Final Report

Bioblitz 2016: Re-assessing marine invasions in Valdez, Prince William Sound, Alaska

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Submitted by

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Abstract

Biological invasions by non-indigenous species (NIS) are a major force of change in coastal marine ecosystems around the world. Relatively few NIS are known from Alaska's waters to date, compared to other regions, but many NIS occur below Alaska and have been spreading northward. While invasions are a significant and growing concern for Alaska, detection of newly arriving NIS is especially challenging for the region, due to the extensive shoreline and limited resources available.

Several methods show great promise to enhance detection capability for particular "target" taxa with modest cost. First, citizen or public participation in NIS detection can be highly effective, when the target species is relatively large, conspicuous, and easily recognized (from other species). Second, genetic tools offer the opportunity to screen for multiple known target species simultaneously, without detailed morphological analyses.

The purpose of this project was to help advance citizen science and genetic methods to detect target NIS in Prince William Sound (PWS), building on a significant body of previous work by Prince William Sound Regional Citizens' Advisory Council (RCAC) and the Smithsonian Environmental Research Center (SERC) along with various partners. Specifically, we conducted (1) a bioblitz and training event for detection of target NIS by citizen scientists in Valdez and (2) training for RCAC staff to collect zooplankton samples for detection of target NIS using genetic tools. We detected one NIS (previously known for the PWS) during this event and initiated zooplankton sampling for genetic analyses. We recommend both citizen science and genetic tools as key components, and part of a broader strategy, for long-term NIS monitoring and detection in PWS.

Introduction

Biological invasions result from the human-aided transfer and introduction of species to new territories, allowing them to establish self-sustaining populations and spread. While many different transfer mechanisms (vectors) contribute to invasions, vessels are a dominant vector in coastal marine habitats, due to the unintentional transfers of organisms associated with ballast water and underwater surfaces such as hulls, rudders, and seachests (Ruiz et al. 2000, 2015). Thus, marine invasions are part of the "ecological footprint" of shipping, affecting the composition, structure, and function of marine communities.

Over 300 marine non-indigenous species (NIS) have become established along the west coast of North America, resulting in a latitudinal gradient with an increase in NIS richness (number) from California to Alaska (Ruiz et al. 2011; NEMESIS 2016). To date, relatively few NIS are known to be established in coastal waters of Alaska, but the number has been increasing in recent years as NIS along the west coast continue to spread northward as a result of human activities (e.g., Ashton et al. 2008, Cohen et al. 2011). Moreover, changes in transportation and climate may serve to enhance invasion opportunities (deRivera et al. 2011; Ruiz and Hewitt 2009, Miller & Ruiz 2014). The potential for new invasions, and associated ecological and economic impacts, is of growing concern for Alaska (Ricciardi et al. 2017; ARIAS 2017).

To help reduce risk of new invasions, the Prince William Sound Regional Citizens' Advisory Council (RCAC) has been engaged in marine invasion science and management since 1996, focusing particular attention on shipping-related invasions in Prince William Sound (PWS). The Smithsonian Environmental Research Center (SERC) has been a long-time partner in marine invasion monitoring in Valdez with RCAC and throughout Alaska. Working with RCAC and other partners, SERC has conducted several studies on ballast water delivery, ballast water management, invasion patterns, monitoring and detection approaches, and control and eradication of NIS in Alaska.

This past research provides a solid baseline for NIS present in Alaska, but one of the challenges is how to efficiently implement sustained monitoring and detection of new NIS arrivals, across the large shoreline of PWS and Alaska. Standardized community surveys, repeated over time, represent the gold standard for detection and identification of diverse taxa, including especially temporal changes in rate and pattern of invasion (Ruiz and Hewitt 2002). While there is no substitution for this approach, in terms of data quality and resolution, this could require a large effort to conduct annual comprehensive surveys, exceeding available resources. Yet, early detection and monitoring are critical to identify potential invasion risks but also for effective management actions, such as eradication and control of NIS soon after colonization, to minimize unwanted invasion impacts.

One approach to meet this challenge is to employ multiple methods at different frequencies. Standardized community surveys could be conducted at a multi-year frequency (2-5 year intervals) to provide high-quality and comprehensive data to evaluate long-term trends and detect previously unknown NIS. This can be combined with more frequent (annual) and streamlined methods to detect particular "target" taxa, including selected NIS that are both well-known and predicted as possible invaders. These target taxa may serve as indicators or early-warning systems for a broader phenomenon, which is tested or verified with the comprehensive community surveys.

Several methods show great promise to enhance detection capability for particular "target" taxa with modest cost. First, citizen or public participation in NIS detection can be highly effective, when the target species is relatively large, conspicuous, and easily recognized (from other species). Second, genetic tools offer the opportunity to screen for multiple known target species simultaneously, without detailed morphological analyses.

The overall goal of this project was to help advance citizen science and genetic methods to detect target NIS in PWS, building on previous work to increase detection and monitoring capacity. Our specific objectives were to (1) conduct a bioblitz and training event for detection of target NIS by citizen scientists in Valdez and (2) train for RCAC staff to collect zooplankton samples for detection of target NIS using genetic tools. We also comment on possible next steps in advancing the monitoring and detection program in PWS and Alaska.

Approach & Methods

Overview

We conducted a bioblitz and training event in PWS over a 2-day period, from 9-10 September 2016. The 2 days of activities included (a) hands on training in monitoring procedures and detection of a target list of NIS, which are present on the west coast but not known to occur in PWS, and are relatively large and easy to identify (b) an overview of biological invasions in coastal marine systems, and (c) a bioblitz field activity and rapid survey to detect non-native marine species. Laboratory activities were in collaboration with the Prince William Sound College in Valdez.

In addition, we provided training to RCAC staff to initiate a plankton monitoring program in Prince William Sound to detect non-native marine plankton species. This included providing basic sampling materials, protocols and data sheets for plankton collections for molecular analyses to screen for non-native species; the molecular analyses will be part of a separate contract or scope of work.

Collections, Training, & Bioblitz Activities

The bioblitz utilized several different sampling techniques, including diver collection, plankton and rapid assessment surveys, as well as fouling community and crab trap surveys (Table 1; see below for further description). Collections were made at a variety of locations associated with vessel traffic, as possible points of entry for NIS, including the Valdez small boat marina, the ferry docks in Valdez and Tatitlek, the Valdez Container Terminal, and Alyeska Terminal. Collections were examined in the field and also returned to the laboratory for further analyses.

Table 1. Bioblitz activities. Shown are the number of samples collected and examined by location and sampling method.

Location	Rapid Assessment Survey	Plankton Tows	Fouling Community Plates	Crab Traps	Dive Surveys
Valdez Marina	1	3	5	6	
Valdez Ferry Terminal		3			1
Alyeska Terminal		3	20		
Valdez Container Dock					1
Tatitlek					1
Cordova Marina			9		
TOTALS	**1**	**9**	**34**	**6**	**3**

Twenty three college and high school students, teachers and RCAC staff participated in the bioblitz, including field collections and NIS detection. Through a series of interactive lectures and hands-on training in non-native species identification, the bioblitz included a significant focus on training (increasing awareness and capacity) for detection of target NIS in Alaska through citizen science in Valdez. We also sought to gain further insight into the opportunities for expanding citizen engagement in NIS detection and monitoring in PWS and Alaska more broadly, through informal assessment.

Below, we provide a more detailed description of the component activities.

1. **Fouling Community Plate Surveys at Valdez marina and Alyeska Terminal (June - September 2016).** Fouling plates are standardized sampling units used throughout the world to assess marine biodiversity and detect introduced species, examining the entire fouling community (versus only target taxa). SERC has been using fouling plates throughout North America (from Alaska to Panama) for nearly 20 years, to provide quantitative and repeated measures of NIS detection and monitoring, including sites in PWS and six other regions of Alaska. The plates (14x14 cm PVC panels) are suspended underwater from docks and serve as

passive collectors for colonization of marine invertebrates found in the fouling community (see Blum et al. 2007 for further description).

For this project, in conjunction with RCAC, 5 plates were deployed in Valdez Marina and 20 plates at the Alyeska Terminal in June 2016 to detect marine invaders in shallow (marina) and deep (terminal) boating and shipping areas in Valdez, respectively. The Marina, and both Berth 1 and the Key West Dock, used for deployment at the Terminal were floating docks, which we had sampled previously in 2011. An additional site in Prince William Sound, in Cordova, Alaska, was included, to expand the detection area and provide contrast to the locally collected material (since Cordova is a more fully marine site), for a total of 34 settlement plates deployed in PWS for 3 months.

After 3 months of invertebrate colonization, in September 2016, all plates were collected, photographed, and scanned for NIS by SERC scientists, with the exception of Valdez Marina plates which were not photographed, due to the presence of only one species of Hydroid in very small densities. Photographs will be archived on the Plate Watch website (platewatch.nisbase.org). In addition, a random subset of 10 plates from the Alyeska Terminal were examined more comprehensively to generate a fouling species list for Valdez, and all species were designated as native, cryptogenic or introduced. The Cordova plates and the remaining 10 plates from the Alyeska Terminal were also used during the bioblitz workshop, for training participants to recognize particular target taxa and to compare with biota collected in diver surveys.

2. **Crab trap surveys (8-10 September 2016).** The European green crab, *Carcinus maenas*, introduced to the west coast of California in the 1990's has been steadily moving northward along the coast and has most recently been detected 100 miles from the Alaskan border. Standardized trapping has been occurring for over a decade and PWS and elsewhere in Alaska, using protocols that SERC and RCAC implemented to detect green crabs. For the bioblitz activity, six traps, 3 minnow (juveniles) and 3 collapsible (adults), were deployed in the subtidal at the Valdez Marina on Sept 8, the day before the bioblitz training. Traps were left out for 48 hours and pulled during the bioblitz field survey.

3. **Bioblitz workshop and citizen science training (9 September 2016).** A workshop was held during the bioblitz, to engage the public in marine invasion science and provide some training to citizen scientist volunteers. The workshop included presentations and training through experiential learning for basic taxonomy, target species lists, protocols in the field, and data recording. We developed a target species list for rapid detection, based on known invaders further south in Alaska and Puget Sound, and ease of identification, which was used in the bioblitz, as well as in the diver surveys, to rapidly assess the presence of non-natives (Appendix 1). SERC researchers provided overview presentations of invasion science and management, including a general introduction to marine invertebrates, the target NIS, the vectors that transport them, SERC invasive species monitoring programs and preventative measures individuals can take to limit introductions (See the Agenda, Appendix 2). Other activities included a plate photo contest and a NIS quiz, designed to assess ability to recognize target taxa after the workshop.

4. **Bioblitz surveys with citizen scientists (10 September 2016).** On the day after the training workshop, the bioblitz team, including the trained citizen scientists, examined the fouling communities of Valdez Marina. Surveys included examination of settlement plates, fauna in crab traps and a rapid assessment of dock structures. The rapid assessment covered the entire marina and involved examining all structures submerged in the water including, buoys, boats, lines, and

dock infrastructure. In addition, we provided hands on training in taking vertical plankton tows and physical measurements in the water column.

5. **Dive surveys of transport hubs in the Valdez region (ongoing 7-10 September 2016).** We conducted dive surveys across a range of sites in the region, to examine man-made maritime infrastructure in high transit areas and expand beyond the survey area assessed with settlement plates. Dive locations included the Valdez Ferry dock, Valdez Container Terminal pilings, and the Tatitlek Ferry dock. Our goal was to sample the deeper, high salinity waters below the freshwater surface lens, because many non-native species established in western North America occur in high salinity waters. We used the target species list to do rapid visual surveys of walls, pilings and man-made structures underwater. A subset of samples of native fauna from several different Phyla were collected to use in the citizen science training and bioblitz (Figure 1).

6. **Zooplankton sampling and training.**
SERC staff provided training to RCAC staff in vertical tow plankton sampling. Sample Sites were located near shipping and recreational boating hubs and in areas over 5 meters deep (Table 1). Three replicate tows were taken at each site (see Appendix 3). The zooplankton samples were sent to Dr. Jon Geller (Moss Landing Marine Laboratory, CA) by RCAC staff, for genetic analyses under a separate contract.

Figure 1. Photo of the native tunicate *Halocynthia igaboja* and a brittle star (photo credit: Nellie Vandenburg). These and other species were collected during dive surveys and used during the training workshop.

Outcomes

<u>Fouling Community Plate Surveys</u>

No new NIS were detected in any of our surveys, neither in high or low salinity waters with the caveat that Cnidarians and sponges provide taxonomic challenges, so these groups were not identified to species. Species composition of the fouling community on panels was similar to previous studies (Table 2). The only cryptogenic species (or species whose native status is unclear) identified on panels was the bryozoan, *Fenestrulina delicia*, which we've found in previous fouling surveys (Ruiz and Geller 2012). Though a few invertebrates on settlement plates were juveniles or very small and could not be identified to species, these were in groups with many native species so are likely native species.

Table 2. List of Species Detected in Fouling Community Panel Survey. List was generated from 10 randomly selected plates from 2 docks at the Alyeska Terminal. Most unidentified specimens were juveniles or very small.

Anthozoa	Anemone sp (1 or 2 spp)
Bryozoa	*Alcyonidium* sp
	Bugula pacifica
	Callopora sp
	Celleporella hyalina
	Crissidae sp
	Dendrobeania sp
	Fenestrulina delicia
	Membranipora villosa
	Primaverans sp
	Rhynchozoon sp
	Tubulipora cf pacifica
Crustacea	*Balanus* sp
Echinodermata	*Pisaster* sp
Hydrozoa	cf *Obelia* sp
	cf *Clytia* sp
Molluscs	*Dendronotus* sp
	Dorid Nudibranch
	Hermissenda crassicornis
	cf *Pododesmus* sp
	Hiatella arctica
	Mytilus cf trossulus
	scallop
	slipper limpet
Polychaeta	*Crucigera zygophora*
	Dorvillaidae
	Nereidae
	Pseudochitinopoma occidentalis
	Serpula sp
	Spirorbidae sp 1
	Spirorbidae sp 2
Porifera	Unidentified sponge
	cf *Halichondria* sp
	Fiberglass sponge
Tunicata	*Corella inflata*
	cf *Halocynthia* sp

Bioblitz Rapid Survey in Valdez Marina

The bioblitz rapid surveys in the marina yielded no NIS but did yield one interesting sample. The bryozoan *Eucratea loricata* was found entangled around a line. The species is one we have not seen previously on panels or in rapid surveys around the state, nor in the recent literature, but it has been identified previously in Alaska from rocky subtidal habitats in Juneau, Orca Prince William Sound, and Yakutat, at the turn of the century (Robertson 1900). *Eucratea loricata* is found globally, in the Arctic and both the Pacific and Atlantic Oceans. There is some confusion over the number of species in the genus with several possible subspecies of *E. loricata*, so further analysis is indicated on this group (Hayward, 2004).

Crab Trap Surveys

Crab trapping yielded native crab species only, in both minnow and collapsible traps.

Dive Surveys

Only one NIS was documented during the bioblitz activities, during the dive surveys. The non-native bryozoan, *Schizoporella japonica*, reported from Valdez and in other areas of Alaska in previous SERC surveys (Hines and Ruiz, 2000; Ruiz and Geller, 2012), was found again in the Tatitlek dive surveys. Evidence suggests that the species was likely introduced to the west coast of the United States from Japan with Pacific oyster cultivation, though transport with shipping is also possible (Powell, 1970). *Schizoporella japonica* has often been confused with another non-native, *S. unicornis* making it difficult to track its introduction, but it has likely been present in Alaska since the 1940's under the latter name (US Navy Report, 1951; Powell, 1970). It is now common at many sites in Alaska, often dominating the encrusting fauna.

It is also noteworthy that the colonial tunicate *Botrylloides violaceus* was not detected during dive surveys at Tatitlek. This species was observed in an earlier survey at this location, during a plate survey (Hines et al. 2000). Only two small colonies were found previously at Tatitlek, and it was uncertain whether a population was established here. Another single colony of this species was detected in a plate survey in Kachemak Bay from 2001 (Ruiz, unpubl. data). Although present in southeast Alaska, including Ketchikan and Sitka, this NIS is not known to be established further north.

Workshop, Training, & Assessment

We accomplished all of our primary goals in advancing understanding and detection capacity for NIS in PWS. Specifically, we provided a broad overview of invasion science and specific training for identification and detection methods for target NIS relevant to PWS. We also provided training to help RCAC implement a zooplankton sampling program, which aims to detect target NIS in PWS using genetic tools.

Our informal assessment is that participants in the bioblitz activities increased their overall knowledge and ability to identify particular NIS. While we view the overall scope of the activities as invaluable, both to provide necessary background and engage effectively, it is also evident that additional time is needed to identify many of the target NIS with accuracy. This is not surprising, as past citizen science research underscores the need for practice and feedback to increase efficacy, indicating that performance improves with practice. Moreover, there is also a trade-off between the number of target taxa in focus and the speed with which people become proficient in detection (i.e., the depth versus breadth of taxonomic knowledge). Recognizing such trade-offs is of critical importance in advancing successful monitoring programs that engage a community with diverse backgrounds and knowledge about target NIS. In general, these attributes make a strong case for citizen science efforts for detection of a single to few species, where expertise and accuracy can be quickly achieved. In fact, this is the model used to initiate Plate Watch and crab trapping in Alaska, which focused primarily on botryllid tunicates and green crabs, respectively. While Plate Watch has slowly expanded to include some additional target NIS and photo documentation, we urge caution in expanding the taxonomic scope of such detection programs too rapidly, without adequately considering trade-offs in data quality (accuracy).

Conclusions & Recommendations

The bioblitz and training activities served multiple purposes. First, we conducted a brief survey of several locations to detect target NIS. Second, we provided an overview and training on NIS detection for a diverse audience, providing us some further insights on effective models and training approaches for citizen science in this area. Third, we helped RCAC initiate a zooplankton sampling program to detect target NIS using genetic tools. Finally, we conducted a fouling community plate survey in Valdez, adding another time point to historical (repeated) measures at the same location.

We view both citizen science and genetic detection programs as important components to a broader NIS detection and monitoring program for PWS and Alaska. These components have some clear benefits, including the ability to sample many locations at potentially low cost. Genetic analyses provides a high level of accuracy in NIS identification, for those target species where previous sequence data exist to confirm taxonomic identity. While citizen science programs often have variable levels of accuracy, there is sufficient baseline knowledge to indicate that successful programs require training and also benefit from focus on particular (few) target taxa, increasing local expertise. Bioblitz events offer an opportunity to provide such training, while providing enhanced NIS detection --- across a broader range of taxa and habitats.

We recommend a sustained NIS detection program in PWS that includes both citizen scientists and genetic zooplankton sampling over time, ideally with annual measures. This should include regular bioblitz and training activities, which could be coordinated with other regions of Alaska, to promote a more cohesive (and broader) program.

In addition, we also recommend that community-level comprehensive surveys be implemented at 2-5 year intervals in PWS, in order to detect a broader range of taxa and track community level changes in NIS over time. We note that the current fouling community survey was much more restricted in scope (including geographic area, number of sites, and number of panels) than previous surveys in PWS. While annual detection measures provide a useful indicator for target NIS, and also may allow for rapid management responses, the more comprehensive community surveys provide a more robust measure of long-term changes in community composition and are required to detect the full spectrum of potential NIS arriving to Alaska.

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Appendix 1. Target Species List of NIS for the Valdez Bioblitz divided into high and low salinities. Asterisks indicate species detected previously in Valdez.

High Salinity

Bryozoans	
Bugula neritina	brown bryozoan
*Schizoporella japonica**	orange bryozoan
Watersipora subtorquata	red rust bryozoan
Tunicates	
Botryllus schlosseri	Botryllid – flower tunicate
Botrylloides violaceous	Botryllid - chain tunicate
Ciona spp.	transparent vase tunicates
Didemnum vexillum	sea vomit
Styela clava	club tunicate
Crustaceans	
Carcinus maenas	European green crab

Low Salinity

Barnacles	
*Amphibalanus improvisus**	smooth walled, 'stripe lipped' barnacles
Amphibalanus eburneus	
Molluscs	
Musculista senhousia	Asian mussel
Polychaetes	
Ficopomatus enigmaticus	Trumpet Tube worm

Detected in plate surveys previously *

Detected Bugula stolonifera in plankton surveys previously**

Appendix 2. Agenda for NIS Bioblitz, Workshop and Training Activities in Valdez Alaska.

Valdez Bioblitz and Citizen Science Workshop
on Marine Non-Indigenous Species (NIS)

(9-10 September 2016)

<u>Friday (9 September)</u>

830 **Check-in**: Registration

9:00 **Classroom Session I: Brief Overview of the Bioblitz**

9:15 **Introduction to Invertebrates and NIS**

9:45 **Target NIS for Alaska and PWS**

10:20 Coffee break

10:40 **A Look at NIS on Panels**

10:50 **Laboratory Session I: Cordova Panels (high salinity) --- Hands-on Exploration of Marine Life and NIS Detection**
Stations 20 min each:
- Station 1-4 - Examination of Panels under the microscope
- Station 5 - Take a Plate Photo Contest
- Station 6 - Examples of NIS

12:30 Lunch in the College Atrium

1:30 **Laboratory Session II: Valdez Deep Water (high salinity) Panels & Diver Samples --- Hands-on Exploration of Marine Life and NIS Detection**
Stations 20 min each:
- Station 1-4 - Examination of Panels under the microscope
- Station 5 - Dive samples under the microscope
- Station 6 - Can you detect the NIS?

3:10 coffee break

3:30 **Laboratory Session III: Snapshot Look at Zooplankton from Valdez**
No Rotation:
- Station 1-6 - Examination and counting of Plankton under the microscope

4:00 **Classroom Session II: Plate Watch Monitoring Program**

(Finish by 4:15pm)

Saturday (10 September)

9:00 Safety Briefing and introduction to the Harbor

9:10 **Field Sampling Session I: Blitz Harbor --- Collection of Panels and Associated Biota (low salinity)**
Stations 20 min each:
- Station 1 -Panels
- Station 2-3 - Crab Traps (minnow and collapsible)
- Station 4 Plankton Tows
- Station 5 Physical measurements

10:50 Survey Overview & Instructions

11:00 **Harbor Field Survey**
All groups: boat hulls, lines, buoys, and anything hanging in the water

12:30 Lunch in the College Atrium

1:30 **Classroom Session: Monitoring for NIS in Alaska**

1:45 **What can you do to stop NIS?**

2:00 **Group Discussion**

3:00 **Laboratory Session IV: Valdez Harbor (low salinity) Panels and Biota**
Informal examination of panels from the harbor
Evaluations

(Finish by 3:30pm)

Thanks for coming!

Appendix 3. Zooplanton Samples Collected with RCAC in Valdez during September 2016 Bioblitz, Workshop, and Training Activities. Each vertical net tow (80micron mesh, 30cm diameter) was collected from 5m depth to the surface and preserved in DMSO, for genetic analysis by Moss Landing Marine Laboratory.

Sample Code	Bay	Site Name	Site Number	Tow Number	Latitude	Longitude	Bottom Depth (m)	Preservation
VZS01-1	Valdez	Harbor	1	1	61.12618	-146.34434	4.4	DMSO
VZS01-2	Valdez	Harbor	1	2	61.12618	-146.34434	4.4	DMSO
VZS01-3	Valdez	Harbor	1	3	61.12618	-146.34434	4.4	DMSO
VZS02-1	Valdez	Ferry Terminal	2	1	61.06063	-146.25715	23.6	DMSO
VZS02-2	Valdez	Ferry Terminal	2	2	61.06065	-146.25715	23.6	DMSO
VZS02-3	Valdez	Ferry Terminal	2	3	61.06065	-146.25715	23.6	DMSO
VZS03-1	Valdez	Alyeska	3	1	61.07413	-146.21978	238.2	DMSO
VZS03-2	Valdez	Alyeska	3	2	61.07413	-146.21978	238.2	DMSO
VZS03-3	Valdez	Alyeska	3	3	61.07413	-146.21978	238.2	DMSO