PINTO ABALONE

Haliotis kamtschatkana Jonas, 1845
(Haliotidae)

Global rank GNR – suggested change to G3 (09Dec2005)
State rank S2S3 (09Dec2005)
State rank reasons
Limited range and patchy distribution in Southeast Alaska. Dramatic declines in abundance over the last twenty years, with no indication of recovery despite commercial fishery closures in 1995. Highly susceptible to overexploitation due to patchy distribution, short larval period, slow growth, low sporadic recruitment, and aggregation of adults during spawning. Recovery may be limited by combined effects of legal recreational/subsistence harvest and suspected illegal harvest, low recruitment levels, and predation caused by reintroduction and recovery of sea otters. Lack of demographic data and northern extremity of the species' range in Alaska add to species' vulnerability.
Other statuses
U.S. Endangered Species Act: SC: Species of concern (15Apr2004)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Threatened (01May2000)
Canada's Species at Risk Act (SARA): Threatened

Taxonomy
McLean (1966) and Geiger and Poppe (2000) recognize the northern *Haliotis kamtschatkana kamtschatkana* and southern *H. k. assimilis* as subspecies; considered separate species by others (Kozloff 1983, Sloan and Breen 1988, Turgeon et al. 1998), based on distribution and morphological characteristics. Between San Luis Obispo and Point Conception in central California, *H. k. kamtschatkana* intergrades with *H. k. assimilis* (Geiger and Poppe 2000).

General description
A small marine mollusk with a thin, ear-shaped wavy shell measuring around 10-15 cm in length. Shell exterior is mottled tan and greenish or reddish and is often encrusted with other marine organisms. Spire is low and 3-6 open holes with raised edges occur along one margin of the shell. Shell interior is nacreous and iridescent white. Body consists of slender green tentacles, a muscular foot, and many other branched and unbranched processes lying along the side of the

body between the shell and the foot (Bailey 1935, Kozloff 1983, Harbo 1997, O'Clair and O'Clair 1998, Field and Field 1999).
Length (cm) range 10-15, max. 17 (shell length)

Reproduction
Generally considered dioecious although a few hermaphroditic individuals have been observed (Sloan and Breen 1988). Fertilization is external; gametes are released into the water column. Spawning occurs mainly from April to August, but some individuals may spawn year round (Sloan and Breen 1988, Campbell et al. 2003). Mating is stimulated by rising water temperatures or mechanical stimulation (Wolotira et al. 1989). Spawning is synchronous with many small spawning aggregations forming near each other, thereby maximizing fertilization rate (Sloan and Breen 1988, Stekoll and Shirley 1993, Campbell 2000, Jamieson 2000). The minimum density for successful fertilization is approximately 0.13-0.33 individuals/m^2 (NOAA/NMFS 2004). Individual females may release up to 2.3 million pelagic eggs (O'Clair and O'Clair 1998). Planktonic phase is short (4-8 days; see sources in Jamieson 2000; 12-13 days at warmer temperatures; Standley 1987 in Toole et al. 2002). Veligers are induced to settle in the presence of coralline algae (O'Clair and O'Clair 1998), but very little is known about the early juvenile stage (Toole et al. 2002). Individuals mature at about 50 mm (6-8 years according to Breen (1980); 3-4 years according to Shepherd et al. 2000), but large females (>100 mm) contribute substantially more to fecundity than do small mature abalone (Campbell et al. 1992, 2003). In a sample of 452 abalone collected in southern Southeast Alaska, maturity began at 31 mm and the largest immature was 42 mm (Woodby, pers. comm.). Maximum age is unknown, but individuals may live 20 years or more in the wild (Sloan and Breen 1988, Field and Field 1999)

and individuals still alive in captivity are currently over 20 years old (Paul and Paul 2000). Breen (1980) speculated that some could live to be 50 years old. The average age of abalone at 102 mm (the minimum legal size in Alaska's now closed commercial fishery) was estimated at 8 years (Shepherd et al. 2000).

Ecology

As adults, may compete with other grazers such as red sea urchins (*Strongylocentrotus franciscanus*) for food (Toole et al. 2002). However, Tomascik and Holmes (2003) found a significant positive correlation between northern abalone size and density and red sea urchin density; at low densities, direct competition for food may not be apparent or the presence of sea urchins may benefit abalone through their maintenance of crusteose red algae habitats preferred by juvenile abalone.

Predators include the sea otter (*Enhydra lutris*), river otter (*Lontra canadensis*), mink (*Mustela vison*), crab (*Cancer* spp.), sea stars (*Pycnopodia helianthoides*), octopus (*Octopus dofleini*), wolf eel (*Anarrhichthys ocellatus*), sculpins (Cottidae*;* Sloan and Breen 1988, Toole et al. 2002), and humans. The pinto abalone has an impressive escape response to some species of sea star in which it raises its shell and violently twists its body to throw the shell from side to side and speeds away (about 15 shell lengths per minute; O'Clair and O'Clair 1998).

Migration

Although mobile, adults seldom move more than a few hundred meters over their lifetime. Known to flee from predators; maximum speeds reported from 25 cm and 15 shell lengths per minute (O'Clair and O'Clair 1998, Field and Field 1999). Meroplanktonic larvae are the primary dispersal stage, but the planktonic stage lasts only a few days and larval behavior probably limits dispersal (Jamieson 2000).

Food

Herbivore; grazes on many species of algae and sessile diatoms (O'Clair and O'Clair 1998), but prefers bull (*Nereocystis luetkeana*) and ribbed kelp (*Costaria costata*). Larvae feed on microscopic plants in the water column; juveniles feed initially on benthic diatoms, then coralline algae, and later on microalgae by grazing on rocks with their radula; adults capture small pieces of drift algae (giant kelp, *Macrocystis integrifolia*, bull kelp, and *Laminari*a kelp) with their feet (Sloan and Breen 1988, Wolotira et al. 1989).

Habitat

Normally found on firm substrates such as rocks, boulders, or bedrock, in areas of moderate to high sea-water exchange, such as exposed or semi-exposed coastlines (Jamieson 2001). At its northern range limit, occurs from the lower intertidal zone to at least 100 m deep, whereas at its southern range limit it is strictly subtidal, occurring at depths of 10-20 m (Jamieson 2001). Off southern California it is most common at 10-30 m (Wolotira et al. 1989). In Southeast Alaska, characteristic of the extreme low intertidal zone to 15 m (O'Clair and O'Clair 1998). Growth is stunted in highly exposed outer coastal areas where food may be limited by strong wave action, and is more rapid in moderately exposed areas with giant or bull kelp forests (Toole et al. 2002). Encrusting coralline algae provides nursery habitat for post-larval juveniles (Sloan and Breen 1988). Juveniles are found under and on exposed areas of rocks, while adults are found on exposed rock surfaces (Toole et al. 2002). However, within the range of sea otters, adults are cryptic and are found only in rock crevices (Sloan and Breen 1988, Jamieson 2001). Adults aggregate in warm shallow water to spawn (Breen and Adkins 1980). In the laboratory, mortality occurs at temperatures less than 0.5º C and greater than 26.5º C (Paul and Paul 1998).

Global range

Temperate distribution. Found along the northern Pacific Coast from Yakutat, Alaska to Point Conception, California (O'Clair and O'Clair 1998).

State range

Southeast Alaska. Northern limit recorded at Yakutat (O'Clair and O'Clair 1998), Sitka (Harbo 1997), Cross Sound (Wolotira et al. 1989), and Icy Strait at the northern tip of Chichagof Island (Sloan and Breen 1988). Found as far south as Dixon Entrance (Imamura 1994). Reported in the literature from Prince William Sound and the Aleutian Islands (Baxter 1983), but type locality specimen for Unalaska has been lost and is evidently in error (Foster 1981, Jamieson 2001). Extremely cold ocean temperatures may explain the absence of pinto abalone in waters north of Southeast Alaska (Paul and Paul 1998). Also see Geiger (2000) for locations of specimen records in Alaska.

Global abundance

Species is patchily distributed and densities vary spatially in relation to human harvest pressure, sea otter predation, and local recruitment rates. Prior to recent declines, densities at index sites on the Queen Charlotte Islands and the B.C. central coast averaged 2.8 abalone/m² and 2.4 abalone/m², respectively (Toole et al. 2002). Current densities at these index sites have declined to 0.5/m² and 0.2/m² (Toole et al. 2002). Elsewhere in B.C., densities of 0.10/m² to 0.15/m² were reported for Barkley Sound in 2000-2002 (Lucas et al. 2002d, Tomascik and Holmes 2003, Lessard et al. 2004); 0.05/m² at Goschen Island and 0.16/m² at McCauley Island, Kitkatla area in 2000 (Lucas et al. 2002b); 0.29/m² at Lotbiniere Bay in 2000 (Lucas et al. 2002c); 0.04/m² at Bere Bay, 0.03/m² at Trinity Bay, 0.05/m² at Cormorant Pass in 2000 (Lucas et al. 2002a); and 0.06/m² for Denman Island in 2000-2001 (Lucas et al. 2002e). Low and decreasing abundance of large individuals has also been reported in British Columbia (Tomascik and Holmes 2003, Atkins et al. 2004). Relatively high abundance still reported for the area close to William Head Penitentiary, near Victoria, B.C., where poaching may have been discouraged by the presence of prison guards (Wallace 1999, Toole et al. 2002).

State abundance

Specific abundance estimates for Alaska are not available. Abundance known to vary spatially depending on human harvest pressure, sea otter predation, and local recruitment rates. During Alaska's 25-year abalone fishing history, the majority (77%) of the harvest was taken from the southwestern end of the Alaska panhandle, specifically along the outside coast of Dall Island, passages between Dall, Suemez, Baker, and Prince of Wales islands, Sea Otter Sound, and to a lesser extent (16%) near Sitka, suggesting these areas were the regions of greatest abundance (Woodby et al. 2000).

Global trend

Abalone abundance in B.C. declined by more than 75% between 1977 and 1984 and has remained low and/or continued to decrease even after the commercial fishery was closed in 1990 (Campbell 2000, Lucas et al. 2002a, b, c, d, e, Toole et al. 2002, Atkins and Lessard 2004, Lessard et al. 2004). Mean densities of pinto abalone at comparable index sites changed from 2.4 to 0.2 abalone/m² on the central B.C. coast during 1979-97, and from 2.8 to 0.5 abalone/m² for the southeastern Queen Charlotte Islands, 1977-98 (Toole et al. 2002). Also noted at these index locations were fewer sites containing pinto abalone in 1997-1998 (10-20%) than during 1978-1979 (45-80%; Campbell 2000). Decreases in density and declines in the number of sites with abalone suggested depletion of large abalone with little recruitment during most of the 1990s (Campbell 2000, Toole et al. 2002). Recent surveys indicated low numbers of large abalone at index locations in Barkley Sound, B.C. (Lucas et al. 2002a, Campbell et al. 2003, Lessard et al. 2004); this contrasts sharply with the many (51%) large abalone sampled there in 1963-64 (Campbell et al. 2003).

Pinto abalone abundance declined nearly 10-fold in northern California between 1971 and 2001(from 156,000 in 1971 to 18,000 in 1999-2001; NOAA/NMFS 2004). Recent surveys in the San Juan Island Archipelago, Washington, indicated a decline in density between 1992 and 1996 at 6 of 10 index sites; densities at all but one of these sites were below or at the minimum level for successful fertilization (NOAA/NMFS 2004).

Commercial harvest in Alaska peaked from 1978 to 1982 (highest annual catch of 172 tons in 1979-1980) and declined sharply thereafter; by 1994, average harvest had declined to 50,000 lbs. (Woodby et al. 2000, NOAA/NMFS 2004). The fishery was closed in 1995 in recognition of localized depletion of stocks (Woodby et al. 2000).

State trend

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Global protection
Prior to fisheries closures, size restrictions and catch limits were the primary means of protection (Woodby et al. 2000). Commercial harvest for pinto abalone has been closed in B.C. since 1990 (Campbell 2000) and in Alaska since 1995 (Woodby et al. 2000). No commercial fishery occurred in Washington and the recreational fishery was closed there in 1994 (NOAA/NMFS 2004).

Because pinto abalone is a coastal species, it is not covered by federal management plans in the U.S. Harvest is monitored by state agencies in Alaska, Oregon, and California, by the Canada Department of Fisheries and Oceans in British Columbia, and the Department of Pesca in Mexico (Wolotira et al. 1989).

State protection
Prior to commercial fisheries closures, size restrictions and catch limits were the primary means of protection (Woodby et al. 2000). Commercial harvest has been closed in Alaska since 1995, but a recreational free-diving sports fishery and subsistence fishery for residents of Southeast Alaska remains (Woodby et al. 2000, NOAA/NMFS 2004, ADFG 2005, USFWS 2005). Harvest is monitored by the Alaska Department of Fish and Game, which allows collection of abalone measuring 3.5 in (shell length) or greater (ADFG 2005).

Global threats
Threats include localized depletion as a result of harvest (both legal and illegal); life history requirements necessitate high densities for successful fertilization and sufficient recruitment, consequently, this species is susceptible to the Allee effect. Other threats include predation by sea otters, disease, and habitat pollution from oil spills, sewage outfall, and forestry and mining runoff. Effects of climate change are unknown, but there is potential for increasing water temperatures to affect populations directly by altering spawning period and length and/or indirectly by affecting the production of algal food sources or local current patterns.

Also see State threat comments.

State threats
Overharvest: Prone to localized depletion due to patchy distribution, short larval period, slow growth, relatively long lifespan, low sporadic recruitment, and tendency for mature individuals to aggregate in shallow water where they are easily accessible to harvesters (Sloan and Breen 1988, Paul and Paul 2000, Jamieson 2001, Toole et al. 2002). There is currently no commercial harvest throughout the species' range, but high market value and difficulty enforcing fishery closures in large, mostly uninhabited coastal areas has encouraged the illegal harvest of pinto abalone in B.C. (Campbell 2000, Toole et al. 2002); the extent of illegal harvest in Alaska and elsewhere in the U.S. is undocumented. Illegal harvesting not only depletes already depressed populations, but also reduces reproductive potential by removing larger mature individuals (Toole et al. 2002). Anecdotal information suggests that illegal harvest is occurring on a scale significant enough to cause severe conservation risk to this species (Toole et al. 2002).

Allee effect: As a broadcast spawner, the species requires high densities to ensure successful fertilization and sufficient recruitment (Toole et al. 2002); consequently it is susceptible to the Allee effect (i.e. for smaller populations, the reproduction and survival of individuals decreases; Campbell 2000, Jamieson 2000).

Predation: Sea otters are major predators of pinto abalone (Sloan and Breen 1988, Campbell 2000). In Alaska, abalone populations were decimated in areas where otters reestablished. These declines came after peak abalone fishery harvests, therefore, otter predation is not considered the major factor in the abalone declines noted in the 1980s (Woodby et al. 2000). Continued expansion of the sea otter population in Southeast Alaska could be a concern to localized abalone populations.

Disease: Abalone stocks in California have been severely impacted by disease (Toole et al. 2002). Extremely high mortality of cultured juveniles occurred from the protozoan parasite *Labryinthuloides haliotidis* in B.C., but adults were not noticeably affected; studies to ascertain prevalence of this and other parasites in the wild have not been conducted (Sloan and Breen 1988, Jamieson 2000, NOAA/NMFS 2004).

Climate change: Ocean climate variability may play a role in keeping abalone populations at their current low levels; declines in red abalone (*H. rufescens*) have been linked to El Niño events that affect kelp abundance (Tegner et al. 2001). Changes in ocean temperature may affect abalone directly by altering their spawning period and length and/or indirectly by affecting the production of their algal food sources or local current patterns.

Habitat degradation: Contamination from oil spills, sewage outfall, anthropogenic and natural heavy metals, and increased sedimentation from forestry and mining can have short-term deleterious effects on intertidal habitats (Jamieson 2001). Coastal development and shallow water trawling are also of potential concern.

State research needs

The relationship between adult concentrations and breeding success needs study; minimum patch size required to maintain sufficient recruitment should be determined. Research needed on genetic variation and larval dispersal to help define stock sizes (Campbell 2000). Information needed about the prevalence and effects of disease and illegal harvest on abalone populations, and about the impacts of coastal development on abalone habitat (Toole et al. 2002). Research also needed on potential effects of spatial closures (e.g., marine reserves) as a tool to restore populations, current and potential effects of sea otter population growth on abalone populations, and the effects of human subsistence harvests on long-term abalone abundance.

Global inventory needs

Baseline surveys in areas not already surveyed (e.g., northern B.C. and Alaska) and continued broad-scale surveys are required to monitor population status of this species (Toole et al. 2002). In addition, intensive, fine-scale local surveys could help to recognize variability within and between areas of biologically distinct populations (Campbell 2000); some of these surveys have already taken place in B.C. (Withler et al. 2003).

State inventory needs

Demographic information for Alaskan populations is virtually nonexistent. Baseline surveys needed in areas not already monitored and continued broad-scale surveys needed at index sites. Monitor subsistence and recreational harvest. Identification of former localized areas of abundance is important for habitat protection and potentially for future reintroduction.

Global conservation and management needs

Abalone population abundance may remain low or continue to decline in B.C. unless illegal harvest is reduced, brood stocks are protected, fisheries remain closed, and other effective rehabilitation methods are implemented (Campbell 2000). Management activities should include the identification, protection, and monitoring of spawning aggregates (and recruits) on a regional basis to examine both demographic and genetic parameters for signs of recovery or decline (Withler et al. 2003). Abalone densities in B.C. are well below the level needed to ensure sustainable populations, therefore any removal of abalone should be done with caution (Jamieson 2001, Lucas et al. 2002a, b, c, d, e, Atkins and Lessard 2004, Atkins et al. 2004, Lessard et al. 2004). Illegal harvest may be prevented by promoting communication, improved public awareness, and local stewardship and surveillance; the development of genetic markers could help identify illegal abalone in the marketplace. Increase enforcement efforts to curtail illegal harvest and trafficking (Campbell 2000, Jamieson 2000, Jubinville 2000, Toole et al. 2002).

State conservation and management needs

Existing management and current understanding of pinto abalone population biology is insufficient to justify reopening a commercial fishery in Alaska at this time (Woodby et al. 2000). Protect local populations during the spawning season, as this species aggregates at this time and is more vulnerable to exploitation. Better enforcement/protection against poaching, which occurs to an unknown extent for commercial and non-commercial purposes, is needed (Woodby et al. 2000). Encourage local communities to participate in monitoring of subsistence harvests and local population changes.

LITERATURE CITED

Alaska Department of Fish and Game (ADFG). 2005. 2005 sport fishing regulations, Southeast Alaska. Available online at: http://www.sf.adfg.state.ak.us/statewide/regulations/2005/southeast/pdfs/person.pdf. Accessed 05May2005.

Atkins, M. and J. Lessard. 2004. Survey of northern abalone, *Haliotis kamtschatkana*, populations along North-West Vancouver Island, British Columbia. Can. Man. Rep. of Fish. and Aqu. Sci. 2690.

Atkins, M., J. Lessard, and A. Campbell. 2004. Survey of northern abalone, *Haliotis kamtschatkana*, populations in southeast Queen Charlotte Islands, British Columbia, April 2002. Can. Man. Rep. of Fish. and Aqu. Sci. 2704.

Bailey, J. L. 1935. West Coast shells. Stanford University Press, Stanford, CA.

Baxter, R. 1983. Mollusks of Alaska: a listing of all mollusks, freshwater, land and marine, reported from the State of Alaska, with known locations of type specimens, maximum sizes, and marine depths inhabited. Alaska Dept. of Fish and Game, Bethel, AK.

Breen, P.A. 1980. Measuring fishing intensity and annual production in the abalone fishery of British Columbia. Canadian Technical Report Fisheries Aquatic Sciences 947. 49 pp.

Breen, P.A. and B.D. Adkins. 1980. Spawning in a British Columbia population of northern abalone, *Haliotis kamtschatkana*. The Veliger 23:177-179.

Campbell, A. 2000. Review of northern abalone, *Haliotis kamtschatkana* stock status in British Columbia. Pp. 41-50 in: Campbell, A. (Ed.). Workshop on rebuilding abalone stocks in B.C. Can. Sp. Pub. of Fish. And Aqu. Sci. 130.

Campbell, A., I. Manley, and W. Carolsfeld. 1992. Size at maturity and fecundity of the abalone, *Haliotis kamtschatkana* in northern British Columbia. Can Man. Rep. Fish. Aquat. Sci. 2169:47-65.

Campbell, A., J. Lessard, and G. S. Jamieson. 2003. Fecundity and seasonal reproduction of northern abalone, *Haliotis kamtschatkana*, in Barkley Sound, Canada. J. of Shellfish Research 22: 811-818.

Field, C. M. and C. J. Field. 1999. Alaska's seashore creatures: a guide to selected marine invertebrates. Alaska Northwest Books, Portland, OR.

Foster, N. R. 1981. A synopsis of the marine prosobranch gastropod and bivalve mollusks in Alaskan waters. Institute of Marine Science, University of Alaska, Fairbanks, AK.

Geiger, D. L. 2000. Distribution and biogeography of the recent Haliotidae (Gastropoda: Vetigastropoda) world-wide. Bollettino Malacologico, Roma. Vol. 35.

Geiger, D. L. and G. T. Poppe. 2000. Haliotidae. Pp. 61-62 in: Poppe, G. T. and K. Groh (Eds.). Conchological Iconography. ConchBooks, Weisbaden. 135 pp.

Harbo, R. M. 1997. Shells and shellfish of the Pacific Northwest: a field guide. Harbour Publishing, Madiera Park, B.C.

Imamura, K. 1994. Abalone. Alaska Department of Fish and Game Wildlife Notebook Series. Available online at: <http://www.adfg.state.ak.us/pubs/notebook/shellfsh/abalone.php> Accessed 05May2005.

Jamieson, G.S. 2000. Marine protected areas and their relevance to abalone (*Haliotis kamtschatkana*) conservation in British Columbia. Pp. 139-147 in: Campbell, A. (Ed.). Workshop on rebuilding abalone stocks in B.C. Can. Sp. Pub. of Fish. and Aqu. Sci. 130.

Jamieson, G.S. 2001. Review of the status of the northern abalone, *Haliotis kamtschatkana*, in Canada. Can. Field Nat. 115: 555-563.

Jubinville, B. 2000. Enforcing the fishery closure for northern (pinto) abalone (*Haliotis kamtschatkana*) in British Columbia [Abstract]. P. 52 in: Campbell, A. (Ed.). Workshop on rebuilding abalone stocks in B.C. Can. Sp. Pub. Of Fish. And Aqu. Sci. 130.

Kozloff, E. N. 1983. Seashore life of the northern Pacific coast: an illustrated guide to northern California, Oregon, Washington, and British Columbia. University of Washington Press, Seattle, WA.

Lessard, J., D. Brouwer, and J. P. Mortimor. 2004. Survey of northern abalone, *Haliotis kamtschatkana*, populations in southeast Barkley Sound, British Columbia, October 2002. Can. Man. Rep. of Fish. and Aqu. Sci. 2685.

Lucas, B. G., D. Brouwer, and A. Campbell. 2002a. Survey of northern abalone, *Haliotis* *kamtschatkana*, populations at Malcolm Island and Cormorant Island, British Columbia, October 1999. Can. Man. Rep. of Fish. and Aqu. Sci. 2620.

Lucas, B. G., D. Brouwer, and A. Campbell. 2002b. Survey of northern abalone, *Haliotis kamtschatkana*, populations near Kitkatla, British Columbia, March 2000. Can. Man. Rep. of Fish. and Aqu. Sci. 2622.

Lucas, B. G., D. Brouwer, and A. Campbell. 2002c. Survey of northern abalone, *Haliotis kamtschatkana*, populations in Lotbiniere Bay, British Columbia, March 2000. Can. Man. Rep. of Fish. and Aqu. Sci. 2622.

Lucas, B. G., A. Campbell, D. Brouwer, S. Servant, and N. Webb. 2002d. Survey of northern abalone, *Haliotis kamtschatkana*, populations in southeast Barkley Sound, British Columbia, July 2000. Can. Man. Rep. of Fish. and Aqu. Sci. 2623.

Lucas, B. G., A. Campbell, and D. Brouwer. 2002e. Survey of northern abalone, *Haliotis kamtschatkana*, populations at Chrome Island and southern Deadman Island, May – June 2000 and May 2001. Can. Man. Rep. of Fish. and Aqu. Sci. 2624.

McLean, J.H. 1966. West American prosobranch gastropoda: superfamilies Patellacea, Pleurotomariacea, and Fissurellacea. Ph.D. dissertation, Stanford University, Stanford, CA. 255 pp.

National Oceanic and Atmospheric Administration (NOAA). 2004. Endangered and threatened species; establishment of species of concern list, addition of species to species of concern list, description of factors for identifying species of concern, and revision of candidate species list under the endangered species act. Federal Register 69(73): 19975-19979.

National Oceanic and Atmospheric Administration (NOAA) and National Marine Fisheries Service (NMFS). 2004. *Haliotis kamtschatkana* Species of Concern. Available online at: <http://www.nmfs.noaa.gov/pr/species/concern/profiles/pinto_abalone.pdf>. Accessed 17May2005.

O'Clair, R.M. and C.E. O'Clair. 1998. Southeast Alaska's rocky shores: animals. Plant Press, Auke Bay, AK. 564 pp.

Paul, A. J. and J. M. Paul. 1998. Respiration rate and thermal tolerances of pinto abalone *Haliotis kamtschatkana*. J. of Shellfish Research 17: 743-745.

Paul, A.J. and J.M. Paul. 2000. Longevity of captive pinto abalones *Haliotis kamtschatkana*. Alaska Fishery Research Bulletin 7: 51-53.

Shepherd, S.A., D. Woodby, J.M. Rumble, and M. Avalos-Borja. 2000. Microstructure, chronology, and growth of the pinto abalone, *Haliotis kamtschatkana*, in Alaska. J. of Shellfish Research 19:219-228.

Sloan, N. A., and P. A. Breen. 1988. Northern abalone, *Haliotis kamtschatkana*, in British Columbia: fisheries and synopsis of life history information. Canadian Special Publications in Fisheries and Aquatic Science 103. 46 pp.

Stekoll, M. S. and T. S. Shirley. 1993. *In situ* spawning behavior of an Alaskan population of pinto abalone, *Haliotis kamtschatkana* Jonas 1845. The Veliger 36: 96-97.

Tegner, M.J., P.L. Haaker, K.L. Riser and L.I. Vilchis. 2001. Climate variability, kelp forests, and the southern California red abalone fishery. J. Shellfish Res. 20:755-763.

Tomascik, T. and H. Holmes. 2003. Distribution and abundance of *Haliotis kamtschatkana* in relation to habitat, competitors and predators in the Broken Group Islands, Pacific Rim National Park Reserve of Canada. J. of Shellfish Research 22: 831-838.

Toole, J., B. Adkins, E. Bornhold, J. Boutillier, G. Caine, A. Campbell, A. Castledine, L. Convey, C. Cote, P. Coulson, T. Down, K. Francis, H. Gill, R. Harbo, H. Holmes, B. Jubinville, D. Lawseth, B. G. Lucas, A. Morgan, G. Parker, and J. Rogers. 2002. National recovery strategy for the northern abalone (*Haliotis kamtschatkana*) in British Columbia. Fisheries and Oceans Canada. 22 pp.

Turgeon, D.D., J.F. Quinn, Jr., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. 2nd Edition. American Fisheries Society Special Publication 26, Bethesda, MD. 526 pp.

U.S. Fish and Wildlife Service (USFWS). 2005. Federal Subsistence Management Program fisheries regulations. Available online at: <http://alaska.fws.gov/asm/law.cfm?fcr=1>. Accessed 17 May 2005.

Wallace, S.S. 1999. Evaluating the effects of three forms of marine reserve on Northern abalone populations in British Columbia, Canada. Conservation Biology 13:883-887.

Withler, R.E., A. Campbell, S. Li, D. Brouwer, K.J. Supernault, and K. M.Miller. 2003. Implications of high levels of genetic diversity and weak population structure for the rebuilding of northern abalone in British Columbia, Canada. J. of Shellfish Research 22: 839-847.

Wolotira, R. J., Jr., M. J. Allen, T. M. Sample, C. R. Iten, S. F. Noel, and R. L. Henry. 1989. Life History and harvest summaries for selected invertebrate species occurring off the West Coast of North America. Vol. 1: Shelled Molluscs. NOAA Technical Memorandum NMFS F/NWC-160.

Woodby, D. 2005. Personal communication between Doug Woodby, Alaska Dept. of Fish and Game, and Jodi McClory, Alaska Natural Heritage Program, Anchorage, AK, in the form of review comments on the *Haliotis kamtschatkana* draft conservation status report, 27Sep2005.

Woodby, D., R. Larson, and J. Rumble. 2000. Decline of the Alaska abalone (*Haliotis* spp.) fishery and prospects for rebuilding the stock. Pp. 25-31 in: Campbell, A. (Ed.). Workshop on rebuilding abalone stocks in B.C. Can. Sp. Pub. Of Fish. And Aqu. Sci. 130.

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