Salish Sea Transboundary Action Plan for Invasive European Green Crab

December 2018

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SIGNATORY PAGE

We, the undersigned, recognize European green crab management is essential for the protection of the Salish Sea and that the best way to provide that protection is through implementation of this Action Plan.

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Washington Dept. Fish and Wildlife (Date)	Department of Fisheries and Oceans Canada (Date)
_____	_____
Puget Sound Partnership (Date)	Washington Sea Grant (Date)
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GLOSSARY

Acronyms used in document:

- "AIS" means Aquatic Invasive Species
- "DFO" means the Department of Fisheries and Oceans Canada.
- "EGC" means European green crab.
- "RCW" means Revised Code of Washington
- "TEGC" means the Transboundary European Green Crab work group.
- "WAC" means Washington Administrative Code
- "WDFW" means the Washington Department of Fish and Wildlife.
- "WSG" means Washington Sea Grant.

"**Contain**" means to prevent an invasive species from spreading outside a designated infested site.

"**Control**" means to stop or slow the growth in number or size, to prevent the maturation and spread, and/or to reduce the number of a species or the population of a species in an ecosystem (Environmental Law Institute 2004).

"**Detect**" means the verification of an aquatic invasive species' presence as determined by the Washington Department of Fish and Wildlife and Department of Fisheries and Oceans Canada within their respective jurisdictions.

"**Early detection**" means invasive species are detected at earliest point in the invasion process to allow cost effective and environmentally sound decisions to be made to prevent their spread and establishment.

"**Eradicate**" means, to the extent technically and measurably possible, to kill, destroy, remove, or otherwise eliminate an invasive species from a water body or property using physical, chemical, or other methods (Based on RCW 77.135.010(10) and Aquatic Invasive Species Regulations (SOR/2015-121))

"**Established**" means a population of a species where reproduction is occurring and that is expected to have a sustained presence.

"**Infested site**" means a geographic region, water body, facility, or water supply system that carries or contains an invasive species. Designation as an infested site does not require the species to be considered established (Based on RCW 77.135.070 and Aquatic Invasive Species Regulations (SOR/2015-121))

"**Invasive species**" means nonnative species that are not naturally occurring in the Salish Sea for purposes of breeding, resting, or foraging, and that pose an invasive risk of harming or threatening the Salish Sea's environmental, economic, or human resources. Invasive species include all stages of species development and body parts. They may also include genetically modified or cryptogenic species.

"**Manage**" means to prevent, control, and/or eradicate the introduction or spread of invasive species.

"**Partners**" are loosely defined as those entities who participate in response, management, and research at some level. While citizen science volunteers are partners, they are referred to as volunteers in some places in the plan because their training and support involve actions unique to them.

"**Rapid response**" means expedited management actions, as provided under RCW 77.135.060 and Aquatic Invasive Species Regulations (SOR/2015-121), triggered when invasive species are detected, for the time-sensitive purpose of containing or eradicating the species before it spreads or becomes further established.

"**Site**" means a geographic area of connected and similar habitat suitability for a given species where sampling, such as for early detection monitoring, can be expressed as representing the whole geographic area. In more complex, but geographically defined habitat, or where more intensive management is required, a site may be subdivided into sub-sites.

"**Stakeholders**" are loosely defined as those entities who don't formally participate in response, management, and research (i.e. partners) but nevertheless have a 'stake' in the outcome of EGC management, including, but not limited to shellfish growers, property owners, and those who rely on intact ecosystems.

EXECUTIVE SUMMARY

The purpose of the Salish Sea Transboundary Action Plan for Invasive European Green Crab (Plan) is to establish and implement a coordinated and collaborative response to incursions of European green crab that pose a risk of harming or threatening the environmental, economic, or human resources within the shared waters of the Salish Sea.

European green crab (EGC) is a globally-damaging invasive species that has produced a variety of ecological and economic impacts on temperate coastal shorelines worldwide. Prolific and gregarious, EGC are known to disturb native habitat, displace resident species, and alter natural food webs, when abundant. Additionally, EGC predation has caused significant harm to shellfish industries in some regions.

The EGC is a notorious aquatic invasive species, able to survive a wide range of temperatures and salinities. To reproduce, individual EGC are capable of releasing hundreds of thousands of larvae that can live up to 80 days and travel hundreds of kilometers on ocean currents. It is a generalist feeder, digging in the sediment for bivalves and other prey and has been linked to (among other documented impacts globally):

- Massive declines in commercial bivalve crops (reducing softshell clam landings from 15.4 million pounds or 7 million kilos to 2.3 million pounds or 1 million kilos) on the east coast of the U.S., contributing to fishery collapse (Glude 1955);
- Decimation of native clams and shore crabs in at least one California embayment causing alterations of the food web (Grosholz et al. 2000); and
- Substantial reduction (up to 75%) in eelgrass density in Nova Scotia and Newfoundland (Garbary et al. 2014; Matheson et al. 2016).

Potential impacts of an EGC invasion in the Salish Sea include degradation and destruction of eelgrass and estuarine marsh habitats, threats to the harvest of wild Salish Sea shellfish and the shellfish aquaculture industry, threats to the Dungeness crab fishery, threats to salmon recovery (and by extension threats to orca recovery), and a complex array of additional ecological impacts to food webs, all of which negatively impact the human uses and cultural resources of the Salish Sea. Because EGC poses risks to the economy, ecology, and cultural food resources of the Salish Sea, it is classified as a prohibited level 1 species in Washington State and as a control species by the Department of Fisheries and Oceans Canada.

Within the Salish Sea, the range of EGC is still quite limited, and to date the only established (self-sustaining) population occurs in Sooke Basin, British Columbia. As of October 2018, small numbers of EGC have been found at several other locations in British Columbia and Washington State. Now is our best chance to manage EGC in the Salish Sea to avoid the calamitous results of EGC invasions seen elsewhere around the world. There is no better time to prevent this harm than through a successful process of early detection, rapid response and proactive adaptive management.

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. Rather than playing ‘catch up’, we are ahead of the curve, acting aggressively to understand, identify and prevent incursions of EGC before they take hold and cause the dramatic impacts to the Salish Sea ecology and shellfish industry that have been seen on the East Coast of the United States and elsewhere around the globe. The coordinated, science-based adaptive response involves a team of dedicated partners executing geographically-broad, intensive trapping efforts. These ongoing management actions are designed to keep incursions within manageable size to avoid massive larval spread to other parts of the Salish Sea and in situ harm to local ecosystems.

Using lessons learned from successful early detection and rapid responses, this Salish Sea Transboundary Action Plan for Invasive European Green Crab lays out clear actions to be taken to prevent and/or minimize

harm to the environmental, economic, and human resources of the Salish Sea as a whole from an invasion of European green crab.

This action plan focuses on six objectives calling for:

- Collaborative management;
- Prevention of human-mediated introduction and spread;
- Early detection;
- Rapid response to newly detected incursions;
- Control of infested sites; and
- Strategic research to improve adaptive management.

Washington Department of Fish and Wildlife (WDFW), Department of Fisheries and Oceans Canada (DFO), and Transport Canada are the key regulatory managers of potential human-mediated introduction and spread of EGC through their respective Aquatic Invasive Species programs. Washington Sea Grant's (WSG) Crab Team program, in coordination with WDFW, plays a major role in early detection and rapid response by training and supporting hundreds of volunteers and agency and tribal staff to monitor sites for early detection.

The actions laid out in this plan follow WDFW's and DFO's legal authority and mandate to lead the response to EGC in the Salish Sea. The estimated costs of implementing this plan for the Washington State 2019-21 fiscal year biennium (July 1, 2019 to June 30, 2021) and projections for future years will be addressed in a separate budget document.

There is still opportunity to avoid major impacts from EGC in the Salish Sea by taking decisive and aggressive actions to contain populations and to prevent further introduction and spread of EGC in other parts of the Salish Sea.

INTRODUCTION

The European green crab (EGC) is included on the International Union for Conservation of Nature's (IUCN's) list of 100 of the world's worst alien invasive species (IUCN, 2018), it is classified as a prohibited level 1 species in Washington State, and is classified as a species for control in Canada. As an Aquatic Invasive Species (AIS), EGC devastates aquatic ecosystems, displacing native species, degrading and disturbing native habitats (including eelgrass), and altering food webs in a variety of locales worldwide. As a voracious consumer of bivalves, it also has caused significant harm to shellfish industries, particularly on the US East Coast. EGC pose serious risks to the economy and ecology of the Salish Sea.

However, it is possible to manage EGC in the Salish Sea to avoid the calamitous results of EGC invasions seen elsewhere around the world. There is time to act to prevent this harm through a successful process of early detection, rapid assessment, and adaptive response.

There is currently only one documented established population (self-sustaining) of EGC in the Salish Sea: Sooke Basin in British Columbia. As of October 2018, the EGC has been found at several other Washington State locations, including Dungeness Spit (USFWS Dungeness National Wildlife Refuge), Dungeness Landing River Park, Sequim Bay, Westcott Bay, Padilla Bay, Fidalgo Bay, Lagoon Point, and Kala Point and Scow Bay (collectively labeled as Pt. Townsend; Figure 3). With the exception of Dungeness Spit, only one to six crab have been captured at each location. In British Columbia, the EGC has been collected at Becher Bay, Port Renfrew and Witty's Lagoon, in addition to Sooke (Figure 1).

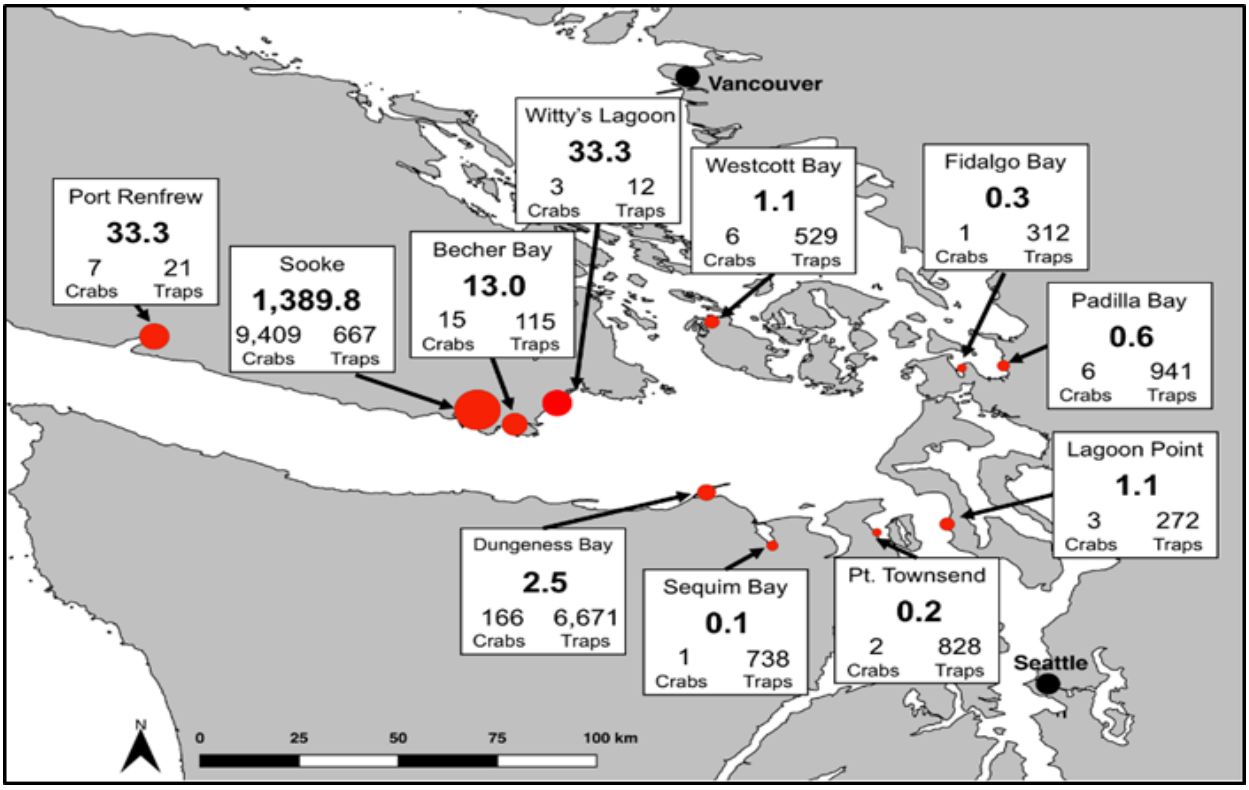

FIGURE 1. European green crab in the Salish Sea. Map of catch per unit effort (CPUE) of European green crab at all detection sites within the Salish Sea. The size of site markers is scaled (logarithmically) with CPUE which is defined as average number of EGC per 100 trap-days, including all trapping effort recorded since 2012. Because effort varies substantially geographically, actual catch (number of crabs) and effort (trap-days) for each location are reported below CPUE. Map data current as of 10/15/18.

The discovery in 2017 of EGC in Dungeness Spit, part of the U.S. Fish and Wildlife Service's Dungeness National Wildlife Refuge, activated rapid response action that had been piloted and refined the previous year in Westcott Bay and Padilla Bay. This resulted in a coordinated, science-based response involving a team of partners executing multi-day trapping efforts. Current ongoing management actions, involving a cadre of dedicated partners are on track to keep this population within manageable size, avoiding massive larval spread to other parts of the Salish Sea and in situ harm to the ecology of the refuge.

Using lessons learned from the successful early detection of EGC and rapid response at Dungeness Spit, this Salish Sea Transboundary Action Plan for Invasive European Green Crab lays out clear actions to be taken to prevent and minimize harm to the environmental, economic, and human resources from EGC in the Salish Sea.

SUCCESSFUL EARLY DETECTION AND RAPID RESPONSE

The response to early detections of EGC in the Salish Sea is a success story seldom seen in the world of Aquatic Invasive Species (AIS) Management. Rather than playing 'catch up' we are ahead of the curve, acting aggressively to prevent incursions of EGC before they take hold and cause the dramatic impacts to the Salish Sea ecology and shellfish industry that have been seen on the east coast of the United States and elsewhere around the globe.

The discovery of EGC in Sooke Basin in 2012 galvanized a forward-thinking management strategy in Washington State, capitalizing on an already active and engaged citizen science community to help detect EGC incursions into the Salish Sea as early as possible. In 2015, in partnership with WDFW, Washington Sea Grant launched Crab Team, a citizen science and outreach program to expand the scope of early detection. This strategy paid off when individual EGC were detected by Crab Team volunteers in Westcott Bay (San Juan County), and by outreach staff in Padilla Bay (Skagit County) in 2016. The subsequent rapid response actions, involving large scale trapping efforts designed in coordination by WDFW and WSG Crab Team scientists and implemented by partners, set the model for all rapid responses to follow.

Subsequently, the discovery in 2017 of EGC in Dungeness Spit, part of the Washington Maritime Wildlife Refuge resulted in another successfully coordinated, science-based adaptive response involving a team of partners executing multi-day trapping efforts at select sites with habitat suitable for EGC. The current site management activities, including active trapping throughout suitable habitats at Dungeness Spit, mobilization of engaged volunteers, education of refuge visitors, coordination of partners, and systematized data collection, are on track to keep this population within manageable size, avoiding massive larval spread to other parts of the Salish Sea and in situ harm to the ecology of the refuge.

TRANSBOUNDARY PLAN DEVELOPMENT

The purpose of the Salish Sea Transboundary Action Plan for Invasive European Green Crab (Plan) is to establish and implement a coordinated and collaborative response to incursions of EGC that pose a risk of harming or threatening the environmental, economic, or cultural resources within the shared waters of the Salish Sea. The Salish Sea includes Washington State's Puget Sound, the Strait of Juan de Fuca and San Juan Islands and British Columbia's Gulf Islands and Strait of Georgia.

This Plan was developed through the expertise of members of the Transboundary European Green Crab (TEGC) working group, comprised of representatives from Washington Department of Fish and Wildlife, Department of Fisheries and Oceans Canada, Washington Sea Grant, University of Washington, and the Puget Sound Partnership. The Plan is designed to drive actions to prevent, detect, and control invasions of EGC into the transboundary waters of the Salish Sea. As such, the Plan focuses on strategies and actions to be taken in the next two years (July 2018 through June 2020) and lays out clear performance measures associated with

each strategy. To inform decision-makers and funders, estimated costs associated with actions will be provided in a separate document. It is anticipated that the TEGC working group will lead the implementation of the Action Plan, applying adaptive management strategies over its term as new research findings or management tools emerge. The Plan is intended to be a living document and will be updated and revised every two years or as needed.

Strategies and actions identified in this plan were evaluated against the following key considerations:

- Does it address Washington State legislative directive under RCW 77.135.080 and Canadian Aquatic Invasive Species Regulations (SOR/2015-121) to:
    - Protect human safety?
    - Minimize adverse environmental impacts?
    - Minimize adverse economic impacts?
    - Consult/coordinate with appropriate federal, state, Tribal, local and other jurisdictions/interests?
- Is it protective of marine species and habitats?
- Will it drive better management?
- Is it economically cost effective?
- Is it science-based?

While a limited number of agencies and organizations are identified as leads for the actions in this plan, it is well understood that effective management of EGC in the Salish Sea will require collaboration from many different partners (federal, state or provincial agencies, and Washington tribal co-managers) and a variety of stakeholders. In this plan, partners are loosely defined as those entities who participate in response, management, and research at some level. While citizen science volunteers are partners, they are referred to as volunteers in some places in the plan because their training and support involve actions unique to them. Stakeholders are loosely defined as those entities who don't formally participate in response, management, and research (i.e. partners) but nevertheless have a 'stake' in the outcome of EGC management, such as shellfish growers, property owners, and those who rely on intact ecosystems.

STRATEGIC GOALS AND OBJECTIVES

The overall goal of this plan is to prevent and minimize harm to the environmental, economic, and human resources of the Salish Sea from invasive EGC. Objectives are identified in the below section 'Actions for transboundary EGC management.' Strategies designed to achieve these objectives are articulated with specific actions listed to implement each strategy. Performance measures for each strategy are identified.

The six plan Objectives are:

1. Collaboratively manage the response to EGC.

2. Prevent human-mediated introduction and spread of EGC.

3. Detect EGC presence at earliest invasion stage.

4. Rapidly eradicate or reduce newly detected populations.

5. Control persistent infested site populations to eliminate or minimize environmental, economic and human resource harm.

6. Conduct research to develop increasingly effective adaptive management strategies.

EUROPEAN GREEN CRAB IN THE SALISH SEA

SUMMARY OF DISTRIBUTION IN THE SALISH SEA

European green crab are native to the western and northern shorelines of Europe. They have spread through various pathways across the globe, establishing on the east coast of the United States more than 200 years ago. EGC became established on the west coast of the United States prior to 1989 in San Francisco Bay. They have since spread north and south from there (Behrens Yamada et al., 2015; Gillespie et al., 2007).

In 2012 DFO confirmed the first established Salish Sea EGC population in Sooke Basin on the Strait of Juan de Fuca. Since that time both DFO and WSG Crab Team have conducted early detection monitoring widely across the Salish Sea at sites identified as most suitable to EGC survival, but covering only about a quarter of all possible sites (Figure 2). DFO Science has trapped opportunistically along the BC shorelines of the Strait of Juan de Fuca, Southern Gulf Islands, and the Strait of Georgia several times since 2012. In 2015, WSG Crab Team launched a citizen science early detection monitoring network, systematically and repeatedly trapping habitats identified as most suitable to EGC survival (Figure 2).

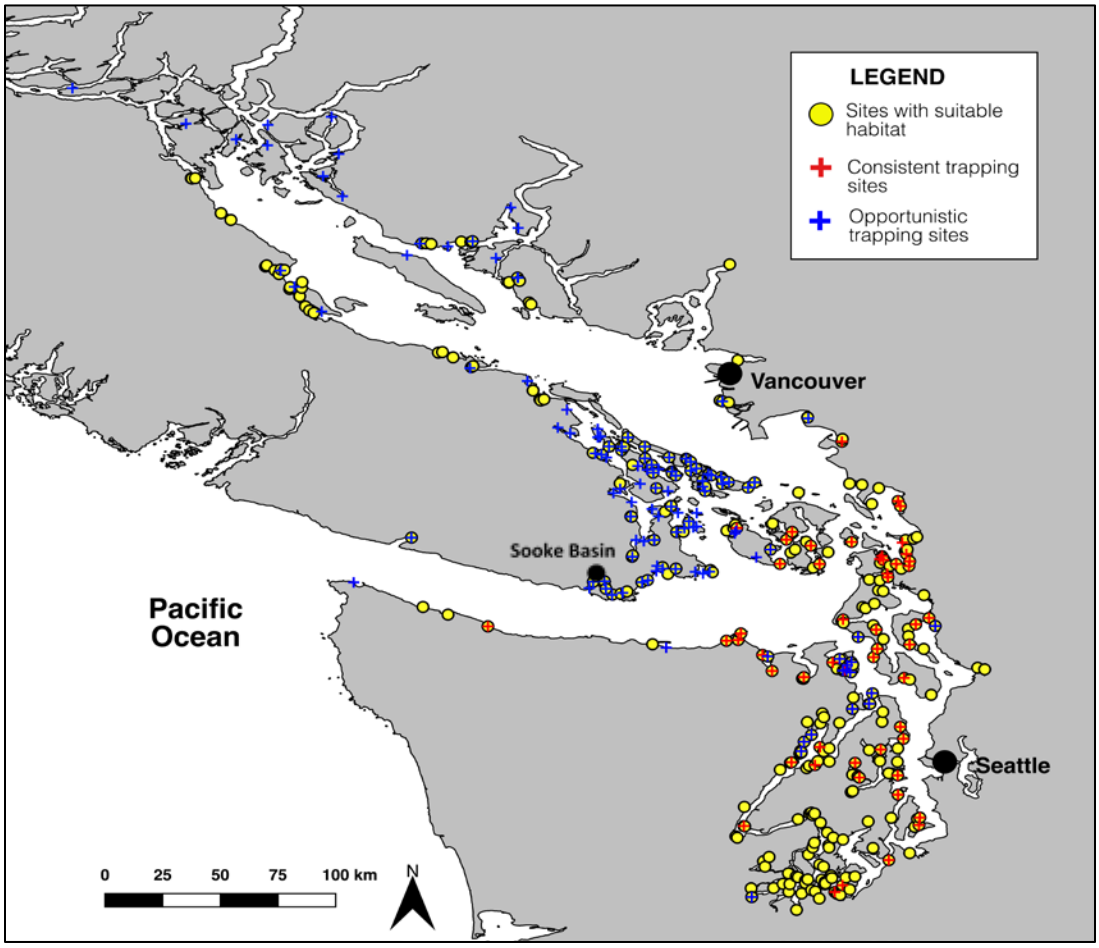

FIGURE 2. Map of European green crab suitable habitat and trapping in the Salish Sea. Suitable habitats indicate sites with medium to high suitability for European green crab based on semi-quantitative algorithm developed by WSG (Grason et al. 2016), but note that assessment of suitable habitat for Canadian shorelines is incomplete. Sites with consistent trapping indicate WSG Crab Team monitoring sites currently trapped each month (April - September) as part of Washington's early detection program. Sites identified as opportunistic trapping sites have had at least one monitoring effort since 2012, but are not regularly trapped. Map data current as of 10/15/18.

EGC were first recorded in the Washington portion of the Salish Sea in 2016 when WSG Crab Team volunteers discovered a single crab in Westcott Bay (San Juan County) and outreach staff found one crab in Padilla Bay (Skagit County) (Behrens Yamada et al., 2017; Grason et al., 2018). Subsequent trapping and monitoring in Washington State waters in 2017 and 2018 has documented small numbers of EGC at Dungeness Spit (USFWS Dungeness National Wildlife Refuge), Dungeness Landing River Park and Sequim Bay (Clallam County), Kala Point and Scow Bay (Jefferson County), Westcott Bay (San Juan County), Padilla Bay (Skagit County), and Lagoon Point (Island County) (Figure 1). With the exception of Dungeness Spit, only one to six EGC have been captured at each location.

Since 2016, DFO has conducted several trapping efforts throughout the southern Gulf Islands and along the southern coast of Vancouver Island. Beyond Sooke Basin, EGC were only found in small numbers at Becher Bay in 2017 and Witty's Lagoon in 2018, both just east of Sooke in the Strait of Juan de Fuca. West of Sooke, exploratory trapping detected a small number of EGC in Port Renfrew in 2018. The Sooke Basin population is known to be large, but no abundance estimates are available. No EGC have yet been found in the Gulf Islands or Strait of Georgia.

EGC were introduced in Sooke Basin through accidental human-mediated activities. However, for most other occurrences of EGC in the Salish Sea, the pathway of introduction is believed to be natural larval dispersal from established EGC populations along the outer west coast and potentially Sooke Basin during optimal ocean conditions. These optimal ocean conditions include storms during relatively warmer winters and unseasonably stormy summers, which can result in flow reversals in the Strait of Juan de Fuca, allowing larvae from the outer coast and Sooke Basin to pass into the Salish Sea. Warm conditions also accelerate the development of EGC larvae and protect them from fatally cold conditions (Behrens Yamada et al., 2017; Brasseale et al., 2018). Nearly all the EGC in the Salish Sea are estimated to have been from the 2015/2016 or later year classes, corroborating expectations that ocean conditions were favorable during those years (Grason et al., 2018)

Recent limited genetic studies of DNA from the outer West Coast, Sooke Basin, and Dungeness Spit EGC indicate that crabs from Sooke Basin are an isolated population, genetically distinct from EGC at Dungeness Spit and elsewhere on the West Coast. EGC found in other parts of the Salish Sea have not yet been genetically tested for source population. The genetic study did find evidence that Sooke Basin crab larvae are dispersing to the outer coast (Tepolt et al., 2018). More DNA research is needed to build our understanding of potential source populations for the Salish Sea.

EUROPEAN GREEN CRAB: BIOLOGY AND HARMFUL IMPACTS

BIOLOGY OF EUROPEAN GREEN CRAB

Mature EGC live in intertidal and shallow subtidal habitats. In the Salish Sea, it is most likely to be successful in intertidal, marshy habitats where it is safe from predation by larger crab (Howard, 2018). With a maximum carapace width of about 100mm (~4"), the green crab can grow larger than native Salish Sea shore crabs (*Hemigrapsus* spp.) but is smaller than adults of large native cancrid species (e.g., red rock, Dungeness and graceful). The carapace is slightly wider than it is long and is distinct from every other Salish Sea crab species in that it has five prominent marginal teeth (points) to the outside of each eye, along the edge of the carapace (Figure 3). Although commonly referred to as "green" this species often turns quite red as it ages and can be found with many different colors and patterns, particularly as juveniles (Grason et al., 2016).

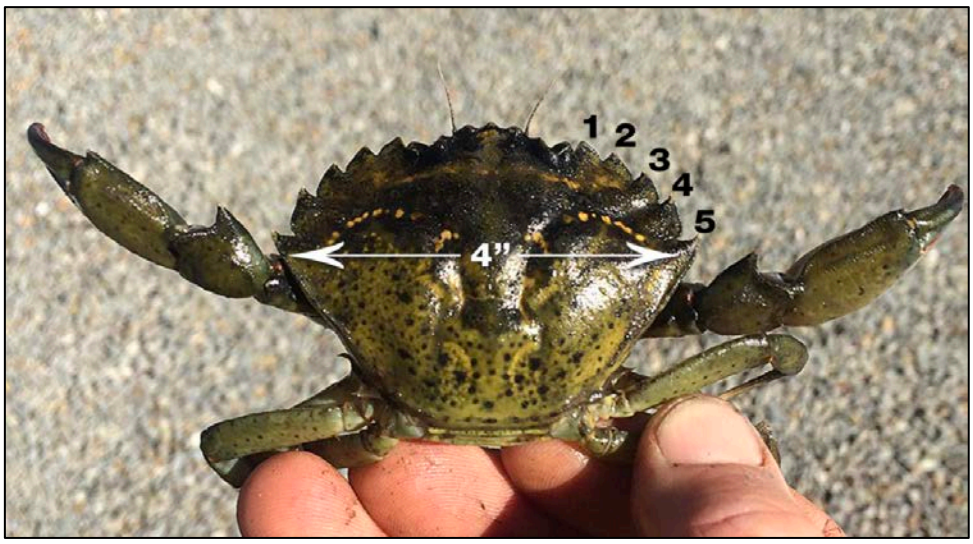

FIGURE 3. Adult European green crab showing most common shell color pattern and five distinct marginal teeth to the outside of each eye. Maximum size is up to about 100mm (4”). Photo courtesy of Jeff Adams/WSG

EGC is a successful invader because it can thrive in a wide variety of temperature and salinity ranges and it eats a wide variety of foods plentiful in the intertidal zone. On the west coast of North America, EGC live from 4-6 years. Female green crab can become reproductively mature during their first year owing to suitable conditions for rapid growth, and can produce up to 200,000 eggs at a time (Behrens Yamada et al., 2005). When eggs hatch, the free-swimming zoeae develop over 17–80 days, depending on water temperature, and can travel hundreds of kilometers on ocean currents as they metamorphose into megalopae that eventually settle onto the seafloor (Grason et al., 2016).

HARMFUL IMPACTS OF EUROPEAN GREEN CRAB

Ecology

The ecological impacts of an EGC invasion into the Salish Sea could include a complex array of interactions, further stressing an ecosystem already under threat from climate change, pollutants, habitat loss, and loss of biodiversity. Green crab can substantially alter food webs through competition with, and predation on, a wide range of native species, and they can degrade habitats through their role as ecosystem engineers. For instance, green crab disturb sediments and destroy below-ground tissue of plants while digging for food and burrows. These activities have been associated with decreased stability of saltmarsh banks (Aman and Grimes, 2016) and loss of eelgrass habitat. In one study in California, the densities of native clams and shore crabs declined by 5 to 10 times within a few years of green crab arrival (Grosholz et al., 2000). Such direct impacts are likely to trigger ripple effects throughout the community. Also in California, preferential predation on native clams by EGC was linked to enabling the population explosion of a previously rare invasive clam (Grosholz, 2005). EGC could also impact the health of shorebirds by damaging nesting and feeding habitat, and competing with them for food.

While the full suite of impacts would be wide-ranging, and due to the nature of invasions, difficult to anticipate, the most concerning anticipated impacts of EGC could be degradation of eelgrass habitats and predation on wild-capture shellfish harvests. Each of these will be described in detail below.

Eelgrass

In the Salish Sea, eelgrass provides valuable structure, stability and habitat where there would otherwise be

relatively bare, unproductive substrate (Plummer et al., 2013). It is an important food source, nursery and refuge for birds, fishes, crabs, and many marine invertebrates, and substrate for epiphytic algae, supporting an extended food web from amphipods to orca pods.

EGC have been associated with drastic (up to 75%) reduction in eelgrass density in Nova Scotia and Newfoundland after invasion. EGC damage eelgrass by disturbing sediments, uprooting eelgrass shoots and grazing directly on the plants (Garbary et al., 2014). EGC have been implicated in damage to eelgrass (*Zostera marina*) beds (Malyshev et al., 2011) and failed efforts to restore eelgrass habitats on the east coast of the United States (Figure 4). EGC can also destabilize the substrate and cause changes in the sediment, affecting eelgrass success.

In the Salish Sea, damage to eelgrass could: reduce quality and habitat availability for juvenile salmonids, forage fishes, crabs and other species; impair carbon-storage capacity of tidelands; increase wave exposure and change tideland shape and reduce available foraging area for shorebirds. Establishment of dense populations of EGC could hinder efforts to achieve the Washington State Puget Sound recovery goal to increase eelgrass area 20% by 2020 (Grason et al., 2016). In addition, establishment of EGC in the Salish Sea could undermine eelgrass restoration efforts funded through DFO's Coastal Restoration Fund and other sources.

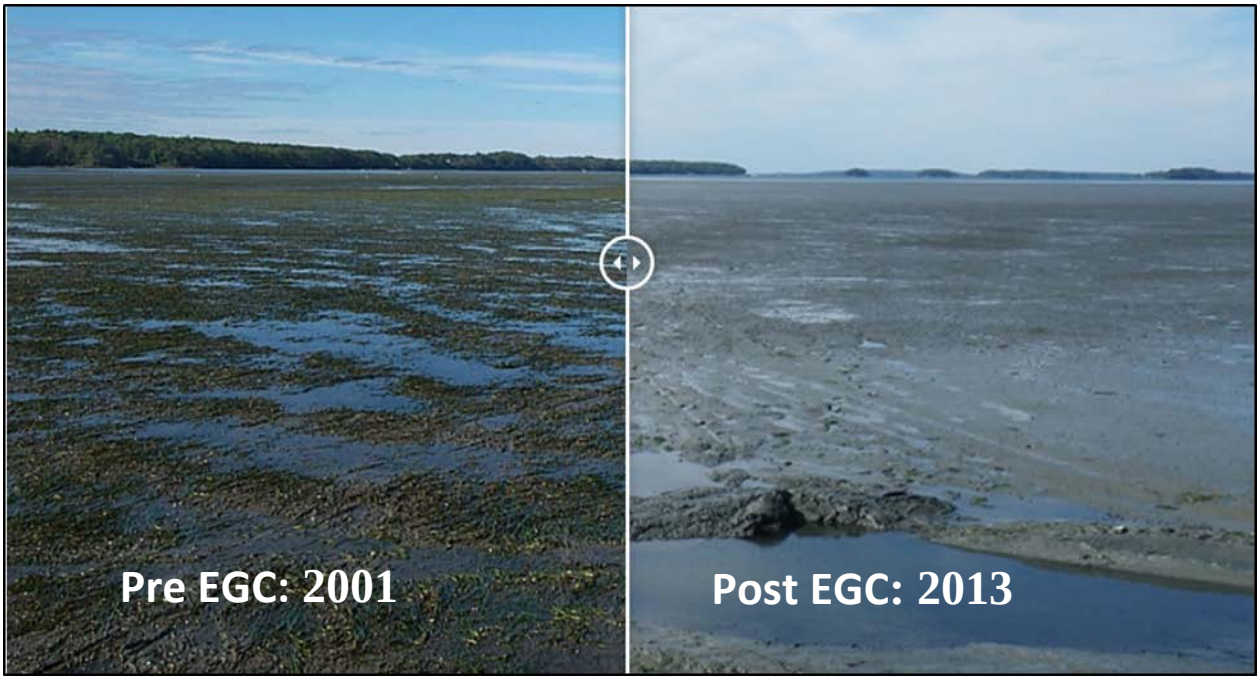

FIGURE 4**.** Photos of Maquoit Bay, Maine, before and after dense European green crab populations. Photos by Hillary Neckles/U.S. Geological Survey (Grason et al., 2016)

Shellfish resources

Harvest of wild shellfish and culture of commercially produced clams, oysters, and mussels are important to the Salish Sea both economically and culturally. Washington Tribes and indigenous groups in British Columbia have harvested wild shellfish for thousands of years. Today they harvest shellfish commercially, ceremonially, and for subsistence (Pacific Shellfish Institute, 2018). Recreational harvest of wild shellfish stocks has long been a popular activity. In 2011, roughly 347,000 recreational fishing/shellfishing licenses were purchased in Washington State. Likewise, Washington State is the largest producer of hatchery-reared

and farmed shellfish in the United States, with estimates that 3,200 jobs are directly or indirectly supported by State shellfish growers, contributing an estimated US$270 million to the State economy (Washington Shellfish Initiative, 2011). In 2016, the value of shellfish produced in British Columbia's aquaculture industry was C$23.6 million (Department of Fisheries and Oceans Canada, 2018). The majority of shellfish aquaculture sites in British Columbia are located in the Salish Sea (Department of Fisheries and Oceans Canada, 2017c).

EGC is a major predator of clams, mussels, oysters, and other species in natural settings and in aquaculture (Gillespie et al., 2007). When EGC are abundant they produce significant impacts to wild harvest and culture of shellfish and this is most pronounced in invaded areas, particularly the western Atlantic including Maine, Nova Scotia, and the Maritime provinces. The invasion of EGC in New England in the 1950s contributed to the decline of softshell clam landings, from 14.5 million pounds to 2.3 million pounds over 20 years, as EGC populations expanded (Welch, 1968 as cited in Behrens Yamada et al., 2005). In a Nova Scotia study, a single EGC consumed up to 21.8 small softshell clams (*Mya arenaria*) per day and the authors linked local clam declines to an expanding crab population (Floyd and Williams, 2004). These impacts appear to be increasing as EGC become more abundant and widespread.

The shellfish industry within the native range of EGC uses anti-predator netting to mitigate losses, which can be significant for mussels (Dare and Edwards, 1976) and cockles (Masski and Guillou, 1999). Similar measures are in development for softshell clams in New England, where beds of wild shellfish have been decimated (Beal and Kraus, 2002). In Washington State and British Columbia, the shellfish industry has a history of using netting and bags to minimize losses of cultured shellfish due to naturally occurring predators. Thus the sector may be insulated from some EGC impacts. However, harvesters who rely on naturally reproducing and seeded geoduck, manila clams and softshell clams, are most at risk (Howard et al., 2018). In Washington State, this includes recreational harvest as well as tribal commercial and subsistence harvest.

The Dungeness crab fishery in the Salish Sea may also be at risk. In Puget Sound (Washington State), the Dungeness crab fishery is valued at upwards of US$10 million (Antonelis et al., 2011). Most of the Puget Sound Dungeness crab fishery occurs from Everett northward, in areas near documented incursions of EGC: Padilla Bay and Dungeness Bay in particular are areas that produce large commercial quantities of Dungeness crab (Washington Department of Fish and Wildlife, 2018). The Dungeness crab fishery in British Columbia averaged C$46 million from 2013-2015, with about 30% of that coming from crab management areas of the Salish Sea (Department of Fisheries and Oceans Canada, 2017a).

Laboratory experiments have demonstrated that EGC outcompete juvenile Dungeness crab for food and shelter and larger EGC will prey upon smaller Dungeness crab or displace them from refuge, potentially exposing them to other predators (McDonald et al., 2001). Moreover, EGC are known to damage eelgrass beds (Garbary et al., 2014), a key habitat for juvenile Dungeness crab (Behrens Yamada et al., 2010) . Dungeness crab preferentially settle in eelgrass beds, where survival is significantly higher than bare mud and sand habitat (Fernandez et al., 1993). Thus eelgrass allows survival of Dungeness crab in early life history, and habitat loss could substantially impact Dungeness crab populations.

Loss of shellfish resources could have important policy implications for Washington State Treaty Tribes. Under the Rafeedie decision of 1994, Washington State is required under Federal Treaties of 1865 to maintain healthy populations of wild shellfish (e.g., clams, mussels, oysters, crab). Judge Rafeedie affirmed that the agreement "reserved an equal share of the sustainable harvest of shellfish for the state's Treaty Tribes" (Rafeedie 1994). It is unclear what impacts spread of EGC could have on co-management of shellfish resources.

PATHWAYS OF EGC INTRODUCTIONS AND SPREAD IN THE SALISH SEA

HUMAN-MEDIATED INTRODUCTIONS AND SPREAD

Like most AIS, the human-mediated pathways of EGC introduction and spread in the Salish Sea may include shipping, aquaculture practices, recreational and commercial boating, live bait and aquarium/water garden trade, and unauthorized introductions. Many of these pathways, such as aquaculture, are already well regulated to avoid the inadvertent transfer of EGC, but vigilance and review is necessary to make sure there are no potential gaps. The introduction of EGC to Sooke Basin is thought to have resulted from non-aquaculture shellfish transfer from an established population on the west coast of Vancouver Island. Initial introductions of EGC to the west coast in San Francisco are thought to have come from seaweed packing in lobster or bait shipments originating from the east coast of the United States (Gillespie et al., 2007; Wonham and Carlton, 2005; Carlton and Cohen, 2003) .

Shipping and boating

EGC can be transported as larvae in untreated ballast water by large commercial vessels (Carlton and Cohen 2003). Ballast water is currently regulated by Transport Canada in British Columbia and by WDFW in Washington to require that vessels replace ballast water collected at the port of origin with open-ocean water or treat their ballast water using an approved management system. However, in Canada, ships entering the Salish Sea from ports north of Cape Blanco, Oregon are exempt from these exchange requirements (Transport Canada, 2006) and ballast water management systems are still only used on a fraction of vessels. Similarly, in Washington, a ship may discharge unexchanged ballast water into the Salish Sea if that water originated within the waters of Washington state, the Oregon portions of the Columbia River system, and the internal waters of British Columbia south of latitude 50° N. Unfortunately, these exemptions from ballast water management requirements create a risk that intracoastal vessels could carry EGC larvae from coastal populations of Oregon, Washington and British Columbia into the Salish Sea, or between infested ports within the Salish Sea (Dibacco et al., 2012; Cordell et al., 2015).

Biofouling, or the gradual accumulation of organisms such as algae, bacteria, barnacles, and protozoa on ships, boats, and marine equipment or structures, is a known pathway for many AIS but has not been a documented source of introduction or spread of EGC. There is currently little regulatory framework in place to address risks of AIS transport by biofouling. Progress is being made across the region on regulatory strategies for biofouling management for commercial merchant and passenger vessels, but not for recreational boats or marine equipment (Scianni et al., 2017).

Sea-chests, or recesses built into vessel hulls, have been identified as pathways for EGC introduction. A recent study in Canada found that 46% of the commercial vessels' sea-chests investigated harbored non-indigenous species (Frey et al., 2014). The study documented a large number of one AIS (the caprellid amphipod, *Caprella mutica*) in sea-chests of vessels exclusively operating in the west or east coast of Canada. This result furthers the argument for investigating management strategies aimed at preventing EGC spread by intra-coastal vessels as well as management of sea-chest.

Shellfish aquaculture practices

Transportation and shipping of shellfish product and movement of gear can be a pathway of introduction and spread for AIS, including EGC. Though the industry is heavily regulated and in general applies practices that have significantly addressed potential pathways of unintentional movement, introduction and spread of EGC in shellfish product transport and during farming operations is still a risk in the Salish Sea. For example, DFO

recently found EGC on samples of three shellfish species which are regularly transferred from the west to the east coast of Vancouver Island for processing (Curtis et al., 2015).

In British Columbia, there are no shellfish processing plants on the west coast of Vancouver Island and all harvested shellfish must be transferred to the eastern side of the Island or to the lower mainland for processing. Shellfish companies throughout the Salish Sea regularly move shellfish products (including oyster seed, cultch and shell) and aquaculture equipment (including aquaculture vehicles and vessels) from one water body to another. There are some conditions of license intended to reduce the likelihood of inadvertent movement of EGC, but the efficacy of these conditions is unknown.

In Washington, WDFW requires shellfish import permits to import live shellfish for aquaculture, research and display purposes (Chapter 77.60 RCW; Chapters 220-340 and 220-370 WAC). Transfer permits are required for the movement of shellfish, shellfish aquaculture products (including oyster seed, cultch and shell), aquaculture equipment (including aquaculture vehicles and vessels) and any marine organism adversely affecting shellfish. There are regulations related to ensuring any cultch placed in the Salish Sea has been dried out before placement.

Shellfish companies implement best management practices to avoid introduction and spread of AIS, including rinsing equipment and product before moving it. Nevertheless, the effectiveness of these measures, and the degree of rigor with which they are applied, needs to be reviewed in collaboration with the industry.

Moreover, there is also a thriving home-based shellfish grower community, which requires targeted education and outreach to prevent the introduction and spread of EGC or other AIS in the Salish Sea.

Trade in live EGC

Introduction and spread of EGC to the Salish Sea from live trade in EGC, from bait trade or otherwise, is considered a lesser risk than ballast water or shellfish aquaculture practices. In Washington, EGC is classified as a prohibited level 1 species, meaning live EGC may not be possessed, purchased, sold, propagated, transported, or released into state waters (RCW 77.135.040, WAC 220-640-030). In British Columbia, DFO regulates any capture of EGC through the Fisheries General Regulations and the Aquatic Invasive Species Regulations. There is currently no live bait trade in EGC on the west coast of North America. All collecting of EGC during early detection trapping is done in compliance with permits issued by WDFW and DFO.

LARVAL DISPERSAL

Dispersal of larvae on ocean currents is a significant non-human mediated pathway of AIS introduction and spread and believed to be responsible for most arrivals of EGC into the Salish Sea. Though initial introduction of EGC to San Francisco Bay was likely through ballast water exchange or packaging of seafood product or live bait from the east coast of the United States, the gradual spread of EGC north to establish populations in British Columbia, Oregon, and the Washington Coast was facilitated through larval dispersal on ocean currents (Behrens Yamada et al., 2005). EGC can survive up to 80 days drifting on ocean currents and can travel for hundreds of kilometers before settling. Strong, positive, El Niño-Southern Oscillation (ENSO) conditions favor the survival, transport, and nearshore retention of green crab larvae to the Salish Sea from as far away as central California (Behrens Yamada et al., 2015; Brasseale et al., 2018).

Recent genomics and ocean modeling research initiated by members of the TEGC working group has helped elucidate patterns of larval dispersal and demonstrated that this pathway can occasionally enable EGC larvae from outer coast populations to enter the Salish Sea. Based on genomics, EGC collected at Dungeness Spit in 2017 originated in outer coast populations (Tepolt et al., 2018). Additional ocean modeling work shows that

larvae can be washed into the Salish Sea from known source populations on the coast during relatively warm and stormy winters or unseasonably stormy summers (Brasseale et al., 2018). Moreover, due to the current patterns, larvae tend to get swept in along the south side of the Strait of Juan de Fuca (Behrens Yamada et al., 2017; Brasseale et al., 2018).

MANAGEMENT OF EUROPEAN GREEN CRAB

Department of Fisheries and Oceans Canada

In British Columbia, management of EGC falls under the AIS National Core Program, managed by the Ecosystem Management Branch of the DFO. EGC are listed as a control species under the AIS Regulations in the Canadian Fisheries Act. The Science Branch of DFO is also active in informing management of EGC in British Columbia. The Science Branch monitors distribution of EGC along the outer coast and in the Salish Sea, documenting presence/absence and relative abundance, size and sex to understand different year classes and maintains this in a database that allows the generation of maps to inform management. Further, DFO has an established AIS rapid response framework to guide development of rapid response plans for specific AIS (Locke et al., 2011).

Transport Canada

Transport Canada is responsible for enforcing regulations associated with vessels greater than 24 meters in length arriving from outside the Canadian Exclusive Economic Zone (EEZ). Therefore, it falls to Transport Canada to enforce ballast water regulations for these vessels. However, as noted above, there are exemption zones and domestic ballast water currently is not regulated in Canada.

Washington Department of Fish and Wildlife

In Washington, management falls under the AIS Program of WDFW. The WDFW AIS program is responsible for preventing the introduction of new AIS and controlling or eradicating established AIS populations. The requirements of WDFW's Ballast Water Management Program are set forth in Chapter 77.120 RCW and Chapter 220-650 WAC. The State shares regulatory responsibility for ballast water activity with the U.S. Coast Guard and the U.S. Environmental Protection Agency, both of which regulate ballast water activity at the federal level.

The WDFW Ballast Water Management Program coordinates a Ballast Water Work Group that is comprised of representatives of shipping interests, ports, shellfish growers, fisheries managers, environmental interests, citizens who have knowledge of the issues, and appropriate governmental representatives including the USCG, EPA, and tribal governments. In 2009, the BWWG was reestablished under WAC 220-650-010 to advise WDFW on developing, revising, and implementing chapters RCW 77.120 and WAC 220-650 regarding ballast water and biofouling management (Aquatic Nuisance Species Committee, 2007; Moore et al., 2017).

Washington Sea Grant

Washington Sea Grant (WSG), in cooperation and coordination with WDFW, plays a major role in managing EGC in the Salish Sea. Its WSG Crab Team citizen science program trains hundreds of volunteers to monitor sites for early detection. The program was responsible for the discovery of the first EGC documented in Washington's Salish Sea and has subsequently succeeded in finding EGC in other locations through systematic early detection monitoring (Grason et al., 2018). The protocols developed for the program are used throughout the Salish Sea and WSG program personnel regularly train WDFW, DFO, and partner staff on trapping, identification, and data collection. The WSG website, blogs, and educational programs are instrumental in

informing the public and partners about the status of EGC in the Salish Sea, and increasing the capacity of early detection in Washington.

Regional Partners

The Pacific States Marine Fisheries Commission (PSMFC) facilitates regional approaches to AIS management in a variety of ways, including by coordinating the Pacific Ballast Water Group. WDFW and DFO participate in that working group. PSMFC, WDFW, DFO and WSG also participate on the Western Regional Panel on Aquatic Nuisance Species. Washington and British Columbia are also represented on the Pacific Northwest Economic Region (PNWER) Invasive Species Working Group. The Jamestown S'Klallam Tribe has jurisdiction and cultural interests on the Olympic Peninsula in Washington and has been a strong partner for early detection monitoring at Sequim Bay and other sites. Other Washington tribes currently contributing to EGC management actions include the Lower Elwha Klallam Tribe, Makah Tribe, Port Gamble S'Klallam Tribe, Samish Indian Nation, Stillaguamish Tribe of Indians, Swinomish Indian Tribal Community, and Suquamish Tribe.

Site Managers and Key Stakeholders

Management of EGC in the Salish Sea naturally involves private property owners as key stakeholders as well as federal and state agency partners as managers of sites. Dungeness Spit is part of the National Wildlife Refuge complex, so management at that site falls to the U.S. Fish and Wildlife Service. Padilla Bay, a federally designated National Estuarine Research Reserve managed by the Washington State Department of Ecology, and Washington Department of Natural Resources (DNR) also participate in EGC management activities at sites under their respective management jurisdiction.

ACTIONS FOR TRANSBOUNDARY EUROPEAN GREEN CRAB MANAGEMENT

OBJECTIVE 1: COLLABORATIVELY MANAGE THE RESPONSE TO EUROPEAN GREEN CRAB.

STRATEGY 1.1: WASHINGTON DEPARTMENT OF FISH AND WILDLIFE (WDFW) LEADS EGC ADMINISTRATION AND COORDINATION EFFORTS IN WASHINGTON STATE.

Action 1.1.1: WDFW's AIS program allocates or seeks adequate funding for administration and coordination of the Salish Sea Transboundary Action Plan for Invasive European Green Crab (Plan).

Action 1.1.2: WDFW consults/coordinates with Tribes in Washington State on the implementation of the Plan.

Action 1.1.3: WDFW maintains participation in the Transboundary EGC (TEGC) working group.

Action 1.1.4: WDFW AIS staff keeps agency leadership and legislature informed about status of Plan implementation and EGC risks in the Salish Sea.

Performance measures:

PM 1.1A: WDFW AIS program allocates dedicated staff time to EGC management.

PM 1.1B: WDFW consults/coordinates with Tribes in Washington State on the implementation of the Plan.

PM 1.1C: WDFW AIS coordinator participates in TEGC working group.

STRATEGY 1.2: DEPARTMENT OF FISHERIES AND OCEANS CANADA (DFO) LEADS EGC ADMINISTRATION AND COORDINATION EFFORTS IN BRITISH COLUMBIA

Action 1.2.1: DFO AIS National Core Program and Science branch allocates or seeks adequate funding for administration and coordination of the Plan.

Action 1.2.2: DFO consults/coordinates with indigenous groups in British Columbia on the implementation of the Plan.

Action 1.2.3: DFO maintains participation in the TEGC working group.

Action 1.2.4: DFO Science and AIS National Core Program staff keeps agency leadership informed about status of the Plan and EGC risks in the Salish Sea.

Performance measures:

PM 1.2A: DFO AIS National Core program and Science branch allocates dedicated staff time to EGC management.

PM 1.2B: DFO consults with indigenous groups regarding coordination on Plan implementation.

PM 1.2C: DFO Science and AIS National Core Program staff participates in TEGC working group.

STRATEGY 1.3: TRANSBOUNDARY EGC WORKING GROUP ENSURES THAT ACTIONS IN WASHINGTON AND BRITISH COLUMBIA ARE COORDINATED AND COMPLEMENTARY.

Action 1.3.1: TEGC working group reviews Plan implementation quarterly.

Action 1.3.2: WDFW leads preparation of a report on implementation of the Plan after two years of implementation.

Action 1.3.3: Partners use Plan Actions to develop individual EGC management workplans.

Action 1.3.4: TEGC coordinates development/collation of standard protocols for EGC monitoring, trapping, data collection, QA/QC, field gear decontamination, and reporting.

Action 1.3.5: WSG coordinates training of partners on protocols and best practices for early detection site selection, trapping techniques, and data collection.

Performance measures:

PM 1.3A: TEGC working group meets at least quarterly and reviews implementation of the Plan and makes adaptive changes as necessary.

PM 1.3B: Partners are consulted when work plans related to Plan Actions are developed.

PM 1.3C: Biennial report of Plan is reviewed and accepted by TEGC working group.

PM 1.3D: Standard protocols for early detection and site management are implemented by partners working to manage EGC in the Salish Sea.

PM 1.3E: Trainings in established protocols are held for new partners as needed.

STRATEGY 1.4: CAPACITY AND FUNDING ARE ADEQUATE FOR PARTNERS TO EFFECTIVELY MANAGE EGC IN THE SALISH SEA

Action 1.4.1: WDFW allocates or seeks adequate funding for implementation of collaborative management of the Plan.

Action 1.4.2: DFO allocates or seeks adequate funding for implementation and collaborative management of the Plan.

Action 1.4.3: WSG seeks adequate funding for implementation of Crab Team program Plan Actions.

Performance measures:

PM 1.4A: WDFW AIS program receives sufficient funding to address EGC management.

PM 1.4B: DFO AIS National Core program receives sufficient funding to address EGC management.

PM 1.4C: WSG Crab Team receives sufficient funding to address EGC early detection and management support.

STRATEGY 1.5: ALL DATA AND RESEARCH RESULTS ASSOCIATED WITH EGC IN THE SALISH SEA ARE CONSOLIDATED AND SHARED EFFECTIVELY.

Action 1.5.1: Partners use standard data collection, record-keeping, and QA/QC protocols.

Action 1.5.2: Partners conducting early detection monitoring share information on new detections with TEGC within 48 hours.

Action 1.5.3: TEGC ensures data on Salish Sea EGC is shared to U.S./Canadian regional, national and global AIS databases.

Action 1.5.4: DFO consolidates and standardizes EGC data collected by Science and Management branches.

Action 1.5.5: TEGC supports the development of an accessible regional EGC database.

Performance measures:

PM 1.5A: Information on new EGC detections is made publicly available within one week of detection.

PM 1.5B: Salish Sea EGC database is operational and accessible to partners by June 30, 2020.

PM 1.5C: Salish Sea EGC data is provided to regional and/or national databases as available at least on an annual basis.

OBJECTIVE 2: PREVENT HUMAN-MEDIATED INTRODUCTION AND SPREAD OF THE EUROPEAN GREEN CRAB.

STRATEGY 2.1: EDUCATE PARTNERS, MARINE USERS AND THE PUBLIC ABOUT HOW TO AVOID INTRODUCING EGC.

Action 2.1.1: WDFW, DFO, and WSG provide information on their websites and in outreach materials to other partners, stakeholders, and the public about how to avoid introducing and spreading EGC.

Action 2.1.2: WDFW, DFO, and WSG coordinate with tribes in Washington, indigenous groups in British Columbia, and other partners to provide information on their websites and in outreach materials about how to avoid introduction and spread of EGC.

Performance measures:

PM 2.1A: EGC information on websites of WDFW, DFO and WSG is current.

PM 2.1B: Public information is available at 10 WA/BC locations/websites frequented by marine user groups in the Salish Sea.

PM 2.1C: WDFW, DFO, and WSG will provide a combined total of at least 10 presentations per year to marine/nearshore user groups.

PM 2.1D: WDFW, DFO, and WSG distribute outreach materials to 10 marine/nearshore user group events per year.

STRATEGY 2.2: PREVENT INTRODUCTION OF EGC FROM AQUACULTURE OPERATIONS.

Action 2.2.1: WDFW and DFO consult/collaborate with shellfish growers association forums and local shellfish growers to ensure growers understand pathways of EGC introduction.

Action 2.2.2: DFO enforces regulations related to moving product from west to east Vancouver Island.

Action 2.2.3: WDFW enforces aquaculture transport regulations in Washington.

Action 2.2.4: WDFW and DFO investigate compliance with and adequacy of current shellfish industry best management practices to prevent spread of EGC.

Performance measures:

PM 2.2A: Pacific Coast Shellfish Growers Association (PCSGA) and British Columbia Shellfish Growers Association (BCSGA) include information about prevention of introduction and spread of EGC in materials for growers.

PM 2.2B: All aquaculture transport complies with regulations designed to prevent introduction and spread of

EGC in the Salish Sea.

STRATEGY 2.3: PREVENT INTRODUCTION OF EGC FROM BALLAST WATER.

Action 2.3.1: WDFW requests Transport Canada review the risks of foreign and domestic intracoastal unexchanged vessels.

Action 2.3.2: WDFW requests Transport Canada enforce current ballast water regulations.

Action 2.3.3: WDFW reviews risk of intracoastal unexchanged vessels.

Action 2.3.4: WDFW enforces current ballast water regulations.

Performance measures:

PM 2.3A: Risks of introduction and spread of EGC from the intracoastal vessel pathway are identified.

PM 2.3B: Ballast water is managed to prevent introduction and spread of EGC.

STRATEGY 2.4: PREVENT INTRODUCTION OF EGC FROM BIOFOULING, RECREATIONAL BOATING, BAIT TRADE, RESEARCH AND EDUCATION, AND LIVE TRADE.

Action 2.4.1: WDFW enforces restrictions on live EGC trade.

Action 2.4.2: DFO enforces regulations and licensing related to AIS.

Action 2.4.3: WDFW enforces regulations related to vessel biofouling.

Action 2.4.4: WDFW evaluates risk of mussel transfer practices of WDFW Mussel Monitoring Survey program.

Action 2.4.5: WDFW and DFO investigate the adequacy of other known pathways to prevent introduction and spread of EGC.

Performance measures:

PM 2.4A: Risks of introduction and spread of EGC from live trade, biofouling, WDFW Mussel Monitoring Survey program and other known pathways are identified.

PM 2.4B: Recommendations are provided on how to prevent introduction and spread of EGC by vessel biofouling.

PM 2.4C: Recommendations are provided on how to prevent the introduction and spread of EGC from other pathways.

OBJECTIVE 3: DETECT EUROPEAN GREEN CRAB PRESENCE AT EARLIEST INVASION STAGE.

STRATEGY 3.1: IDENTIFY AND CATEGORIZE POTENTIALS SITES OF EGC INVASIONS.

Action 3.1.1: WSG continues to use existing habitat suitability assessments to select early detection monitoring sites in Washington.

Action 3.1.2: DFO develops habitat suitability maps for BC using same protocols as WSG.

Performance measures:

PM 3.1A: WSG habitat suitability maps are evaluated against EGC detection data in Washington State.

PM 3.1B: DFO habitat suitability maps are evaluated against EGC detection data in BC.

STRATEGY 3.2: TRAIN AND SUPPORT VOLUNTEERS AND PARTNERS TO MONITOR FOR EGC.

Action 3.2.1: DFO pilots volunteer EGC monitoring with an existing citizen group or with interested indigenous groups.

Action 3.2.2: DFO expands recruitment and support of volunteers and partners to monitor for EGC.

Action 3.2.3: WSG and DFO train volunteers and partners on established monitoring protocols.

Action 3.2.4: WSG and DFO support active volunteers and partners with communication and data reporting.

Performance measures:

PM 3.2A: 100 or more volunteers are trained for monitoring EGC in Washington using standard protocols.

PM 3.2B: 20 or more volunteers are trained (intent to eventually reach 100 volunteers) for monitoring EGC in British Columbia using standard protocols.

STRATEGY 3.3: MONITOR 160+ SITES REGULARLY FOR INVASIONS OF EGC

Action 3.3.1: DFO, WDFW, and WSG develop a Salish Sea monitoring plan for high and moderate sites identified in habitat suitability maps.

Action 3.3.2: DFO, WDFW, and WSG monitor highly-suitable sites monthly during months of April through September using established protocols.

Action 3.3.3: DFO, WDFW, WSG and partners, monitor additional moderate to high risk sites at least once annually.

Performance measures:

PM 3.3A: 50 Washington State moderate to high suitability sites are monitored monthly for EGC from April through September.

PM 3.3B: 10 British Columbia moderate to high suitability sites (intent to eventually reach 50 sites) are monitored monthly for EGC between April and September.

PM 3.3C: 50 additional Washington State moderate to high suitability sites are monitored at least once per year.

PM 3.4C: 50 additional British Columbia moderate to high suitability sites are monitored at least once per year.

STRATEGY 3.4: ENCOURAGE AND FACILITATE PUBLIC REPORTING OF EGC SIGHTINGS

Action 3.4.1: Ensure DFO AIS reporting system is functional and develop education/outreach to public for use.

Action 3.4.2: WSG, WDFW, and DFO include reporting information in all EGC outreach and presentations.

Action 3.4.3: Ensure WSG reporting information is up-to-date on their website.

Action 3.4.4: Ensure "WA Invasives" Smartphone App EGC reporting is functional and EGC reports are forwarded to the appropriate groups.

Action 3.4.5: Verify/enhance BC general invasive species reporting App for EGC and reports are directed to the appropriate agency(s).

Performance measures:

PM 3.4A: Online and digital reporting systems are in place, functional, and used by the public.

PM 3.4B: All Washington reports of EGC are provided to WDFW and WSG.

PM 3.4C: All British Columbia reports of EGC are provided to DFO.

OBJECTIVE 4: RAPIDLY ERADICATE OR REDUCE NEWLY DETECTED POPULATIONS.

STRATEGY 4.1: RAPIDLY RESPOND TO DETECTION OF EGC AT NEW LOCATIONS.

Action 4.1.1: WDFW, DFO and partners assess threat level (species densities and geographic scope of infestation) for all detections at new locations.

Action 4.1.2: WDFW and DFO activate formal Incident Command Structure rapid response process for all newly detected sites reaching thresholds to be developed under Action 4.2.

Performance measure:

PM 4.1A: All detections of EGC at new locations are investigated and EGC populations are controlled or eradicated.

STRATEGY 4.2: DEVELOP A FORMAL INCIDENT COMMAND STRUCTURE TO RESPOND TO SIGNIFICANT DETECTIONS OF EGC IN THE SALISH SEA.

Action 4.2.1: WDFW and DFO define thresholds for activation of a formal Incident Command Structure.

Action 4.2.2: Develop Incident Command Structure consistent with DFO response process to include: site specific benchmarks for success, defined partner roles, methods, and reporting.

Action 4.2.3: WDFW and DFO obtain partner commitments to implement rapid response actions.

Performance measure:

PM 4.2A: Incident Command Structure is formalized and agreed to with partners.

OBJECTIVE 5: CONTROL PERSISTENT INFESTED SITE POPULATIONS TO ELIMINATE OR MINIMIZE ENVIRONMENTAL, ECONOMIC AND HUMAN RESOURCE HARM.

STRATEGY 5.1: DEVELOP PROCESS TO MANAGE INFESTED SITES

Action 5.1.1: WDFW and DFO develop Infested Site Management Plan process including: site specific benchmarks of success; menu of available management actions; menu of available mitigation measures to minimize harm; defined partner roles, data collection and reporting.

Action 5.1.2: WDFW and DFO develop an infested site management plan for the EGC population in Sooke Basin.

Action 5.1.3: WDFW and DFO develop an infested site management plan for the EGC population in Dungeness Spit.

Action 5.1.4: WDFW and DFO develop infested site management plans for all new sites if/when meeting threshold criteria.

Action 5.1.5: Obtain partner commitments to implement infested site management plans.

Performance measure:

PM 5.1A: Infested Site Management Plan process is formalized and agreed to with partners.

PM 5.1B: Infested Site Management Plans are developed and initiated for Sooke Basin and Dungeness Spit.

PM 5.1C: Infested Site Management Plans are developed and implemented for any other sites meeting threshold criteria.

OBJECTIVE 6: CONDUCT RESEARCH TO DEVELOP INCREASINGLY EFFECTIVE MANAGEMENT STRATEGIES.

STRATEGY 6.1: ENSURE THAT RESEARCH RESOURCES ARE FOCUSED ON THE HIGHEST PRIORITY RESEARCH GAPS TO IMPROVE PREVENTION AND MANAGEMENT OF EGC IN THE SALISH SEA.

Action 6.1.1: TEGC working group develops a ranked list of needed research annually to coincide with funding cycles to improve prevention, detection, and management of EGC in the Salish Sea.

Performance measure:

PM 6.1A: Ranked list of EGC research priorities is produced.

STRATEGY 6.2: RESEARCH EGC GENETICS AND ENVIRONMENTAL DNA (EDNA) APPLICATIONS

Action 6.2.1: Continue to collect tissue samples from EGC at Salish Sea sites and conduct genetic analyses.

Action 6.2.2: Investigate utility of sampling eDNA to detect presence of EGC.

Performance measures:

PM 6.2A: Population analysis is updated to refine understanding of population connectivity.

PM 6.2B: Utility of eDNA analysis to detect EGC presence is understood.

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