

PUGET SOUND MARINE AND NEARSHORE GRANT PROGRAM

ANALYSIS OF 2016-2019 INVASIVE SPECIES AND OIL SPILL INVESTMENTS

ADDENDUM TO THE PART 2 REPORT

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AUGUST 2019

This project has been funded in part by the United States Environmental Protection Agency under assistance agreement PC 00J90701 to Washington Department of Fish and Wildlife. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

Since 2011, the Puget Sound Marine and Nearshore Grant Program has invested National Estuary Program funds to implement priorities outlined in the [Action Agenda for Puget Sound](#).

In July 2016, Puget Sound Institute released a report analyzing 10 grants relating to **invasive species, oil spills, and toxics** that had been funded by the Grant Program through 2014 (Kinney et al. 2016a). This report is an addendum that summarizes four projects completed since 2016.

INVASIVE SPECIES DETECTION AND RESPONSE

The Grant Program funded Washington Sea Grant to establish a European green crab (*Carcinus maenas*) early detection monitoring program and outreach effort. The resulting volunteer-based [Crab Team](#) was established in 2015 and has grown to consist of two full time staff, a student assistant, over 200 volunteers, 54 monitoring sites, and 40 partner staff from agencies and tribes (Washington Sea Grant 2018b).

Monitoring has revealed green crab are slowly beginning to spread in the Salish Sea. **Monitoring associated with this project was responsible for the first discovery of green crab at eight sites.**

Continued early detection monitoring Washington Sea Grant's Crab Team was included as a strategy in the recent *Salish Sea Transboundary Action Plan for Invasive European Green Crab* (Drinkwin et al. 2019). That report said of the detection and response effort partially supported by the Grant Program: **"The current response to early detections of EGC in Washington State waters of the Salish Sea is a success story seldom seen in the world of Aquatic Invasive Species (AIS) management."**

INVASIVE SPECIES PREVENTION

The 2016 Part 2 analysis report concluded that implementation of ballast water management criteria and development of a biofouling program was hindered by a lack of staff resources in WDFW's Aquatic Invasive Species (AIS) Program. Funding for WDFW's AIS and Ballast Water programs had declined, resulting in deferral of several high-priority activities. Crucial program components were being funded through grants. For example, a 2015 award from the Grant Program resulted in a **strategic plan for WDFW's ballast water program** (Moore et al. 2017), and **recommendations for development of a new biofouling program** (McClary et al. 2017).

Grant Program investments in ballast water and biofouling informed and likely contributed to 2017 legislative action that increased funding for WDFW's Aquatic Invasive Species program and authorized WDFW to promulgate biofouling regulations.

However, subsequent passage of the federal Vessel Incidental Discharge Act of 2018— after the grant period—will affect how ballast water and biofouling are regulated in the future. The Act

preempts states from adopting standards stricter than those set at the federal level, which may ultimately weaken protections for Puget Sound.

OIL SPILL PREVENTION

The Grant Program supported updates to the **Vessel Traffic Risk Assessment (VTRA)** model summarized in the 2016 Part 2 analysis report. The new model evaluated changes to risk based on scenarios involving **14 terminal development projects that could become operational by 2025**, compared against **2015 traffic levels**.

Model results indicate that vessel traffic associated with proposed terminal developments would significantly increase potential oil spill risk. A VTRA 2015 scenario that **added 1600 vessels** (tankers, articulated tug barges, bulk carriers, and container ships) showed an **11% increase in potential accident frequency and 85% increase in potential oil loss**. Accident risk varied by geographic area. The largest increases occurred at the Strait of Juan de Fuca entrance, Haro Strait, and Boundary Pass. VTRA 2015 scenarios that included a portfolio of five risk mitigation measures reduced potential oil loss. However, unlike VTRA 2010 outputs, the **risk mitigation measure portfolios did not reduce risk below the Base Case 2015 levels in most cases**.

Results of the VTRA 2015 model informed discourse at a **two-day Salish Sea Vessel Oil Spill Risk Assessment and Management Workshop**. This October 2016 workshop had **75 attendees** representing federal/Canadian agencies, state agencies, Tribes/First Nations, local governments, industry, and non-governmental organizations. Workshop facilitators engaged participants in a **collaborative process to develop actionable recommendations** to reduce and prevent oil spills from vessel traffic. Participants identified 9 high-priority risk mitigation measures and developed implementation plans for each.

This work **supported policy deliberations during 2 legislative sessions as well a high-profile Governor's task force**. Ecology has been directed by the Legislature and Governor to begin rule-making for the tug escort risk mitigation measure modeled in the VTRA and to continue technical evaluations cross-boundary coordination for emergency response towing vessels.

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1. INTRODUCTION

The Puget Sound Marine and Nearshore Grant Program (“the Grant Program”) is a partnership between the Washington Department of Fish and Wildlife (WDFW) and the Washington Department of Natural Resources (WDNR). Since 2011, the Grant Program has distributed National Estuary Program funds to support about 80 projects that implement recovery priorities identified in the [Action Agenda for Puget Sound](#).

Five years into their 6-year funding cycle, the Grant Program funded the Puget Sound Institute (PSI) to analyze and synthesize the results of their first 4 years of awards. The aim of this grant was to evaluate the results of completed work in order to inform and optimize future work at project, programmatic, and Puget Sound recovery levels.

PSI evaluated and synthesized the reports and deliverables of 50 grants in a series of four analysis reports:

- Part 1 covered 14 regulatory effectiveness and stewardship grants (Kinney et al. 2015);
- Part 2 covered 9 grants related to high-priority threats and the Puget Sound Pressures Assessment (Kinney et al. 2016a);
- Part 3 covered 20 habitat protection and restoration grants and 6 outreach efforts (Kinney et al. 2016b); and
- A final report synthesizing all 2011-2014 investments (Kinney et al. 2016c).

In 2018, the Grant Program funded PSI to analyze and synthesize results of projects completed since 2016. Results of the 30 most recent awards are summarized in 3 addendums to the original analysis reports and one new analysis report. **This addendum covers 4 new grants (Table 1) in topic areas covered in the 2016 Part 2 Report.** Themes addressed in this report are (1) invasive species detection and response, (2) invasive species prevention, and (3) oil spill prevention.

Table 1. Invasive Species and Oil Spill Investments

Award	Grantee	Product Citations
European Green Crab Early Detection and Monitoring	Washington Sea Grant	Washington Sea Grant 2016 Grason et al. 2018
European Green Crab Phase 2	Washington Sea Grant	Washington Sea Grant 2018(a) Washington Sea Grant 2018(b)
Ballast Water & Biofouling Strategic Plans	Washington Department of Fish and Wildlife	Lane et al. 2016 McClary et al. 2017 Moore et al. 2017
Vessel Traffic Risk Assessment Update	Washington Department of Ecology	Van Dorp and Merrick 2016 Ecology 2017

2. INVASIVE SPECIES DETECTION AND RESPONSE

The European green crab (*Carcinus maenas*) has established populations on the Atlantic and Pacific coasts of North America. This invasion has resulted in several well-documented negative impacts on native species, habitats, and fisheries (e.g., predation on oysters, mussels, clams, and juvenile crabs; competition with other crabs; loss of eelgrass beds due to digging and burrowing). Initial introductions are thought to have occurred through ballast water, biofouling, or transport with fishery products intended for food or bait.¹ **Once enough green crabs are present in an area to reproduce, their planktonic larvae can spread locally via currents.** Green crab was first observed on the Pacific coast of North America in San Francisco Bay in 1989. Over the next two decades, green crab dispersed and became established along the coast and in coastal embayments of California, Oregon, Washington, and British Columbia.

The 2012 discovery of a population of green crab in Sooke Basin near Victoria, British Columbia prompted establishment of an early detection monitoring network in Puget Sound (Grason et al. 2018). **The intent of early detection monitoring is to increase the likelihood of finding and eradicating green crabs before they become established in large enough numbers to cause harm** (Washington Sea Grant 2016). Early detection can significantly improve the effectiveness of rapid response efforts; intensive and sustained trapping has reduced green crab populations in central California (Grason et al. 2018).

The Grant Program funded Washington Sea Grant to establish an ongoing regional monitoring program and outreach effort. Because volunteers can collect data over large spatial and temporal scales at relatively low cost, a citizen science approach was used for early detection monitoring. Sea Grant's [Crab Team](#) was established in 2015 and has grown to consist of 2 full time staff, a student assistant, over 200 volunteers, and 40 partner staff from agencies and tribes (Washington Sea Grant 2018b).

Crab Team activities supported by the grant included:

- Development of monitoring protocols.
- Recruitment and training of volunteers to conduct monitoring and habitat surveys.
- Habitat suitability assessment to identify and prioritize monitoring sites.

¹ **Ballast water** is water taken up and stored in a ship's ballast tank to maintain trim and stability during voyages, then released in port when the ship takes on cargo, containers, passengers, or fuel. Ballast water is a significant global pathway for movement and spread of invasive non-indigenous species. **Biofouling** refers to the community of marine organisms that adhere to submerged surfaces. Biofouling species include sessile organisms that attach to surfaces, as well as mobile species that inhabit a matrix of those sessile organisms. Biofouling of mobile surfaces like vessel hulls is another significant global pathway for movement and spread of invasive non-indigenous species. Management of these two transport pathways is discussed in Section 3.

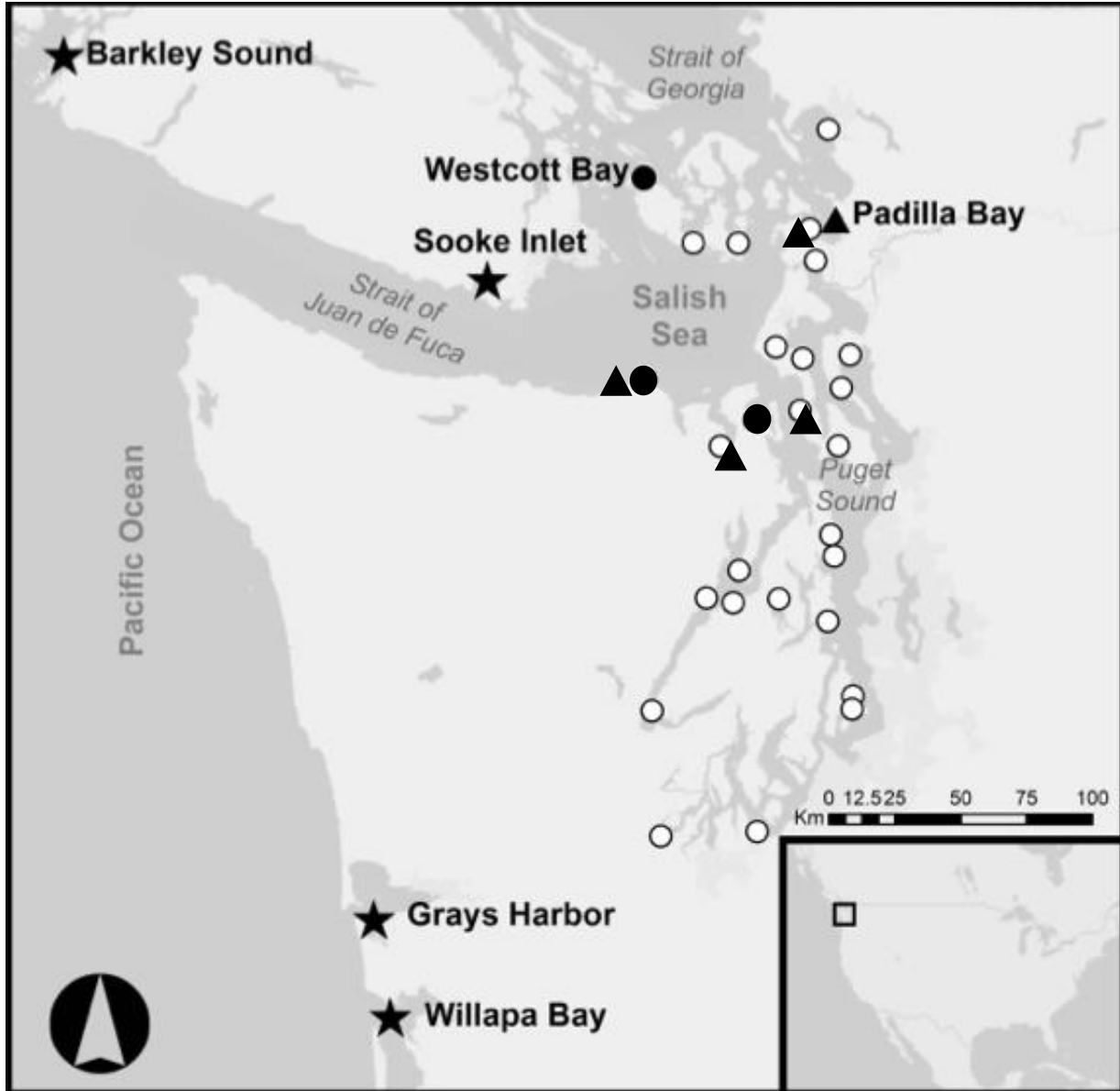
- Collaboration with WDFW to establish a rapid assessment process for responding to the discovery of green crab during monitoring. Response to discovery of a green crab involves an intensive trapping period led by professional biologists to assess the scope of any potential established local population.
- Public outreach, including communications to recruit and retain volunteers, provide information to visitors of habitats suitable for green crabs, and increase general awareness
- Larval transport modeling to identify the most likely source(s) for green crab introductions into Puget Sound.
- Internal program evaluation to enhance its effectiveness year to year.

2.1 RESULTS

- In August 2016, **a team of Crab Team volunteers made the first confirmed observation of a green crab in Washington inland marine waters** (Grason et al. 2018).
- Strong volunteer engagement allowed Sea Grant to develop and grow a successful program:
 - During the 2015-2016 grant period, Sea Grant held 11 training workshops; established 26 monitoring sites; and recruited 116 volunteers who set 912 traps (Washington Sea Grant 2016). **One green crab was captured at the Westcott Bay monitoring site.**
 - During the 2017-2018 grant period, Sea Grant held 7 training workshops; established an additional 28 monitoring sites (for a total of 54 sites); expanded participation to end the grant period with a total of 204 volunteers; and set an additional 3,594 traps (Washington Sea Grant 2018b). **Eleven green crabs were captured at 3 monitoring sites (Dungeness Spit Lagoon Point and Sequim Bay).**
 - Program evaluations and modifications based on participant feedback led to increased volunteer retention.
 - **During 2015-2018, the program benefited from 3,576 volunteer hours with an estimated value of \$111,145** (Washington Sea Grant 2018b).
- Crab Team trainings also built capacity and awareness of green crabs in other organizations. In 2018, two WDNR Puget Sound Conservation Corps members who received Crab Team monitoring training found, recognized, and reported a green crab molt while in the Fidalgo Bay Aquatic Reserve to conduct other monitoring.
- After an initial introduction, regional spread often occurs via larval dispersal. During Phase 2 of the project, **larval transport modeling** was conducted to quantify risk and identify the most likely natural source of green crab introduction into the Salish Sea (Washington Sea Grant 2018a)
 - Four source sites were analyzed: Sooke Harbor and Barkley Sound (B.C.), Willapa Bay, and Coos Bay (OR).
 - When oceanographic conditions were supportive of larval dispersal at a site, the computer model released 10,000 particles representing larvae from each source site

and tracked the for 75 days (the approximate maximum time larvae stay in the water column before settlement). Releases occurred during simulated night time high tides to mimic green crab behavior. In total, 38 simulated releases across all 4 locations over multiple dates were conducted totaling 38,000 simulated larvae.

Figure 1. Map of green crab Phase 1 monitoring sites and captures through 2018



○ WSG Crab Team sampling sites ● Captures by WSG Crab Team

▲ Captures by others ★ Established populations

- All 4 source locations had more than one release date where at least 1 of 10,000 larvae from each location ended up within the Salish Sea (Washington Sea Grant 2018a). The

model demonstrated that, while the probability of larvae reaching the eastern Salish Sea were low, under favorable ocean conditions associated with El Niño events larvae can be successfully transported from all 4 locations.

- **The model suggests that currents in Puget Sound were more likely to enable successful larval transport from coastal sources during strong El Niño periods**, such as those observed from 2014-2016 (Washington Sea Grant 2018a).

2.2 KEY OUTCOMES

- The recent *Salish Sea Transboundary Action Plan for Invasive European Green Crab* (Drinkwin et al. 2019) said of the detection and response effort partially supported by this grant: **“The current response to early detections of EGC in Washington State waters of the Salish Sea is a success story seldom seen in the world of Aquatic Invasive Species (AIS) management.”**
- Volunteer monitoring revealed the start of a full-scale green crab invasion of Dungeness Spit, where 166 were captured by volunteer and agency trapping.
- Given successful larval transportation from the coast only occurred under rare, but predictable events, monitoring and rapid assessment trappings can be adapted to match these events (Washington Sea Grant 2018a).
- The Transboundary Action Plan includes early detection monitoring as a strategy. The plan assigns Washington Sea Grant to train and support volunteers and partners to monitor for green crab (Drinkwin et al. 2019). The plan assigns WDFW’s AIS Program as the lead for administration and coordination efforts in Washington, including seeking funding for implementation.

3. INVASIVE SPECIES PREVENTION

The 2016 Part 2 analysis report summarized previous Grant Program-funded projects that characterized the threat of Aquatic Invasive Species (AIS) introductions to the Puget Sound region and suggested strategies to reduce invasion risk (Davidson et al. 2014, Cordell et al. 2015). The investigations were designed to inform development of ballast water and biofouling management plans.

A 2015 grant built on this previous work and resulted management plans for WDFW’s AIS Program. Deliverables included:

- A regulatory gap analysis (Lane et al. 2016),
- A 6-year strategic plan for WDFW’s ballast water program (Moore et al. 2017), and
- Recommendations for development of a new biofouling program (McClary et al. 2017).

3.1 RESULTS

REGULATORY GAP ANALYSIS

Multiple state and federal agencies have authority to regulate ballast water and biofouling on the same vessels. WDFW and the U.S. Coast Guard (USCG) regulate under non-indigenous species authorities, while the Washington Department of Ecology (Ecology) and U.S. Environmental Protection Agency (EPA) are involved through their water quality authorities. EPA regulates “discharges incidental to normal operation of commercial vessels” (ballast water is one type of incidental discharge) under their National Pollutant Discharge Elimination System (NPDES) Vessel General Permit. In addition, the International Maritime Organization (IMO) has issued international guidelines and conventions on ballast water and biofouling management.

The first step of the gap analysis was development of a regulatory matrix comparing state and federal regulations. Overlap and gaps in these regulatory frameworks were identified by WDFW, vessel operators, and the BWWG input. Lane et al. (2016) then evaluated the **costs/benefits of specific requirements and considerations for potential modifications to state law**. Results of the gap analysis were used to inform management plans.

BALLAST WATER STRATEGIC PLAN

This plan included an assessment of ballast water management program performance. Moore et al. (2017) concluded that **Washington’s ballast water management program has achieved a high degree of risk reduction:**

- The overall **number of arrivals failing to meet ballast water management regulations decreased by a factor of 4** during the evaluation period: 34 instances in 2012 to 9 instances in 2015.
- In an average year WDFW prevents 0.9 million m³ of ballast water from being discharged post-arrival.
- Federal regulations do not require submittal of ballast water reports early enough to allow for intervention with noncompliant vessels before they discharge raw ballast water. Moore et al. (2017) contend that **Washington’s requirement for advance submittal is a key way the ballast water management program offers value to the state**. The authors recommend that WDFW continue to require early submittal of reporting forms and maintain their own database on vessel arrivals and discharges.
- WDFW’s ballast water program has **measurably improved vessel compliance with state and federal regulations**. The combination of state and federal legislation and enforcement efforts have resulted in a relatively low annual volume of raw ballast water discharge in state waters.

This decade has been a time of rapid change for ballast water management—ballast exchange is being phased out as federal requirements for installation of vessel treatment systems are

being implemented. In response, the ballast water plan recommends that WDFW be flexible and responsive to minimize risks of AIS introduction. The plan's overarching objectives and near-term (FY 2017-2019) action items are summarized below:

- **Strengthen program** – Future regulatory changes and forecasted growth in vessel arrivals/discharge activity will require additional staff resources and upgrades to data management infrastructure.
 - Increase state program staffing from 3.5 FTE to 5 FTE positions. Current staffing does not adequately meet existing needs, much less additional needs expected in the future.
 - Improve state program data management infrastructure. Automate data collection to reduce data management burden. Upgrade database.
- **Evolve methods** – Management methods must evolve with changing technology. The introduction of treatment systems presents uncertainty relating to equipment reliability so new inspection procedures are required.
 - Enhance process for inspection selection based on risk indicators. The strategic plan includes a proposed Risk Matrix (formulaic process for applying risk indicator to arrivals).
 - Restart ballast water exchange sampling to provide insight into management effectiveness as treatment is phased in. Thresholds developed by Cordell et al. (2015) should be refined and utilized to identify vessels for additional evaluation.
 - Develop training and protocols that account for treatment system installations. Research treated ballast water sampling equipment and protocols. Address treatment system hazards (electrical safety, chemical exposures, etc.).
- **Increase cooperation** – Data sharing and inspection coordination with USGS would result in more efficient and effective protection of state waters. Cooperation with Pacific states could result in aligning methods to the extent possible. Outreach and engagement with the regulated community should continue.
 - Continue regional and national coordination. USCG inspection data is not readily available to WDFW on a real-time basis. This lack of information sharing prevents WDFW from understanding if high-risk vessels are going to be or have been inspected. Develop formal agreements with USCG for data sharing and vessel inspections.
 - Increase outreach to and education of industry and consider developing an incentive program. Engage with vessel owners and operators to support information sharing and co-development of inspection and sampling methods for vessels with treatment systems.
 - Establish performance measures and adapt authorities. Consult with BWVG to develop program performance measures. Adopt rules establishing a state standard consistent with national rules. Provide general rule updates as necessary. Consult with BWVG to propose legislation to adjust revenues to meet program performance measure needs.

Two positive developments since the plan was completed have accelerated progress on some strategic plan priorities:

- **Dedicated funding for the AIS Program** – During the 2017 session, Washington’s Legislature passed an Act relating to aquatic invasive species management.² This Act provided WDFW with authority to issue, for a \$20 fee, aquatic invasive species prevention permits to operators of vessels and aquatic conveyances registered in other states. **Revenue will be used for AIS, ballast water, and biofouling program funding.**
- **New law requiring federal information sharing** – The Vessel Incidental Discharge Act (VIDA) of 2018³ requires the National Ballast Information Clearinghouse to immediately disseminate electronic forms to interested states, and establishment of a working group to develop a process for readily sharing enforcement data.

However, **VIDA also limits WDFW’s ability to promulgate a state standard for treated ballast water.** The new law restructures the way EPA and USCG are to regulate discharges incidental to normal operation of commercial vessels. Ballast water, one type of incidental discharge, will no longer be regulated through NPDES. Instead, it will be regulated through a new Clean Water Act program: *Uniform National Standards for Discharges Incidental to Normal Operation of Vessels*. **VIDA specifically prevents from states from enacting more stringent requirements for ballast water.**

VIDA does provide states with **authority to enforce the new uniform federal standard, and maintains state requirements to exchange or treat ballast water for coastal voyages** (where the vessel remains within 200 nautical miles of shore) in the Pacific Region (defined as waters adjacent to Alaska, California, Hawaii, Oregon, or Washington).

BIOFOULING STRATEGIC PLAN

This grant allowed WDFW to develop a management plan for biofouling that includes an evaluation of WDFW’s current AIS program management structure and mission; a biofouling pathway and vector analysis; guiding principles; and a **recommended operational framework for a new biofouling program at WDFW** (McClary et al. 2017).

The plan recommends development of a biofouling program **modeled after the program that had recently been instituted in California.** McClary et al. (2017) The authors propose the following elements be included in a new Washington biofouling program:

- **Recordkeeping**—Require vessels to maintain Biofouling Record Books and submit an annual Husbandry and Voyage History reporting form. Work with other jurisdictions to develop the form and reporting requirements to harmonize with other programs.

² [Engrossed Substitute Senate Bill 5303](#) was signed into law on July 6, 2017.

³ Title IX of the [Frank LoBiondo Coast Guard Authorization Act of 2018](#) was signed into law on December 14, 2018.

- **Reporting**—Require incoming vessels intending to be present in state waters for more than 2 days to submit a Vessel Risk Self-Assessment (VeRSA) at least 10 days in advance of arrival. The VeRSA is a spreadsheet that calculates a risk rating that can be readily verified from ship records.
- **Inspections**—Hire inspection staff to audit biofouling record books, inspect hulls of identified high-risk vessels, and collect organisms from heavily fouled vessels to identify potential AIS.
- **Data management**— Expand ballast water data collection and management to include information collected on biofouling reporting forms. Proposed reporting form that automatically assigns risk to a vessel instead of requiring staff to do so
- **In-water hull cleaning**—Maintain current level of oversight.
- **Rapid response**—Increase response equipment and staff able to provide rapid response for introductions by vessels covered under plan.
- **Infested site management**—Monitor established AIS infestations, test various treatments, and pursue eradication.
- **Early detection monitoring**—Expand to other species and environments (current focus on zebra and quagga mussels in freshwater).

Implementing this type of program would require a 4 FTE increase in WDFW AIS Program staffing: 1 FTE operations manager, 1 FTE data management, 1 FTE benthic ecologist/rapid response specialist, and 1 FTE inspection staff.

The new state and federal laws mentioned in the previous section also affect WDFW’s ability to implement the biofouling strategy:

- The 2017 Act relating to aquatic invasive species management amended [RCW 77.102.140](#) to **grant WDFW authority to promulgate rules for biofouling standards and requirements** for vessels arriving or moored at a Washington port. As described in the previous section, this same bill created a dedicated funding source for the AIS Program.
- The inclusion of a preemption clause in VIDA will likely limit Washington’s ability regulate biofouling. There is no mention of biofouling in VIDA, but hull husbandry practices are currently included in the NPDES Vessel General Permit and may be included in the new uniform national standards. **It is unlikely that any new standards would be as stringent as those currently in place in California.**

3.2 KEY OUTCOMES

The 2016 Part 3 report concluded that implementation of ballast water management criteria and development of a biofouling program was hindered by a lack of staff resources (Kinney et al. 2016a). Funding for WDFW’s AIS and Ballast Water programs had declined, resulting in deferral of several high-priority activities. Crucial program components were being funded

through grants. A lack of authority and budget consistency prevented development of a new marine biofouling management program.

Grant Program investments in ballast water and biofouling informed and likely contributed to 2017 legislative action that increased funding for WDFW's AIS program and authorized WDFW to promulgate biofouling regulations. The new funding and authority will support WDFW in implementing the ballast water and biofouling strategic plans.

4. OIL SPILL PREVENTION

The 2016 Part 2 analysis report summarized **Vessel Traffic Risk Assessment (VTRA)** modeling that was used to evaluate: (1) changes in the probability of an oil spill associated with **3 proposed maritime terminal developments**, and (2) actions to mitigate potential effects of increased vessel traffic resulting from these projects. The VTRA model identified several management measures that could reduce oil spill risk, even if none of the terminal developments were constructed. This analysis was based on **2010 traffic levels**.

A second award by the Grant Program helped to fund development of an updated VTRA model based on **2015 traffic levels** and evaluation of changes to risk based on scenarios involving several new terminal development proposals. This grant also supported an October 2016 **Oil Spill Risk Assessment and Management Workshop**, where cross-border and multi-sector stakeholder attendees participated in a collaborative process to prioritize risk mitigation measures and develop actionable recommendations for their implementation.

4.1 RESULTS

Van Dorp and Merrick (2016) updated the VTRA 2010 model to ensure the VTRA remains a current tool for analysis. The majority of this work was funded by Ecology, but grant funding supported additional analysis of an Ecology-led Working Group's highest priority "What-If" cases and risk mitigation measures.

The VTRA 2015 model evaluated changes to risk based on scenarios involving **14 terminal development projects that could become operational by 2025**, compared against 2015 traffic levels. Simulations suggest:

- Vessel traffic associated with proposed terminal developments would significantly increase potential risk compared to 2015 traffic levels. A VTRA 2015 scenario that **added 1600 vessels** (tankers, articulated tug barges, bulk carriers, and container ships) showed an **11% increase in potential accident frequency and 85% increase in potential oil loss**.
- Accident risk varied by geographic area. The largest increases occurred at the Strait of Juan de Fuca entrance, Haro Strait, and Boundary Pass.
- VTRA 2015 scenarios that included a portfolio of five risk mitigation measures reduced potential oil loss. However, unlike VTRA 2010 outputs, the **risk mitigation measure portfolios did not reduce risk below the Base Case 2015 levels in most cases**.

Results of the VTRA 2015 model informed discourse at a **two-day Salish Sea Vessel Oil Spill Risk Assessment and Management Workshop**. This October 2016 workshop had **75 attendees** representing federal/Canadian agencies, state agencies, Tribes/First Nations, local governments, industry, and non-governmental organizations.

Workshop facilitators engaged participants in a **collaborative process to develop actionable recommendations** to reduce and prevent oil spills from vessel traffic. During the workshop, participants reviewed VTRA 2015 model results; discussed and ranked 24 risk mitigation measures (RMM); and developed implementation plans to identify champions and next steps for the 9 highest-priority RMM (Table 2).

Table 2. Prioritized risk mitigation measures from 2016 Oil Spill Workshop

RMM number	Name	Number of votes	Modeled in VTRA
1	Escort tank vessels including oil barges and articulated tug barges in Puget Sound	56	yes
2	Create a Canada/U.S. Transboundary Marine Safety Forum	53	no
3	Pre-position a multi-mission emergency response towing vessel for Haro Strait/Boundary Pass	51	yes
4	Conduct a Ports and Waterways Safety Assessment for Port Angeles Precautionary Area and Rosario Strait	32	no
5	Share transboundary marine incident data	25	no
6	Support implementation of pending RMM: <ul style="list-style-type: none"> • Increased automatic identification system carriage • Vessel Traffic Service upgrades • Protected fuel tanks • Commercial towing vessel inspection standards • Fishing vessel inspections 	22	partial
7	Broaden the oil spill prevention community with “Keep it in the tank” education and outreach campaign	19	no
8	Require a minimum two-person bridge watch on: <ul style="list-style-type: none"> • Tugs towing laden barges carrying pollutants in VTS zone • Commercial vessels in reduced visibility 	16	partial
9	Optimize anchorage number/location	15	no

Ecology (2016) summarized key observations about the final list of RMM:

- The topics of most interest were escort tugs, transboundary coordination, waterways management, education and outreach, and increased bridge watch.
- Most RMMs were considered implementable within a 2- to 5-year time frame.
- The geographic reach of the RMMS extends throughout the Salish Sea, including Haro Strait, Boundary Pass, and the Strait of Juan de Fuca.

- Further deliberation is needed on comparability of U.S. and Canadian regulations in transboundary waterways.

Since 2016, Ecology has made progress towards implementing some of the priority RMMs. VTRA 2015 simulation outputs and Workshop recommendations were incorporated into the following policy processes:

- [2018 Strengthening Oil Transportation Safety Act](#) – E2SSB 6269 directed Ecology to take several actions to promote marine transportation safety. These included reporting on vessel traffic management options (see bullet below) and establishing a Salish Sea Shared Waters Forum with Canadian partners (RMM 2).
- [Strait of Juan de Fuca and Puget Sound Vessel Traffic Safety Report](#) – The Act required Ecology to evaluate existing risk assessments and other available studies to make recommendations on the viability of tug escorts (RMM 1) and emergency response vessels (RMM 3). The resulting report was to provide information for the Legislature to take action in during the 2019 session.
- [Southern Resident Killer Whale Task Force Recommendations](#) – Recommendation 24 of the Task Force’s November 2018 final report involves implementation of two Workshop RMMs. The Task Force recommended that the Legislature (1) initiate zone-based rule-making on tug requirements for oil laden tank vessels over 5,000 tons but less than 40,000 dead weight tons, including oil barges and articulated tug-barge (RMM 1); and (2) support stationing of an emergency response towing vessel for Haro Strait (RMM 3). Both of these measures were modeled as part of the VTRA RMM scenarios and target on a geographic area subject to increased risk as result of planned terminal projects.
- [2019 Reducing Threats to Southern Resident Killer Whales by Improving the Safety of Oil Transportation Act](#) – ESHB 1578 directed Ecology to engage in rule-making for tug escorts (RMM1) and assess whether an emergency response towing vessel in the San Juan Islands will reduce oil spill risk then report to the Legislature by 2023 (RMM3). The bill also directed Ecology to host a Shared Salish Sea Forum to further discuss emergency response systems.

4.2 KEY OUTCOMES

Work funded by the Grant Program’s oil spill response grants supported policy deliberations during 2 legislative sessions as well a high-profile Governor’s task force. VTRA modeling provided Ecology with a strong technical basis for the evaluation and development of legislative recommendations.

The Salish Sea Oil Spill Risk Mitigation Workshop provided a venue for Ecology to introduce stakeholders to vessel traffic risk assessment methodology and projections and allowed regional partners to build relationships necessary for the type of collaborative evaluations required by the 2018 and 2019 bills.

5. REFERENCES

Cordell, J., O. Kalata, A. Pleus, A. Newsom, K. Strieck, and G. Gersten. 2015. Effectiveness of Ballast Water Exchange in Protecting Puget Sound from Invasive Species: Results from WDFW/UW Ballast Water Sampling, 2001-2014. Report to the Washington Department of Fish and Wildlife and Washington Department of Natural Resources.

Davidson, I., C. Zabin, and G. Ruiz. 2014. An Assessment of Biofouling Introductions to the Puget Sound Region of Washington State. Report to the Washington Department of Fish and Wildlife and Washington Department of Natural Resources.

Drinkwin, J., A. Pleus, T. Therriault, R. Talbot, E.W. Grason, P.S. McDonald, J. Adams, T. Hass, and K. Litle. 2019. Salish Sea Transboundary Action Plan for Invasive European Green Crab. Washington Department of Fish and Wildlife, Department of Fisheries and Oceans Canada, Washington Sea Grant, and Puget Sound Partnership.
<https://wdfw.wa.gov/sites/default/files/publications/02045/wdfw02045.pdf>

Grason, E.W., P.S. McDonald, J.W. Adams, K. Litle, J.K. Apple, and A. Pleus. 2018. Citizen science program detects range expansion of the globally invasive European green crab in Washington State (USA). *Management of Biological Invasions*. 9(1): 39–47.

Kinney, A., T. Francis, and J. Rice. 2015. Analysis of Effective Regulation and Stewardship Findings: A Review of Puget Sound Marine and Nearshore Grant Program Results, Part 1. Puget Sound Institute. Tacoma, WA. <https://www.eopugetsound.org/articles/review-puget-sound-marine-and-nearshore-grant-program-results-part-1>

Kinney, A., T. Francis, and J. Rice. 2016a. Analysis of Invasive Species, Toxics, Oil Spill, and Integrated Risk Assessment Findings: A Review of Puget Sound Marine and Nearshore Grant Program Results, Part 2. Puget Sound Institute. Tacoma, WA.
<https://www.eopugetsound.org/articles/review-puget-sound-marine-and-nearshore-grant-program-results-part-2>

Kinney, A., T. Francis, and J. Rice. 2016b. Analysis of Strategic Capital Investments for Habitat Restoration and Protection: A Review of Puget Sound Marine and Nearshore Grant Program Results, Part 3. Puget Sound Institute. Tacoma, WA.
<https://www.eopugetsound.org/articles/review-puget-sound-marine-and-nearshore-grant-program-results-part-3>

Kinney, A., T. Francis, and J. Rice. 2016c. Synthesis of 2011-2014 Results and Key Recommendations for Future Recovery Efforts: Final Analysis Report for the Puget Sound Marine and Nearshore Grant Program. Puget Sound Institute. Tacoma, WA.
<https://www.eopugetsound.org/articles/puget-sound-marine-and-nearshore-grant-program-results-final-analysis-report>

Lane, H., Z. Brooks, and K. Reynolds. 2016. Ballast Water and Biofouling Regulatory Gap Analysis. Prepared for the Washington Department of Fish and Wildlife by Glosten.

McClary D., P. Paschke, M.A. Rempel-Hester, M. Knowlen, and M. Pinza. 2017. Washington state vessel-related biofouling management 6-year strategic plan. Prepared for the Washington Department of Fish and Wildlife by Ramboll Environ.

Moore, Z., A. Pleus, H. Lane, and K. Reynolds. 2017. Washington Department of Fish and Wildlife Six-Year Strategic Plan, Ballast Water Management. Document No. 16050.01. Prepared for the Washington Department of Fish and Wildlife by Glosten.

Van Dorp, J.R. and J. Merrick. 2016. VTRA 2015 Final Report: A Potential Oil Loss Comparison of Scenario Analyses by Four Spill Size Categories. Prepared for the Department of Ecology.

Washington Department of Ecology. 2016. 2016 Salish Sea Oil Spill Risk Mitigation Workshop Summary Report. Publication No. 17-08-005.

Washington Department of Ecology. 2017. Focus Sheet: 2015 Vessel Traffic Risk Assessment (2015 VTRA) Final Report Summary. Publication No. 17-08-007.

Washington Department of Ecology. 2017. Focus Sheet: 2016 Salish Sea Oil Spill Risk Mitigation Workshop. Publication No. 17-08-003.

Washington Sea Grant. 2016. European Green Crab Early Detection and Monitoring Final Report. Prepared by E.W. Grason, J.W. Adams, K. Litle, P.S. McDonald, and P.D. Dalton. Report WSG-TR 16-07 prepared for Washington Department of Fish and Wildlife.

Washington Sea Grant. 2018a. European Green Crab Early Detection and Monitoring Larval Transport Modeling Summary. Prepared by E. Brasseale, P. MacCready, E. Grason. P.S. McDonald, J. Adams, and K. Litle for Washington Department of Fish and Wildlife.

Washington Sea Grant. 2018b. European Green Crab Early Detection and Monitoring, Phase 2 Final Report. Prepared by E.W. Grason, J.W. Adams, P.S. McDonald, K. Martin, and K. Litle for Washington Department of Fish and Wildlife.

U.S. Environmental Protection Agency. 2019. National Pollutant Discharge Elimination System (NPDES): Vessels Incidental Discharge Permitting. Web Page. Accessed March 2019.
<https://www.epa.gov/npdes/vessels>