Periodic Status Review for Pinto Abalone

DRAFT

Washington Department of Fish & Wildlife

April 2025

The Washington Department of Fish and Wildlife maintains a list of endangered, threatened, and sensitive species (Washington Administrative Codes 220-610-010 and 220-200-100). In 1990, the Washington Wildlife Commission adopted procedures for listing and for writing recovery and management plans for listed species (WAC 220-610-110, Appendix A). The procedures were developed by a group of citizens, interest groups, and state and federal agencies. They include how species listings will be initiated, criteria for listing and delisting, a requirement for public review, the development of recovery or management plans, and the periodic review of listed species.

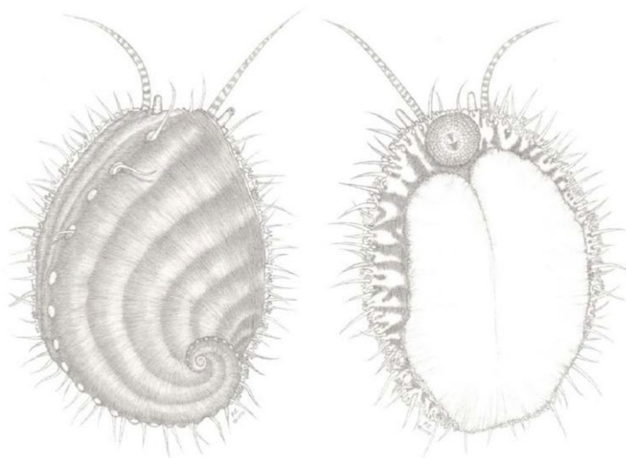
The Washington Department of Fish and Wildlife is directed to conduct reviews of each endangered, threatened, or sensitive wildlife species at least every five years after the date of its listing by the Washington Fish and Wildlife Commission. Periodic status reviews are designed to include an update of the species status report to determine whether the status of the species warrants its current listing status or deserves reclassification. The agency notifies the general public and specific parties who have expressed their interest to the Department of the periodic status review at least one year prior to the five-year period so that they may submit new scientific data to be included in the review. The agency notifies the public of its recommendation at least 30 days prior to presenting the findings to the Fish and Wildlife Commission. In addition, if the agency determines that new information suggests that the classification of a species should be changed from its present state, the agency prepares documents to determine the environmental consequences of adopting the recommendations pursuant to requirements of the State Environmental Policy Act.

This is the Draft Periodic Status Review for the pinto abalone (*Haliotis kamtschatkana)*. It contains a review of information pertaining to the status of the pinto abalone in Washington. It was reviewed by species experts and will be available for a public comment period from April 15 through June 1, 2025. Comments received will be considered during the preparation of the final periodic status review. The Department will present the results of this periodic status review to the Fish and Wildlife Commission at a meeting in 2025.

Submit written comments on this document by June 1, 2025 via email to: abalone@dfw.wa.gov or by mail to: Kathleen Sowul, WDFW, 1111 Washington St. SE, Olympia, WA 98501

Draft Periodic Status Review for Pinto Abalone in Washington State

April 2025



Haliotis kamtschatkana
PINTO ABALONE

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Report acknowledgements

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Acknowledging the Indigenous People of the Pacific Northwest

Since time immemorial, Indigenous People have lived in the Pacific Northwest and hunted, fished, and gathered natural resources, traditional foods, and medicinal plants to support their diverse cultures. They were the original occupants and stewards of this land that all Washingtonians enjoy today.

The very survival of the Pacific Northwest Tribes is a testament of resiliency of what they have endured and continue to endure throughout generations on this landscape. Through many historical encounters of massacre, renunciation of religious freedom, systemic racism, cultural assimilation of native children through institutional residential schools, and the fight for their inherent rights and liberties, they have prevailed. Throughout this painful history brought by colonization, abrogated treaties, infringement of civil rights, and the salmon protests of the 1960s, the Northwest Tribes and the Washington Department of Fish and Wildlife (WDFW) have founded a commitment of respect, unity, and alliance informed by the realities of the past.

Today, tribal governments and WDFW work collaboratively to conserve and manage aquatic and terrestrial resources statewide and practice sound science to guide management decisions. The Tribes and WDFW work together to ensure the sustainability of fish, wildlife, ecosystems, and culture for the next seven generations and beyond.

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Executive Summary

Pinto abalone *Haliotis kamtschatkana* are large marine snails that inhabit rocky reef and kelp forest habitats in the San Juan Islands and Strait of Juan de Fuca. They are the only species of abalone present in Washington State, and their grazing activities play a key role in kelp forest ecosystems. Prized for their meat and iridescent shells, the population in the state was severely reduced by a legal personal use fishery and illegal harvest that was commercial in scale. After a 1994 fishery closure, abalone populations in the state continued to dwindle. The size structure of remnant abalone showed the population was aging with little or no juveniles present. Populations were likely fished to such a low density that, as broadcast spawners, pinto abalone were not in sufficiently close proximity to allow for successful fertilization and significant reproduction. Accordingly, human intervention was likely necessary to increase densities to self-sustaining levels.

In 2002, WDFW, the University of Washington, Puget Sound Restoration Fund (PSRF), and NOAA formed a partnership with the goal of restoring pinto abalone through hatchery rearing and release of juveniles. In 2007, the first experimental releases were made. In 2019, pinto abalone was listed as endangered in the state of Washington by the Fish and Wildlife Commission. The 2019 status review found that the species was at risk of extinction due to low population density and from additional potential threats, including kelp forest habitat loss, disease, changing ocean conditions, illegal harvest, increased predation, or catastrophic oil spill. In 2024, these same threats remain. WDFW and partners released the Washington State Pinto Abalone Recovery Plan in 2022, with hatchery rearing and release as the keystone restoration strategy. The recovery plan also outlined the criteria for downlisting the species. Now in 2024, five years after the endangered listing, we seek to update the status of pinto abalone relative to those criteria.

We find that from 2019 to 2024, pinto abalone populations do not meet the criteria for downlisting to threatened or sensitive. Only one wild aggregation in the Strait of Juan de Fuca, and none in the San Juan Islands, qualifies toward the goal of 30 wild aggregations identified in the 2022 Recovery Plan. At least five other aggregations have more than the minimum six individuals required, but do not qualify on the basis that their overall density is lower than the 0.3 abalone per meter squared requirement. The size structure of these wild abalone would qualify for downlisting to threatened, but not sensitive, because more than 20% of the individuals are smaller than 90 mm, a sign of recent reproduction. The overall population trend over the past 10 years is not increasing, however, and therefore this final criterion has not been met. **On the basis of these findings, we recommend that pinto abalone retain its endangered status.**

Despite the above recommendation to retain the endangered status, the outlook for Washington's pinto abalone is more positive than it was five years ago. As of 2019, the partnership had not seen a juvenile wild abalone (<50mm shell length) for over 10 years. Since then, we have observed a small number of them. Our primary indicator of abundance, the San Juan Island index stations, had more abalone on or near the index stations in 2024 than the previous survey in 2017. This is the first time in the history of the index station surveys (which began in 1992) that the total number of observed abalone increased.

More importantly, three smaller abalone (<75mm) were observed on one of the stations, decreasing the average size/age of pinto abalone within the index station surveys for the first time. Although very limited in scope, any sign of natural reproduction is encouraging.

The progress toward recovery plan goals, particularly the success of the hatchery rearing and reintroduction program, is also cause for optimism. From 2009 through 2024, the partnership has released over 60,000 disease-free, genetically diverse juveniles to 37 sites in Washington. Production has been increasing rapidly, with two-thirds of those released in the last five years. 2024 alone saw the release of almost 13,000 juveniles to 18 sites, eight of which were newly established. Nine of the older sites now have aggregations of 20 - 180 hatchery reared adult abalone at a density that is likely sufficient for reproduction (note that hatchery-origin aggregations do not qualify toward downlisting criteria).

Perhaps most importantly, the partnership has grown in the last five years thanks to legislative funding that has allowed the program to expand in many ways. PSRF has established “satellite” juvenile rearing facilities with the Port Townsend Marine Science Center and the Seattle Aquarium. These facilities increase production, mitigate risk, and allow the public to see the program in action. Pass-through funds have been provided to the Makah Tribe, Samish Indian Nation, and Lummi Nation to increase tribal capacity for abalone restoration. Research projects with students at the University of Washington, Western Washington University, and other institutions have filled key knowledge gaps. To further illustrate the program’s successful expansion, prior to 2024, the WDFW-PSRF team had been the only team to release and monitor juvenile outplant sites. In 2024, three independent teams from the Samish Indian Nation, Seattle Aquarium, and Western Washington University established their own release sites for the first time. In 2025, these partner teams are monitoring their outplant sites, and plan to outplant again.

The partnership has made significant progress on filling research gaps since the last status review. The finding that juveniles released at age one instead of age two have similar survival (Sowul et al. 2025) has led to a more efficient utilization of space in the hatchery through mixed-age outplanting each year. We continue to investigate why some release sites have higher survival and retention of juveniles than others, including monitoring the first 48-72 hours post-outplant with time-lapse cameras to observe predation, as well as a project with University of Washington to monitor oceanographic conditions at several sites. PSRF continues to optimize growth and survival in the hatchery through experimentation with culture systems, feed regimens and tank microbiomes.

The partnership has many additional projects planned for the coming years, including: adding to the network of 10 original index stations that track wild aggregations (four new stations were added in 2024), and the expansion of monitoring and restoration into the Strait of Juan de Fuca, (which began with a focus on habitat surveys in the Eastern Strait in 2024). This expansion could eventually extend to the outer coast of Washington, pending the results of an environmental DNA study being conducted by the Makah Tribe. The partnership retains a goal of establishing a network of self-sustaining spawning aggregations in order to achieve downlisting criteria and to re-establish this species’ relationships with its ecosystem and the tribal and non-tribal communities of Washington State.

Introduction

This periodic status review briefly summarizes the natural history, population status, threats, and recent conservation and management activities involving the pinto abalone. We assess whether the species should retain its current regulatory status, or if it should be reclassified under state law. We provide a recommendation for the Washington Fish and Wildlife Commission to consider regarding its status.

Description

Pinto abalone, *Haliotis kamtschatkana*, are herbivorous marine snails found in rocky reefs and kelp forests in nearshore coastal habitat. They are found in the 3 to 15 m depth range in Washington State waters. Adult pinto abalone grow to about 120 mm in shell length but can reach as large as 165 mm. They have the iridescent inner shell nacre that is characteristic of all abalone, and the outer shells display a wide variety of colors. Their shells have a row of 4 to 6 fluted, open pores along the ridge that allow the animal to cycle seawater through the gills even while gripped tightly 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 rock surfaces. The head and foot are surrounded by epipodial tentacles that sense their surroundings.

Distribution

Globally, pinto abalone are distributed from Salisbury Sound, Alaska to Bahia Tortugas in Baja California Sur, Mexico, making them the northernmost and widest ranging Haliotid species in North America (Geiger 2000). In Washington, pinto abalone have been documented from the northern edge of the San Juan Island Archipelago, west throughout the Straits of Juan de Fuca to Cape Flattery, extending south into the northern waters of Puget Sound (Neuman et al. 2018). Due to the lack of historical data and contemporary surveys, it is unclear if significant populations exist or existed on the outer coast.

Natural History

Habitat Requirements

Pinto abalone are predominately found in rocky reef habitat characterized by having a benthic substrate of exposed bedrock, boulders, and cobble (Sloan and Breen 1988; Lessard and Campbell 2007). Most macroalgae species settle and thrive in these habitats and they are often referred to as ‘kelp forests’ due to both canopy and understory kelp species being present in abundance. Kelp forests are home to fast-growing canopy kelps like giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis luetkeana*) as well as understory kelps such as stalked kelp (*Pterygophora californica*) and prostrate kelps (e.g. *Neoagarum* spp., *Costaria* or *Saccharina* spp.) that cover the seafloor with blades reaching several feet in length (Mumford 2007). These many varieties of kelp provide shelter and food sources for hundreds of species of fish, invertebrates, and marine mammals, including pinto abalone. Additionally, rocky reef structures support microalgae, calcareous coralline algae, and diatoms, all of which are also essential to the pinto abalone as a source of food and a settlement cue (Roberts et al. 2007, Rogers-Bennett et al. 2011). As juveniles, pinto abalone are highly cryptic and utilize complex benthic habitat near and in kelp forests by hiding in crevices and under boulders (Read et. al. 2013, Sloan and Breen 1988). As they age and become less vulnerable to predation (Griffiths and Gosselin 2008), the abalone become emergent onto exposed rock surfaces where they have better access to macroalgal food sources, both drift and attached (Sloan and Breen 1988). Pinto abalone in Washington State inhabit a shallow subtidal zone and are rarely seen deeper than 20m.

Diet

Newly settled juvenile pinto abalone (up to 5 mm shell length) rely on diatoms and other components of the biofilm as their main food source (PSRF, unpublished data). Diatoms are single-celled, photosynthesizing organisms that form thin mats on subtidal substrate. Diatoms are rich in nutrients and provide sustenance to abalone even in their adult stage. As their feeding structure, known as a radula, develops, juvenile abalone begin to graze on available macroalgae in combination with the biofilm. Access to algae is vital to maturation and as they continue to grow, fleshy algae becomes the main source of nutrition in an abalone's diet (PSRF unpublished data). Algae species such as bull kelp, giant kelp, *Saccharina* spp., *Neoagarum* spp., and stalked kelp (*Pterygophora californica*) all grow within the pinto abalone's range and are common in healthy kelp forest ecosystems. Adult abalone are often observed eating drift kelp that settles on the seafloor after sloughing off the main stipe.

Reproduction and Life Cycle

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. This release of gametes is timed to environmental cues, including seawater temperature. Due to the short period of gamete viability, male and female abalone need to be near each other for successful reproduction to occur (Babcock & Keesing, 1999; Zhang, 2008). Pinto abalone spend the first 7–10 days of their lives as swimming planktonic larvae feeding off only their egg yolk (Carson et al. 2019; Sloan and Breen 1988; PSRF unpublished data), before settling onto hard substrate. Although there are still knowledge gaps in the settlement process, research shows that abalone sense specific cues on surfaces to settle, such as the presence of crustose coralline algae (CCA) (Miner et al. 2006; Li et al. 2006), a slow growing, encrusting, calcareous algae found in many rocky reef environments around the world. In addition to chemical cues emitted from the calcium-rich CCA, certain species of bacteria form a layer of biofilm on the surface of CCA that gives off an additional settlement cue to larval abalone. These cues trigger the abalone to attach to the crustose coralline algae and begin a metamorphosis process from swimming larva to crawling juvenile (Li et al. 2006; Miner et al. 2006).

Juvenile pinto abalone are highly cryptic, taking advantage of complex benthic habitats by hiding in cracks and crevices and under rocks and boulders. At a shell length between 50 and 70 mm, which can take between three and five years to reach, pinto abalone become sexually mature and emerge to more exposed areas of the benthos (Campbell et al. 1992; Larson & Blankenbeckler, 1980; Paul & Paul, 1981).

The wild lifespan of pinto abalone is unknown, but individuals have been kept in aquaria for over 20 years (Paul & Paul, 2000).

Population and Habitat Status

In 2013 the National Marine Fisheries Service received petitions to list the pinto abalone as endangered or threatened under the Endangered Species Act. A 2014 status review (Neuman et al. 2018) declined to list the species as federally endangered in the U.S. but retained them as a 'Species of Concern'. In 2019 pinto abalone were added to the Washington State Endangered Species List. Shortly thereafter in 2021, the International Union for Conservation of Nature (IUCN) added pinto abalone to their endangered species list.

Washington State

Washington state has never had 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 divers and implemented a state personal use fishery.

Harvest estimates from Bargmann (1984) and Gesselbracht (1991) suggest that legal personal use harvest of pinto abalone was centered in the San Juan Islands (SJI) and may have been as high as 41,000 individuals per year. No similar estimate was made for the Strait of Juan de Fuca (SJDF), although that population was also subject to intensive personal use harvest. The diver self-reported survey utilized in Bargmann (1984) and Gesselbracht (1991) may underestimate true exploitation rates and does not account for cumulative harvest over several decades. These reports certainly did not account for commercial-scale illegal harvest of pinto abalone that likely also occurred during this time period. The combined legal and illegal harvest was too aggressive for populations of abalone in Washington state waters. Concerns over reduced densities led to successive fishery management actions including size limits, gear limits, and reduced daily bag limits (Carson and Ulrich 2019). The personal use fishery was closed in 1994 due to observed decline in abundance.

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. Ten index stations were created in areas with observed high densities of pinto abalone. Index stations are stationary rectangular areas approximately 100 meters squared, marked by metal pitons that are installed into the substrate to allow for repeated surveys of density in fixed locations. Index stations are surveyed intensively over the course of several hours to identify all abalone within the area. These index stations have been intermittently surveyed 10 times over the last 22 years.

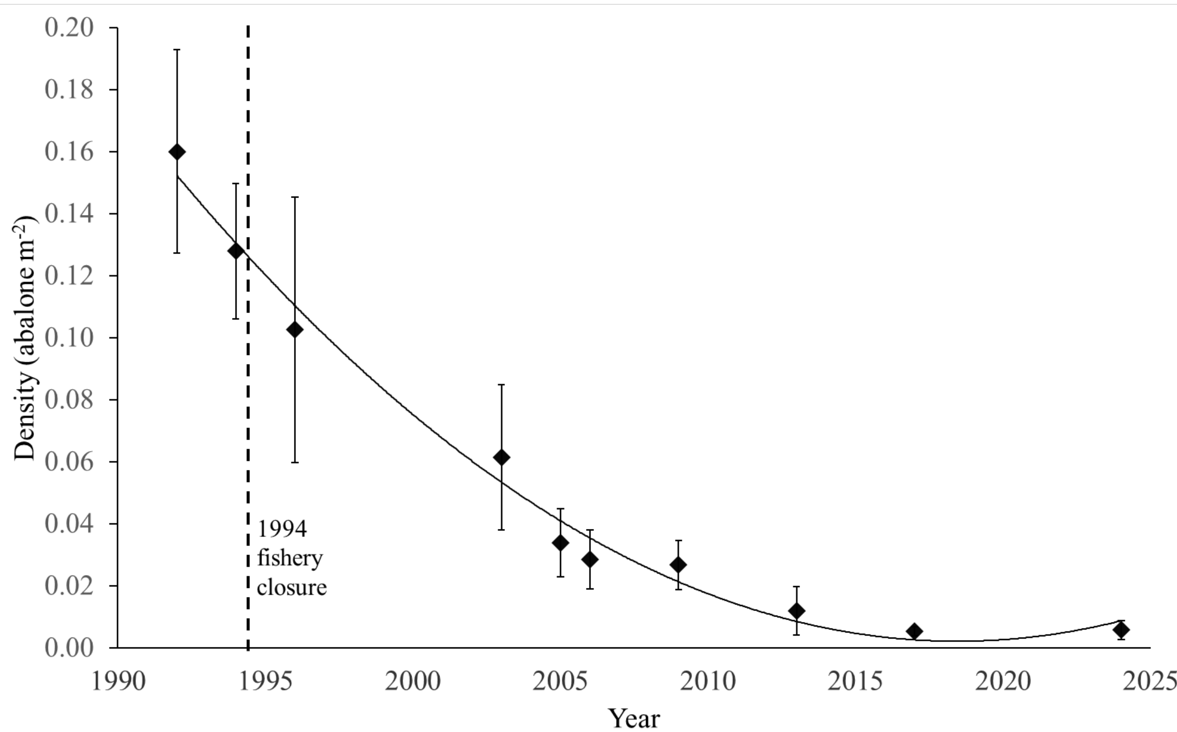


Figure 1. Average density of pinto abalone on ten fixed stations in the San Juan Islands
Error bars are standard error of the mean.

Between 1992 and 2017, abundance of pinto abalone within the 10 index stations declined by 97% (Rothaus et al. 2008, Carson and Ulrich 2019). In 2024, for the first time since index site implementation, there was an increase in the total number of abalone observed, bringing the decline from 97% to 96.4% (Figure 1). However, abalone were found on only 3 of the 10 index stations, down from 7 of 10 in 2017 (WDFW unpublished data; see Progress Toward Downlisting Criteria in Washington State, Monitoring of Remnant Wild Populations).

Alaska, BC, Oregon, California, Baja California

Elsewhere in their range, the fishing and monitoring of pinto abalone varies by region. Pinto abalone are one of three abalone species found in Oregon, and one of seven in California. Due to the presence of red abalone (*Haliotis rufescens*), a highly desired harvest species found in both Oregon and California, as well as other larger abalone species south of Point Conception, California, pintos alone were not highly targeted for commercial or sport harvest in these states. Thus, pinto abalone populations in California and Oregon lack formal surveys, stock assessments, or commercial landing data. In 2016 and 2017, due to catastrophic kelp die-off and expansion of extensive urchin barrens, regional declines of several abalone species occurred along the Pacific coast, and it is assumed these environmental shifts similarly affected pinto abalone populations.

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 (Obradovich et al. 2021). 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. In 2011, the species was added to Schedule 1 of the Species at Risk Act (SARA) (Fisheries and Oceans Canada 2012). Recovery efforts for the species have been on-going since the early 1990's. Similar to trends in Washington State, pinto abalone populations continued to decline after the closure of both commercial and recreation fishing in 1990. However, in recent years there has been a substantial increase in the number of juvenile and young abalone observed, particularly in Northern BC (Obradovich et al. 2021).

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 in the 1979-1980 season (Smith 2024). 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 Alaskan residents only.

In Baja California, Mexico, harvest of pinto abalone is illegal. However, other species of abalone are a highly valuable economic resource for the community-based cooperatives that both fish and farm abalone (McCay et al. 2014). Unlike in their northernmost range, pinto abalone share the Baja California coast with five other abalone species. Both green abalone (*Haliotis fulgens*) and pink abalone (*Haliotis corrugata*) are the primary target of harvest divers. However, Ponce-Díaz et al. (2013) estimated that poachers harvested 62.5 tons of abalone in 2005, equivalent to 26.8% of the legal catch that year. Though pinto abalone are protected from legal harvest, it is unknown how this species is impacted by illegal take in Baja California.

Habitat Status

The Pacific coastline of North America is known for its dense kelp forests that flourish due to strong upwelling events that cycle nutrient-packed water from the seafloor to the surface. These kelp forests support understory species, and canopy kelps such as giant kelp and bull kelp. 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 have been in decline (Tolimieri et al. 2023) 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. This loss is seen throughout other parts of the Salish Sea: bull kelp forests in southern Puget Sound declined by 63% between 1878 and 2017, with the highest concentration of losses occurring after 1980 (Berry et al. 2021). The only location in the Salish Sea where bull kelp populations have remained stable, but variable, is in the Western Strait of Juan de Fuca (Krumhansl et al. 2016; Pfister et al. 2018). This follows a global trend in kelp populations where canopy forming kelps, such as bull kelp, that have oceanic influence have remained stable while more sheltered interior populations have experienced a decline (Conroy et al. 2023). There is no information available regarding changes in abundance or distribution of the understory kelps in the Salish Sea (Mumford 2007).

In addition to supporting abalone, Washington's kelp habitat forms the foundation of food webs which include many of Washington's wild resources, including ESA-listed species of rockfish, salmon, and orcas (Calloway et al. 2020). Kelp forest restoration and conservation work is foundational to the prosperity of Washington's endangered species. Advancements in our understanding of the relationship between abalone and kelp continually show that abalone populations are dependent on the presence of healthy kelp forests. Kelp forest resilience may also be enhanced by pinto abalone as Washington's largest marine snail, as grazing activities of abalone help keep rock surfaces free of filamentous algae and encrusting invertebrates, potentially allowing space for the microscopic reproductive stages of kelp to establish.

Factors Affecting Continued Existence

Recruitment failure

Perhaps the greatest threat to the survival of pinto abalone is recruitment failure. 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). 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, despite the fishery closure, suggests a depensatory recruitment failure, as indicated by an increase in the mean size of abalone over time (Carson and Ulrich 2019).

The biological phenomenon, known as the Allee effect (Allee et al. 1949), wherein a significant decrease in density correlates with a decrease in reproductive success, may explain continued population declines in pinto abalone in Washington State, despite decades of fishery closures. Allee thresholds of ~0.15-0.3 abalone/m^2 have been adopted in evaluating densities and conservation concerns in various abalone species, including pinto abalone (Rothaus et al. 2008; Obradovich 2021). While the Allee thresholds specific for pinto abalone are unknown for Washington, White (2024) studied this in the pinto abalone populations near Sitka, Alaska. During dive surveys in 2018 and 2019, she found the consistent presence of recruit size (< 40 mm) abalone at sites with adult densities greater than 0.2 abalone m^{-2}, and a less-consistent density of recruits at sites below that density. Although it is impossible to know the density of adults that produced the observed recruits, it is possible evidence of an Allee threshold near that value. A model of white abalone (*Haliotis sorenseni*) population dynamics developed by Catton et al. (2016) predicted a minimum density of 0.23 abalone m^{-2} necessary for recovery. Babcock and Keesing (1999) estimated that this density threshold was between 0.15 and 0.30 individuals per m^{-2} for the greenlip abalone *H. laevigata* in Australia, based on anecdotal fishery information. Obradovich et al. (2021) have adopted these same thresholds to evaluate the density of pinto abalone in British Columbia. On the SJI index stations, pinto abalone density dropped below $0.15/m^{-2}$ in 1994 and is currently at $0.005/m^{-2}$. (see Figure 1). The current density at these sites is far below any of the three estimates of minimum density for reproductive success.

Harvest

Pinto abalone are protected from illegal harvest in Washington State by RCW 77.15.120, however potential for illegal harvest remains. Pinto abalone are acutely vulnerable to harvest for several reasons:

1. Their meat and shells remain highly prized by consumers
2. Enforcement of harvest laws is challenging. The pinto abalone's range within Washington state covers hundreds of square kilometers of navigable waters. Enforcement resources are limited with a small number of patrol vessels and cannot be on the water every day.
3. Unlike other abalone species, pinto abalone in Washington state solely inhabit the shallow subtidal zone and are rarely observed deeper than 20 m, making them acutely vulnerable to dive harvesters. Pinto abalone are sedentary animals that aggregate together, making it relatively easy for entire spawning aggregations to be located and harvested with a short amount of time and effort.

There have been no reports of illegal harvest of pinto abalone since the 2019 listing, but the current densities in Washington state are still low enough to make opportunistic poaching of remnant aggregations by commercial or recreational divers a major threat.

Biosphere/Ecosystem Changes

Pinto abalone recovery is dependent on the survival of kelp forests due to their role as both habitat and food source. As mentioned above (see Adequacy of Regulatory Mechanisms) many kelp forests in the pinto abalone range are under some form of protection. However, even if kelp forest habitats themselves are preserved, abalone exist in rocky reef habitats outside of canopied kelp forests where drift algae is still plentiful, but the marine environment is less protected.

Changes in environmental conditions and stressors have been drivers of the evolution of abalone for millennia. The addition of anthropogenic influences and an increased speed at which environmental changes - such as salinity, temperature, and dissolved oxygen - are taking place may have a negative impact on abalone populations. These changes can impact abalone directly through heightened mortality in both larval and adult stages and indirectly through food and habitat availability. The direct impacts of climate change on larval and juvenile stages have been examined by Dr. Eileen Bates (UW) (see below: Ongoing Research).

Predation

Predation is another potential threat that has been shown to impact abalone populations worldwide. There are a variety of naturally occurring predators to pinto abalone in Washington State, including but not limited to sea stars, octopus, crabs, fish, and sea otters in coastal Washington waters (Griffiths and Gosselin 2008, Sowul et. al 2022). The partnership is attempting to learn more about pinto abalone predation through time lapse camera monitoring (see below: Ongoing Research). Additionally, Shannon Point Marine Center's Research Experience for Undergrad (REU) program conducted one outplant in 2024 followed by a rigorous survey that required taking observations every ~2 hours. During these surveys, divers observed the mollusk, *Amphissa columbiana*, preying on juvenile abalone directly after outplant; however, it was unclear whether the snails were preying on live juvenile abalone, or if they were scavenging on abalone that had died in the tubes during transit.

Disease and Parasites

No disease has been reported in wild or hatchery pinto abalone populations in Washington. However, pinto abalone are susceptible to a variety of diseases and parasites that are already present on the West Coast of North America, as reviewed in the initial status review (Carson and Ulrich 2019). Since that review, WDFW is aware of only one significant incident of a possible disease vector in the state, and no incidences of actual disease. A Washington aquarium received and held an unpermitted delivery of red abalone from California (where abalone diseases occur) in a tank with sea water effluent flowing into Puget Sound. Upon discovery, the abalone were destroyed. In partnership with American Fisheries Society certified pathologists at AquaTechnics, Inc., the recovery team diligently monitors whole hatchery health with annual screenings at all partner facilities to reduce the risk of disease introduction through outplant activities. WDFW has further invested in efforts to educate the public and other stakeholders about regulatory requirements and the risks of unpermitted imports and transfers of live shellfish, storage of live seafood, and discard of seafood products–all of which are potential vectors for the introduction of harmful pathogens.

Progress Toward Downlisting Criteria in Washington State

The Pinto Abalone Recovery Plan (Sowul et al. 2022) describes the criteria to meet before recommending a downlisting to threatened or sensitive. They are: 1) a minimum number of wild spawning aggregations (this can include index sites) distributed among regions and subregions, 2) an overall size distribution of wild aggregations that is evidence of both ongoing natural recruitment and survival to high-fecundity size, and 3) An overall increasing wild population trend over a ten-year time frame.

For the first criterion, as of 2024, the Department and partners have documented only one natural aggregation in the Strait of Juan de Fuca region, and none in the San Juan Islands region, that are qualifying aggregations toward downlisting. To qualify, aggregations must contain six or more individuals at an overall density of at least 0.3 abalone per m^{-2}square meter. Four other aggregations of between 9 and 22 abalone each have been documented and will be tracked in the future but have densities between 0.10 and 0.15 abalone m^{-2}. Overall, the partners have just begun to search for and document spawning aggregations in the Strait of Juan de Fuca, so the lack of more qualifying aggregations may be due to unexplored habitat. However, as of 2024, only one of the 30 total aggregations needed to recommend a downlisting to threatened has been documented. Nine restoration sites in the San Juan Islands stocked with hatchery-origin abalone have reached adult densities greater than 0.30, but those populations do not count toward downlisting. They are intended to produce larvae that will settle in other locations in Washington, leading to a self-sustaining network of aggregations and eventual downlisting.

For the second criterion, an encouraging development is found in the size distribution data from historic and current index station surveys. Delisting criteria defined in Sowul et al. (2022) require that natural populations have at least 20% of individuals with a shell length less than 90 mm, and 20% with shell length greater than 110 mm to qualify for threatened status. Shell length measurements of the 62 abalone on index stations, both historical and newly established, in 2024 meets this criterion, as 24% of them were <90 mm. The criterion to recommend further downlisting to sensitive is 30%, and has not been met. This suggests that there has been ongoing natural recruitment to the population, even if in isolated areas. Index station populations have always met the criterion that more than 20% of the abalone have shell lengths greater than 110 mm, and still do today (46%). This part of the criterion was designed to protect pinto abalone from different threats, such as a renewal of widespread poaching or stunted growth due to lack of algal food, neither of which appear to be limiting pinto abalone populations in Washington at this time.

We do not yet have sufficient data to evaluate the third criterion, an overall increasing population trend over the last ten years. We are still establishing index stations in many subregions, and even where they have been established, there is only one data point available. Going forward, we plan to establish and survey in such a way that a ten-year population trend can be discerned. If using only the historic index station data from the San Juan Islands, there is a negative population trend observed from the 2013, 2017, and 2024 surveys, despite the encouraging results from 2024 as compared to 2017.

Monitoring of Remnant Wild Populations

San Juan Islands

Since the creation of the 10 San Juan Island fixed index stations in 1992, WDFW and PSRF have continued periodic monitoring of all stations with the most recent surveys taking place in 2024. This monitoring includes exhaustive, non-invasive diver surveys for abundance and size of pinto abalone within the 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, this generally happens at sizes beyond 50 mm shell length.

Up until 2024, the overwhelming trend observed shows limited new abalone recruitment in the Salish Sea. These observations concur with a directed pinto abalone recruitment study done in the San Juan Islands (Bouma 2007, Bouma et al. 2012). A decrease in numbers and an increase in overall shell length has suggested a population that is aging out without significant recruitment (see Figures 1 and 2). In 1992 there were 359 abalone at the index stations with an average size of 105 mm, and the smallest individual encountered was 42 mm. By 2017, the number of abalone on these stations had dwindled to

12, with an average size of 127 mm, and the smallest individual was 83 mm. Qualitatively, it does not appear that the habitat on these stations has degraded in any way that would explain the loss of abalone, however habitat degradation cannot be completely ruled out. Reproductive decline from low adult density is the most parsimonious explanation (Rothaus et al. 2008).

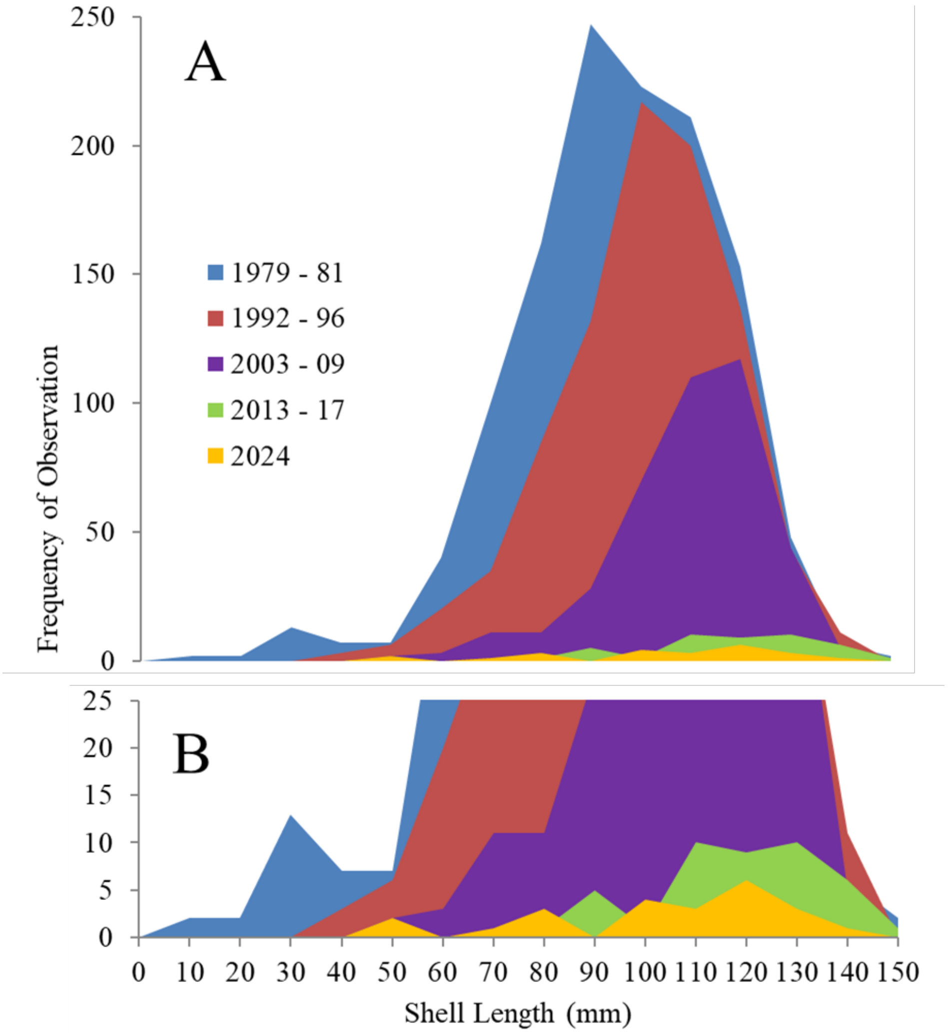
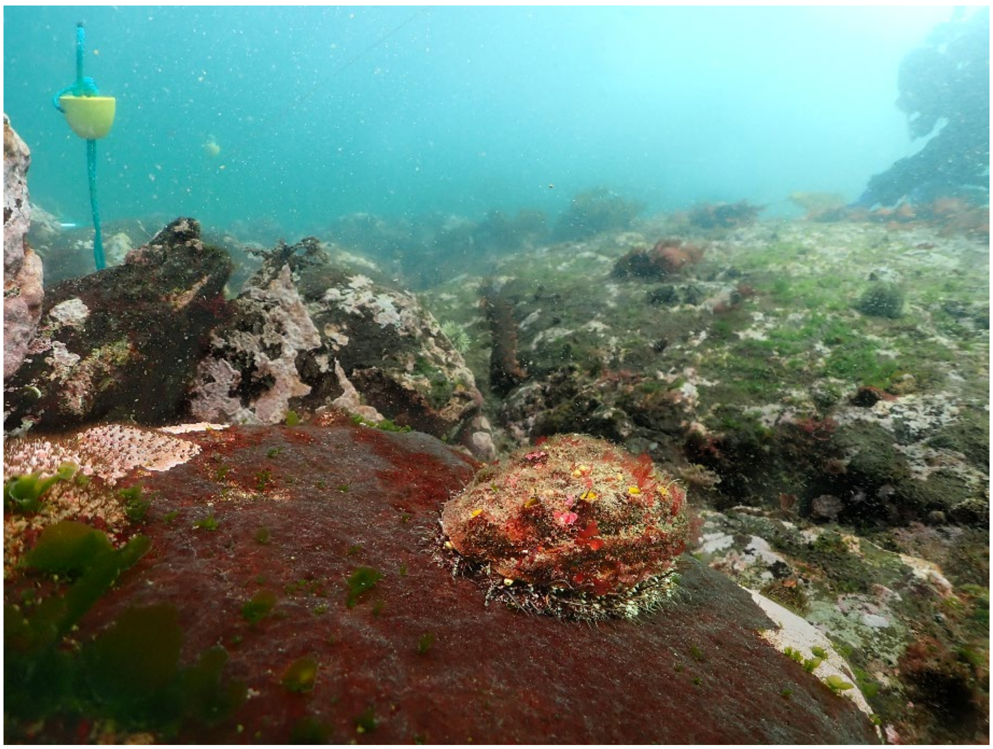


Figure 2. Abalone shell length frequency by decade

A: Maximum shell length frequency from timed swim (1979 – 81; blue) and index station (1992 – 2024; all other colors) surveys in the San Juan Islands. B: Enlarged lower portion of the graph to show detail of recent surveys.

There were small signs of hope in the data from the 2024 San Juan Island Index Station Surveys. Although only 3 of the 10 original index stations had abalone inside the station boundaries, the total number of abalone increased from 12 abalone observed in 2017 to 13 in 2024. This was the first time in the program's history that consecutive surveys did not maintain a declining trend. Adding in abalone observed just outside the stations, the total number observed increased from 17 in 2017 to 23 in 2024. Most importantly, one of the stations contained two recruits which were not present during the 2017 survey (52 mm and 58 mm). The recruitment of sub-adult abalone to this one station caused the average size of pinto abalone observed at index stations to *decrease* for the first time – from an average shell length of 127 mm in 2017 to 109 mm in 2024 (Figure 2). After a 10-year gap in observing recent-recruit sized wild abalone anywhere in Washington, it is encouraging to see evidence that some reproduction is occurring.

While all 10 of the original stations will continue to be monitored for the potential of new recruitment, four new index stations were added to the San Juan Islands in 2024, to better understand the population trends of wild abalone (Figure 3). All new stations were established on existing wild aggregations and are located far enough away from outplant sites to ensure that hatchery-raised individuals will not emigrate onto the index stations. These new index stations were censused upon establishment in 2024.



A wild pinto abalone sits atop a boulder while divers set up one of the four new index stations established in 2024. A diver can be seen in the background laying out transect tape. When setting up an index site, yellow buoys are used to mark abalone. The buoys are a visual aid to divers allowing them to include all or most of the aggregation within the boundaries of the index site.

Strait of Juan de Fuca

While there is evidence of pinto abalone in the Strait of Juan de Fuca from historical and contemporary surveys, as well as anecdotal evidence from harvest divers, little formal data on current populations exist. It has long been a goal to expand on existing knowledge and employ a more systematic scouting approach to identify existing populations and potential locations for index and outplant sites.

In the fall of 2024, a long-term project was initiated to investigate the extent of abalone populations and their preferred rocky reef habitat in the Strait of Juan de Fuca Region. To accomplish this, a grid of squares with 250 m sides was overlaid on a map of all potential habitat in this region with depths less than 70 ft mean lower low water (MLLW). Available resources including bathymetric data, previous dive observations, and aerial maps showing the presence/absence of surface kelp were utilized to automatically eliminate squares that have been assessed to be unsuitable for abalone. All remaining squares will be visited in the field. If observations from the depth sounder and nearby shoreline appear unlikely to contain abalone habitat (e.g. apparently only sand), grid squares can be eliminated from consideration without deploying divers. Otherwise, divers will explore the area for suitable habitat and existing wild abalone. Fieldwork during fall of 2024 established pilot trials of this method in the Port Townsend and Whidbey Island Subregions; we completed dive surveys of 84 squares and eliminated 29 squares. In total, we observed 14 wild pinto abalone and identified 11 possible outplant sites.

Hatchery Facilities

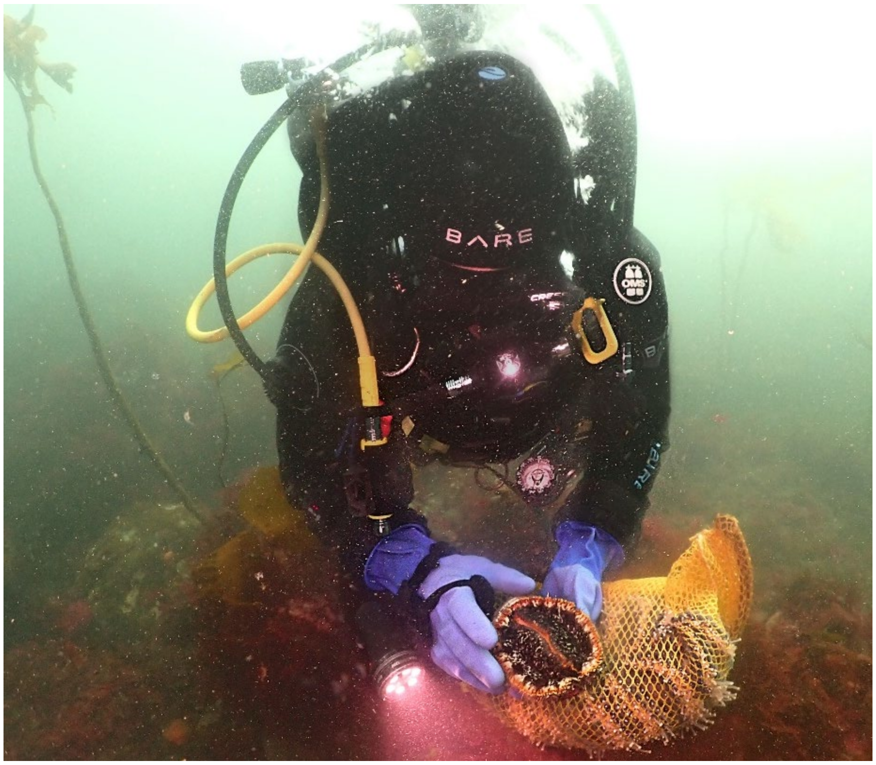
Grow-out tanks in the hatchery are regularly monitored, cleaned, and stocked with kelp and/or diatoms.

The pinto abalone hatchery program has 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 State. A complete synopsis of the history of the pinto abalone's conservation aquaculture program can be found in the Pinto Abalone Recovery Plan. In summary, the program was established in 2003 at the NOAA Mukilteo Research station, but 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. The Chew Center facility has allowed for a significant expansion of capacity for juvenile abalone production, as well as continued research into husbandry techniques and restoration strategies.

Previous research has informed current practices and allowed for a recent scaling up of both production and restoration efforts. Hatchery capacity is currently being expanded through the development of partnerships that house "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, which has 5 grow-out tanks, and the Seattle Aquarium which has 32 tank grow-out systems that are in their off-site Animal Care Center. This expansion increases capacity, decentralizes production to guard against unforeseen catastrophes, and allows the program to be more accessible to the public. Furthermore, PSRF is building another quarantine-grade hatchery facility at the USGS Field Station on Marrowstone Island which will be running in early 2025. The Marrowstone facility will primarily focus on broodstock conditioning, spawning, larval rearing, and associated research.

Broodstock Collection

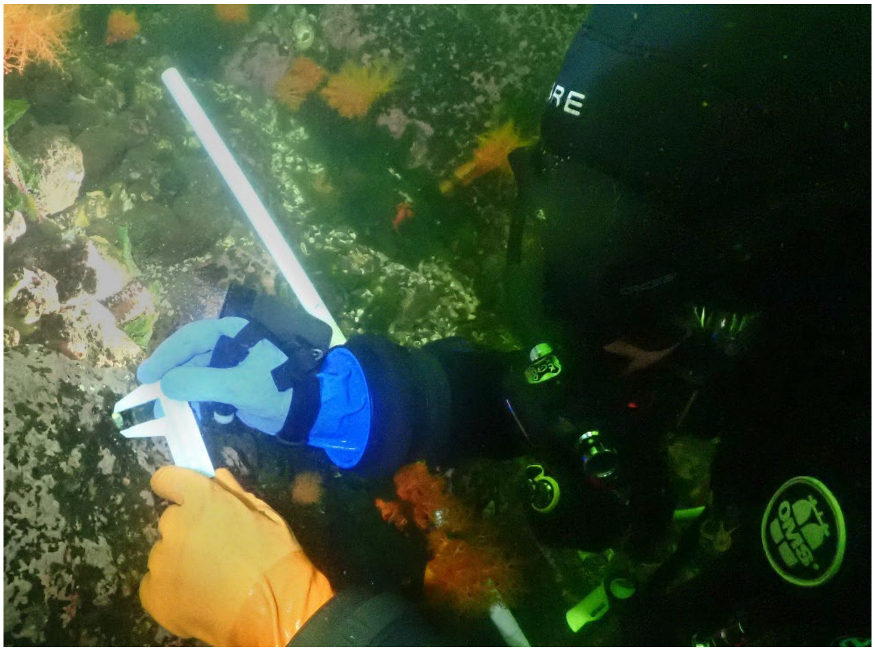
The Chew Center houses broodstock collected as isolated individuals, nicknamed "singletons", from the wild. Broodstock collections occur annually to maintain high genetic diversity of hatchery produced progeny. When divers find one abalone, a thorough search is conducted in a 5-meter radius of the abalone 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. When a singleton is found, sea stars are utilized in the removal process as abalone are hemophiliacs and can be easily injured if removed using force or tools (Figure 5). The presence of sea stars causes the abalone to move away from the star. Once an abalone is moving on the substrate, it can be removed by hand with low risk of injury. Currently, 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 (Babcock and Keesing 1999). Therefore, isolated individuals are considered to be functionally sterile (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 spawned in the hatchery are not retained to use as broodstock themselves to prevent hatchery-induced inbreeding.



A diver examines the foot of an abalone being collected as broodstock. Sea stars (seen in the mesh bag) are used to trigger abalone's "escape" mechanism, allowing them to be safely removed.

Juvenile Outplant Program

The outplanting of hatchery raised pinto abalone began as a pilot study in 2007-2008 in Freshwater Bay (D. Rothaus internal DFW report, Stevick 2010). In 2009, WDFW and PSRF conducted the first restoration-scale juvenile outplant in the San Juan Islands. Since 2009, over 60,000 healthy, genetically diverse juvenile abalone have been released at 37 sites in the San Juan Islands representing over 250 genetically distinct families (Figures 6 and 7). For a description of the site selection process see Carson 2019 methods. To date these efforts have resulted in at least 9 sites where juvenile outplants have matured into adult spawning aggregations that have maintained densities greater than the 0.3 individuals per m^{-2} threshold over several years. As the outplant program increased in scale over the years, a variety of research has been done to better inform outplant and survey strategies resulting in the methodology we use today. Please see the Pinto Abalone Recovery Plan for a more comprehensive view of the development of the juvenile outplant program.



A diver carefully measures the shell length of a juvenile abalone, outplanted approximately 10 months prior, during the first post-outplant survey at this site.

Since publishing the Recovery Plan in 2022, more research has been done comparing the survival of 1-year-old (9 months) and 2-year-old (20 months) outplants. Preliminary results suggested that post-outplant survival is similar between the two cohorts. These results, combined with a decreased cost per individual for earlier release, encouraged further exploration. Mixed age cohorts were outplanted on a larger scale from 2019 through 2022, and analysis of their survival suggests multiple benefits. Outplanting individuals greater than 5 mm at 9 months, while holding the smaller individuals for an extra year of growth maximized hatchery output, reduced cost, and increased genetic diversity in each outplant group by including families from two separate years (Sowul et al., 2025).

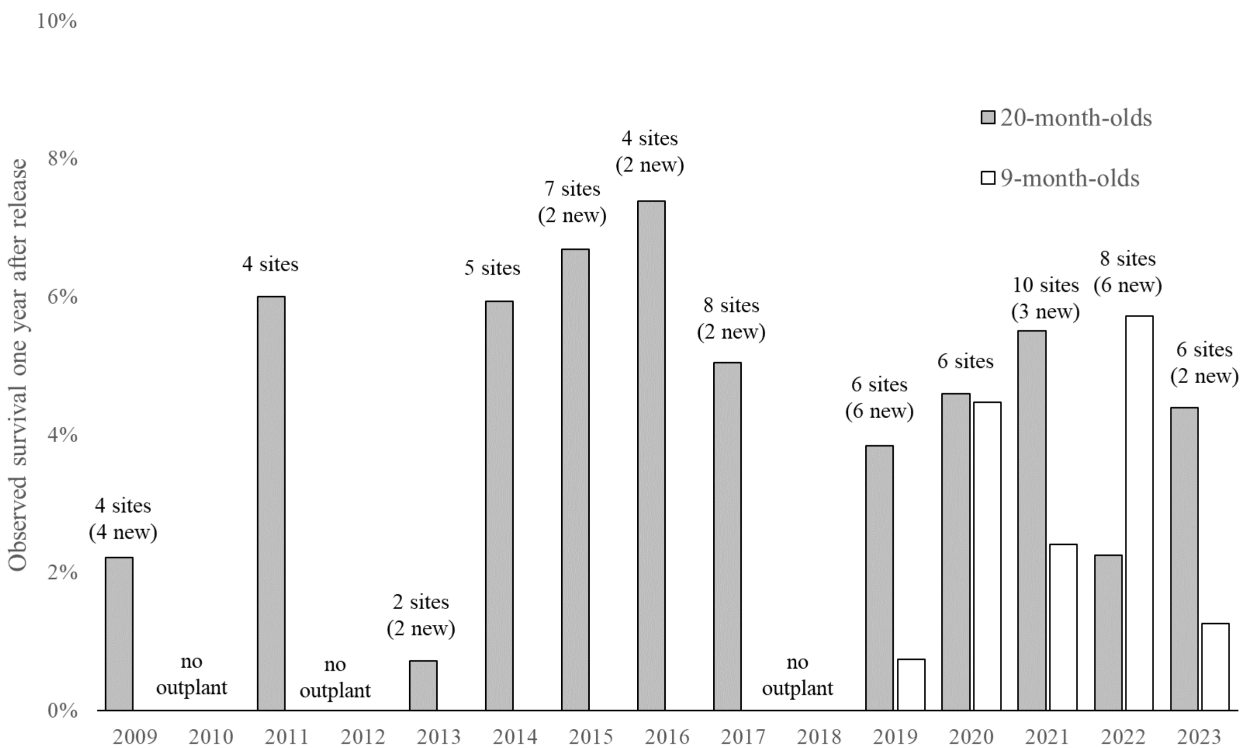


Figure 3. Observed survival for hatchery-origin juveniles

Average observed survival for one year after release for hatchery-origin juvenile abalone in Washington. Due to low detection probabilities for juvenile abalone on complex habitat, actual survival is likely 2 - 5 times higher (Carson et. al 2019). Grey bars represent juveniles released at 20-months average age, white bars are 9-months average age.

The outplanting of mixed cohorts over the past four years combined with the addition of the satellite facilities has increased hatchery output and allowed the program to grow immensely. In 2024, WDFW and PSRF, in collaboration with the Seattle Aquarium, Samish Indian Nation, and Shannon Point Marine Center, outplanted 12,579 juvenile abalone to 18 sites, the largest outplant in both number of abalone and number of sites that this program has seen since its inception in 2009. This substantial effort required two separate outplant efforts. The first outplant occurred during the standard week in April, and for the first time in the program's history, a second week of outplants was conducted in June. The first wave of outplanting in April cleared a large portion of the rearing tanks in the hatchery which were then available to be used for the early summer abalone spawn, while the second wave of outplanting in June allowed many one-year-olds to stay longer in the hatchery and reach a size suitable for release.

Partnership Building

In the five years since the initial status review, the pinto abalone restoration partnership has significantly expanded. Legislative funding has allowed for two key initiatives: 1) increasing tribal capacity to participate in abalone restoration, and 2) developing satellite juvenile rearing capabilities at partner facilities (see above section "Hatchery Facilities").

Re-engagement with tribal governments renewed in 2021 with tribal review of the recovery plan (Sowul et al. 2022). The Makah Tribe, in particular, submitted significant edits that were incorporated into the final draft. Pass-through legislative funding has enabled a tribal grants program for the 2023-25 biennium. All three applying tribes were awarded funds. The Makah Tribe is undertaking an environmental DNA study to investigate the possible presence of abalone on the outer coast. Makah staff have also accompanied WDFW-PSRF field operations in the Western Strait. The Samish Tribe is using funds to participate in the establishment and monitoring of juvenile outplant sites of their own. In 2024 they outplanted abalone at one new site, Kwósen (Xws7ámeshqen/Samish for “star”), and one existing site renamed Kwú:l (Xws7ámeshqen/Samish for “gold”) in the San Juan Islands. The Lummi Nation is utilizing the funds to train and equip two new divers to continue participating in abalone restoration. Their divers previously scouted one new site that has been successful for juvenile releases. These growing partnerships will be vital to achieving recovery, and the availability of pass-through funds has been a key part of that growth.

Enforcement of Harvest Prohibition

The range of pinto abalone in Washington state is located within two WDFW enforcement regions, in which roughly 20 Fish and Wildlife Officers (FWOs) are assigned. FWOs are fully commissioned, general authority police officers with responsibilities including endangered species protection, regulation of fishing and shellfishing activities, both commercial and recreational, and habitat protection. These broad responsibilities translate to daily patrols and operations on both land and water around the San Juan Islands and Strait of Juan de Fuca.

The majority of pinto abalone habitat in Washington is accessible only by boat. WDFW Enforcement has an extensive fleet of both long and mid-range patrol vessels that are utilized to patrol these areas. WDFW Police also operate one twin engine, fixed wing aircraft. Flights are available to and used by WDFW Officers for patrolling Washington waters. Additionally, FWOs routinely patrol with US Coast Guard aircrews in fixed wing aircraft and helicopters. WDFW Enforcement also has a dive team that is available to respond to reports of potential underwater poaching, evidence recovery, and other specialized investigative needs.

FWOs coordinate their daily patrol duties with full awareness of the endangered status of pinto abalone and are highly responsive to any public reports of potential illegal harvest. Additionally, WDFW Officers are either on duty or on call to respond to poaching crimes in progress 24 hours a day, seven days a week. These officers and sergeants are positioned near or live within the communities they patrol and deploy directly from their homes.

Ongoing Research

As the number of partners involved in pinto abalone restoration increases, so does our capacity for research. While there are still knowledge gaps that need to be filled to achieve the required downlisting criteria, progress has been made in a variety of areas. It is important to highlight the work done by Dr. Eileen Bates in collaboration with PSRF during the completion of her PhD at the University of

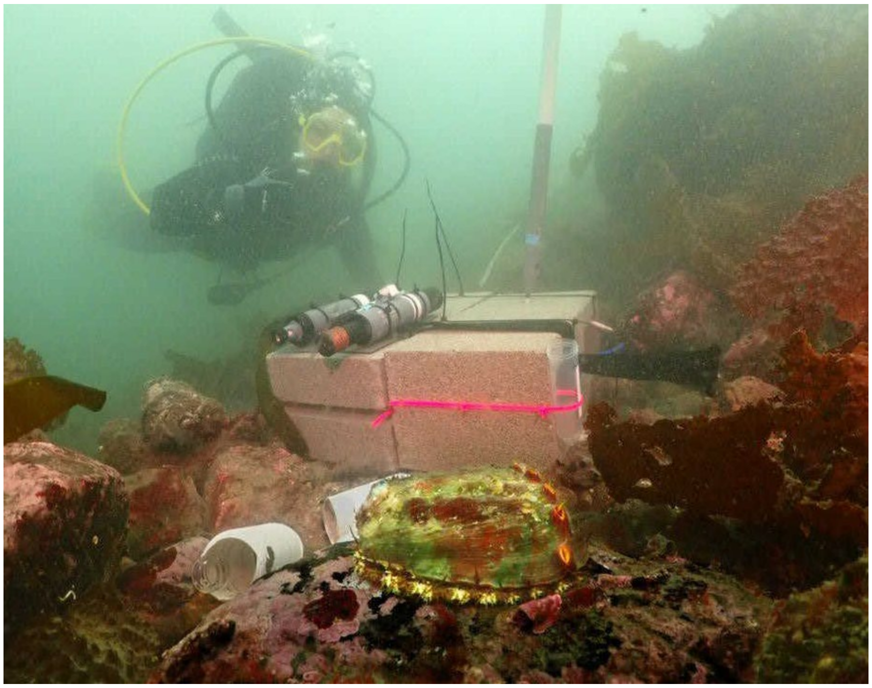
Washington School of Aquatic and Fisheries Sciences (see below: Impacts of Climate Change and Assessing Oceanographic Site Suitability) and Dr. Jay Dimond in collaboration with WDFW and PSRF (see below: Range Wide Population Genetics and eDNA).

Impacts of Climate Change

Threats from ocean acidification and warming in the northeast Pacific jeopardize current restoration actions and pinto abalone recovery (Crim et al. 2011). One of our research priorities with partners aimed to deepen our understanding of the physiological tolerance of early life history stages of pinto abalone, with the goal of informing hatchery practices under future climate change scenarios. Collaborators conducted an experiment to test the impacts of pH and temperature stress on larval abalone (Bates et al. in press). Abalone were exposed to one of four treatments for ten days spanning their larval development period: (1) 7.95pH/14°C (ambient) (2) 7.60pH/14°C, (3) 7.95pH/18°C and (4) 7.60pH/18°C 4. The results suggested that abalone exposed to ambient hatchery temperature and pH levels post-fertilization had the highest rates of survival, while higher temperatures and lower pH levels led to the lowest rates of survival. For surviving larvae, temperature appeared to have a minor effect on settlement, while lowered pH was the dominant stressor determining settlement success. Lower pH also had a stronger effect than temperature on shell length. This study informs how warming and ocean acidification impact the early life stages of pinto abalone (Bates et al. in press). This information is essential for optimizing future restoration aquaculture and determining the species' ideal habitat and potential geographic range.

Following this experiment, and in an effort to better understand the possible role of coralline algae in abalone cultivation and resilience to climate change, our collaborators conducted a longer-term experiment on early abalone life stages. Coralline algae plays an important role in the success of restoration efforts by serving as a natural settlement inducer and potentially creating a pH refuge for juvenile abalone through photosynthesis (Roberts 2001, Hamilton et al. 2022) In their study, collaborators again exposed abalone to four oceanographic treatments: 7.90 pH/14°C (ambient), 7.90 pH/18°C, 7.55 pH/14°C; and 7.55 pH/18°C), this time also using two substrates: CCA-covered rocks and clean rocks with GABA (a chemical settlement inducer). Bates (2024a) found that both larval settlement (assessed after 8 days) and juvenile survival (assessed after three months) were negatively impacted by lower pH.. The presence of coralline algae did appear to increase settlement, but the results were not statistically significant. Coralline algae led to an approximately two-fold increase in juvenile survival (Bates 2024a). Results show the potential of coralline algae to increase pinto abalone juvenile survival and ameliorate the negative effects of low pH. Using coralline algae in hatchery culture and selecting sites with coralline algae cover for pinto abalone outplants in the wild may improve the efficiency of restoration efforts in Washington. Coralline algae is already being introduced to hatchery tanks as a result of these findings.

Assessing Oceanographic Site Suitability

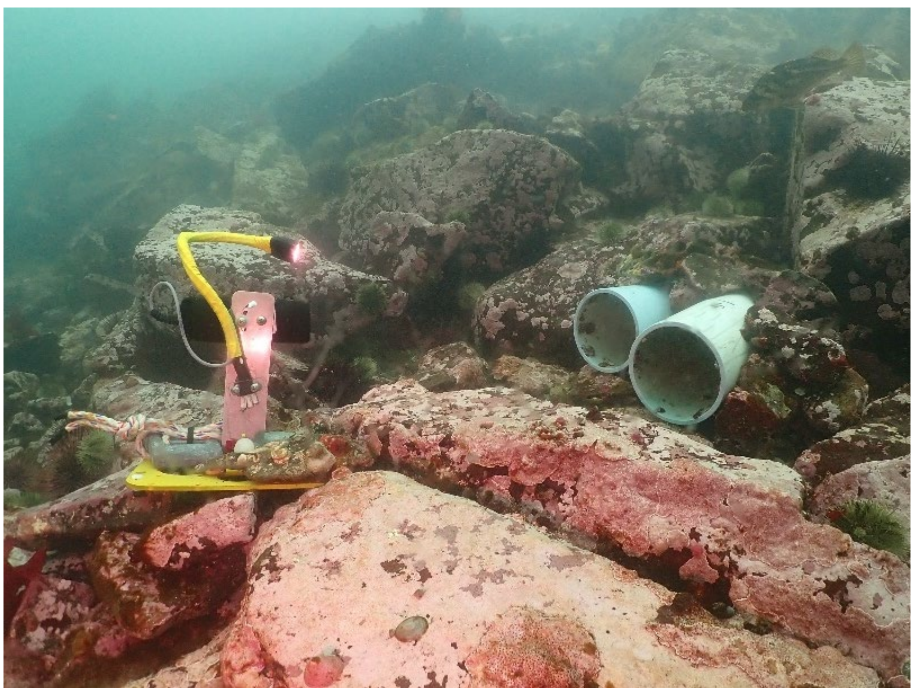


An outplanted pinto abalone, several years post-release, in front of an oceanographic sensor array (attached to cement blocks) and water sampling bottles.

In an effort to understand and address the considerable variability in juvenile abalone survival between the restoration sites, a three-year study of fine-scale oceanographic parameters was conducted. To determine if differences in oceanographic conditions might correlate with differences in survival, we deployed oceanographic sensor arrays at six abalone restoration sites for three years to monitor temperature, salinity, dissolved oxygen, pH, and current speed (Figure 8). Monitoring spanned the period from when abalone were outplanted until sites were surveyed approximately 10 months later to assess abalone survival. Observed survival (not accounting for the undetected, hidden juveniles) at sites ranged from 0.43% - 9.63%. Overall, oceanographic conditions were within known tolerable ranges for pinto abalone, though pH conditions did occasionally reach levels that could be stressful to abalone early life stages based on hatchery experiments. Clear differences in seasonal variability of both salinity and temperature were observed between sites, with sites in the northern islands most clearly distinguished from the rest of the San Juans. Dissolved oxygen and pH both changed seasonally, and variability increased during spring and summer months with algal growth, but clear spatial patterns could not be determined. Current speeds also varied between sites, though currents seemed to be mostly tidally driven as opposed to having seasonal shifts. Despite these measured differences in survival of abalone and in environmental conditions observed across sites, the data did not indicate any correlation between oceanographic variables and abalone survival. However, this study provided valuable baseline data on the environmental conditions experienced by abalone in the wild in Washington State. These data will facilitate tracking and understanding of the evolving environmental conditions over time and their impact on the success of restoration sites (Bates 2024).

Time lapse camera monitoring

Direct predation is one of the leading hypotheses to explain why some sites have poor survival or retention despite being chosen with the same criteria as successful sites with high survival. A variety of predators *could* consume juvenile pinto abalone including fish, crabs, sea stars, octopus, other gastropods, diving birds, and marine mammals. Identifying the major predator(s) at unsuccessful sites could help to choose new sites or inform mitigation strategies such as implementing protective measures. Previous studies have documented high predation in the time period immediately after release of hatchery-reared pinto abalone (Hansen and Gosselin 2013). To that end, the partnership has deployed time-lapse cameras with strobe lights facing outplant tubes for the first 48 - 72 hours after release (Figure 9). Camera deployments in 2019 and 2021 were used to fine tune methods and identify none showed obvious n. During the 2022 camera deployment, divers noticed fish exploring empty abalone transport tubes, so empty control tubes were included in the 2022 deployment in an attempt to determine whether the animals seen in the tubes were attracted to the tubes themselves or to the abalone. In 2022, 15,157 non-control photos and 13,051 control photos were collected. Though the analysis of the 2022 photos is still in progress, no obvious signs of predation are evident in the 7,824 photos that have been analyzed.



Timelapse cameras capture images for 48 to 72 hours post-release.

Population genetics

Because pinto abalone populations have been reduced to a small fraction of their former population size, there is a possibility that genetic diversity within the population has decreased. Populations with high genetic diversity are more resilient to changing environmental conditions. The depletion of pinto abalone populations in Washington state, along with evidence that conservation breeding programs produce abalone with lower genetic diversity than wild populations (Lemay and Boulding 2009), highlights the need for comprehensive genetic data on broodstock, hatchery-released outplants, and wild populations.

PSRF, in collaboration with WDFW, used genomic sequencing to assess the genetic diversity of wild populations in Washington and the efficacy of the outplant program from a genetic standpoint. Results suggest that the remnant abalone population in Washington state have not experienced a reduction in genetic diversity and have sufficient genetic diversity to support a restoration program. Across all of the abalone that were sampled, on average, hatchery bred animals showed a similar level of heterozygosity, a lower allelic richness, a smaller effective population size, and a higher relatedness than wild individuals. However, abalone from more recent hatchery bred cohorts had genomic profiles that better resembled wild abalone. This suggests that recent changes to the hatchery program which lead to higher numbers of broodstock and thus larger family sizes have been effective in increasing allelic richness and reducing genomic divergence from wild stocks. See Dimond et al. 2022a for methods and further discussion of the results.

The above results show the necessity of having access to a large number of broodstock parents to produce offspring in the hatchery. Currently we are limited by our ability to locate existing singletons (see below: ongoing research eDNA). To date, broodstock have been sourced in the San Juan Islands. Identifying other sources for broodstock may become a priority in the future to continue fostering genetic diversity. Results of a range-wide analysis of pinto abalone population genomics suggests that the species is panmictic, meaning a random mating strategy where any member of the species can breed with any other member, across its 3700 km range, and thus using broodstock from areas outside Washington would not significantly impact the evolutionary history of the species (Dimond et al. 2024)

Environmental DNA

One of the current challenges to abalone restoration in Washington State is locating novel and wild pinto abalone singletons and aggregations. Dimond et. al (2022b), in collaboration with WDFW and PSRF, tested the viability of using eDNA to detect pinto abalone. After confirming that there was a positive relationship between abalone biomass and the concentration of DNA in an aquarium setting, initial tests were done at restoration sites with known abalone densities to establish the best sampling methods. Over the summer of 2021, seawater samples were collected at 80 different sites in the San Juan Islands and the Strait of Juan de Fuca to test for presence of abalone eDNA. A combination of benthic habitat maps and aerial imagery was used to target areas that had potential favorable benthic habitat for pinto abalone. Initial tests were done with quantitative PCR (qPCR), but for the field collections the assay was modified for droplet digital PCR (ddPCR) in hopes of increasing detection probability (see Dimond et al. 2022b for methods). Out of the 80 sites that were sampled, there were 11 eDNA detections with qPCR and an additional 19 detections with ddPCR. WDFW is still in the process of revisiting the sites that tested positive for abalone eDNA; so far, the results have been mixed. For example, when divers surveyed one site that tested positive for abalone eDNA, they observed one large adult abalone and also determined the habitat was ideal for outplant. Though still new, this particular outplant site has been highly successful. On the other hand, another site that tested positive for eDNA was exhaustively surveyed with no abalone observed and poor habitat recorded (though no abalone observations by divers does not mean an absence of abalone). The use of eDNA has the potential to further restoration efforts while lowering field time and costs, but further research and refinement is needed before it can be applied on a restoration scale. The Makah Tribe is currently conducting an eDNA study in the Western Strait of Juan de Fuca and outer coast.

Conclusions and Recommendation

Available information on the status of pinto abalone in Washington suggests that the species is still at significant risk of extinction in the state. Although there are encouraging signs of reproductive success in the wild, such as the sighting of a few juvenile-sized individuals for the first time in over a decade, the main threat of overall low densities of adults preventing widespread reproduction remains. Other potential threats such as loss of kelp, disease, changing ocean conditions, illegal harvest, increased predation, or catastrophic oil spill persist and could thwart recovery efforts. Pinto abalone have met only one of three criteria in the 2022 Recovery Plan to support a downlisting recommendation to threatened: a size-structure that demonstrates recent reproduction has occurred in the wild. Populations are far from meeting the primary criterion for downlisting, as only one wild aggregation has been documented that meets the number and density standards to qualify. More work is needed to locate and document wild aggregations and to continue to monitor known aggregations that have yet to meet the density requirement. **We recommend that pinto abalone retain its classification as endangered wildlife within the state.**

Despite the long road ahead for pinto abalone, the expanded partnership has made excellent progress implementing the Washington State Pinto Abalone Recovery Plan. Release of hatchery-reared juveniles has increased exponentially compared to the early years of the program, aided by hatchery research, increased capacity at partner facilities, and a more efficient rotation of juveniles that includes release at much younger ages. Successful restoration sites from the early part of the program now hold dense aggregations of reproductive adults. These aggregations are intended to produce larvae that will settle in Washington waters and eventually contribute to a self-sustaining population and downlisting. Tribal governments have engaged with the partnership in abalone restoration and utilized seed funds. Collaborative research with universities continues to fill knowledge gaps. More effort has been diverted to the Strait of Juan de Fuca and Outer Coast to plan monitoring and potential juvenile-release activities there. Although many hurdles must still be overcome, we believe we have the pathways and infrastructure to achieve recovery and downlisting. Perseverance from researchers, enforcement officers, hatchery staff, and divers across the coalition of state government, tribal governments, non-profit organizations, and universities will translate into future populations that are more resilient and less vulnerable to extinction.

Literature cited

The references cited in this document are categorized for their 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 A.

Table 1. Key to cited reference categories.

Category Code	34.05.271(1)(c) RCW
i	Independent peer review: review is overseen by an independent third party.
ii	Internal peer review: review by staff internal to the Department of Fish and Wildlife.
iii	External peer review: review by persons that are external to and selected by the Department of Fish and Wildlife.
iv	Open review: documented open public review process that is not limited to invited organizations or individuals.
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	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	Records of the best professional judgment of Department of Fish and Wildlife employees or other individuals.
viii	Other: Sources of information that do not fit into one of the categories identified in this subsection (1)(c).

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