADVISING

- MARN 170 & MARN 171 (now MARN 1002 & 1003) Introduction to Oceanography (Fall 2005-2010)
- MARN 172 (now MARN 1004) Introduction to Oceanography Laboratory (Fall 2005-2010)
- MARN 270 (now MARN 4060) Descriptive Physical Oceanography (Spring 2007-2011, Fall 2012-2014)
- MARN 410 Coastal Ocean Circulation (Spring 2006, Fall 2007)
- MARN 5898 Special Topics: River Influences in the Marine Environment (Spring 2012-2013)
- Major advisor for 3 PhD students and 2 Masters students
- Associate advisor for 3 PhD students and 4 Masters students
- Undergraduate advisor for Marine Sciences and Environmental Sciences students

PEER-REVIEWED PUBLICATIONS

- **Whitney, M. M**., D. L. Codiga, D. S. Ullman, P. M. McManus and R. Jiorle. Tidal Cycles in Stratification and Shear and Their Relationship to Gradient Richardson Number and Eddy Viscosity Variations in Estuaries. *J. Phys. Oceanogr.*, 42, 1124-1133.
- O'Donnell, J., R. Wilson, K. Lwiza, **M. M. Whitney**, W. F. Bohlen, D. L. Codiga, T. Fake, M. Bowman, J. Varekamp. 2013. *Physical oceanography of Long Island Sound*. Elsevier, in press.
- **Whitney, M. M**. and D. L. Codiga. 2011. Response of a large stratified estuary to wind events: Observations, theory, and simulations of Long Island Sound. *J. Phys. Oceanogr.*, 41, 1308-1327.
- Xia, M., L. Xie, L. J. Pietrafesa, and **M. M. Whitney**. 2011. The response of a Gulf estuary plume to wind forcing: its connection with salt flux and a Lagrangian view. *J. Geophys. Res.*, doi: 10.1029/2010JC006689.
- **Whitney, M. M**. 2010. A study on the variability of river discharge and salinity in the Middle Atlantic Bight and Long Island Sound. *Cont. Shelf Res.*, 30, 305-318.
- **Whitney, M. M.** and J. S. Allen. 2009. Coastal wind-driven circulation in the vicinity of a bank: Part 1. Modeling flow over idealized banks. *J. Phys. Oceanogr.*, 1273-1297.
- **Whitney, M. M.** and J. S. Allen. 2009. Coastal wind-driven circulation in the vicinity of a bank: Part 2. Modeling flow over the Heceta Bank complex. *J. Phys. Oceanogr.*, 1298-1316.
- Rice, A. E., **M. M. Whitney**, R. W. Garvine, and P. Huq. 2008. Energetics in Delaware Bay: Comparison of two box models with observations. *J. Mar. Res.*, 66, 873-898.
- **Whitney, M. M**. and R. W. Garvine. 2008. Estimating tidal current amplitudes outside estuaries and characterizing the zone of estuarine tidal influence. *Cont. Shelf Res.*, 28, 280-290.
- Garvine, R. W. and **M. M. Whitney**. 2006. An estuarine box model of freshwater delivery to the coastal ocean for use in climate models. *J. Mar. Res*., 64, 173-194.
- Wetz, M. S., B. Hales, P. A. Wheeler, Z. Chase, and **M. M. Whitney**. 2006. Riverine input of macronutrients, iron, and organic matter to the coastal ocean off Oregon, USA, during the winter. *Limnol. Oceanogr.*, 51, 2221-2231.
- **Whitney, M. M.** and R. W. Garvine. 2006. Simulating the Delaware buoyant outflow: Comparisons to observations. *J. Phys. Oceanogr.*, 36, 3-21.
- Tilburg, T. E., J. T. Reager, and **M. M. Whitney**. 2005. The physics of blue crab larval recruitment in Delaware Bay: A model study. *J. Mar. Res.*, 63, 471-495.
- **Whitney, M. M.** and R. W. Garvine. 2005. Wind influence on a coastal buoyant outflow. *J. Geophys. Res.*, 110, doi:10.1029/2003jc002261.
- **Whitney, M. M.** 2003. Simulating the Delaware Coastal Current. University of Delaware dissertation.

SCIENTIFIC OUTREACH AND PROFESSIONAL SERVICE

- Presenter for over 40 scientific oral and poster presentations at colleges and regional and international conferences
- Contributor to many science outreach workshops including the Groton Maritime Academy, Northeast Academy Math and Science Day, and "Y.E.S. I Can" (Youth Endeavoring to Succeed)
- Convener of 2012 Middle Atlantic Bight Physical Oceanography and Meteorology Workshop
- Co-convener of special sessions at 2010, 2012, 2014 AGU Ocean Sciences Meetings
- Reviewer for the National Science Foundation, Sea Grant, Journal of Physical Oceanography, Journal of Marine Research, Journal of Marine Systems, and Estuaries and Coasts
- Member of American Geophysical Union, Coastal and Estuarine Research Federation, and Thames River Basin Commission

AWARDS

- National Science Foundation CAREER Award (2010)
- College of Marine Studies Frances Severence Award for best thesis in Physical Ocean Science & Engineering (2004)
- College of Marine Studies E. Sam Fitz Award for academic excellence (2003)
- University of Delaware Competitive Fellowship (2000, 2001, 2002)
- American Meteorological Society/NOAA Scholarship (1998)
- Yale University Pat Wilde Prize for excellence in marine geology and oceanography (1996)
- American Meteorological Society Howard H. Hanks Scholarship (1995)