STATE OF WASHINGTON **DRAFT September 2021**

Pinto Abalone Recovery Plan

In 1990, the Washington Wildlife Commission adopted procedures for listing and delisting species as endangered, threatened, or sensitive and for writing recovery and management plans for listed species (WAC 220-610-110; Appendix A). The procedures, developed by a group of citizens, interest groups, and state and federal agencies, require preparation of recovery plans for species listed as threatened or endangered, and periodic review of listed species at least every five years.

Recovery, as defined by the U.S. Fish and Wildlife Service, is the process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured.

This document is the first Washington State Recovery Plan for the pinto abalone. It prescribes strategies to recover the species, such as protecting populations and existing habitat, hatchery supplementation of wild populations, and initiating research and cooperative programs. Target population objectives and other criteria for downlisting to state Threatened and Sensitive statuses are also identified.

As part of the State's listing and recovery procedures, the draft recovery plan is presented for a 90-day public comment period. Responses to the public comments will be included in Appendix B; comments received will be considered in the preparation of the final document. The Department will present a summary of the recovery plan to the Fish and Wildlife Commission at a future meeting.

For additional information about Pinto Abalone or other state-listed species, check our website, or contact us by e-mail at abalone@dfw.wa.gov, or by mail to:

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DRAFT
Washington State Recovery Plan for Pinto Abalone

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LIST OF ACRONYMS

ESA - Endangered Species Act
NOAA – National Oceanic and Atmospheric Administration
PSRF – Puget Sound Restoration Fund
SJI - San Juan Islands
SJDF – Strait of Juan de Fuca
SPMC – Shannon Point Marine Center, Western Washington University
UW – University of Washington
WDFW - Washington Department of Fish and Wildlife

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EXECUTIVE SUMMARY

Pinto abalone (*Haliotis kamtschatkana*) is an iconic species of marine snail found in kelp forests along coastal waters. Among the seven abalone species found off the west coast of North America, pinto abalone are the only species found in Washington State. They serve an essential role in kelp forest environments as grazers, "cleaning" subtidal rock surfaces and allowing new kelp to settle. Their flavorful meat and beautiful shells also made them a highly sought-after shellfish for harvesters since time immemorial. While populations in Washington never supported a commercial fishery, pinto abalone harvest in the recent past brought sport fishers to the San Juan Islands (SJI) and Strait of Juan de Fuca (SJDF) and supported an economically significant recreational fishery for Washington. However, by the early 1990's their population in Washington waters had drastically declined beyond the point of sustaining an annual fishery.

Although the pinto abalone state sport fishery was officially authorized in 1959, the first subtidal pinto abalone population surveys were conducted in the late 1970s. Post-fishery abalone surveys revealed the population continued to decline well after legal harvest of the species ended. In 2013, two petitions were submitted to NOAA requesting the addition of pinto abalone to the federal endangered or threatened species list under the Endangered Species Act (ESA). In December 2014, a 12-month comprehensive status review concluded that the species was not in danger of extinction throughout all or a significant portion of its range. The Status Review Team did, however, acknowledge that depensatory processes and resulting recruitment failure were a specific concern for Washington pinto abalone (Neuman et al. 2018). By 2017, abalone survey results showed a 97% decline in densities at 10 permanent survey sites around the San Juan Islands (Carson and Ulrich 2019). In 2019, after a status review by WDFW (Carson and Ulrich 2019), pinto abalone were added to the Washington State Endangered Species List.

This document is the Washington Department of Fish and Wildlife's Pinto Abalone Recovery Plan. It identifies the recovery goal for WDFW and its partners, specifies population targets for reclassification, and outlines strategies and tasks necessary to meet the recovery goal. This plan also describes the essential partnerships and collaborations needed to restore this subtidal shellfish species back to a self-sustaining, healthy population. This document does not directly address the status of pinto abalone populations in Washington relative to recovery criteria. That will occur during the next status review, to take place every five years since the initial listing in 2019.

Populations of pinto abalone in Washington are presently well below the density threshold of 0.30 individuals per m^{-2}, which is the presumed minimum density that allows for successful reproduction (Carson and Ulrich 2019). Furthermore, based on an increasing mean shell length in surveys, and few observations of juvenile abalone in recent years, it is apparent that populations are aging without significant replacement by new generations. Pinto abalone face actual and potential threats from illegal harvest, predation, loss of kelp forests as habitat and food, changing ocean conditions, introduced diseases or parasites, and oil or contaminant spills (see Section I). There are several knowledge gaps that must be filled in order to achieve downlisting goals. These include understanding specific habitat requirements that promote survival and retention, improving husbandry techniques, exploring the impacts of ocean acidification, measuring population genetics, and understanding the relationship between adult density and fertilization efficiency (see Section III).

Effective recovery of pinto abalone will require not only a halt of population decline but an increase in population density and habitat occupancy. Given the low densities, it seems unlikely that such an increase will be possible without an active supplementation program that relies on placing hatchery raised abalone into the wild. Until populations are above a minimum density for natural reproduction, and size structure observations indicate strong recruitment, pinto abalone in Washington are at risk of local extinction. WDFW and partners including the Puget Sound Restoration Fund (PSRF) have worked on active restoration of pinto abalone since 2002. Restoration efforts to date have included the foundation and maintenance of an abalone hatchery and the outplanting of 40,000 juvenile abalone onto 21 sites in the San Juan Islands. Researchers have studied abalone survival, growth, movement, and detectability using tags (Carson et al. 2019). They have explored the use of outplanting younger juveniles and competent larvae and continue to sample and analyze population genetics and disease risk (see Section II).

Washington's recovery goal for pinto abalone is to reverse the decline of pinto abalone stocks and attain self-sustaining populations throughout regions of historic abundance in the state. Our recovery strategy includes separating SJI and SJDF into separate regions, each containing 5 subregions. Pinto abalone will no longer be considered Endangered and may be reclassified as Sensitive within the state when the following criteria are met: Thirty documented, naturally-formed spawning aggregations, each containing at least 6 pinto abalone and having an overall density of at least 0.3 abalone m^{-2} are located within each of the two regions. At least 4 of the 5 subregions in each region must have at least 3 spawning aggregations within their bounds to ensure that aggregations are dispersed throughout the historic range.

In both regions, surveys of wild pinto abalone either on the 10 historic index stations or on newly monitored, naturally-formed aggregations must result in at least 30% of all surveyed abalone with shell lengths less than 90 mm. This is to ensure that recent reproduction is ongoing and that the population does not only consist of older individuals.

These criteria are based on the first surveys for pinto abalone in the San Juan Islands which took place in 1979. The number of identified aggregations and their size distribution is not representative of the unfished population but is presumed to represent a self-sustaining state prior to widespread loss of reproductive output. A minimum of 360 abalone (6 per aggregation, 30 aggregations per region, 2 regions) would not be sufficient for downlisting. However, due to the abalone's cryptic behavior and limitations of dive surveys, each identified individual or aggregation is assumed to represent others that are not documented, in both the 1979 data on which the criteria are based and the modern surveys. Therefore, we stipulate that these aggregations must be documented, and set a four-year expiration date for each survey to allow for rotational surveying of parts of each region while maintaining current information. To meet the goal of self-sustaining populations, aggregations formed with hatchery-origin abalone will not count toward this downlisting criterion but are meant to support it by increasing reproduction in the wild. Criteria for downlisting from the current Endangered status to Threatened status use similar criteria, with thresholds of 15 aggregations per region spread over at least 3 subregions, and a size distribution with at least 20% smaller than 90 mm shell length (see section IV).

Monitoring abalone populations is quite unlike most wildlife monitoring methods used for endangered species in Washington. Since pinto abalone are found in the subtidal zone between 3 and 20 meters depth, advanced scientific scuba diving and boating skills as well as abalone identification experience are required. Due to the limitations in time underwater for scuba divers, monitoring is highly time sensitive. To maximize efficiency, divers split into teams and conduct multiple dives per day; each dive lasting approximately 1 to 1.5 hours. Additionally, the strong tidal exchanges in the San Juan Islands and Strait of Juan de Fuca require advanced planning to ensure dive safety and limit available windows for dive work.

This recovery plan intends to achieve downlisting goals through hatchery supplementation, intensive monitoring, and scientific research. This includes ongoing efforts to maximize hatchery production through efficient rearing techniques, and to increase hatchery capacity with the development of satellite growout facilities. It includes continued outplanting of hatchery-origin juveniles with the goal of creating adult spawning aggregations throughout the SJI and SJDF. The outplanting program will continue to investigate factors that promote juvenile survival on certain sites and explore the outplanting of younger stages. Research is needed to fill identified knowledge gaps, which may include monitoring of changing kelp forest communities and oceanographic water quality/chemistry. Enforcement inspections of recreational and commercial dive harvest are key to protecting remnant wild and restored aggregations. Outreach to the public and building new partnerships is necessary to achieve downlisting goals. Currently, WDFW and existing partners do not have the financial or staff resources to undertake all facets of the expanding recovery effort identified herein (see Sections V and VI).

Despite the challenging field work environment, WDFW and partners have made major strides towards reaching pinto abalone recovery goals. We believe this plan will guide continued advances in research and restoration of this species in Washington.

I. BACKGROUND

Species Information & Nomenclature

Taxonomy
Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Subclass: Prosobranchia
Order: Vetigastropoda (Archaeogastropoda)
Superfamily: Pleurotomariacea
Family: Haliotidae (abalone)
Genus: *Haliotis*
Species: *kamtschatkana*

Common name:

In the United States, the most common name used is ‘pinto abalone’ (which describes the yellow and brown mottling of the epipodium), and in British Columbia, the common name generally used is ‘northern abalone’ (to describe the northernmost species of haliotid). For the sake of consistency with existing Washington State documentation, we use the common name ‘pinto’ throughout this document but acknowledge that ‘northern’ is equally acceptable.

Description

Pinto abalone are marine snails found in rocky reefs and kelp forests in nearshore coastal habitats. Adult pinto abalone will grow to about 110 mm in shell length but can reach as large as 165 mm shell length and are most often observed in the 3 to 20 meter depth range. Abalone are known for their iridescent, vibrant inner shell nacre, and pintos display a wide variety of colorful outer shell patterns as well. Their shells have a row of 3 to 6 fluted, open pores along the ridge that allow the animal to continue cycling seawater through the gills even while gripped tight on the rock to fend off predators. Like all snails, adult abalone are relatively slow-moving animals that use their primary foot muscle to grip rocks and boulders. The head and foot are surrounded by epipodial tentacles that sense their surroundings.

The herbivorous pinto abalone plays a critical role in the rocky subtidal as a primary consumer. By grazing, digesting, and excreting micro and macroalgae, abalone cycle nutrients throughout the system, clear habitat space for settlement of new recruits, and improve habitat resilience to perturbations. Pinto abalone, especially in their juvenile stage, are also a nutritious prey species for predators such as crab, octopus, sea stars, and fish.

Like other abalone species, pinto abalone are dioecious broadcast spawners, meaning that male and female individuals release sperm and eggs into the water for potential fertilization. Because of this, male and female abalone need to be near each other for successful reproduction to take place.

Population History and Distribution

Pinto abalone are distributed from southeast Alaska (Fig. 1) to Baja California, Mexico, making them the northernmost and widest ranging Haliotid species (Geiger 2000). They are generally found on hard, rocky substrates in exposed coastal areas, including the Strait of Juan de Fuca and the San Juan Islands.

The species is unusual in that the population south of Point Conception, California, has a noticeably different shell morphology than northern pinto abalone. In the past, it was thought that the two populations were separate, distinct species. In papers published before 2014, pinto abalone are stated to range from southeast Alaska to Point Conception, California. The southern subspecies, found below Point Conception, was given the name *Haliotis kamtschatkana assimilis* and was referred to as threaded abalone. However, the Status Review Report for pinto abalone released by the National Marine Fisheries Service (NMFS) in 2014 highlights that while there is still much to learn about pinto abalone genetics, researchers have found little discernible difference at the molecular level between the two subspecies, and thus the population from Alaska to Baja is now referred to as *Haliotis kamtschatkana* (Neuman et al. 2018).

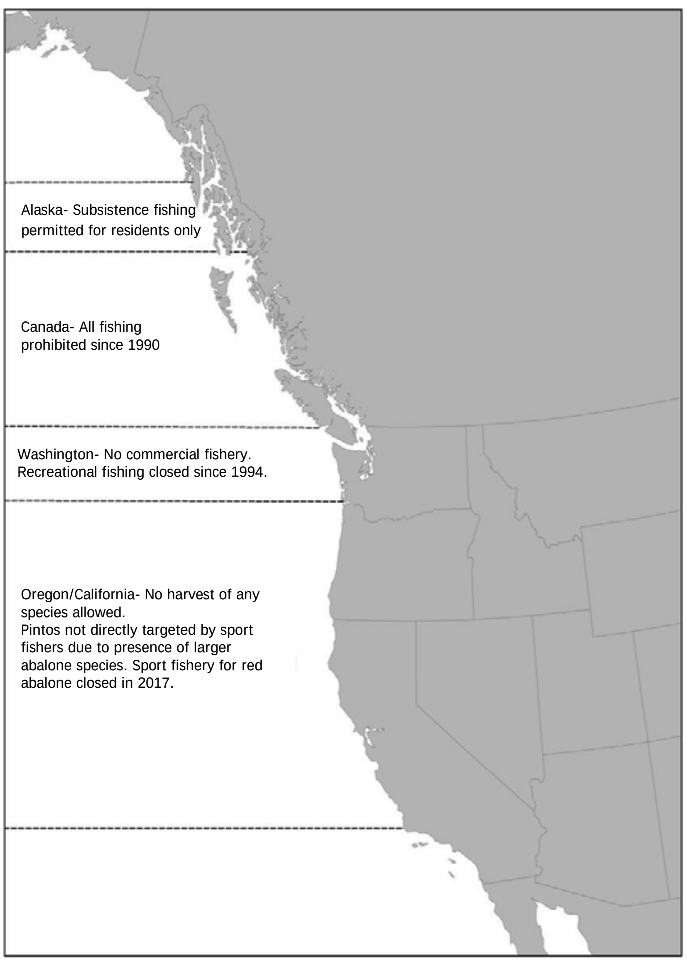

Figure 1. General historic distribution of northern populations of pinto abalone (*Haliotis kamtschatkana*) and current harvest status by respective jurisdictions.

Fishery and Population Monitoring

In contrast to Alaska and British Columbia, Washington State did not have a commercial abalone fishery. However, pinto abalone harvest occurred within the state via subsistence and sport catch. For thousands of years, Native American communities harvested abalone for subsistence and used their shells for trading, tools, and creating ceremonial objects (Vileisis 2020). In 1959, Washington State Department of Fisheries recognized the harvest of pinto abalone by recreational non-tribal divers and implemented a state sport fishery. The sport fishery was closed in 1994 due to observed abundance decline.

Pinto abalone populations in Washington have been surveyed using various methods since 1979. The first survey method utilized by research divers was the timed-swim survey. These surveys were conducted in 1979, 1980, and 1981 and involved divers swimming over swaths of seafloor counting and measuring each abalone observed within 20-minute increments. In 1992, WDFW implemented the use of index station surveys throughout the SJI. Index stations are stationary rectangular areas approximately 100 meters squared, marked by metal pitons that are installed into the substrate. Each station was surveyed repeatedly to document changing densities in fixed locations. Index stations are surveyed intensively over the course of several hours in order to identify all abalone within the area. Ten index stations were created in areas with high presence of pinto abalone. Between 1992 and 2017, abundance of pinto abalone within the 10 index stations declined by 97% (Rothaus et al. 2008, Carson and Ulrich 2019).

Elsewhere in their range, the fishing history and monitoring of pinto abalone varies by region. In California and Oregon, pinto abalone were not highly targeted for commercial or sport harvest due to the presence of red abalone (*Haliotis rufescens*) (a highly desired harvest species) and other larger abalone species south of Point Conception. Thus, pinto abalone populations in California and Oregon greatly lack formal surveys, stock assessments, or commercial landing data.

In 2017 and 2018, California and Oregon respectively closed their red abalone sport fisheries due to a catastrophic kelp die-off and extensive urchin barrens that caused regional declines in abalone populations. Although formal pinto abalone surveys are not conducted in these areas, it is assumed these environmental shifts similarly affect pinto abalone populations in the regions.

In British Columbia, Canada, pinto abalone were harvested by First Nations, sport fishers, and commercial fishers. However, population declines in British Columbia prompted the closure of all pinto harvest in 1990 (DFO 2020). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated pinto abalone as threatened in 1999, then uplisted their status to endangered in 2009 (DFO 2020). Recovery efforts for the species have been on-going since the early 1990's (Lessard and Egli 2011).

In Alaska, a commercial fishery for pinto abalone was active from the 1960's until its closure in 1996. The commercial landings for pinto abalone peaked with 379,000 pounds harvested between 1979-1980. By 1995, commercial harvest had fallen to 14,000 pounds. Concerns about population levels resulted in a commercial fishery closure in 1996; however, a personal use and subsistence fishery still exists in the state for residents of Alaska only.

Habitat Requirements and Habitat Status

Although pinto abalone have a range that spans thousands of kilometers of coastline, they are found in the same type of rocky reef habitat throughout. Rocky reef ecosystems are habitats in which a majority of the benthic substrate is exposed bedrock, boulders, and cobble, with little or no stretches of sand. Most macroalgae species settle and thrive in rocky reef habitats, as do the invertebrates that graze these kelps. Pinto abalone are solely found in rocky reef habitat; thus, rocky reefs and healthy kelp forests are necessary foundational habitat for the species.

The Pacific coastline of North America is known for its dense kelp forests that thrive due to strong upwelling events that cycle nutrient-packed water from the seafloor to the surface. These kelp forests are home to fast-growing kelps like giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis luetkeana*) that can reach vertical lengths of 30 - 36 meters within a year, providing shelter and food sources for hundreds of species of fish, invertebrates, and marine mammals. Additionally, rocky reef structure supports microalgae and calcareous coralline algae that play important roles in many benthic invertebrate life cycles.

After pinto abalone spend the first 10–14 days of their lives as swimming larvae feeding off only their egg yolk (Sloan and Breen 1988; Pearce et al. 2003), they settle onto hard substrate and begin crawling and feeding. Although there are still knowledge gaps in the settlement process, research shows that abalone look for specific cues on surfaces to settle. One of these cues is associated with crustose coralline algae, a calcareous alga found in many rocky reef environments around the world. Crustose coralline algae is a slow growing, encrusting algae that forms on hard surfaces that receive sunlight. Certain species of bacteria are present on crustose coralline, forming a layer of biofilm on top of the calcium-rich algae. This biofilm gives off a settlement cue to larval abalone, triggering the abalone to attach to the crustose coralline and begin a metamorphosis process from swimming larva into crawling juvenile.

In addition to crustose coralline algae, the presence of diatoms in rocky reef environments is essential in juvenile abalone survival. After an abalone completes its metamorphosis process, it begins feeding on diatoms and other components of the biofilm. Diatoms are single cell, photosynthesizing organisms that can form thin mats on substrate. While abalone are in their post-larval stage (up to 5 mm shell length), they rely on diatoms as their main food source, and as the radula develops, juveniles begin to graze available macroalgae in combination with the biofilm (PSRF, unpublished data) Despite their small size, diatoms are rich in nutrients and provide sustenance to abalone even in their adult stage.

As they continue to grow, abalone require fleshy algae as the main source of nutrition in their diet. Access to algae is vital to abalone maturation, and they are often observed eating drift kelp that settles on the seafloor after sloughing off the main stipe. Algae species like bull kelp, giant kelp, *laminaria* spp., *agarum* spp., and stalked kelp (*Pterygophora californica*) all grow within pinto abalone's range and are common in healthy kelp forest systems. In the Salish Sea, bull kelp is the dominant canopy kelp, although giant kelp can be found in the western portion of the SJDF. Unlike the perennial giant kelp, bull kelp is an annual, single stipe kelp with several dozen long, leaf-like blades attached to one buoyant pneumatocyst floating at the surface. When bull kelp blades detach from the pneumatocyst, they "fall" to the seafloor and become drift kelp, feeding abalone, urchin, and many other benthic organisms.

Bull kelp is known as an indicator species throughout its range, meaning its population status usually indicates the health of the surrounding kelp forest ecosystem. In the past decade, bull kelp populations along the west coast of Washington, Oregon, and California have been in decline. Since a majority of bull kelp's biomass is held in its canopy, population surveys are often conducted using aerial imagery and kayak mapping to depict the area of blade coverage on the ocean's surface. In Washington, researchers with the Samish Department of Natural Resources documented a 36% loss in bull kelp forest canopy within the San Juan Islands from 2006 to 2016 (Samish Indian Nation

2020). Certain areas within the island chain suffered a greater loss than others, such as Patos and Blakely Islands which lost 77% and 72% of their bull kelp canopy respectively. The loss of bull kelp is a signal that other kelp species - and organisms that rely on them - may decline as well.

It is imperative to acknowledge that pinto abalone recovery is dependent on the survival of kelp forests. In addition to supporting abalone, Washington's bull kelp habitat forms the foundation of food webs which include many of Washington's wild resources, that include ESA-listed species of rockfish, salmon, and orcas. Bull kelp forest restoration and conservation work is the key to the prosperity of Washington's endangered species. As the advancements in our research and knowledge continue to increase juvenile abalone outplant survivorship, the presence of healthy kelp forests is one of the main factors that will support self-sustaining pinto abalone populations.

Available evidence suggests the historic range of pinto abalone in Washington was restricted to shallow rocky reefs between the Canadian border in the north, the entrance to Admiralty Inlet in the South and East, and the Neah Bay area in the West (Carson and Ulrich 2019). It is unclear if significant populations exist or existed on the outer coast. Although the population within that range has declined precipitously, the overall range remains relatively unchanged. Recent observations have been made in the northern San Juan Islands, on either side of the entrance to Admiralty Inlet, and in the western Strait of Juan de Fuca (Carson and Ulrich 2019).

Sources of Mortality and Future Vulnerabilities

Fishing pressure

Pinto abalone are acutely vulnerable to fishing pressure for the following reasons:

- They are sedentary animals and aggregate together, making it feasible for fishers to harvest full spawning aggregations with relative ease
- In legal and illegal fishing efforts, fishers often target the largest abalone, which may have the most reproductive potential due to their size and maturity
- Enforcement of abalone harvest laws is challenging due to the remoteness of abalone diving locations
- They typically occur in shallow subtidal areas and may have no deep-water refuge from harvest divers
- Their meat and shell are prized by consumers
- Their recruitment may be dependent on local larval production and settlement due to their short 10 to 14-day planktonic larval stage
- The cryptic nature of juveniles combined with the longevity and slow growth of adults may mask recruitment failure over several years, complicating fishery management
- Long lived, broadcast spawning invertebrates, like abalone, may exhibit high recruitment variability (Rothaus et al. 2008).

Fishing pressure: historical legal harvest

Harvest estimates from Bargmann (1984) and Gesselbracht (1991) suggest that legal sport harvest of pinto abalone was centered in the SJI and may have been as high as 41,000 individuals per year. No similar estimate was made for the SJDF, but that population was also subject to intensive recreational harvest. The diver self-reported survey utilized in Bargmann (1984) and Gesselbracht (1991) may under-estimate true recreational exploitation rates and does not account for cumulative harvest over several decades. This level of harvest was likely too aggressive for populations of abalone in Washington. Concerns over reduced densities led to successive fishery management actions including size limits, gear limits, and reduced daily bag limits (Carson and Ulrich 2019). They also prompted the 1992 establishment of 10 fixed, permanent index stations to monitor relative abundance of abalone in the SJI. A resurvey of those sites in 1994 that showed steeply declining densities led to a total fishery closure that year. Density on those sites continued to decline after the closure (Carson and Ulrich 2019). Similar pinto abalone population declines have been documented in British Columbia, Canada (Sloan and Breen 1988); where declines continued despite closure of both commercial and recreational fishing in 1990 (Tomascik and Holmes 2003).

Fishing pressure: illegal harvest

Illegal harvest has dramatic impact on the fate of abalone. Poaching not only directly affects populations, it also makes population dynamics and stock assessments more complicated to understand, as the magnitude of poaching is unreported and difficult to estimate. Furthermore, because poaching is unregulated, it is impossible to ensure that animals have spawned at least once, or have even reached reproductive age, before they are harvested. In such cases, the effects of low population densities are exacerbated and the removal of even a few individuals may have drastic and lasting consequences.

Abalone researchers in British Columbia have long stressed the destructive consequences of abalone poaching. A population model by Camaclang et. al (2016) found that the chances of extinction are twice as high when populations are subject to illegal harvest. Prior models show that a 50% reduction in illegal harvest of pinto abalone within British Columbia would be a minimum requirement to reverse the decline of the population (Chadès et al. 2012).

Although current densities in Washington are low enough to make illegal harvest on a commercial scale impossible, opportunistic poaching of remnant aggregations by commercial or recreational divers is still a major threat to abalone in Washington.

Recruitment failure

Perhaps the greatest threat to the survival of abalone is recruitment failure. Evidence for this is strong among surveyed populations. Data from the SJI show that mean shell length of observed abalone is increasing and observations of juveniles less than 50 mm in length are almost non-existent. This suggests that populations are aging without replacement by younger (smaller) individuals (Rothaus *et al*. 2008, Bouma *et al*. 2012).

Low adult densities are a common reason for recruitment failure in broadcast spawner species. Due to the nature of their reproduction, wherein individuals must be near each other for successful spawning, catastrophic decreases in density often result in reproduction failure even after harvest has ended. When densities of abalone significantly decrease, the reproductive success of the population also decreases. This biological phenomenon, known as the Allee effect (Allee et al. 1949), may explain continued population declines despite decades of fishery closures. Zhang *et al*. (2007) did not observe a depensatory effect in Beverton-Holt stock-recruit models at low spawning stock biomass for *H. kamtschatkana*, though several studies did observe a weak depensation with Ricker models for *H. laevigata* (Shepherd *et al*. 2001; Shepherd and Partington 1995). In Washington, early population declines were likely the result of over-exploitation and some fraction of this decline was (and perhaps still is) the result of poaching (Carson and Ulrich 2019). Taken together, over-exploitation and declining density in spite of fishery closure suggest a depensatory recruitment failure, as indicated by an increase in the mean length of abalone over time (Carson and Ulrich 2019).

While smaller abalone (defined here as < 90 mm shell length, see page 28) comprised 30% of individuals in 1979, and 16% of individuals in the 1990s, less than 6% of the population was in this size class from 2003 to 2006 (Rothaus *et al*. 2008). At five of the ten index sites surveyed in 2003 no smaller abalone were observed, and less than ten smaller abalone were observed on the remaining 5 index sites. By 2013 five of the ten index sites had zero abalone present, and the remaining 5 sites had densities below 0.1 abalone m^{-2}. This trend continued in 2017 when only 12 total animals were located during surveys of the 10 sites, bringing the overall average density of sites down to 0.005 abalone m^{-2} (Carson and Ulrich 2019). In addition, the mean shell length of abalone between 1992 and 2017 increased by 22 mm, suggesting that abalone in the SJI are continuing to age without replacement. Davis *et al*. (1996) observed a similar trend in length frequencies of endangered white abalone and suggested that the observed recruitment failure was a key factor in the demise of white abalone populations.

As broadcast spawners, abalone require a minimum density threshold to achieve reproductive success. If populations fall below this threshold density, they can experience recruitment failure or a mating related Allee effect. Allee thresholds specific for pinto abalone are unknown. In general, broadcast spawning sedentary invertebrates (such as abalone) must be aggregated for successful fertilization and prevention of stock collapse. Babcock and Keesing (1999) estimated that this density threshold was between 0.15 and 0.30 individuals m^{-2} for the greenlip abalone *H. laevigata* in Australia, based on anecdotal fishery information. A population growth model developed for endangered white abalone in California found that recovery was poor for a stocking density less than 0.23 individuals per m^{-2} (Catton et al. 2016), in general agreement with the evidence from Australia. In abalone, fertilization inefficiencies may be exacerbated by a tendency toward episodic spawns (Tegner et al. 1989, McShane 1992, Shepherd and Daume 1996). Thus, although early declines may have been the result of fishing, continued declines suggest recruitment failure as a major cause (Rothaus et al. 2008).

Recruitment failure: adult condition

Adult pinto abalone may be experiencing intrinsic and extrinsic conditions that affect reproductive success. Factors such as reproductive senescence and changing ocean chemistry (including ocean acidification) may be factors contributing to reduced spawning activity, reduced gamete production and poor gamete condition (Friedman *et al*. unpublished data).

Recruitment failure: larval dispersal

Abalone larvae have a planktonic phase that may last as long as two weeks so it is feasible that the recruitment failure observed in the SJI and assumed for the SJDF may be the result of changes to source populations such that larvae are no longer being imported to the appropriate habitats. For example, a shift in the physical oceanography (water currents) of the region, perhaps accompanying recent changes in SJI temperature and salinity (Masson and Cummings 2004) may have altered the import or the retention of abalone larvae. The densities of previous source populations in Canadian waters may have declined (DFO 2020), contributing to reduced numbers here.

Recruitment failure: settlement habitat has changed/diminished

The association between abalone larvae and crustose coralline algae (CCA) as a settlement surface has been well-documented (Morse & Morse 1984). Settlement of abalone larvae on CCA has been correlated with biological (Miner et al. 2006) and chemical cues (Li et al. 2006). Changes in the marine environment that alter either the availability of CCA surfaces or the cues associated with these surfaces may impede the settlement of abalone larvae. Furthermore, a lower density of abalone results in less localized "conditioning" or grazing of substrate surfaces, thereby reducing the amount of settlement habitat. The result may be a negative feedback mechanism contributing to population reduction.

Community shifts

Between 2014 and 2017, several ecological events occurred that are continuing to impact kelp forest ecosystems on the Pacific coast. In 2014 and 2015, a wasting disease killed large numbers of sea stars along the entire west coast of North America. The sunflower star (*Pycnopodia helianthoides*), a predator of invertebrates, was notably impacted. While sea stars were still declining, a prolonged El Niño event brought abnormally warm sea water temperatures to the Pacific coast of North America. These warm temperatures caused mass die-offs of bull kelp (*Nereocystis luetkeana*), a primary food source for abalone. In addition, purple sea urchin (*Strongylocentrotus purpuratus*) densities increased dramatically, quickly creating urchin barrens - areas devoid of kelp due to intensified urchin grazing. Extensive dive surveys in 2015 by the California Department of Fish and Wildlife showed purple sea urchin populations had reached 60 times their previous densities, creating urchin barrens along hundreds of miles of coastline (Rogers-Bennett & Catton 2019). The loss of sea stars, a primary predator of urchin, may have been one of the causes of these widespread urchin barrens. Without sea stars present to control urchin populations, these urchins consume the already depleted kelp stocks and outcompete other marine herbivores, like abalone, for food.

This "perfect storm" of events has disrupted ecosystem balances and caused regional abalone starvation and mortality. By 2018, red abalone densities had dropped 43-96% at monitoring sites in Sonoma and Mendocino, California. Although these recent widespread urchin barrens were first seen in Northern California, there is evidence the barrens are moving north. In 2019, Oregon Department of Fish and Wildlife reported that purple sea urchin densities had increased to 100 times the density seen in 2014 surveys. (S. Groth, ODFW, pers. comm.), and recreational divers have reported red and purple sea urchin barren sightings in Washington waters as well. While formal pinto abalone surveys are not conducted in California or Oregon, it is assumed that pinto abalone are equally affected by the loss of kelp.

Widespread loss of kelp forest and expansion of urchin barrens has not been observed within the range of pinto abalone in Washington to date. There have been documented increases of purple sea urchin densities in the western SJDF (Shelton et al. 2018), as well as other observations of high densities in the central SJDF (WDFW unpublished), that are under monitoring by WDFW and partners. However, dedicated underwater surveys for the purpose of detecting ecosystem shifts throughout the entire pinto abalone's range in Washington have not been conducted.

Predation

Predators may exacerbate population declines and may complicate restoration efforts. There are many possible predators of larval abalone and recently settled juveniles (including polychaetes, nematodes, polyclad flatworms, and anemones; Shepherd and Breen 1992). Griffiths and Gosselin (2008) conducted controlled experiments and observed predation of juvenile abalone by as many as 14 naturally encountered predators (including fish, crustaceans and echinoderms). Meanwhile adult abalone are vulnerable to several of the same predators as juveniles (e.g., red rock crab [*Cancer productus*], sunflower star, cabezon [*Scorpeanichthys marmoratus*], and octopuses) plus additional predation by sea otters (*Enhydra lutris*) and humans. Significant aggregations of sea otters have been documented feeding in the western SJDF, greatly reducing urchin populations as far east as Pillar Point. Few sea otters have been documented in the SJI.

Environmental change (temperature, salinity, dissolved oxygen, pH, siltation)

While some oceanographic factors such as turbulent surf, unfavorable current trajectories and seasonal variations in conditions (e.g., rainfall, river input) have been drivers of the evolution of abalone for millennia, recent alterations in oceanographic and coastal characteristics may be responsible for increased mortalities, especially during the larval and early juvenile stages of development.

Global concerns have arisen regarding the impacts of environmental change on marine ecosystems (Harley et al. 2006). While much of this attention often focuses on large scale phenomena like polar ice melt, the impacts of changing conditions will be felt at the organismal level first. A slight increase in temperature and decrease in salinity in the north SJI was observed decades ago (Masson and Cummings 2004). Regional sea surface temperatures in the 1990s were the warmest in recent history at the time (Strom et al. 2004), but warming has only increased since then (PSEMP Marine Waters Workgroup 2020). How such changes affect marine ecosystems can be better understood through the use of controlled experiments, in this case, with pinto or other species of abalone.

Temperature has been shown to both directly (e.g., disease expression) and indirectly (e.g., food availability) affect abundance in other abalone species (e.g., Vilchis et al. 2005). An effect of temperature increase on pinto abalone would be more likely observed in shallow aggregations, yet survey data reveal more rapid declines among index sites at deeper depths (Rothaus et al. 2008). Meanwhile, studies of the effects of different temperatures on larval development reveal that pinto abalone larvae tolerate a relatively broad temperature range (Bouma 2007; Friedman et al. unpublished data). Temperature increase may impact the abalone's habitat and diet (i.e., kelp forests) before it impacts them directly.

Marine waters entering the SJDF, SJI, and Puget Sound are mixed with numerous freshwater inputs.

Salinity may prove to exert great influence on recruitment; low salinity has been shown to reduce larval and post-larval survival (Bouma 2007). Freshwater input can also include an abundance of nutrients, which in turn can lead to changes in phytoplankton communities and an increase in low-dissolved-oxygen (hypoxia) events (PSEMP Marine Waters Workgroup 2020).

Crim et al. (2011) found that larval development of pinto abalone was affected by ocean acidification. Larval survival decreased and shell abnormalities occurred under experimentally elevated pCO2 conditions. Ocean acidification and low salinity may impede recruitment in marine invertebrates (e.g., Wootton et al. 2008) but more studies on temperature, salinity, and pH effects on pinto abalone abundance are necessary.

In addition, elevated sedimentation and levels of pollutants may be affecting reproduction, settlement and juvenile survival. The direct effects of increased levels of pollution on abalone in Puget Sound have been poorly studied or documented, but suspected impacts on other species within the region are well documented (e.g., Orcas, kelp [Springer *et al*. 2007], eel grass). Such anthropogenic inputs may include not only toxins, but sediment and nutrient fluxes that may block light or create eutrophic conditions in coastal systems.

Disease and parasites

No disease impacting abalone has been reported in wild or hatchery pinto abalone populations in Washington. However, pinto abalone are susceptible to a variety of diseases that are already present on the West Coast of North America. Disease threats to pinto abalone range-wide include two that have caused mortality in juvenile farmed abalone in British Columbia, a protist *Labyrinthuloides haliotidis* and a coccidian *Margolisiella haliotis* (reviewed in Neuman et al. 2018). The origin of the coccidian was from illegally imported California red abalone detected at a community pinto abalone aquaculture facility in British Columbia. That facility was closed in 2010, and there are not currently any pinto abalone aquaculture facilities operating in Canada (C. Wells, DFO, pers. comm.). Neuman et al. (2018) listed three other possible diseases: Withering Syndrome caused by a rickettsiales-like organism, ganglioneuritis, and vibriosis. Withering Syndrome is particularly concerning, as in a laboratory study, all the pinto abalone exposed to the syndrome died (Crosson and Friedman 2018). Lastly, Meyer et al. (2017) reported a mortality event in farmed scallops in British Columbia apparently caused by the bacteria *Francisella halioticida*, known to cause mortality in Japanese abalone (Brevik et al. 2011).

An example of a parasite that is a threat to pinto abalone is the sabellid polychaete worm *Terebrasabella heterouncinata*. It was introduced to California from South Africa and, grows on abalone shells and caused deformities in farmed abalone there (Kuris and Culver 1999). Although the worms do not feed on abalone, they can weaken the shell, exposing the animal to infection or predation. This introduction highlights the sensitivity of abalone to threats that may not already exist locally. A disease or parasite outbreak among the remaining populations of abalone in Washington could cause irreversible damage to already struggling populations and highlights the need for careful screening and thoughtful consideration with respect to all handling of animals.

Oil or Contaminant Spills

A catastrophic spill of oil or another harmful substance could severely affect pinto abalone populations through direct mortality or ecosystem impacts. The San Juan Island and North Puget Sound Geographic Response Plan (Washington Department of Ecology 2003), for instance, points out the abalone's vulnerability to oil spills because of their shallow depth distribution and reliance on kelp as food. Although the chance of a catastrophic spill in Washington in any given year is remote, oil tanker traffic through the SJDF and past the SJI (the entire documented range of the species in Washington) is likely to increase. If expansion of the Trans Mountain Pipeline terminating in Burnaby, British Columbia is completed, the increased capacity could raise the number of oil tanker transits per month seven-fold compared to the current level (National Energy Board Canada 2016). The range of pinto abalone does not extend far enough north to have been impacted by the 1989 Exxon Valdez oil spill in Alaska. That spill, however, had extensive and long-term effects on intertidal and subtidal communities that would be likely to also occur during a spill in Washington. In particular, the loss of intertidal algae at oiled sites was implicated in community-wide impacts from which there had not been full recovery through at least 2014 (Exxon Valdez Oil Spill Trustee Council 2014). Oil spills may also result in the bioaccumulation of contaminants in algae and kelp, which may then be transferred to abalone through grazing (R. Govender, pers. comm). Impacts were not restricted to the intertidal zone; an estimated 13% of the oil spill was deposited onto subtidal habitats (Exxon Valdez Oil Spill Trustee Council 2014). The Trans Mountain pipeline oil being transported past Washington's abalone populations is even more likely to sink onto subtidal habitats in large quantities because of its density. "Tar sands" or "dilbit" oil from Alberta is denser and must be diluted with volatile compounds to facilitate transport. During a spill, these dilutants may quickly evaporate, leaving the dense oil to sink more readily, as was the case during a 2010 spill of this type of oil on the Kalamazoo River in Michigan (U.S. Environmental Protection Agency 2016). Less dense components of oil may be dispersed through currents via attachment to drift kelp, suspended sediment, and debris. Additionally, oil spill cleanup efforts may make extensive use of dispersants to make oil more biologically available in the waters below the surface. These dispersants, used during the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, were shown to have a variety of potentially toxic and developmental effects on marine organisms (e.g., Almeda et al. 2014, Vignier et al. 2015).

II. Restoration Efforts

Although the pinto abalone was placed on Washington's endangered species list in 2019, restoration considerations began even before the fishery closure in 1994. Later, when it became clear that closing the fishery would not be enough to restore populations to self-sustaining densities, researchers and conservationists began enacting measures in 2002 that laid the foundation for pinto abalone recovery. A brief synopsis of the efforts between 2002 and 2020 is provided below.

Hatchery facilities

In 2003, a conservation aquaculture program for pinto abalone was established at the NOAA Mukilteo Research Station. The program was maintained full-time by Dr. Carolyn Friedman's lab at University of Washington (UW), School of Aquatic and Fisheries Sciences. The hatchery program aimed to 1) develop and optimize efficient abalone culture techniques, 2) produce and rear healthy, genetically diverse larvae and juveniles for research and 3) ultimately use hatchery-cultured progeny for restoration outplants to rocky reef habitat throughout their range in Washington.

The initial years of operation between 2003-2007 included research focused on broodstock conditioning, spawning induction, early life history dynamics including tolerances of and behavioral responses to temperature and salinity, optimizing feeding regimens and culture habitat preferences. In 2005, experiments were conducted at the NOAA Mukilteo hatchery to determine whether abalone behavior (habitat selection and movement patterns) differed between habitat-enriched and conventional rearing tanks. Results indicated that rearing conditions can affect abalone behavior and should be a consideration when developing restoration efforts (Straus and Friedman 2009).

In 2006, mesocosm and microcosm studies examined the effects of salinity and temperature on larval behaviors and survival. Results demonstrated that developing larvae are highly sensitive to changes in salinity but are relatively robust to temperature variability (Bouma 2007). These studies are important to understanding how changes in the Salish Sea environment may be affecting abalone recruitment.

In 2012, WDFW, Puget Sound Restoration Fund (PSRF), and UW collaborated on a study evaluating broodstock conditioning in the hatchery. To assess whether artificial methods of abalone husbandry were affecting broodstock survival in the hatchery, broodstock abalone were placed under either natural or artificial light treatment. To test whether diet was influencing survival, abalone were separated into either macroalgal diet or artificial food diet treatments. Results of the study indicated that gonad maturation was enhanced in natural daylight conditions, but the different diet treatments had no impact on gonad conditioning.

By 2018, most pinto abalone husbandry operations had moved to the Kenneth K. Chew Center for Shellfish Research and Restoration (Chew Center) at the NOAA Manchester Research Station, where they remain today. This facility has allowed for a significant expansion of capacity for juvenile abalone production, as well as continued research into husbandry techniques and restoration strategies. PSRF collaborated with a graduate student at the Shannon Point Marine Center (SPMC) to test various benthic diatom diets on growth and survival of early juveniles (Kuehl 2020). Currently, PSRF is in collaboration with a graduate student at UW to investigate the effects of climate change and ocean acidification on larval development, survival and growth of various life stages and settlement success of abalone as well as the impacts of coralline encrusted substrates and tank microbiome on success of various hatchery cohorts. This research could also soon include an investigation into whether the use of probiotics in abalone culture tanks could improve and stabilize production success of hatchery cohorts.

Currently, capacity is being further increased by developing partnerships to use “satellite” rearing facilities. Under this strategy, the Chew Center continues to be the hub for conservation aquaculture activities including holding and conditioning broodstock, induced spawning efforts, and larval and juvenile rearing. Additional juvenile rearing takes place in other partner facilities, such as the Port Townsend Marine Science Center and the Seattle Aquarium. This will increase capacity, decentralize production to guard against unforeseen catastrophes, and allow the program to be more accessible to the public.

The Chew Center houses broodstock collected as isolated individuals, nicknamed “singletons”, from the wild. Broodstock collections occur annually to maintain high genetic diversity of hatchery produced progeny. When divers find one abalone, a thorough search is conducted in a 5-meter radius of the abalone to determine if other abalone are in spawning range of the individual. If at least one other abalone is found in the 5-meter vicinity of the first individual, it is considered an aggregation. Divers do not collect abalone from existing aggregations so as not to interfere with the existing population’s ability to spawn naturally. There is little evidence that abalone undertake large-scale migrations to aggregate during spawning. Successful spawning events in the wild require dense adult aggregations for gametes to be fertilized. Therefore, isolated individuals are considered to be ecologically dead (unlikely to contribute to reproduction in the wild) and are taken into the hatchery conservation aquaculture program as broodstock. The vast majority of the hatchery offspring of wild collected broodstock are placed in the wild. Offspring from wild abalone created in the hatchery are not retained to use as broodstock themselves; this is to guard against hatchery-induced inbreeding.

PSRF is conducting ongoing research into pinto abalone gamete cryopreservation. If successful, the collection, preservation and biobanking of abalone sperm for future use from all males brought into the conservation hatchery will maximize the contribution of wild collected broodstock and increase the genetic diversity of hatchery-produced cohorts released to restoration sites.

Monitoring of remnant wild populations and impact of recovery efforts

As restoration strategies have been developed over the past 15 years, WDFW and PSRF have continued intermittent monitoring of the 10 San Juan Island fixed index stations established in 1992. Results of this work appear in Carson and Ulrich (2019). This monitoring includes exhaustive, non-invasive diver surveys for presence and size of pinto abalone within complex habitat on the delineated index plots. Due to the non-invasive nature of index station survey methods, it is unlikely that new recruitment is observed on these plots until juvenile abalone become more emergent at sizes beyond 50 mm shell length.

In addition to the ongoing index station monitoring, from 2004-2007, WDFW and UW conducted a recruitment study in the San Juan Islands. Abalone recruitment modules (n=66) were distributed at different locations and depths throughout the SJI to assess juvenile abalone recruitment. Little to no recruitment success was observed within the modules, and no significant differences were observed among sites and depths (Bouma 2007, Bouma et al. 2012). This finding is supported by index site data, which has similarly shown limited new abalone recruitment in the SJIs.

Development of juvenile outplant protocols

From 2007 - 2009, the first cohorts of hatchery-raised juvenile pinto abalone were outplanted by WDFW to Freshwater Bay in the SJDF, with partners PSRF, UW, and Jamestown S'Klallam Tribe. A small number of juvenile abalone were stocked in two cohorts to assess natural mortality post-outplant, and an additional outplant of post-larval abalone were placed to explore outplant of smaller sizes. Additional research tied to these outplants tested whether rearing techniques influenced juvenile outplant survival between abalone raised in conventional (seawater only) and enriched (presence of natural algae covered rock) tanks. No difference in survival with respect to rearing treatment was detected (Stevick 2010). Overall results demonstrated that the chance of survival was significantly increased for larger-sized juvenile abalone across habitat types assessed. This experiment prepared researchers for future, larger scale outplants.

In 2008, an experiment was conducted examining broodstock reintroductions and wild aggregations. Individual abalone that successfully produced offspring during captive-spawning events were returned to the wild. These animals were placed into aggregations along with a small subset of wild collected singletons to boost their reproductive potential. The release of these adult abalone was assessed as a restoration strategy. In the years following broodstock reintroduction efforts, divers observed several cases of mortalities and evidence that many of the "replaced" pinto abalone had dispersed. While initial survival or retention of these adults at the site of reintroduction was good during the months following release, this trend did not continue, and long-term survival and maintenance of the aggregation was low and causes of migration or mortality are unclear (Friedman et al. 2010).

In 2009, WDFW and PSRF conducted the first restoration-scale juvenile outplant in the San Juan Islands. 1,130 hatchery raised, juvenile abalone were stocked at four sites. Post-outplant surveys showed that survival was satisfactory, which set the stage for expansion of the program (detailed below). WDFW joined with SPMC to conduct post-outplant surveys for these sites. Divers completed a set of surveys during the day and a second set of surveys at night to determine if stocked juvenile encounter rates varied based on time of day. Results indicated no differences in detection rate between day and night surveys.

Tagging Research

The pilot outplant of juvenile abalone in 2007 was the first mark-recapture study of abalone conducted in Washington. However, since it was confined to experimental plots for a period of one year, it can offer only preliminary data on growth rates and mortality. In subsequent outplants conducted by WDFW, the mark-recapture method was employed using numbered tags adhered to each individual abalone shell. This proved effective for identifying particular individuals for as long as the tag remained on the shell. Researchers detected and verified repeated sightings of tagged abalone and were also able to discern whether tagged individuals had been “missed” in previous surveys. Tags remained adhered to the shells for 1 to 6 years before falling off due to deterioration of adhesive (Carson et al. 2019).

In 2011, PSRF and UW experimented at the NOAA Mukilteo Research Station with passive integrated transponders (PIT) as an abalone tracking method. PIT tags were placed on individual abalone in one of three places: adhered to the dorsal exterior of the shell, ventral interior of the shell, or injected into the foot muscle. Researchers assessed whether the attachment of a PIT tag affected the growth or survival of individuals. Results indicated that there was no difference in growth or survival regardless of tag location, but PIT retention was greater for shell attachment vs. injected tags (90% vs. 10%, respectively) over a 9-month period (Hale et al. 2012). Adhering PITs on the ventral anterior of the shell was optimal as abalone quickly formed nacre over the tags, incorporating them into the shell as a long-term identification. Subsequent studies evaluated tagging smaller juveniles using PITs with varying results. PIT tagging of juveniles may become more realistic as PIT technology develops smaller tags. Field testing of PIT tagged abalone has focused on tracking adults. PIT tags are detectable with a separate detection scanning device held by a diver. The ability to detect individual abalone via scanner is effective when abalone are present but not visible to divers (i.e., the abalone is underneath a ledge).

Carson et al. (2019) synthesized the data from tagging studies between 2009 and 2017 in the SJI and described the variability in growth and survival. They learned that site was by far more important to outplant survival than was family origin or size-at-outplant. They learned from repeated surveys that between 20 – 40% of juveniles existing on site are likely to be detected in a given survey.

Genetics research

Genetic data are crucial to ensure that hatchery production does not negatively affect or diminish the natural genetic structure of local pinto populations. One of the main challenges with captive breeding programs is ensuring proper genetic diversity within captive-bred juvenile cohorts. However, little is known about the genetic diversity of Washington’s pinto abalone over time, which may be experiencing a genetic bottleneck due to an increasingly reduced population size.

In 2019 NOAA, WDFW, and PSRF began a multi-faceted genetics study on pinto abalone populations. The goals are to assess the genetic diversity and potential relatedness of wild-collected individuals used as broodstock, their progeny released onto restoration sites, and how the genetics of these groups compare to remaining wild populations in Washington and additional pinto abalone stock structure from outside Washington (Alaksa to Baja California, Mexico). This research has developed restriction site-associated DNA sequencing (RADseq) techniques for genotyping thousands of pinto abalone genetic markers (single nucleotide polymorphisms, or SNPs) and the bioinformatics results from this effort are still being analyzed (Dimond et al., in prep). Understanding the genetic structure of wild and hatchery-stocked pinto abalone in Washington and throughout their range will greatly advance pinto abalone recovery efforts.

Expansion of the juvenile outplant program

For the period of 2009 to 2021, approximately 40,000 healthy, genetically-diverse juvenile abalone were released on 21 sites in the SJI. Site locations will not be specified here in a public document due to concerns of illegal harvest, and site names have been changed to a coded system. All sites have received multiple follow-up surveys in subsequent years to track survival and growth of the outplants (see Carson et al. 2019 for full results).

Analysis of tagged abalone from early outplants suggested that size at outplant was not as important to later survival as previously believed (Carson et al. 2019). Therefore, the pilot experiments were performed in 2018 comparing the survival of 1-year-old and 2-year-old outplants. Initial results suggested that survival was similar between the two cohorts leading up to the 3-year-old age. Outplants of 1-year-olds and marked 2-year-olds then began on a larger scale, first to six new sites in 2019, then again to six sites that had been previously established to have high juvenile survival in 2020. Future surveys will compare the survival of these two cohorts.

Table 1. The history of outplants of hatchery-produced juvenile abalone to the San Juan Islands

Year	**2-year-olds outplanted**	**1-year-olds outplanted**	**Sites (*italics* = new site)**
2009	1131		*Utah, Omaha, Gold, Juno*
2010			
2011	2119		Utah, Omaha, Gold, Juno, *Sword, Jubilee*
2012			
2013	700		Sword, Jubilee
2014	1921		Utah, Omaha, Gold, Juno, Sword
2015	2543		Utah, Omaha, Gold, Juno, Sword, *Husky, Baytown*
2016	2439		Husky, Baytown, *Avalanche, Dragoon*

2017	4170		Utah, Omaha, Gold, Baytown, Avalanche, Dragoon, *Blackstone, Brushwood*
2018			
2019	1721	4838	*Vitality, Switchback, Infatuate, Abstention, Slapstick, Chariot*
2020	370	3247	Utah, Omaha, Gold, Baytown, Avalanche, Dragoon
2021	2548	8145	Chariot, Juno, Husky, Switchback, Vitality, Infatuate, Abstention, *Landcrab, Agreement, Ironclad*
Total	24,042	16,230	21 sites

As of 2021, the above outplanting operation has resulted in at least 8 sites that have matured into adult spawning aggregations that maintain densities greater than the 0.3 individuals m^{-2} threshold over several years.

Experimental larval outplants

In 2012, WDFW and PSRF conducted the first larval outplant trials in Washington. Settlement-inducing gamma-aminobutyric acid (GABA) was introduced to the hatchery-produced microscopic larval cohort immediately prior to being released to nine gabions (cage structures filled with coralline-encrusted rock) located along a rocky shoreline in the SJI. Follow up surveys during subsequent months and years did not detect settled juveniles. A student at SPMC partnered to repeat this experiment, this time with tenting to retain the larvae in the settlement modules. Tented modules did show successful settlement (Mills-Orcutt et al. 2020). More discussion on these experiments is located in Section V.

Public engagement

A public outreach campaign was started in 2008 to inform the public of the pinto abalone population plight. Posters were created and distributed to dive shops and Washington State ferries. The PSRF-affiliated website *www.pintoabalone.org* was launched and a series of public presentations was initiated.

A second outreach campaign was initiated in 2018 in preparation for the status review of pinto abalone in the state. WDFW and PSRF staff gave presentations to marine resources committees and the public in Port Townsend, Anacortes, Bellingham, Clinton, and Olympia. A press release was issued from WDFW public affairs to engage with local media, and WDFW reached out to non-profits, boating and diving clubs, ports, and other organizations around the state to seek public input on the listing process. After listing pinto abalone as endangered in 2019, WDFW staff created a new informational poster, and performed additional outreach to the diving and dive harvest community.

III. Key Knowledge Gaps

Outplant Site Selection

One of the biggest hurdles facing abalone restoration success is outplant site selection. This is a challenge that abalone researchers face coastwide. Choosing an area of seafloor to place a large amount of carefully raised abalone is arguably the most important decision in the recovery of this species, yet the most difficult. It is still unclear which specific variables have the strongest relationship to outplant success and failure. For example, past outplants have been conducted in which the same cohort of juvenile abalone are distributed between two comparably similar plots of seafloor, yet years later one yields a healthy abalone aggregation and the other does not. There appears to be some consistency when successive cohorts are added to the sites, i.e., survival and/or retention remains comparatively high at some sites and not others (Carson et al. 2019).

There are several well documented pinto abalone habitat features that likely need to be present on a site for abalone survival, such as bedrock or boulders covered in crustose coralline algae instead of fouling organisms, ample macroalgae for food, cracks or other spaces in which to hide, and a depth range of approximately three to ten meters. However, acute variables that are not noticeable to the human eye could be playing significant roles in the success of abalone outplants. Factors like microbiome composition, differences in water chemistry, sedimentation, and current speeds may be heavily influencing these juvenile abalone, especially during the sensitive first days and weeks post-outplant.

One key feature of sites is the community of predators that may feed on outplanted juveniles. Prior to the 2013 outbreak of sea star wasting syndrome (Montecino-Latorre et al. 2016), large sea stars were an abundant potential predator of abalone. A known common predator was the sunflower star which grows to a size large enough to consume adult abalone, and to which abalone show a consistent behavioral response of rapid escape movements. Crabs are likely an important predator, particularly of juvenile abalone (Griffiths and Gosselin 2008). Multiple species of octopus are likely pinto abalone predators, as they are on other abalone species (Hofmeister et al. 2018). Other potential predators include fish, birds, otters and other marine mammals, and drilling whelks. Identification of the most important predators on outplanted juveniles will aid in site selection, outplant timing, and development of protection measures, as will a program to remove potential predators from otherwise suitable habitat.

Effects of changing ocean conditions: acidification and temperature

Rising atmospheric carbon dioxide concentrations lower the pH of global oceans (Feely *et al*. 2004), increasing concern about the effects of such ocean acidification on the development of marine mollusks (Wootton *et al*. 2008; Shirayama and Thornton 2005). Abalone, like other mollusks, grow a calcium carbonate shell and the effects of decreased pH on shell development are currently being explored. Crim *et al*. (2011) found that shell abnormalities occurred or shell size was reduced for pinto abalone larvae under increasingly acidic conditions in the laboratory. Several critical areas of related study need to be addressed. This includes the synergistic effects of ocean acidification, temperature and pathogens; the immediacy/delay of potential acidification exposure on abalone health, and the role that temperature may play; and the effects of ocean acidification on both broodstock fitness and the quality of their eggs and larvae. Such understanding would inform future restoration efforts and provide a broader understanding of ocean acidification effects on abalone and mollusks in general.

Genetic diversity of remnant populations and restoration sites

Populations of organisms may lose genetic diversity when their numbers are reduced to a fraction of the former population size. Once lost, the genetic traits likely cannot be regained on a relevant timescale – a genetic "bottleneck". Genetic diversity increases the likelihood that populations will be able to persist during physical or biological shifts in the ecosystem when conditions favor a different set of traits than previously. In laboratory populations of spawning pinto abalone, it was observed that some individuals were responsible for more of the resulting embryos than would be expected given the number of abalone spawning (Lemay and Boulding 2009). In every case, one "family" of full siblings dominated each of the resulting groups of offspring, indicating that factors other than the concentration of eggs and sperm affected fertilization success (Lemay and Boulding 2009). Therefore, a diverse spawning population does not necessarily ensure commensurate genetic diversity in the next generation. Studies of wild populations of pinto abalone in British Columbia did not find evidence of a loss of genetic diversity despite an estimated 80% population reduction (Withler et al. 2003). The Washington population of pinto abalone has likely been reduced even further than in Canada (surveyed populations in Washington are down 97%).

Determining the relatedness of wild individuals collected for broodstock is necessary to evaluate the genetic diversity of restoration outplants. Results of these analyses will allow the restoration partnership to evaluate whether importing broodstock from out-of-state is necessary. Although tagging studies have shown little evidence of differential survival of families after outplant, sampling of adults on current restoration sites will allow for this to be evaluated more definitively. Genetic analyses in process will provide more information on the degree to which wild and hatchery populations of pinto abalone are experiencing a genetic bottleneck in Washington.

Establish baseline monitoring for kelp forest ecosystem shifts

Pinto abalone habitat in California and Oregon has undergone severe shifts in recent years including loss of macroalgae, loss of sea stars, expansion of sea urchin populations, and mass mortality of abalone (see section I). Many of these same shifts could occur in Washington, and some, such as loss of sea stars, already have. An adequate baseline to track the development of future shifts does not exist for Washington's pinto abalone habitat. Undersea monitoring of kelp density, purple sea urchin populations, and extent or expansion of possible "urchin barrens" could establish metrics to track major ecosystem changes. Although mitigating changes such as kelp loss in a complex ecosystem would be challenging, some tools are available.

Relationship between adult density and fertilization efficiency

Our current target for adult abalone density on restoration sites and naturally-formed aggregations is minimum of 0.3 abalone m^{-2}, but this target is based on computer simulations and anecdotal evidence from another species on another continent (Babcock and Keesing 1999). This estimate is also similar to densities of two self-sustaining populations of pinto abalone in Southeast Alaska, that have *average* densities of 0.17 and 0.25 abalone m^{-2}, with localized spawning aggregations at higher density (up to 1.2 m^{-2}, Alaska Department of Fish and Game unpublished data). In a small-scale study, Seamone and Boulding (2011) analyzed the distance between pinto abalone at three sites in Barkley Sound, British Columbia and found evidence to support the belief that pinto abalone aggregate at distances less than 1 meter from each other during the spawning season. Development of field or laboratory experiments to measure fertilization efficiency in Washington abalone, under the approximate tidal current conditions experienced by the state's population, would greatly aid in setting meaningful density targets.

Life history data

Species of the genus *Haliotis* are valued worldwide, but for many species there is still a dearth of biological and ecological data. Such scarcity combined with the cryptic nature and patchy distribution of abalone in the wild makes the species difficult to study and even more difficult to manage. With better life history data for each species comes a better understanding of the species' reproduction and growth characteristics. This will lead to a better understanding of how populations may be affected by particular threats and how such vulnerabilities may be specifically targeted by restoration strategies.

Our ability to recover pinto abalone populations would benefit greatly from a better understanding of population connectivity, movement/migration distance at each post-settlement life stage, age/size at both reproductive maturity and senescence, life-stage-specific survival rates, and effects of water quality on behavior, reproductive potential, and survival at various life stages.

IV. Recovery Goal and Downlisting Criteria

RECOVERY GOAL

The goals of abalone recovery efforts in Washington are to reverse the decline of pinto abalone stocks and to attain self-sustaining populations throughout regions of historic abundance in the State. For pinto abalone populations to once again become self-sustaining, the density of abalone must significantly increase within a majority of the sub-regions listed below.

DOWNLISTING CRITERIA

Pinto abalone were historically found in the San Juan Island Islands as well as the Strait of Juan de Fuca. To address recovery needs within the complicated geography of pinto abalone's range in Washington, recovery objectives are split into 2 main regions with 5 sub-regions each (Figs. 2 and

3). The San Juan Islands and the Strait of Juan de Fuca will be treated as two different regions and downlisting criteria will be tracked separately for each. In SJI, sub-regions were separated by known abundance of existing abalone as well as breaks in viable habitat. In SJDF, where less is known about pinto abalone abundance, sub-regions were chosen by dividing the coastline into 5 regions of similar area, each with suitable abalone habitat.

The status of pinto abalone will be considered for downlisting from **endangered** to **threatened** when the following conditions are achieved*:*

1. **Fifteen documented, naturally-formed aggregations, each containing at least 6 pinto abalone, and having an overall density of at least 0.3 abalone m^{-2}, are located within each of the two regions.** At least 3 of the 5 subregions in each region must have at least 3 spawning aggregations within their bounds to ensure that aggregations are dispersed throughout the historic range. For the purposes of this effort, to be counted as a separate aggregation, the closest individuals in each aggregation must be greater than 200 meters of coastline distance apart from the nearest individual of any other aggregation. Because there will likely be insufficient resources to survey all aggregations and subregions in a single season, "documentation" of each aggregation shall consist of a survey no more than four years old.

2. **In both regions, annual surveys of wild pinto abalone either on the 10 historic index stations or on newly monitored, naturally-formed aggregations must result in at least 20% of the total number of abalone surveyed having shell lengths less than 90 mm.** This is to ensure that recent reproduction is ongoing and that the population does not consist only of older individuals.

Pinto abalone will be considered for downlisting from **threatened** to **sensitive** when the following conditions are achieved:

1. **Thirty documented, naturally-formed aggregations, each containing at least 6 pinto abalone, and having an overall density of at least 0.3 abalone m^{-2}, are located within each of the two regions.** At least 4 of the 5 subregions in each region must have at least 3 spawning aggregations within their bounds to ensure that aggregations are dispersed throughout the historic range. For the purposes of this effort, to be counted as a separate aggregation, the closest individuals in each aggregation must be greater than 200 meters of coastline distance apart. Because there will likely be insufficient resources to survey all aggregations and subregions in a single season, "documentation" of each aggregation shall consist of a survey no more than four years old.

2. **In both regions, surveys of wild pinto abalone either on the 10 historic index stations or on newly monitored, naturally-formed aggregations must result in at least 30% of the total number of abalone surveyed having shell lengths less than 90 mm.** This is to ensure

that recent reproduction is ongoing and that the population does not consist only of older individuals.

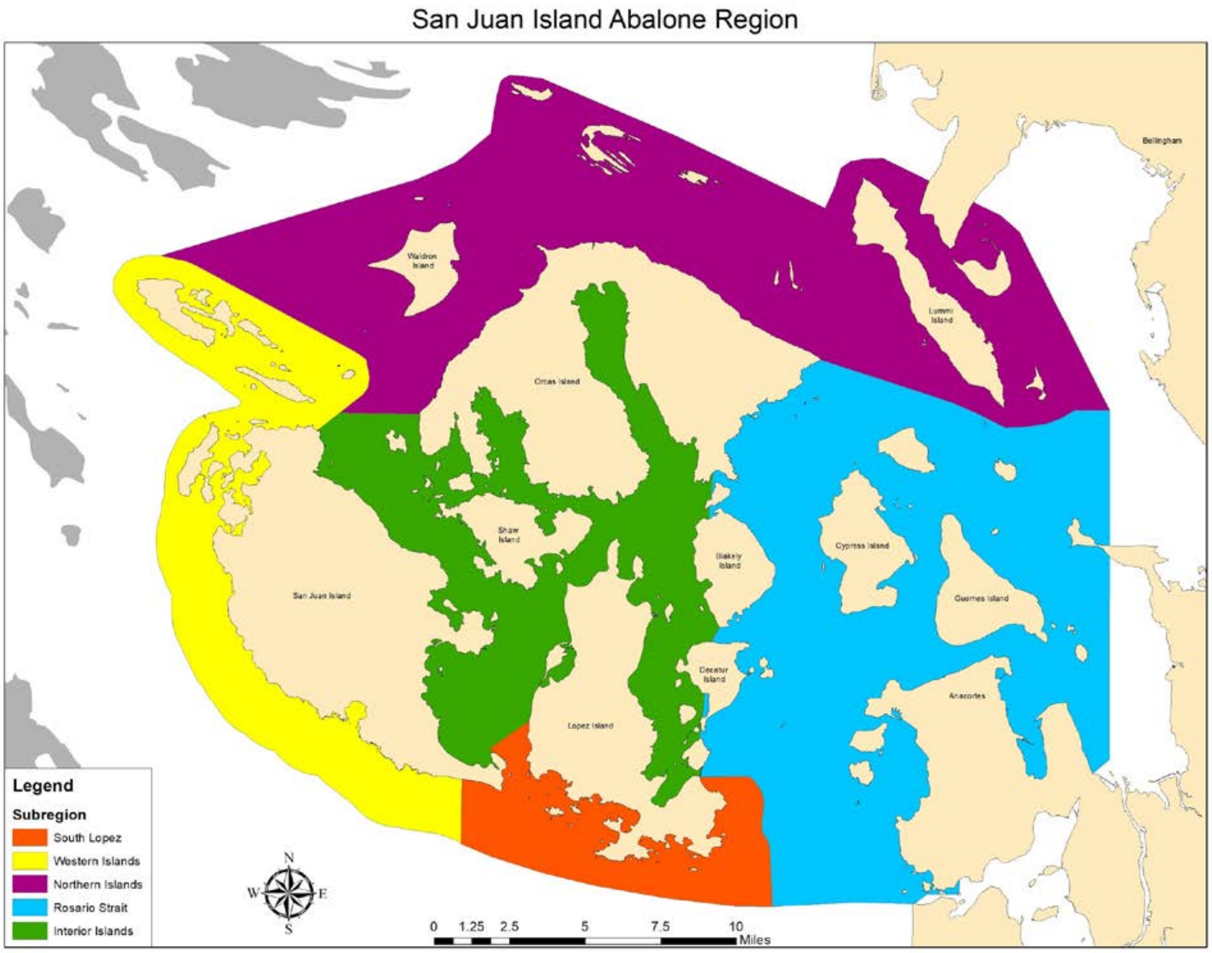

Figure 2: Five subregions within the San Juan Islands Region. Subregions are based on the distribution of wild abalone as surveyed in 1979 and breaks in viable abalone habitat. Subregions include large areas of unsuitable habitat (e.g., deep water, soft sediment) so as to be contiguous.

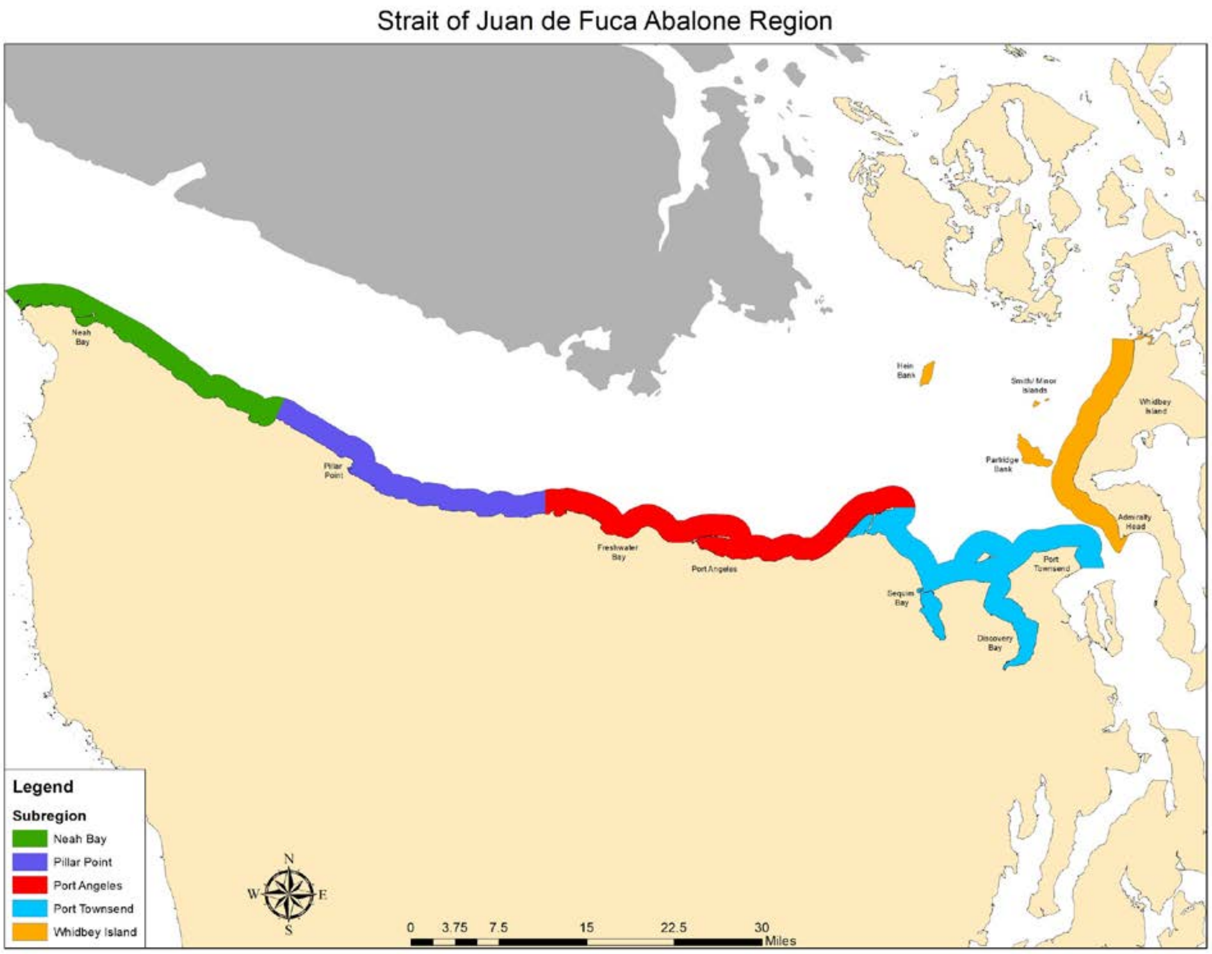

Figure 3: Five subregions within the Strait of Juan de Fuca Region. Subregion boundaries are based on the location of potential abalone habitat and information about past distribution of wild abalone. Subregions include large areas of unsuitable habitat (e.g., deep water, soft sediment) so as to be contiguous.

Criterion	**Status**		
	Endangered	*Threatened*	*Sensitive*
Number of documented spawning aggregations in each of the two regions	< 15	15 - 30	> 30
Number of subregions (out of five) that have at least three spawning aggregations in each of the two regions	0 - 2	3	4 - 5
Percent of wild individuals with a shell length less than 90 mm in each of the two regions	< 20%	20 – 30%	> 30%

Table 3: Recovery criteria relative to endangered, threatened, and sensitive status. Each of the three criteria must be met in both subregions to qualify for a change in status.

Rationale and Assumptions

Full recovery of an endangered species requires evidence that the species is self-sustaining and has achieved reproductive independence without human involvement.

The overall, long term goals of the Washington Abalone Recovery Plan are to halt the decline of abalone stocks in the Pacific Northwest and to return the population to a self-sustaining level. Given that fishing prohibition and 25+ years of recovery have failed to halt the decline in wild populations, abalone supplementation is currently the key activity identified as necessary to reach our overall goal. Collaborative restoration efforts so far have been scientifically methodical and have followed the primary principle of “do no harm”. Washington restoration strategies follow the American Fisheries Society (Williams et al. 1988) and the World Conservation Union (IUCN/SSC 2013) guidelines for reintroduction of endangered or threatened species.

The recovery criteria listed above focus on naturally-formed spawning aggregations, and do not directly hinge on the performance of the major restoration strategy – creation of spawning aggregations using hatchery-reared progeny of wild adults (see section II). Although those created aggregations may in turn seed “naturally-formed” aggregations elsewhere, they will not count toward the delisting criteria themselves. The overall goal is self-sustainability, without hatchery enhancement. If aggregations created by the restoration partnership persist for many years after the last outplant of hatchery abalone, and experience natural recruitment, this standard may be re-evaluated.

The downlisting criterion of at least 30 aggregations per region comes from the earliest available quantitative data on pinto abalone populations in Washington from 1979. Surveys that year documented at least 30 spawning aggregations in the San Juan Islands. The surveys were non-random and did not attempt to estimate density or overall population size. They targeted areas of known abundance. These surveys do not represent the virgin state of the population. The state recreational fishery had been in place for 20 years at that point, and a harvest estimate made two years later documented intensive harvest that had likely been the case for some years prior to the estimate (Bargmann 1984). However, the goal of this recovery plan is not to return pinto abalone populations to a virgin state, it is to return them to a self-sustaining, expanding state. It is likely that the abundance detected in 1979 was not yet below the Allee threshold for recruitment failure.

The 1979 survey did not cover the Strait of Juan de Fuca region, however, we apply the same thirty -aggregation standard to that region based on the comparable amount of available shallow, rocky-reef habitat there.

Although a total of 360 individuals (minimum 6 per aggregation, 60 aggregations in the state) would not be sufficient for downlisting, the criterion includes the stipulation they be “documented”. The cryptic nature of the animals and the expense needed to adequately survey underwater means that each animal documented likely represents several more either nearby or in undiscovered aggregations. This was likely also true of the 1979 survey data on which we base this criterion.

There will likely never be the resources to survey a large portion of the available habitat or known aggregations across both regions in any one year. Therefore, we have defined what constitutes a “documented” aggregation, and that is having a survey of the aggregation not less than four years old. That will allow managers to rotate survey effort around subregions, but still maintain relatively current information on each aggregation.

The criterion requiring a certain percentage to be smaller than 90 mm is an attempt to measure recruitment to the adult populations in the recent past. The 90 mm threshold represents young adults without any reproductive senescence, also recognizing that small juveniles are difficult to detect in surveys (Carson et al. 2019).

The requirement that 30% of the monitored population have a shell length less than 90 mm is also based on data collected during the 1979 survey of the San Juan Islands. Approximately 30% of the 755 individuals measured in that survey were smaller than 90 mm. It is possible that the sampled populations in that year were not representative, or that fishers targeting larger individuals shifted the size distribution, thus making abalone smaller on average. However, surveyed populations in British Columbia that have not been subject to legal harvest for many years (but are significantly threatened by poaching) routinely have size distributions in which 50% or more of the population are smaller than 90 mm shell length (DFO 2020). It is therefore our assumption that 30% is an attainable standard that also demonstrates significant reproduction and recruitment is occurring.

We have chosen to require that a spawning aggregation consist of at least 6 individuals in part to make the existence of both male and female abalone in that aggregation highly probable. Given an equal sex ratio, the odds that 6 randomly chosen abalone would all be the same sex would be one in sixty-four (1.5%). An alternative would be to require that each aggregation consist of members from each sex. However, sexing abalone requires their removal from the rock to examine the gonad color and is not always definitive depending on seasonal gonad maturation status. Removal can be stressful to the animal and could result in injury, mortality, or eventual flight from the aggregation site. Therefore, we have written the criteria to allow for monitoring that requires minimal disturbance to the animal (observation, shell measurement if possible). If we have reason to suspect significantly unbalanced sex ratios in the overall population (from singleton broodstock collection, for instance, when the animals *are* removed and sexed), this standard may be re-evaluated.

We have added a proviso to mandate geographic spread (3 of 5 subregions for threatened status, 4 of 5 for sensitive status) of the spawning aggregations to mitigate against possible catastrophic loss of animals and habitat. A major oil spill, for instance, could impact a significant portion of the pinto abalone range in Washington. For the abalone to be considered at a reduced risk of extirpation, robust spawning aggregations must exist throughout much of both the SJI and SJDF (Figure 1 and 2). Subregional boundaries are based on groupings of historic spawning aggregations and existence of appropriate habitat, either as documented from 1979 or later abalone survey data in the SJI, or observations made during surveys for other purposes in the SJDF.

We have set the separation of aggregations at 200m in order to ensure that aggregations are well dispersed within a subregion. Dispersal of aggregations within subregions will likely protect the subregion's population from threats such as poaching, oil spills, and other threats that may affect a given reef.

The Strait of Juan de Fuca and the San Juan Islands were separated into two regions to account for variation in habitat, historical knowledge, and fieldwork access. The two regions were subdivided into 5 subregions each as a means to document the progress of pinto abalone recovery throughout each region. The boundary of each subregion was influenced by historical and current knowledge of abalone abundance.

Insufficient biological and ecological data exist for determining the minimum density threshold needed for pinto abalone populations to be at self-sustainable levels. Generally, broadcast spawning, sedentary invertebrates, such as abalone, must be aggregated above some minimum density range for successful fertilization and prevention of population collapse. We use a mature adult density of 0.3 individuals m^{-2}, borrowed from Babcock and Keesing (1999) until pinto-abalone-specific information is available, as a minimum target for guiding our recovery estimates. Until populations exceed this critical threshold density range (or until above a critical density specifically characterized for pinto abalone) they will be considered at risk of recruitment failure, and ultimately, extirpation.

V: Recovery Strategies and Tasks

METHODS TO ACHIEVE DOWNLISTING CRITERIA

The strategies needed to increase the size and density of pinto abalone populations to a self-sustaining level (i.e., recovery) will require a multi-faceted approach of education, monitoring, restoration, and management. This is unlikely to be achieved by the Department of Fish and Wildlife alone. In order to meet the monitoring and other goals outlined below, a coalition of non-profit organizations, universities, tribes, and other agencies is necessary.

1. Captive breeding and propagation of pinto abalone for the enhancement of the wild population

1.1 *Maintenance of current pinto abalone hatcheries*

The restoration program began at the NOAA Mukilteo Research Station but is currently based at the Kenneth K. Chew Center for Shellfish Research at the NOAA Manchester Research Station. Wild broodstock are maintained here, and all spawning and larval production takes place. Juvenile rearing occurs jointly here and at satellite facilities. Hatchery protocols include the use of periodic disease screening.

1.2 *Increase in hatchery capacity*

Scaling up conservation aquaculture will require additional tank space and staff time to care for animals, beyond the capacity of the existing hatchery in Manchester. Establishment of "satellite" facilities that can be stocked with embryos fertilized in Manchester will increase production and hatchery capacity. Juveniles held in these facilities will also guard against catastrophic loss of individuals in any single facility and provide greater opportunities for outreach and education (method 4). Current satellite sites are located at the Port Townsend Marine Science Center and the Seattle Aquarium.

1.3 *Continuation of research regarding best captive abalone husbandry methods and juvenile rearing methods*

Improvement of husbandry and hatchery techniques will be necessary to scale-up conservation aquaculture operations. Barriers still exist for the reliable production of hatchery pinto abalone to outplant size. These barriers primarily include gonad conditioning, spawning induction, and early post-settlement growth and survival. To maximize genetic diversity and the number of distinct families produced within the hatchery that are subsequently outplanted to restoration sites, hatchery and nursery techniques need improvement. This includes ongoing research into pinto abalone gamete cryopreservation.

1.4 ***Rotation of hatchery broodstock into wild spawning aggregations***

Prior to late spring captive spawning events, research divers collect adult “singleton” pinto abalone from the wild and transport them to the hatchery to become broodstock. Shortly after they arrive at the hatchery, they are spawned to produce juvenile abalone for outplanting purposes. If not retained for future spawning, these adults can be returned to the wild after their time at the hatchery is complete. During the release, divers place these abalone in aggregations and near other wild abalone, if possible. By returning healthy adults to the wild proximate to other mature abalone, increased densities may help to promote successful wild spawning.

1.5 ***Develop quarantine protocols for possible importation of out-of-state broodstock***

Wild pinto populations continue to dwindle in Washington waters, yet the need for wild adults in the broodstock program increases as the recovery program grows. This program must be prepared for the possibility of needing more broodstock abalone in the captive breeding program than the wild population can sustainably supply. In the event that Washington’s pinto population can no longer supply the hatchery with wild adult abalone, there is potential to “import” abalone into Washington from other states. Abalone brought in from other states must undergo a quarantine process before coming in contact with the hatchery’s seawater system. This will require a dedicated quarantine facility that does not currently exist at the Manchester hatchery.

2. Expansion of outplant program

2.1 ***Large-scale juvenile abalone outplanting***

Pinto abalone densities continued to decline even after the closure of the fishery in 1994. All evidence shows the wild pinto population in Washington had experienced an Allee effect even prior to the fishery closure. Until 2021, research divers had not seen a juvenile pinto abalone (<50mm) since 2008. In 2021, research divers observed one abalone of approximately 45cm shell length.

Although not abundant, wild aggregations have been documented within state waters, but densities overall have become too low to support self-recovery. Without human intervention to supplement the population, pinto abalone in Washington will likely disappear.

Since 2009, the pinto abalone outplant program has represented one of the most substantial efforts for abalone recovery. As of 2021, WDFW and PSRF have established and stocked over 40,000 hatchery-raised abalone to 21 sites around the SJI to supplement extant populations with an objective of maximizing genetic diversity. Because of the outplant program, there now exists healthy aggregations of hatchery-raised adult abalone at appropriate densities in the wild.

Pilot studies have informed our team with respect to optimization of outplant densities, abalone sizes and re-introduction techniques (Carson et al. 2019). The goal is to add 2 - 6 new outplant sites each year, recognizing that not every site will lead to the establishment of adult aggregations above the fertilization threshold. Sites at which survival is low will be abandoned, and successful sites will receive new cohorts in a multi-year rotation to maintain densities and increase genetic diversity of spawners.

2.1.1 Outplant a combination of younger and older juveniles

Most pilot juvenile outplants consisted of "2-year-old" abalone, produced through spawns in the summer months, reared in the hatchery for on average 20 months, and outplanted in the following spring. Recent experiments suggest that the survival of "1-year-old" abalone, of approximate 10 months age at outplanting, is comparable to that of 2-year-olds. These younger abalone can be produced at greatly reduced cost and may be less acclimatized to hatchery conditions, hence are preferable. However, not all 1-year-olds attain a size that can be safely transferred to outplant sites. Therefore, significant numbers of them can be retained and consolidated in the hatchery, and outplanted the following year with a new cohort of eligible 1-year-olds. This new cycle has increased overall hatchery production per year with the same resources.

2.1.2 Continue monitoring established outplant sites

Because not all sites promote successful survival and/or retention of outplanted abalone, follow-up surveys are needed to evaluate site performance and gauge overall success of the outplant program. Each site takes approximately one day for 4 divers to survey. Traditionally all sites have received at least a one-year follow up survey, with several sites receiving surveys at shorter intervals. The network of existing sites is already too big to survey in any one field season. Therefore, future monitoring will consist of surveys of the most recently established sites, followed in priority by rotating through a subset of older sites - those with good survival/retention that are due to be outplanted again that year.

2.1.3 Continue research into favorable site characteristics

Existing sites are chosen in areas of known historic abalone abundance, and/or with complex, hard substrate, free of dominant cover by encrusting invertebrates, well-circulated seawater, and ample algae. However, abalone mortality and/or emigration is high at approximately half of chosen sites, and it is not obvious why.

This issue plagues restoration of various abalone species on the West Coast. Ongoing research includes the use of time-lapse cameras to identify predation on the outplanted juveniles, and water quality monitoring. If variables that promote abalone survival and retention can be identified, the efficiency of the outplant operation can be increased substantially.

2.2 ***Further research into the efficacy of larval and post-larval abalone outplants***

As used herein, the term 'larval' with respect to outplants may be used to include true abalone larvae (i.e., abalone whose developmental stage is between a fertilized egg and pre-settlement, ~0-10 days old) and post-larval abalone (~0-30 days post-settlement). These animals are described collectively as we explore methods that yield the lowest mortality.

'Larval' outplants have been attempted for abalone restoration and ranching purposes in many studies, and have shown a range of success in outplant survival rates (0.02-10%; Tong et al. 1987, Schiel 1992, Preece et al. 1997, Shepherd et al. 2000, Hamasaki and Kitada 2008, Read et al. 2012, Searcy-Bernal et al. 2013). These studies continue to be attempted because the relative costs of outplanting at such early stages are nominal when compared to outplanting after being reared in a hatchery. In 2020, the estimated cost of rearing a cohort of captive bred pinto abalone is $12,000 per month (J. Bouma, pers. comm.). The ability to successfully outplant larval abalone would allow funds to be used for other restoration costs. Furthermore, outplanting animals early in their development eliminates the risk of hatchery habituation.

However, larval outplants also result in the propagation of large numbers of full and half siblings in the same location, potentially increasing the long-term genetic risks of inbreeding depression. This risk can be reduced through repeated outplants from multiple families at the same location. Such small animals are impossible to physically tag (with traditional methods). To identify them as hatchery individuals after they emerge, genetic, trace element or other methods could be used to determine parental lineage. Additionally, larval outplants are much more difficult for research divers to survey and determine survival. In a clean laboratory setting, newly settled abalone are barely visible to the naked eye. In the wild, abalone are not visible to the trained diver's eye until they reach around 4-5mm shell length several months after settling. Even then, juvenile abalone are extremely cryptic and fragile, making surveying exceptionally time consuming and risky for small abalone. Thus, researchers may not know whether a larval outplant is successful until years after a larval outplant takes place.

A 2013 experimental larval outplant conducted by WDFW and PSRF resulted in no detected juveniles as of the last survey. However, competent larvae and the settlement cue were placed into cobble habitat without any tents or other mechanism to retain larvae. In 2018, an experimental larval outplant was conducted in sites off Fidalgo Island, Washington (Mills-Orcutt et al. 2020). The study involved seeding 39,000 pinto abalone larvae into tented and un-tented larval abalone modules (LAMs) at two field sites as well as in a lab aquarium. Although overall settlement percentages were low at the conclusion of the 4-month field trial, divers found a higher number of abalone in tented LAMs as well as abalone that settled on the tent material itself, suggesting this outplant method has potential for success with expanded research and modifications.

There are many potential benefits and disadvantages of larval outplants. However, there are major knowledge gaps regarding natural juvenile pinto abalone behavior, and further research into this unique method may help researchers answer key questions about early life stages of pinto abalone in the wild.

3. Continuous and expanded identification and monitoring of remnant wild aggregations

3.1 *Continuous monitoring of index sites*

Continuous monitoring of index sites will be essential to evaluate the success or failure of recovery efforts. Efficacy of recovery will be measured in the same way that declines have been quantified among surveyed populations: (1) densities (numbers of animals per area) and (2) changes in mean shell lengths (size structure).

3.1.1 Expand index survey staff and vessel time

Since 1992, 10 SJI index stations have been surveyed on an irregular schedule ranging from annually to as long as a 7-year gap between surveys. Surveying all 10 stations requires the allocation of 4 staff per day and approximately 10 dive days (assuming conditions are safe for diving, vessels are available and working, etc.) This is the only standardized time series of relative abundance available in the State of Washington. Care should be taken to prevent interference with natural densities, however low, at these sites.

3.1.2 Addition of new index sites or identified wild aggregations

It is likely that more monitoring stations will need to be established to track recovery, especially in the SJDF where none exist now. The 10 existing index stations in the SJI had an average of 36 individuals per station at establishment in 1992. At last survey in 2017, 5 of the 10 stations had zero individuals. It is reasonable to imagine a scenario wherein pinto abalone experience significant recovery, but not at all or any of the existing index sites. To meet criteria for downlisting, new spawning aggregations encountered during surveys will be added to the monitoring plan so their density and size structure can be tracked. To qualify an aggregation under the downlisting criteria, surveys must be less than four years old, necessitating a rotation through the subregions.

3.2 ***Exploratory dives to find new aggregations, singleton broodstock, and outplant friendly habitat***

3.2.1 Expand scouting in the San Juan Islands

Dives on unexplored shallow, rocky reefs can have three uses - identification of previously unknown wild aggregations, collection of singleton abalone to be used as broodstock in the hatchery, and discovery of habitat apparently suitable for abalone that can host hatchery-origin juveniles. A habitat-mapping project undertaken by the SeaDoc Society, combined with reports of abalone sightings from recreational or commercial divers, aids in the identification of unexplored territory.

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3.2.2 Extend scouting surveys into the Strait of Juan de Fuca

Wild aggregations and suitable outplant habitat have been identified opportunistically during dives for other purposes in the SJDF, but no systematic scouting approach has been employed. The SeaDoc habitat mapping project was specific to the SJI and did not include the SJDF.

4. Continued relations with partners and the public

4.1 ***Build partnerships and secure financial support for outplant and monitoring program***

With considerable dive time already spent on Methods 1 and 3, as recovery expands a single team on one vessel will not be able to monitor wild populations, survey outplant sites, scout for new sites, and collect broodstock across both the SJI and SJDF. Partnerships with universities, tribes, non-profit organizations or other government agencies to field additional teams during key seasons would allow the restoration program to meet its goals.

4.2 ***Maintenance of fishery closures and diligent enforcement***

Continuation of fishery closures and enforcement will be necessary to prevent the further decline of abalone populations while we develop new strategies to facilitate population recovery. Rather than patrol the scattered areas with aggregations of hatchery-origin or wild abalone, enforcement effort may be better spent on inspections of recreational and commercial dive harvest in the SJI and SJDF.

To protect current and future outplant sites from poaching and human disturbance, neither WDFW nor our collaborators release geospatial information regarding the location of these sites. This geospatial information is also protected from public disclosure per RCW 42.56.430.

4.3 *Education and public outreach*

Education and public outreach will help reduce the risk of accidental poaching of abalone by those individuals who may be unaware of the status of abalone populations in Washington. Furthermore, by increasing awareness among the public and by involving them in restoration efforts, we aim to develop a greater sense of stewardship and conservation of the species and hope to reduce the demand for illegally harvested abalone. Outreach efforts include posting informational flyers in dive shops, participating in virtual educational events, and hosting abalone workshops to share knowledge amongst the abalone research community and the public. Furthermore, the developing strategy of satellite growout facilities open to the public, such as the Port Townsend Marine Science Center and Seattle Aquarium, is expected to make the project more accessible.

5. Close additional knowledge gaps in pinto abalone life history and ecology

Although some of the identified knowledge gaps outlined in Section III are already addressed in the above methods (e.g., outplant site selection), others may require separate research programs. See section III for discussion of each item.

5.1 *Ocean acidification impact on pinto abalone*

5.2. *Barriers to recruitment and survival including water quality and sedimentation*

5.3 *Genetic diversity of remnant wild population and hatchery-origin population*

5.4 *Baseline monitoring of kelp forest ecosystem shifts*

5.5 *Relationship between adult density and fertilization efficiency*

5.6 *Basic life history information for pinto abalone in Washington waters*

VI: Implementation Plan

Table 2 details the implementation plan for pinto abalone in Washington, listing and prioritizing all recovery tasks, and identifying the type of potential partners needed to help achieve them. The listing of a potential partner does not require them to implement the action(s) or to secure funding for implementing the action(s), but they are possible collaborators to accomplish the action(s). Each task is ranked by a priority system based on its potential contribution to the overall recovery effort (described below). Potential WDFW resources affected by each task are also identified. A check mark indicates that WDFW is likely to be involved in that task, but does not mandate specific WDFW staff time, equipment, or funding. Implementation of this recovery plan is contingent upon current and future funding levels and staff capacity of WDFW and its partners.

The following conventions are used for priority rankings:
Priority 1: Actions essential for advancing the recovery process, and/or with potential to provide rapid and significant benefit to pinto abalone in Washington.

Priority 2: Actions with high potential for informing and advancing the recovery process, and/or with potential to provide long-term benefit to pinto abalone in Washington.

Priority 3: All other actions desirable for advancing the recovery of pinto abalone in Washington.

The following acronyms are used for potential partners:

EDU – Educators and Scientific Community (e.g., local schools, universities)
IG – Interest groups (e.g., commercial fishers, recreational scuba dive organizations)
NGO – Non-governmental organizations (e.g., PSRF, the SeaDoc Society)
OGA – Other government agencies (e.g., federal and other state agencies, counties, municipalities)
TG – Tribal governments (e.g., Samish Tribe, Makah Tribe)
VO – Volunteers

Table 3: Recovery Tasks

Recovery Task	**Priority**	**Timing**	**Potential Partners**	**Potential WDFW Resources**	
				Staff	**Funding**
1.1 Maintenance of current pinto abalone hatcheries	**1**	ongoing continuous	NGO		✔
1.2 Increase in hatchery capacity	**1**	ongoing periodic	NGO, TG, EDU		✔
1.3 Research: best captive abalone husbandry	**1**	ongoing periodic	NGO, TG, EDU		✔

Recovery Task	Priority	Timing	Potential Partners	Potential WDFW Resources	
				Staff	Funding
and juvenile rearing methods					
1.4 Rotation of hatchery broodstock into wild spawning aggregations	**3**	planned periodic	NGO	✔	✔
1.5 Develop quarantine protocols for possible importation of out-of-state broodstock	**2**	planned one-time	NGO, OGA		✔
2.1 Large-scale juvenile abalone outplanting	**1**	ongoing continuous	NGO, TG, EDU, VO	✔	✔
2.2 Further research into the efficacy of larval and post-larval abalone outplants	**2**	ongoing periodic	NGO, TG, EDU	✔	✔
3.1 Continuous index site monitoring	**1**	ongoing periodic	NGO, TG, EDU, OGA	✔	✔
3.2 Exploratory dives: new aggregations, broodstock and outplant-friendly habitat	**1**	ongoing continuous	NGO, TG, EDU, VO, OGA, IG	✔	✔
4.1 Build partnerships and secure financial support for outplant and monitoring program	**1**	ongoing periodic	NGO, TG, OGA, VO, IG	✔	
4.2 Maintenance of fishery closures and diligent enforcement	**1**	ongoing continuous	IG, OGA, TG	✔	✔
4.3 Education and public outreach	**1**	ongoing periodic	NGO, IG, EDU, TG	✔	✔
5.1 Research: Ocean acidification impact on pinto abalone	**2**	planned periodic	NGO, TG EDU, OGA		✔
5.2. Research: Barriers to recruitment and survival, water quality and sedimentation	**2**	ongoing periodic	NGO, TG, EDU, OGA	✔	✔
5.3 Research: Genetic diversity of remnant wild and hatchery-origin population	**1**	ongoing periodic	NGO, TG, EDU	✔	✔
5.4 Research Baseline monitoring of kelp forest ecosystem shifts	**2**	ongoing continuous	TG, OGA, VO	✔	✔
5.5 Research: Relationship between adult density and fertilization efficiency	**3**	planned one-time	NGO, TG, EDU	✔	✔
5.6 Research: Basic life history information for pinto abalone in WA	**3**	TBD	NGO, G, EDU	✔	✔

Literature cited for the Pinto Abalone Recovery Plan

The literature cited in the *Pinto Abalone Recovery Plan* is presented below. Each reference is categorized for its level of peer review pursuant to section 34.05.271 RCW, which is the codification of Substitute House Bill 2661 that passed the Washington Legislature in 2014. A key to the review categories under section 34.05.271 RCW is provided in Table 2.

Table 4. Key to 34.05.271 RCW Categories:

Category Code	34.05.271(1)(c) RCW
i	(i) Independent peer review: review is overseen by an independent third party.
ii	(ii) Internal peer review: review by staff internal to the department of fish and wildlife.
iii	(iii) External peer review: review by persons that are external to and selected by the department of fish and wildlife.
iv	(iv) Open review: documented open public review process that is not limited to invited organizations or individuals.
v	(v) Legal and policy document: documents related to the legal framework for the significant agency action including but not limited to: (A) federal and state statutes; (B) court and hearings board decisions; (C) federal and state administrative rules and regulations; and (D) policy and regulatory documents adopted by local governments.
vi	(vi) Data from primary research, monitoring activities, or other sources, but that has not been incorporated as part of documents reviewed under the processes described in (c)(i), (ii), (iii), and (iv) of this subsection.
vii	(vii) Records of the best professional judgment of department of fish and wildlife employees or other individuals.
viii	(viii) Other: Sources of information that do not fit into one of the categories identified in this subsection (1)(c).

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APPENDIX A. **Washington Administrative Code 220-610-110. Endangered, threatened, and sensitive wildlife species classification.**

PURPOSE

1.1 The purpose of this rule is to identify and classify native wildlife species that have need of protection and/or management to ensure their survival as free-ranging populations in Washington and to define the process by which listing, management, recovery, and delisting of a species can be achieved. These rules are established to ensure that consistent procedures and criteria are followed when classifying wildlife as endangered, or the protected wildlife subcategories threatened or sensitive.

DEFINITIONS

For purposes of this rule, the following definitions apply:

2.1 "Classify" and all derivatives means to list or delist wildlife species to or from endangered, or to or from the protected wildlife subcategories threatened or sensitive.

2.2 "List" and all derivatives means to change the classification status of a wildlife species to endangered, threatened, or sensitive.

2.3 "Delist" and its derivatives means to change the classification of endangered, threatened, or sensitive species to a classification other than endangered, threatened, or sensitive.

2.4 "Endangered" means any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state.

2.5 "Threatened" means any wildlife species native to the state of Washington that is likely to become an endangered species within the forseeable future throughout a significant portion of its range within the state without cooperative management or removal of threats.

2.6 "Sensitive" means any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened in a significant portion of its range within the state without cooperative management or removal of threats.

2.7 "Species" means any group of animals classified as a species or subspecies as commonly accepted by the scientific community.

2.8 "Native" means any wildlife species naturally occurring in Washington for purposes of breeding, resting, or foraging, excluding introduced species not found historically in this state.

2.9 "Significant portion of its range" means that portion of a species' range likely to be essential to the long term survival of the population in Washington.

LISTING CRITERIA

3.1 The commission shall list a wildlife species as endangered, threatened, or sensitive solely on the basis of the biological status of the species being considered, based on the preponderance of scientific data available, except as noted in section 3.4.

3.2 If a species is listed as endangered or threatened under the federal Endangered Species Act, the agency will recommend to the commission that it be listed as endangered or threatened as specified in section 9.1. If listed, the agency will proceed with development of a recovery plan pursuant to section 11.1.

3.3 Species may be listed as endangered, threatened, or sensitive only when populations are in danger of failing, declining, or are vulnerable, due to factors including but not restricted to limited numbers, disease, predation, exploitation, or habitat loss or change, pursuant to section 7.1.

3.4 Where a species of the class Insecta, based on substantial evidence, is determined to present an unreasonable risk to public health, the commission may make the determination that the species need not be listed as endangered, threatened, or sensitive.

DELISTING CRITERIA

4.1 The commission shall delist a wildlife species from endangered, threatened, or sensitive solely on the basis of the biological status of the species being considered, based on the preponderance of scientific data available.

4.2 A species may be delisted from endangered, threatened, or sensitive only when populations are no longer in danger of failing, declining, are no longer vulnerable, pursuant to section 3.3, or meet recovery plan goals, and when it no longer meets the definitions in sections 2.4, 2.5, or 2.6.

INITIATION OF LISTING PROCESS

5.1 Any one of the following events may initiate the listing process.

5.1.1 The agency determines that a species population may be in danger of failing, declining, or vulnerable, pursuant to section 3.3.

5.1.2 A petition is received at the agency from an interested person. The petition should be addressed to the director. It should set forth specific evidence and scientific data which shows that the species may be failing, declining, or vulnerable, pursuant to section 3.3. Within 60 days, the agency shall either deny the petition, stating the reasons, or initiate the classification process.

5.1.3 An emergency, as defined by the Administrative Procedure Act, chapter 34.05 RCW. The listing of any species previously classified under emergency rule shall be governed by the provisions of this section.

5.1.4 The commission requests the agency review a species of concern.

5.2 Upon initiation of the listing process the agency shall publish a public notice in the Washington Register, and notify those parties who have expressed their interest to the department, announcing the initiation of the classification process and calling for scientific information relevant to the species status report under consideration pursuant to section 7.1.

<u>INITIATION OF DELISTING PROCESS</u>

6.1 Any one of the following events may initiate the delisting process:

6.1.1 The agency determines that a species population may no longer be in danger of failing, declining, or vulnerable, pursuant to section 3.3.

6.1.2 The agency receives a petition from an interested person. The petition should be addressed to the director. It should set forth specific evidence and scientific data which shows that the species may no longer be failing, declining, or vulnerable, pursuant to section 3.3. Within 60 days, the agency shall either deny the petition, stating the reasons, or initiate the delisting process.

6.1.3 The commission requests the agency review a species of concern.

6.2 Upon initiation of the delisting process the agency shall publish a public notice in the Washington Register, and notify those parties who have expressed their interest to the department, announcing the initiation of the delisting process and calling for scientific information relevant to the species status report under consideration pursuant to section 7.1.

<u>SPECIES STATUS REVIEW AND AGENCY RECOMMENDATIONS</u>

7.1 Except in an emergency under 5.1.3 above, prior to making a classification recommendation to the commission, the agency shall prepare a preliminary species status report. The report will include a review of information relevant to the species' status in Washington and address factors affecting its status, including those given under section 3.3. The status report shall be reviewed by the public and scientific community. The status report will include, but not be limited to an analysis of:

7.1.1 Historic, current, and future species population trends.

7.1.2 Natural history, including ecological relationships (e.g., food habits, home range, habitat selection patterns).

7.1.3 Historic and current habitat trends.

7.1.4 Population demographics (e.g., survival and mortality rates, reproductive success) and their relationship to long term sustainability.

7.1.5 Historic and current species management activities.

7.2 Except in an emergency under 5.1.3 above, the agency shall prepare recommendations for species classification, based upon scientific data contained in the status report. Documents shall be prepared to determine the environmental consequences of adopting the recommendations pursuant to requirements of the State Environmental Policy Act (SEPA).

7.3 For the purpose of delisting, the status report will include a review of recovery plan goals.

<u>PUBLIC REVIEW</u>

8.1 Except in an emergency under 5.1.3 above, prior to making a recommendation to the commission, the agency shall provide an opportunity for interested parties to submit new scientific data relevant to the status report, classification recommendation, and any SEPA findings.

8.1.1 The agency shall allow at least 90 days for public comment.

8.1.2 The agency will hold at least one public meeting in each of its administrative regions during the public review period.

<u>FINAL RECOMMENDATIONS AND COMMISSION ACTION</u>

9.1 After the close of the public comment period, the agency shall complete a final status report and classification recommendation. SEPA documents will be prepared, as necessary, for the final agency recommendation for classification. The classification recommendation will be presented to the commission for action. The final species status report, agency classification recommendation, and SEPA documents will be made available to the public at least 30 days prior to the commission meeting.

9.2 Notice of the proposed commission action will be published at least 30 days prior to the commission meeting.

PERIODIC SPECIES STATUS REVIEW

10.1 The agency shall conduct a review of each endangered, threatened, or sensitive wildlife species at least every five years after the date of its listing. This review shall include an update of the species status report to determine whether the status of the species warrants its current listing status or deserves reclassification.

10.1.1 The agency shall notify any parties who have expressed their interest to the department of the periodic status review. This notice shall occur at least one year prior to end of the five year period required by section 10.1.

10.2 The status of all delisted species shall be reviewed at least once, five years following the date of delisting.

10.3 The department shall evaluate the necessity of changing the classification of the species being reviewed. The agency shall report its findings to the commission at a commission meeting. The agency shall notify the public of its findings at least 30 days prior to presenting the findings to the commission.

10.3.1 If the agency determines that new information suggests that classification of a species should be changed from its present state, the agency shall initiate classification procedures provided for in these rules starting with section 5.1.

10.3.2 If the agency determines that conditions have not changed significantly and that the classification of the species should remain unchanged, the agency shall recommend to the commission that the species being reviewed shall retain its present classification status.

10.4 Nothing in these rules shall be construed to automatically delist a species without formal commission action.

RECOVERY AND MANAGEMENT OF LISTED SPECIES

11.1 The agency shall write a recovery plan for species listed as endangered or threatened. The agency will write a management plan for species listed as sensitive. Recovery and management plans shall address the listing criteria described in sections 3.1 and 3.3, and shall include, but are not limited to:

11.1.1 Target population objectives.

11.1.2 Criteria for reclassification.

11.1.3 An implementation plan for reaching population objectives which will promote cooperative management and be sensitive to landowner needs and property rights. The plan will specify resources needed from and impacts to the department, other agencies (including federal, state, and local), tribes, landowners, and other interest groups. The plan shall consider various approaches to meeting recovery objectives including, but not limited to regulation, mitigation, acquisition, incentive, and compensation mechanisms.

11.1.4 Public education needs.

11.1.5 A species monitoring plan, which requires periodic review to allow the incorporation of new information into the status report.

11.2 Preparation of recovery and management plans will be initiated by the agency within one year after the date of listing.

11.2.1 Recovery and management plans for species listed prior to 1990 or during the five years following the adoption of these rules shall be completed within five years after the date of listing or adoption of these rules, whichever comes later. Development of recovery plans for endangered species will receive higher priority than threatened or sensitive species.

11.2.2 Recovery and management plans for species listed after five years following the adoption of these rules shall be completed within three years after the date of listing.

11.2.3 The agency will publish a notice in the Washington Register and notify any parties who have expressed interest to the department interested parties of the initiation of recovery plan development.

11.2.4 If the deadlines defined in sections 11.2.1 and 11.2.2 are not met the department shall notify the public and report the reasons for missing the deadline and the strategy for completing the plan at a commission meeting. The intent of this section is to recognize current department personnel resources are limiting and that development of recovery plans for some of the species may require significant involvement by interests outside of the department, and therefore take longer to complete.

11.3 The agency shall provide an opportunity for interested public to comment on the recovery plan and any SEPA documents.

CLASSIFICATION PROCEDURES REVIEW

12.1 The agency and an ad hoc public group with members representing a broad spectrum of interests, shall meet as needed to accomplish the following:

12.1.1 Monitor the progress of the development of recovery and management plans and status reviews, highlight problems, and make recommendations to the department and other interested parties to improve the effectiveness of these processes.

12.1.2 Review these classification procedures six years after the adoption of these rules and report its findings to the commission.

AUTHORITY

13.1 The commission has the authority to classify wildlife as endangered under RCW 77.12.020. Species classified as endangered are listed under WAC 220-610-010, as amended.

13.2 Threatened and sensitive species shall be classified as subcategories of protected wildlife. The commission has the authority to classify wildlife as protected under RCW 77.12.020. Species classified as protected are listed under WAC 220-200-100, as amended. [Statutory Authority: RCW 77.12.020. 90-11-066 (Order 442), § 232-12-297, filed 5/15/90, effective 6/15/90.]

Appendix B: Public comment received on the draft recovery plan

Washington State Status Reports, Periodic Status Reviews, Recovery Plans, and Conservation Plans

Periodic Status Reviews

2020 Mazama Pocket Gopher
2019 Tufted Puffin
2019 Oregon Silverspot
2018 Grizzly Bear
2018 Sea Otter
2018 Pygmy Rabbit
2017 Fisher
2017 Blue, Fin, Sei, North Pacific Right, and Sperm Whales
2017 Woodland Caribou
2017 Sandhill Crane
2017 Western Pond Turtle
2017 Green and Loggerhead Sea Turtles
2017 Leatherback Sea Turtle
2016 American White Pelican
2016 Canada Lynx
2016 Marbled Murrelet
2016 Peregrine Falcon
2016 Bald Eagle
2016 Taylor's Checkerspot
2016 Columbian White-tailed Deer
2016 Streaked Horned Lark
2016 Killer Whale
2016 Western Gray Squirrel
2016 Northern Spotted Owl
2016 Greater Sage-grouse
2016 Snowy Plover
2015 Steller Sea Lion

Conservation Plans

2013 Bats

Recent Status Reports

2019 Pinto Abalone
2017 Yellow-billed Cuckoo
2015 Tufted Puffin
2007 Bald Eagle
2005 Mazama Pocket Gopher, Streaked Horned Lark, and Taylor's Checkerspot
2005 Aleutian Canada Goose
1999 Northern Leopard Frog
1999 Mardon Skipper
1999 Olympic Mudminnow
1998 Margined Sculpin
1998 Pygmy Whitefish
1997 Gray Whale
1997 Olive Ridley Sea Turtle
1997 Oregon Spotted Frog

Recovery Plans

2021 Pinto Abalone
2020 Mazama Pocket Gopher
2019 Tufted Puffin
2012 Columbian Sharp-tailed Grouse
2011 Gray Wolf
2011 Pygmy Rabbit: Addendum
2007 Western Gray Squirrel
2006 Fisher
2004 Sea Otter
2004 Greater Sage-Grouse
2003 Pygmy Rabbit: Addendum
2002 Sandhill Crane
2001 Lynx
1999 Western Pond Turtle
1996 Ferruginous Hawk
1995 Pygmy Rabbit
1995 Snowy Plover

Status reports and plans are available on the WDFW website at:
http://wdfw.wa.gov/publications/search.php