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Pinto Abalone Recovery Project
2025 Final Report to the Skagit MRC
Josh Bouma, Puget Sound Restoration Fund
Paul Dinnel, Skagit MRC
September 30th, 2025

Introduction

The pinto (northern) abalone, *Haliotis kamtschatkana*, is the primary abalone species indigenous to Washington waters, but populations are severely depleted and considered functionally extinct. The current number and distribution of reproductive wild abalone is too low and too widely distributed to maintain a sustainable population. The precipitous decline of abalone in Washington is largely due to anthropogenic factors, including overharvesting during the legal recreational fishery and poaching during the 1980-90s (Bouma 2007). Numbers in Washington state never supported a commercial fishery for abalone. Between 1992 and 2017, the density of pinto abalone declined by 97% at 10 index sites in the San Juan Archipelago (SJA) even after the closure of the recreational fishery in 1994 (Rothaus et al. 2008, WDFW unpublished data). Insignificant numbers of juvenile recruits have been observed and the average size of abalone continues to increase (Rothaus et al. 2008, Bouma et al. 2012, WDFW unpublished data). Both measures indicate likely recruitment failure of pinto abalone in areas of historical presence. They are now listed as a Washington State Endangered Species as of May 2019 (Sowul et al. 2021). They are also listed as a U.S. Federal Species of Concern and a Canadian Endangered Species (PSRF 2014).

Abalone are broadcast spawning invertebrates; gametes undergo fertilization in the water column. After a 7-10 day planktonic larval phase, the larvae go through metamorphosis and settle onto rocks encrusted with pink coralline algae. Juveniles prefer rocky reef and cobbled substrates with crack and crevice habitat to hide in. This large marine snail occurs primarily in the shallow subtidal zone, although they have been found in depths up to 100 ft (NOAA 2007). The abalone diet changes during different life stages; larval abalone are lecithotrophic while planktonic, small juvenile abalone primarily graze on the diatom and bacterial biofilm, and the adults feed on various species of macroalgae.

The apparent recruitment failure and complete lack of recovery for this species is thought to be largely due to the Allee effect (Allee et al. 1949). This can occur when existing animals, particularly broadcast spawning invertebrates like abalone, are not able to find each other and reproduce successfully. A low population density means less successful reproduction and a positive feedback loop that leads to eventual population extinction. Babcock and Keesing (1999) estimated that the minimum density for successful reproduction to occur is 0.15

abalone/m^2. Extensive sampling has shown that the remaining San Juan Archipelago (SJA) pinto abalone population is well below this threshold and unable to facilitate necessary reproduction for natural population recovery.

Steps are being taken to help restore the pinto abalone population in northern Puget Sound waters. The recovery project is a long-term collaboration between government agencies, NGOs, universities, tribes and more. This group includes researchers, resource managers, students, technicians and facilities support from Washington Department of Fish & Wildlife (WDFW); Puget Sound Restoration Fund (PSRF); Western Washington University (WWU)and WWU's Shannon Point Marine Center (SPMC); Skagit County Marine Resources Committee (Skagit MRC); Clallam County Marine Resources Committee (CCMRC); the NOAA Manchester Research Station; Port Townsend Marine Science Center (PTMSC); University of Washington, School of Aquatic & Fishery Sciences (UW); the Seattle Aquarium; Samish Indian Nation; Lummi Nation; Makah Tribe and others.

More than 75,000 healthy, genetically diverse hatchery produced juvenile abalone have now been outplanted to 50 rocky reef sites in Skagit, San Juan, Island and Jefferson County waters since 2009, creating a recovery network across a significant portion of their geographical range in Washington. Surveys of some of these outplant sites are conducted each year to monitor survival, growth and movement, which provide estimates of survival and growth of abalone populations released into the wild (Carson et al. 2019). Methods and results of surveys prior to 2025 can be found in annual WDFW, PSRF and Skagit MRC summary reports (Bouma and Dinnel 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024) as well as project reports by Shannon Point Marine Center (SPMC) students (Bergman 2009, Pratt and Dinnel 2010, Hester et al. 2011, Benolkin et al. 2012, Walker et al. 2013, Garden and Hoffman 2024). The following report summarizes PSRF project accomplishments related to the contract listed above during the period from October 1st, 2024-September 30th, 2025.

History of Pinto Abalone Restoration Efforts in Skagit County

Efforts to restore pinto abalone in Skagit County waters began in 2005 when a survey was conducted at six county sites by Goergen and Dinnel (2005). Abalone densities at these sites were found to be substantially less than previous surveys by WDFW. During the period of 2009 through 2013 WWU's SPMC research staff and students teamed with PSRF to assist with juvenile abalone outplants, monitoring of the outplanted abalone, and conducted various laboratory feeding and predation studies (Bergman 2009, Pratt 2010, Hester et al. 2011, Benolkin et al. 2012, Walker et al. 2013). In 2013, the lead abalone researcher and student mentor, Dr. Paul Dinnel, retired from WWU. Dr. Dinnel was an appointed member of the Skagit County Marine Resources Committee (Skagit MRC) dating back to 2000. His continuation with

Skagit MRC post-retirement lead to the MRC's adoption of pinto abalone restoration efforts and collaboration with PSRF. The MRC's adoption of the abalone restoration project in 2014 fit very well with the stated purpose of the MRC: "To protect and restore marine populations to healthy sustainable levels" (www.skagitmrc.org/about-us/) and "To protect and restore marine, coastal and nearshore habitats, prevent loss and achieve a net gain of healthy habitat" (www.skagitmrc.org/about-us/background/).

Additionally, teaming with PSRF was necessary as the MRC did not have the necessary facilities to raise juvenile abalone, nor did it have the boats and certified scientific divers required for abalone outplanting and monitoring. Since 2014 Dr. Dinnel has worked with PSRF personnel in non-hatchery and non-diving activities. He has lent his expertise to the project through team coordination, planning, contractual and reporting duties, presentations at annual Pinto Abalone Recovery Collaboration workshops, and observations on selected outplanting/monitoring cruises. During this time approximately 33,000 juvenile abalone have been outplanted at 15 Skagit County restoration sites. For a year-by-year summary of abalone restoration activities see our annual reports (Bouma and Dinnel, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024).

Kenneth K. Chew Center: Abalone Hatchery Production & Nursery Husbandry

Puget Sound Restoration Fund, with oversight from WDFW, has developed a conservation aquaculture program designed to supplement depleted wild stocks. The hatchery, wet laboratory and nursery facilities are located at the NOAA Marine Fisheries Research Station in Manchester, WA. This shellfish hatchery, named the Kenneth K. Chew Center for Shellfish Research and Restoration (Chew Center), is devoted to restoration and conservation of native shellfish and other marine species; work is ongoing on species such as pinto abalone, Olympia oysters, giant sea cucumbers, basket cockles, Dungeness crab, littleneck clams, bull kelp and sugar kelp. The Chew Center has been operated by PSRF since 2013 through a Cooperative Research and Development Agreement (CRADA) with NOAA. PSRF began moving the abalone aquaculture program from the NOAA Mukilteo Research station to the Chew Center in 2016 and all pinto abalone hatchery production and research activities are now conducted at the NOAA Manchester Station.

Adult broodstock abalone are collected from the wild and brought into the Chew Center. These animals are spawned in the laboratory to produce larval and juvenile abalone for future outplanting and to provide early life stages for a variety of laboratory experiments. During the 2025 production season, we induced two successful spawns in May that filled all available nursery tanks at the Chew Center and Seattle Aquarium Animal Care Center (SA ACC). The first spawn (May 13th) produced 10 new families from four females and three males. There were 3.3 million eggs released and 1.8 million larvae surviving to settlement day (7 days post-spawn).

Larvae were set in 40 tanks at the Chew Center at a density of 10,000 larvae per tank and in 22 tanks at the SA ACC at a density of 5,000 larvae per tank (Figure 1). The second spawn (May 27th) created 15 new families from six females and five males. Broodstock were prolific, with all eight of the females releasing eggs (n > 8.3 million). Two of the females were not used in pair-mating crosses due to genetic considerations, number, and quality of eggs. There were 3.2 million surviving larvae, and 49 tanks at the Chew Center were set with 10,000 larvae each.

Figure 1. *The PSRF Chew Center crew count abalone larvae for settlement, summer 2025.*

In more than 15 years since pinto abalone restoration aquaculture began in Washington, this season was the most successful early production effort that the program has seen. Completing all necessary spawning before June provides post-set with the best nursery growing season possible which could lead to larger, more robust juveniles ready for outplant next year. In total during the 2025 season, the hatchery produced 25 new families from 9 females and 9 males and filled 111 tanks at the Chew Center and the SA ACC with nearly 1 million larvae.

Abalone Broodstock

Regular inventory, health, and maintenance checks were conducted on all broodstock, tanks were fed and cleaned weekly, and animals were measured and re-tagged as necessary. Broodstock abalone were fed two types of macroalgae species: dulse (*Palmaria mollis),* and bull kelp (*Nereocystis luetkeana).* PSRF staff cultured the dulse in tumble culture tanks and bull kelp was wild collected as needed. Annual broodstock collections were conducted by PSRF and WDFW divers in the San Juan Islands prior to the spawning season. All new broodstock underwent the standard intake protocol: they were measured, ranked by gonad index, fouling sponges removed from the shell, animals were tagged with vinyl disc tags and PIT tags, non-lethal genetic samples were taken and archived using epipodial tentacle clips, and general observation of overall health was noted (Figure 2). In 2025, 6 females and 4 males

were collected. Two broodstock were retired to the SEA Discovery Center in Poulsbo and three broodstock to the Marine Life Center in Bellingham. All retired broodstock were males and have parented >1,000 outplanted juveniles.

Figure 2. *Ripe male and female gonad tissue ranking and general health observation.*

At the end of June 2025, PSRF housed a total of 58 broodstock (24 females, 34 males). Broodstock mortality was much lower during this reporting period than in previous years (Figure 3). During the 2024 and 2025 induced spawns, we did not use temperature shock (i.e., 3°C increase in the spawning buckets), which may have reduced stress to the broodstock.

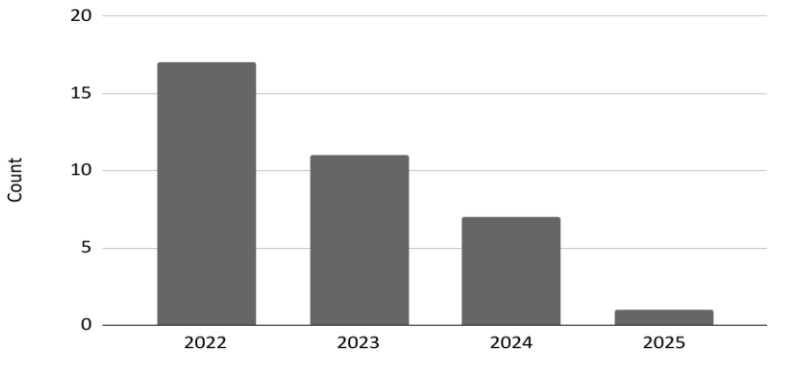

Figure 3. *Decrease of broodstock mortalities, January 2022-June 2025.*

Abalone Health & Disease Screening

To confirm no disease-causing pathogens were present in hatchery-reared animals prior to moving abalone between facilities and outplanting animals into the wild, an annual hatchery health assessment was conducted by pathologists Dr. Ralph Elston and Clara Duncan, AquaTechnics Inc. Live samples were sent for histology to detect known infectious diseases and PCR analysis to determine if withering syndrome was present. On January 29th, 2025, health screening results from all three nursery facilities (PSRF Chew Center at NOAA Manchester, Seattle Aquarium, PTMSC) showed no disease-causing pathogens present. Each facility sent 60 live juveniles for histology and 60 live juveniles for Withering Syndrome PCR. Upon this confirmation of abalone hatchery health, new transfer permits were received from WDFW to move abalone from the nursery facilities for outplanting.

Juvenile Abalone Outplant Site Monitoring

Between February-April 2025, PSRF, WDFW, Samish Tribe and Seattle Aquarium divers surveyed for survival, growth and emergence of hatchery reared pinto abalone at 9 Skagit County sites outplanted in 2024 (Figure 4). Following guidelines adopted by WDFW and described in the Recovery Plan, when restoration sites are established, they are outplanted in the first year and if successful then subsequently overseeded every three years to maintain aggregations and boost genetic diversity.

Figure 4. *PSRF and WDFW divers prepare for an outplant site survey while also celebrating a birthday.*

Survey set-up in 2025 included locating the four permanently marked plot corners, extending a survey tape measure around the plot to establish a perimeter, and installing weighted lines to distinguish 2 m survey lanes across the plot. Surveys also included the addition of a 2 m perimeter lane around the entire outside of each plot. This additional perimeter lane roughly doubles the amount of area surveyed at each site during a standard survey and provides informative emigration data. Divers meticulously conducted non-invasive surveys of each lane, including the full perimeter sweep. Dive lights were used to investigate cracks, crevices and overhangs. The shell length and presence/absence of tags, if identifiable, were recorded for all abalone observed. The 2024 outplants included almost entirely one-year-old cohorts, with the addition of a very small number of 2-year-olds, which were marked with purple glue dots easily visible underwater to divers, although none of the purple marked juveniles were observed during the one-year surveys in 2025. Notes were also taken on where each observation was made within the plot lane (deep, mid or shallow) and how the animal was oriented within the substrate (cryptic, semi-cryptic or emergent). If found, empty abalone shells from mortalities were collected, measured and observed for tags when encountered and then removed from the plot.

Of the Skagit County sites outplanted in 2024 and surveyed in 2025, two of the original locations established in 2009 continue to be the strongest recovery sites with high survival. Omaha and Kwú:l (Gold) both had densely aggregated populations of abalone. Multiple generations have been outplanted at these sites during 15 years of overseeding and observed shell lengths in 2025 ranged from 10-145 mm. Estimated survival of the most recent outplant is calculated by dividing the number of abalone less than 40 mm by the total number seeded to the site last year. Omaha and Kwú:l had 4.3% and 4.2% survival respectively (Table 1).

Six of the nine sites surveyed in 2025 had been seeded multiple times with successful results, one site had been seeded twice (Goodenough) and the remaining two sites were seeded for the first time in 2024 (Kwósen and King). Estimated survival across all Skagit County sites seeded in 2024 and surveyed in 2025 was lower than expected at 2%. Many variables could have contributed to this, including but not limited to hatchery health, handling and transport, oceanic conditions during or after outplant, or dive conditions (current, limited visibility) during some surveys impacting accuracy.

Table 1. *2025 survey results for Skagit County sites outplanted with abalone in 2024. Juveniles measured to be less than 40 mm shell length were assumed to be from the 2024 outplant cohort and not survivors from previous seedings. Survival is estimated for the 2024 cohort.*

Outplant site	Total N observed	N < 40 mm SL	N seeded 2024	Est. % Survival
Utah	61	7	631	1.1
Omaha	158	30	705	4.3
Kwú:l (Gold)	112	34	806	4.2
Juno	74	7	727	1.0
Husky	23	13	759	1.7
Baytown	40	11	740	1.5
Goodenough	19	8	649	1.2
Kwósen (Star)	16	16	794	2.0
King	2	2	525	0.3
Total	**505**	**128**	**6336**	**2.0**

Juvenile Abalone Outplanting

Between April and August 2025, in collaboration with divers from the WDFW subtidal shellfish team, Samish Indian Nation, Seattle Aquarium and the SPMC REU program, the PSRF team completed a series of juvenile abalone outplants at nine recovery sites in Skagit County. A fundamental objective of the pinto abalone conservation aquaculture program is to "do no harm" to existing wild stocks of abalone and therefore extreme care was taken during the restoration effort described here to outplant a genetically diverse and disease-free cohort of abalone. Since 2009, almost 33,000 pinto abalone from over 270 genetically distinct families have been outplanted to 15 different restoration sites in Skagit County; four of which were newly established in 2025.

Figure 5. *Juvenile abalone loaded into tubes and ready for outplant.*

This year, 6596 juvenile abalone (combination of one- and two-year olds) were outplanted to 9 sites in Skagit County, representing 22 genetically distinct families produced at the Chew Center in 2023 and 2024 and reared at the Chew Center, Seattle Aquarium and PTMSC. In preparation for outplanting, PSRF and SA ACC staff conducted inventory, collected shell length data, and sorted families into outplant

groups and loaded into tubes (Figure 5). The number of abalone outplanted in 2025 ranged from approximately 521-752 per site.

Similar to the previous year, PSRF partnered with the Samish Indian Nation natural resources team, and more reconnaissance dives were conducted in Skagit County this year to establish new outplant sites (Figure 6). Of the 9 sites outplanted this year, four were newly established and seeded for the first time. Two of these sites were outplanted by Samish divers and will be monitored and maintained by the Samish dive team next year. All new sites were set up with permanent corner markers; site maps were created including site features, depths, compass headings between corner markers and GPS coordinates.

Figure 6. *Samish Tribe dive team prepares for abalone outplant site scouting.*

Collaboration Building with SPMC

During summer 2025, PSRF Senior Abalone Biologist, Eileen Bates, worked closely with SPMC researchers Derek Smith and Nate Schwarck and a group of students on abalone outplant projects. The students and scientific diver trainees were Research Experience for Undergrads (REU) participants, Our World Underwater scholars and others from WWU who were at SPMC for the summer. Overall, 2471 abalone were outplanted by SPMC divers to four sites (3 of which were in Skagit County) in collaboration with PSRF and WDFW during this summer

research experience. Juveniles that had not been released during spring outplants were moved from the Chew Center and SA ACC to SPMC in June and held in flow through tanks for 1.5 months. This husbandry of juveniles at SPMC provided good insights into what will be needed for planned full-time husbandry at the facility in the near future. SPMC has plans to repurpose a workshop space with controlled heating into a wet lab and abalone nursery, with set up help from PSRF, aiming to have it ready to receive juveniles in 2026.

Several projects were conducted with the juveniles held at SPMC in 2025—a successful pilot year for building a partnership in juvenile rearing and abalone research. First, another new SPMC managed outplant site was developed on an island near SPMC for easy access from the labs. On this site, named Victor, we outplanted 750 juveniles in 5 clear tubes and 5 of our typical opaque outplant tubes (Figure 7). Eileen and the REU students then did repetitive dives counting remaining abalone in the tubes every hour post-outplant. Students shared that they found that abalone left the clear tubes significantly faster than the opaque tubes, which could bolster survival. To further test this, the students, with help from WDFW and Eileen, tagged 600 abalone with individual tags and outplanted them to newly established (spring 2025) site Gymnast, in half clear and half opaque tubes. With this outplant, we will be able to survey abalone in winter 2026 to determine if those from clear tubes had higher survival than those in opaque tubes. The hypothesis is that leaving the tubes faster and finding rock crevices would increase survival of juveniles, and this will allow us to test that theory.

Figure 7. *Juvenile abalone crawling from SPMC experimental clear outplant tubes.*

Additionally, we performed 3 surveys on King, the site that SPMC students established last year, and found different tagged animals on every survey. Although survey numbers were low, this does back up evidence that our detection rate is relatively low for juvenile abalone (expected due to their cryptic nature and small size), and that "survival" rates on outplant sites are likely severe underestimates. After these surveys, we outplanted 600 additional abalone on King, and put timelapse cameras on each of the 6 clear tubes used for outplant to observe how fast abalone left the tubes and to see if any notable predation events occurred. These photos are still being analyzed.

Finally, we outplanted the remaining 521 abalone to Vitality, a long-established Skagit County site. Because we'd noted some movement off site of abalone here in the past, we elected to expand this site substantially and outplant these abalone in the new section of it. This is a somewhat new approach we are testing, out of the norm of our standard outplant site size, but is backed by evidence that abalone spread from our outplant sites to nearby preferred habitat if it exists, so ideally this will help us build an aggregation over a larger area at Vitality.

REU students also conducted predator choice experiments seeing if *Amphissa*, a snail they have noted on abalone outplant sites, would target healthy abalone, injured abalone, or neither when given the option. They did find clear evidence that these snails preferentially moved towards and predated upon injured abalone —useful information as some abalone likely are injured in outplant processes, and this may bring predators such as *Amphissa* to outplant sites.

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