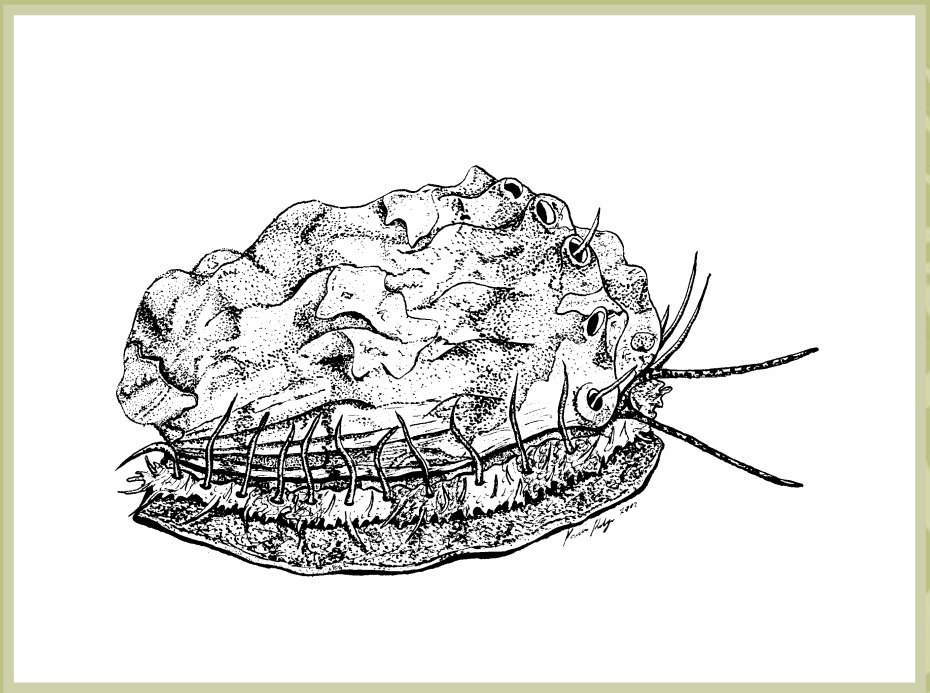
Species at Risk Act
Recovery Strategy Series

Recovery Strategy for Northern Abalone (*Haliotis kamtschatkana*) in Canada

Northern abalone



September 2007

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003 and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency, and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (http://www.sararegistry.gc.ca/the_act/) outline both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/) and the Web site of the Recovery Secretariat (http://www.speciesatrisk.gc.ca/recovery/).

Recovery Strategy for the Northern Abalone (*Haliotis kamtschatkana*) in Canada

September 2007

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Additional copies can be downloaded from the SARA Public Registry (http://www.sararegistry.gc.ca/)

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DECLARATION

The recovery strategy for the northern abalone has been prepared in cooperation with the jurisdictions described in the Preface. Fisheries and Oceans Canada has reviewed and accepts this document as its recovery strategy for the northern abalone as required under the *Species at Risk Act* (SARA). This recovery strategy also constitutes advice to other jurisdictions and organizations on the recovery goals, approaches and objectives that are recommended to protect and recover the species.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. In the spirit of the National Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all Canadians to join Fisheries and Oceans Canada in supporting and implementing this strategy for the benefit of the species and Canadian society as a whole. Fisheries and Oceans Canada will support implementation of this strategy to the extent possible, given available resources and its overall responsibility for species at risk conservation. Implementation of the strategy by other participating jurisdictions and organizations is subject to their respective policies, appropriations, priorities, and budgetary constraints.

The goals, objectives and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new information. The Minister of Fisheries and Oceans will report on progress within five years.

This strategy will be complemented by one or more action plans that will provide details on specific recovery measures to be taken to support conservation of the species. The Minister of Fisheries and Oceans will take steps to ensure that, to the extent possible, Canadians interested in or affected by these measures will be consulted.

RESPONSIBLE JURISDICTIONS

Fisheries & Oceans Canada
Parks Canada Agency
Government of British Columbia

AUTHORS

The Abalone Recovery Team (Appendix 1) prepared this recovery strategy for Fisheries and Oceans Canada.

ACKNOWLEDGMENTS

The development of the recovery strategy for northern abalone was the result of valuable contributions by a number of individuals and organizations. The Abalone Recovery Team is

grateful to the following reviewers for their valuable advice and contributions on the 2002 recovery strategy: Paul Breen, National Institute of Water and Atmospheric Research, New Zealand; Konstantin Karpov, California Fish and Game; Michele Patterson, World Wildlife Fund; Scoresby A. Shepherd, South Australian Research and Development Institute; Norm Sloan, Parks Canada; Anne Stewart, Bamfield Huu-ay-aht Community Abalone Project Society; and Jane Watson, Malaspina University-College.

The recovery team also acknowledges the many people who provided advice and comments through consultation workshops, and the following individuals for their written submissions in 2002: Lorne Clayton, IEC International Collaborative Marine Research and Development Ltd.; Erica Boulter, World Wildlife Fund; Robert DeVault, Outer Coast Oysters; Larry Golden; Michele James, Underwater Harvesters Association; Stefan Ochman, Fisheries Manager, Huu-ay-aht First Nation; Dawn Renfrew, Bamfield Marine Sciences Center; Fred Hawkshaw; Mike Featherstone, Pacific Urchin Harvesters Association; Mark Biagi, Community Futures Development Corporation of Powell River and John Shepherd, Northwest Community College.

Fisheries & Oceans Canada would like to thank the numerous individuals and their organizations that are working to achieve the long-term recovery of northern abalone.

STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

In accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*, the purpose of a Strategic Environmental Assessment (SEA) is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally-sound decision making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats.

This recovery strategy will clearly benefit the environment by promoting the recovery of the northern abalone. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. Refer to the following sections of the document in particular: Needs of the Northern Abalone, Approaches Recommended to Meet Recovery Objectives, and Effects on other species.

RESIDENCE

SARA defines residence as: "*a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*" **[SARA S2(1)]**.

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the SARA public registry:
http://www.sararegistry.gc.ca/plans/residence_e.cfm

PREFACE

Northern abalone is a marine species under federal jurisdiction of the Minister of Fisheries and Oceans under the *Fisheries Act* and the *Species at Risk Act* (SARA). SARA (Section 37) requires the competent minister to prepare recovery strategies for listed extirpated, endangered or threatened species. The northern abalone was listed as threatened under SARA in June 2003.

The Province of British Columbia has jurisdiction over the use of seabed and foreshore under the BC *Land Act*. Aquaculture facilities are subject to licensing under the BC *Fisheries Act*. Artificial movements of northern abalone into and within coastal waters and to aquaculture facilities are subject to review and licencing by the federal-provincial Introductions and Transfers Committee. Under the *Canada National Marine Conservation Areas Act*, Parks Canada Agency has involvement in abalone management and protection in National Marine Conservation Areas (NMCAs). The Province of BC and Parks Canada Agency have cooperated in the development of this recovery strategy.

Fisheries & Oceans Canada formed the Abalone Recovery Team in 2001 to develop the 'National Recovery Strategy for the Northern Abalone in British Columbia', which was adopted under the *Accord for the Protection of Species at Risk* in 2002. In 2007, the recovery strategy was updated to meet the requirements of SARA (this document).

This recovery strategy meets SARA requirements (Sections 39-41) in terms of content and process and covers the period 2007-2012.

EXECUTIVE SUMMARY

The northern or pinto abalone has been declining in numbers and distribution in surveyed areas of coastal British Columbia (B.C.), Canada, as documented by regular surveys since the late 1970s. The northern abalone fisheries in B.C. were closed to all harvest in 1990 to protect the remaining population. Despite the complete ban on harvest, the population continued to decline and showed no sign of recovery. As a result, northern abalone were assigned a threatened status by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1999. In June 2003, northern abalone were legally listed and protected as threatened under the *Species at Risk Act* (SARA).

Illegal harvest is considered to be the most significant threat to northern abalone. The northern abalone is especially vulnerable to harvest because this species has a patchy distribution, short larval period, is slow growing, relatively long-lived, has low or sporadic recruitment, and mature individuals, which tend to accumulate in shallow water, are easily accessible to harvesters. Low recruitment in an area, over a protracted period of several years, further threatens the northern abalone population by not replenishing the reproductive adults that have died from natural causes or illegal harvest. While low recruitment caused by unfavourable environmental and biotic factors usually can not be predicted nor controlled, ensuring that there are sufficient adult northern abalone to reproduce each year will allow recruitment to occur when environmental conditions are favourable. Future threats may include habitat loss in localized areas to works or developments on, in and under the water in the event they are unregulated and predation by sea otters in areas where northern abalone are already severely depleted.

The immediate recovery goal is to halt the decline of the existing wild northern abalone population in order to reduce the risk of northern abalone becoming endangered.
The long-term recovery goal is to increase the number and densities of wild northern abalone to levels where the population becomes self-sustainable within five biogeographic zones, Haida Gwaii (Queen Charlotte Islands), Queen Charlotte and Johnstone Straits, North and Central Coast, Georgia Basin, and West Coast of Vancouver Island, in order to remove northern abalone from threatened status. The goal of increasing northern abalone to sustainable levels can be expected to take several decades.

The recovery objectives on which northern abalone's recovery will be monitored over the next five years are:

1) To observe that mean densities of large adult ($\geq$ 100 mm shell length (SL)) northern abalone do not decline below 0.1 per m^2 at surveyed index sites in Haida Gwaii and North and Central Coast, and that the percentage of surveyed index sites with large adult ($\geq$ 100 mm SL) northern abalone does not decrease below 40%.

2) To observe that the mean total density estimates at newly established index sites in the Queen Charlotte and Johnstone Straits do not decline below the level observed in 2004 (0.06 northern abalone per m^2 and 0.02 northern abalone per m^2, respectively), and the mean total density estimates for the West Coast of Vancouver Island do not decline below the level observed in 2003 (0.09 northern abalone per m^2).

3) To observe at the index sites (in areas without sea otters) that the annual estimated mortality rate for mature (≥ 70 mm SL) northern abalone is reduced to <0.20 and the mean densities of mature (≥ 70 mm SL) northern abalone are increased to ≥ 0.32 per m^2.
4) To observe at the index sites (in areas without sea otters) that the proportion of quadrats (m^2) with northern abalone is increased to > 40%.

The approaches recommended for the long-term to meet the recovery objectives are:
1) maintaining the fisheries closures;
2) implementing a proactive protection plan;
3) implementing a communication campaign to stop illegal harvest and raise public awareness;
4) undertaking research and rebuilding experiments;
5) monitoring the population status.

Critical habitat for northern abalone has not been identified. Critical habitat may exist in certain habitats where juvenile survival is better, or where the reproducing adults contribute to a larger portion of the total recruitment. Identification of these key habitats is an important component to the abalone research and rebuilding plans.

One or more action plans, which provide the specific details for recovery implementation, will be completed within three years of completion of the recovery strategy.

Fisheries and Oceans Canada has facilitated the completion of this recovery strategy with the assistance of the Abalone Recovery Team. Through workshops, public consultations and external reviews, other government agencies, stewardship groups, First Nations communities, universities, external experts, businesses, private citizens, international organizations and non-government organizations (NGOs) have also contributed to the recovery strategy. Many of these groups are actively working to help stop the decline and remove this species from the threatened status list.

*To report suspicious or illegal harvesting activities call **1-800-465-4336** and help protect northern abalone.*

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1. BACKGROUND

1.1 Species Assessment Information from COSEWIC

Date of Assessment: May 2000

Common Name (population): northern abalone

Scientific Name: *Haliotis kamtschatkana*

COSEWIC Status: threatened

Reason for designation: A patchily distributed marine mollusc found along the west coast. Highly prized for harvesting, it continues to decline since complete closure of the fishery in 1990, probably as a result of continued high levels of poaching. There is evidence that the decline and fragmentation of the population are impairing the reproductive ability of the species even though there persists a reservoir of reproductive adults.

Canadian Occurrence: Pacific Ocean

COSEWIC Status History: Designated threatened in April 1999. Status re-examined and confirmed in May 2000. Last assessment based on existing status report.

1.2 Description

Abalone are a marine mollusk related to snails and whelks. The northern abalone, *Haliotis kamtschatkana* (Jonas 1845) is one of approximately 65 species of abalone (*Haliotis spp*.) found world-wide (Geiger and Poppe, 2000). *H. kamtschatkana* is called 'pinto' abalone in the United States, in keeping with the tradition of naming abalone according to their colour. In B.C., the term 'northern' is used as the species is the world's northernmost abalone (Sloan and Breen 1988).

The ear-shaped shell of northern abalone is relatively small, thin, elongate-oval and low, with three to six open holes, and sculpture of irregular lumps superimposed over the spiral structure. The colour is mottled reddish or greenish with areas of white and blue (McLean 1966). The top of the shell is usually camouflaged with algae. The mother-of-pearl on the inside of the shell is less colourful than many other species (the New Zealand paua, *H. iris*, is the species most commonly seen in jewelry) and lacks a muscle scar. The muscular foot is fringed with tentacles. Two prominent tentacles mark the anterior end of the abalone. The top spiral is carried posterior.

1.3 Populations and Distribution

Northern abalone are found off the west coast of North America in shallow subtidal waters along exposed and semi-exposed rocky coastlines from Yakutat, Alaska (O'Clair and O'Clair 1998) to

Turtle Bay, Baja California (McLean 1966). In Canada, northern abalone occur only on the Pacific coast in patchy distribution on hard substrate in the intertidal and shallow subtidal. Most of the adult abalone occur in near shore, exposed or semi-exposed coastal waters at <10 m depth.

Canada – B.C.

The northern abalone population has been assessed in B.C. since 1978 through surveys of index sites using a standard survey design (Breen and Adkins 1979). Many of the surveys between 1978-90, and much of the commercial fishery, were conducted in areas along the south-east Haida Gwaii / Queen Charlotte Islands (QCI) and the central coast of B.C. (Winther *et al.* 1995; Harbo 1997; Campbell *et al*. 1998). Most surveys were conducted in areas with significant commercial harvests, where northern abalone were most abundant (Sloan and Breen 1988). Although there were a few surveys of southern B.C. (Quayle 1971; Breen *et al*. 1978; Adkins 1996; Wallace 1999), they did not afford the extended coverage provided by the northern surveys.

Surveys at index sites in south east QCI and the central coast of B.C. have provided general time-series trends indicating that the abundance of northern abalone declined more than 75% between the period of 1977-84 and remained low and or continued to decrease through 2002 (Winther *et al*. 1995; Thomas and Campbell 1996; Campbell *et al*. 1998, 2000a; Atkins *et al*. 2006; Lessard *et al*. 2006). The mean total northern abalone density at comparable index sites changed from 2.4 to 0.27 abalone per m^2 for the central coast, during 1979-2001, and from 2.2 to 0.34 abalone per m^2 for QCI during 1977-2002. The similarity in northern abalone density between new random sites and index sites indicated that the mean densities from all index sites were reasonably representative of adult northern abalone sampled in areas of the central coast of B.C. in 1997 and south east QCI in 1998 (Campbell *et al.* 1998, 2000a). Other surveys using different sampling designs also confirmed the low densities of northern abalone found by the index surveys in the same areas (Lessard *et al*. 2002; J. Lessard, Fisheries and Oceans Canada, Nanaimo, BC, V9T 6N7, *pers. comm.*)

Examination of surveyed index sites in both QCI and the central coast indicated a general decline in the number of sites with at least one northern abalone per m^2 between 1978 and 2002 (Campbell 2000b, Atkins *et al*. 2006; Lessard *et al*. 2007). The proportion of index sites with large adult abalone ($\geq$ 100 mm shell length (SL)) generally decreased from 89% and 77% to 27% and 25% for the central coast and QCI, respectively. The decrease in density and decline in the number of sites with northern abalone suggested serial depletion of large abalone.

Surveys and observations in southern B.C. have indicated even lower densities of northern abalone (J. Lessard, *pers. comm.*). New index site surveys were initiated on the West Coast of Vancouver Island in 2003 (WCVI) and in Queen Charlotte and Johnstone Straits in 2004. Limited surveys were conducted in Georgia Basin in 2005. The mean total density estimate was 0.09 abalone/m^2 for WCVI from all sites sampled, but 0.21 abalone per m^2 in Quatsino Sound where more sheltered abalone habitat was present (Atkins *et al*. 2004). The mean total density estimates were 0.06 abalone per m^2 in Queen Charlotte Strait and 0.02 abalone per m^2 in Johnstone Strait (Davies *et al*. 2006). Wallace (1999) reported relatively high population abundance of northern abalone in an area close to William Head Penitentiary, near Victoria, where the presence of penitentiary guards may have discouraged poachers from nearshore

access. However, during the more recent surveys at William Head in 2005, only three individuals were found at two (11%) of the 19 sites surveyed, and all were large (>100mm SL). The most likely reason is simply that the large abalone found during previous surveys died and recruitment was low (J. Lessard, *pers. comm*.). The mean density for all sites surveyed in Georgia Basin in 2005 was 0.0098 abalone per m^2, which was significantly lower than the densities estimated in 1982 and (0.73 abalone per m^2) and 1985 (1.15 abalone per m^2) in the same area. The lack of immature individuals and low adult density suggest poor potential for future recruitment in this area.

Breen (1986) and Sloan and Breen (1988) suggested that abalone populations probably fluctuated even in the absence of commercial fishing. Exploratory surveys conducted in south eastern QCI during 1955 by Quayle (1962) suggested that northern abalone were less abundant in 1955 than in both 1914 (Thompson 1914) and in the late 1970s (Sloan and Breen 1988). The extirpation of sea otters from B.C. by early 1900s had an effect on a number of invertebrate populations, including northern abalone. With the re-introduction and recent expansion of the sea otter population, restoration of the northern abalone population to the levels seen in the late 1970s is unlikely.

Global – U.S.A.
The IUCN Species Survival Commission has listed the global status of *H. kamtschatkana* as endangered based on an observed population size reduction of >50%. Although the observed declines in B.C. and Washington showed a population size reduction of >80%, the assessment judged that "the historical elimination of sea otters led to abnormally large pre-exploitation level [of abalone]" and accordingly reduced the classification from critically endangered. The assessment considers significant populations of northern abalone to be absent south of San Juan, Orcas and Lopez Islands in Washington State (IUCN 2005).

By comparison to B.C., the average density of northern abalone in Washington in 2006 at the San Juan Island index sites was 0.032 abalone per m^2 and ranged from 0.000 to 0.082 abalone per m^2; two sites out of ten had no abalone (Don Rothaus, Washington Department of Fish and Wildlife, Mill Creek, WA 98012-1296, *pers. comm*.). Pinto (i.e., northern) abalone were designated as a 'State Candidate Species' in Washington in 1998 and were listed as a 'Species of Concern' by NOAA Fisheries in 2004 for protection under the federal *Endangered Species Act*.

There are no estimates of population density from Alaska since the commercial fishery closed in 1996 (IUCN 2005).

1.4 Needs of the Northern Abalone

1.4.1 Habitat and biological needs

Northern abalone are normally found on firm substrates, such as rocks, boulders, or bedrock, and in areas of moderate to high sea water exchange, such as in exposed or semi-exposed coastlines. Most of the adult northern abalone occur in near shore, exposed or semi-exposed coastal waters at <10 m depth (Breen and Sloan, 1988).

Currently, there is ample habitat available for the northern abalone population on the coast of B.C. Although the abalone population has declined, there has been no known significant reduction in available habitat. Therefore, habitat loss is not a major concern in the recovery of northern abalone at this time in comparison with the identified threats.

Northern abalone growth can vary considerably between areas depending on the extent of exposure to wave action and availability and quality of food. Growth of adults tends to be stunted in highly exposed outer coastal areas where food may be limited because of strong wave action and water currents (referred as 'surf abalone'). Feeding opportunities may be reduced because abalone would be less able to catch and hold onto drift algae. When "surf" abalone were transplanted to calmer, kelp abundant habitats, growth rates were higher than for abalone in high-energy areas (Emmett and Jamieson 1988). Abalone growth was more rapid in moderately exposed areas with giant kelp, *Macrocystis integrifolia,* or bull kelp, *Nereocystis luetkeana,* kelp forests than at highly exposed areas with *Pterygophora californica* kelp forests (Sloan and Breen 1988).

Adult northern abalone aggregate in warm shallow water areas to broadcast their gametes simultaneously (Breen and Adkins 1980). Spawning off B.C. generally occurs between April and July. Large female northern abalone ($\geq$ 100 mm SL) contribute substantially more to population fecundity than small mature abalone (Campbell *et al*. 1992; Campbell *et al*. 2003). Cues that cause mass spawning in *Haliotis* spp. can include environmental factors such as temperature changes (Sloan and Breen 1988), and minor storms and typhoons (Sasaki and Shepherd 1995). Studies on *Haliotis* spp. (Clavier 1992; McShane 1995a,b; Shepherd and Partington 1995; Babcock and Keesing 1999) and sea urchins (Levitan *et al.* 1992) have emphasized reduced fertilization success can be caused by dilution of gametes through reduced adult spawner densities (Levitan and Sewell 1998). Since fertilization success depends on the aggregation density of abalone, exploitation rates and high natural mortality on abalone aggregations are likely important in influencing egg production (Campbell 1997).

Within 48 hours after fertilization, the planktonic trochophore larvae emerge from their egg membranes. The planktonic phase of northern abalone is short and temperature dependent (12 days at 14 degrees Celsius, 13 days at 17.5 degrees Celsius)(Standley 1987). Larvae settle on crustose algae (Sloan and Breen 1988). Small juvenile (<10 mm SL) northern abalone are hard to find. Juvenile northern abalone (10-70 mm SL) are found under and on exposed areas of rocks, whereas the majority of adults ($\geq$ 70 mm SL) are found on exposed rock surfaces. More juvenile abalone emerge on to exposed rock surfaces at night than in the day. Densities of juvenile abalone ($\leq$ 30 mm SL) surveyed at study sites in the Pacific Rim National Park Reserve were significantly higher (by a factor of 15.74) at night than in the day (H. Holmes, Parks Canada Agency, Pacific Rim National Park Reserve, Ucluelet, BC VOR 3A0, *pers. comm.*). As the juveniles develop to maturity, their diet changes from benthic diatoms and micro-algae by moving to shallower, more exposed areas to feed on drift macro-algae. The general habitat areas of the adults and their juvenile offspring could be within close proximity of each other. Studies have suggested that larval dispersal in some *Haliotis* spp. may occur in small geographic areas, on a scale of hundreds of meters to several kilometres (Tegner and Butler 1985a; Prince *et al.* 1987; McShane 1992, 1995a,b; McShane *et al.* 1988).

1.4.2 Ecological role

Within the near shore, exposed or semi-exposed coastal waters, northern abalone play the role of herbivore and are prey of many species. Recovery of northern abalone may be related to the abundance and health of kelp forests in certain areas. Northern abalone compete with other species (e.g., red sea urchins, *Strongylocentrotus franciscanus*) for food and space. Northern abalone are prey for sea otter, *Enhydra lutris*; river otter, *Lutra canadensis*; mink, *Mustela vison*; crab, *Cancer* species; sea stars, *Pycnopodia helianthoides*; octopus, *Octopus dofleini*; wolf eel, *Anarrhichthys ocellatus* cabezon, *Scorpaenichthys marmoratus*; and other sculpin fish species, *Cottidae* spp. The role of sea otters in shaping the nearshore kelp forest ecosystem likely has a significant impact on the structure of the northern abalone population where the two species co-exist. Studies have shown that abalone, in areas where sea otters are present, are restricted to crevices and other cryptic habitats where they are inaccessible or hidden from sea otters (Watson 2000).

1.4.3 Limiting factors

The northern abalone is vulnerable to harvest because this species has a patchy distribution, a short larval period, is slow growing, relatively long-lived, and has low or sporadic recruitment. Also, mature individuals, which tend to accumulate in shallow water, are easily accessible to harvesters.

The appropriate size and distribution of the northern abalone population required to provide effective reproduction and subsequent sufficient recruitment are unknown. Current knowledge of abalone species, in general, suggests there needs to be sufficient densities within patches of large mature abalone close enough together to successfully spawn and produce viable offspring (Babcock and Keesing 1999).

Recruitment is defined as the number of juveniles growing and surviving to the adult population. Generally, high densities of adult northern abalone are required to ensure sufficient recruitment. Shepherd and Partington (1995), using a Ricker stock recruitment curve, suggested that there was a critical stock density threshold (0.15 per m^2) for the *H. laevigata* in Waterloo Bay, South Australia, below which the risk of recruitment failure was high. Later studies by Shepherd and Rodda (S. Shepherd, SARDI Aquatic Sciences, Henley Beach, South Australia, *pers. comm.*) have shown higher thresholds at around 0.3 per m^2. Shepherd and Brown (1993) found that a "minimum viable population" of more than 800 individuals of *H. laevigata* was required at West Island, Australia; anything less caused recruitment failure. Shepherd and Baker (1998) suggested that recruitment to an abalone fishery could be relatively lower and more variable in small abalone populations than in larger populations. In this case, small populations would need to have more egg production to prevent depletion. These studies supported the influence of the Allee effect or depensation (Allee *et al*. 1949) in which low abalone densities and few aggregations reduced reproductive success due to low fertilization of gametes.
Recent model simulations suggested that mortality would have to decrease in order for northern abalone populations to increase (Lessard *et al*. 2006).

1.5 Socio-economic value

Long harvested by coastal First Nations, abalone (*Haliotis* spp.) meat was consumed as food and the shells or pieces of shell of northern abalone or red abalone (*H. rufescens*) traded from California were used in B.C. as fishing lures, in jewelry and as an inlay for carvings (Stewart 1977, Sloan 2003). Abalone buttons on a ceremonial blanket were a sign of wealth to the Tsimshian (Reece 2000). Harvest was generally restricted to the lowest tides, although some, such as the Haida, also used a three-pronged spear to access abalone in subtidal areas, 2 m below the lowest tide (Jones 2000). B.C.'s coastal First Nations express continued concern that the northern abalone population is threatened, which results in food, social and ceremonial fisheries being closed[1]. Interest in food, social and ceremonial fisheries for abalone has provided an incentive for northern abalone rebuilding programs in some areas. Some of these programs go beyond the objectives of the recovery strategy, but nonetheless support northern abalone recovery.

In addition to the concerns of First Nations, the closures of B.C.'s commercial and recreational abalone fisheries represented significant economic and recreational loss to participants, associated industries and coastal communities. While small recreational and commercial fisheries for northern abalone occurred in B.C. as early as 1900, a commercial dive fishery directed on northern abalone began in earnest in 1972. Developing through the 1970s, B.C.'s commercial fishery peaked in 1977 with landings of 481 t. The majority of harvest occurred in the north and central coast of B.C. and in the Queen Charlotte Islands (Adkins 2000; Campbell 2000b). The value of the commercial fishery peaked at $1.86M (landed value) in 1978 (Sloan and Breen 1988). Northern abalone were also regarded as a gourmet food and recreational divers were known to have had a keen interest in northern abalone harvest. Conservation concerns led to the complete closure of all northern abalone fisheries in B.C. in 1990, including recreational, commercial and First Nations' food, social and ceremonial fisheries.

There is no other abalone species occurring within Canada's Pacific Coast with sufficient abundance to directly replace the northern abalone fisheries. Recreational and commercial dive fisheries and First Nations' food, social and ceremonial fisheries continue for other invertebrate species (the value of commercial invertebrate fisheries in B.C. is significant, currently estimated at $122.1M) (*2005 British Columbia Seafood Industry Year in Review*).

There is currently no commercial harvest of northern abalone. There has never been a commercial fishery for northern abalone in Washington State, and Alaska's commercial fishery was closed in 1996. The recreational fishery in Washington also closed in 1994, but there is currently an Alaskan sport/subsistence fishery. Other species of abalone (e.g., red abalone, *H. rufescens*) from aquaculture and commercial fisheries in other jurisdictions (including Australia, Mexico, China, Chile, and the U.S.) are still available in B.C.

Pilot projects were initiated in 2000 under the abalone rebuilding strategy (Dovetail 1999) to develop aquaculture techniques for northern abalone in B.C. The Bamfield Huu-ay-aht Community Abalone Project (BHCAP) continues to provide support to the abalone recovery

[1] In the event abalone populations are recovered to sufficient levels, priorities will be given to First Nations' food, social, ceremonial fisheries pursuant to Section 35(1) of the Canadian Constitution.

strategy (including population rebuilding by out-planting hatchery-raised northern abalone to the wild) and also has the goal of providing economic opportunity in the community. The BHCAP's operations are authorized under section 73 of SARA. The first sales of cultured northern abalone were made by BHCAP in 2006.

Recreational diving and tourism associations have expressed an interest in maintaining healthy aquatic environments, including healthy and abundant invertebrate communities, which generally support abalone recovery efforts. The general public also has an interest in addressing species at risk and maintaining a healthy environment.

1.6 Threats

1.6.1 Threat classification

Table 1. Threat Classification Table

1	**Illegal harvest**	**Threat Information**		
Threat Category	Consumptive Use	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Harvesting	**Occurrence**		Historic and current
		Frequency		Continuous/recurrent
Specific Threat	Illegal Harvesting	**Causal Certainty**		High
		Severity		High
Stress	Reduced population size	**Level of Concern**	High	
2	**Low recruitment**	**Threat Information**		
Threat Category	Changes in Ecological Dynamics or Natural Processes	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Low (or no) recruitment	**Occurrence**		Historic and current
		Frequency		Unknown
Specific Threat	Insufficient spawner densities and natural causes	**Causal Certainty**	High	Medium
		Severity	High	High
Stress	Reduced population size	**Level of Concern**	High	
3	**Works or developments on, in and under water**	**Threat Information**		
Threat Category	Habitat Loss or Degradation	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Works or developments on, in and under water	**Occurrence**	Anticipated	
		Frequency	Recurrent	
Specific	Alteration of habitat	**Causal Certainty**	High to unknown	

Threat	characteristics (e.g., siltation), or loss of habitat (e.g., obstruction, burying)	**Severity**	High	Low
Stress	Reduced population size	**Level of Concern**	Low	
4	**Sea otter predation**	**Threat Information**		
Threat Category	Changes in Ecological Dynamics or Natural Processes	**Extent**	Overlapping portion of range	
			Local	**Range-wide**
General Threat	Sea otter predation	**Occurrence**	Current and Imminent	Anticipated
		Frequency	Continuous or Recurrent	Unknown
Specific Threat	Altered predator-prey dynamics (predation)	**Causal Certainty**	Medium	Unknown
		Severity	High	Unknown
Stress	Increased mortality and unknown effects on population dynamics	**Level of Concern**	Medium	

1.6.2 Description of threats

Continued illegal harvest and low recruitment levels have had predominant and widespread impacts and are considered to be the most significant threats to northern abalone recovery.

Illegal Harvest

Mature northern abalone, which tend to accumulate in shallow water, are easily accessible to harvesters. The market value of abalone, and the difficulty in enforcing the fisheries closures in a large, mostly uninhabited coastal area, has encouraged illegal harvesting. Illegal harvesting not only depletes the already depressed northern abalone population, but also reduces their reproductive potential by removing large mature abalone and leaving the remaining mates too far apart to successfully spawn. Samples from northern abalone illegally harvested during 1995-98 suggested that harvesters indiscriminately removed mostly large mature abalone (Campbell 2000b). Recent mortality rates estimated by Lessard *et al*. (2006) indicated that the mortality rate (all sources) for northern abalone were too high to be sustainable.

In 2006, three separate abalone poaching events culminated in February when Fisheries Officers seized the largest single haul of illegally harvested northern abalone in Canada's history; 1,120 kg or an estimated 11,000 animals were seized. Illegal harvesters have generally come from coastal communities, and the abalone have been destined for sale or personal consumption. Convictions for buying or selling northern abalone have been made in recent years against seafood wholesalers in Vancouver and a Chinese restaurateur in Victoria, B.C. The Courts have taken illegal harvesting seriously; heavy fines, forfeiture of vessels, vehicles and gear, and prohibitions on fishing are now standard sentences.

Without reductions in illegal harvest, protection of mature abalone, a continued closure of the fisheries, and other effective rehabilitation methods, northern abalone population abundance will remain low or continue to decline in many areas.

Low Recruitment

Low recruitment in an area, over a protracted period of several years, may contribute to further declines in the northern abalone population by not replenishing the reproductive adults that have died from natural causes or illegal harvest. Generally, high densities of adult northern abalone are required to ensure sufficient recruitment (refer to Section 1.4.1 Habitat and biological needs).

Low recruitment caused by unfavourable environmental and biotic factors usually can not be predicted nor controlled. Ensuring that there are sufficient adult northern abalone to reproduce each year will allow high recruitment to occur when environmental conditions are favourable.

Habitat Loss or Degradation

Works and developments on, in, and under the water (e.g., marinas, loading facilities, aquaculture farms) may have negative impacts on northern abalone habitat and numbers in localized areas, and will need to continue to be monitored and regulated in order to maintain habitat in which the northern abalone can be recovered and to prevent losses to important spawning aggregations. Protocols for authorizing and monitoring works and developments around abalone habitat have been developed (Lessard *et al*. 2006).

Sea Otter Predation

Historically, sea otters were common in coastal regions of the North Pacific. They were hunted to near extinction from the mid-1700s until protected in 1911, and were reintroduced to B.C. by the Federal and Provincial governments in a series of three translocations of 89 sea otters in 1969, 1970, and 1972 (Watson 2000). The sea otter population is also listed as threatened under SARA (2003). In areas off the west and north coasts of Vancouver Island and in the Goose Group on the central coast of B.C., where sea otters are now established, sea otters prey on northern abalone, reducing the density, size, and distribution of northern abalone compared to areas without sea otters (Breen *et al*. 1982; Watson 1993). While sea otters are clearly not responsible for the observed decline in the northern abalone population over the last few decades, as the range of sea otters expands, northern abalone may only be sustained at low levels.

Northern abalone and sea otters have co-existed in the past before the extirpation of sea otters. However, the levels at which they co-existed or whether populations may have fluctuated in the past is unknown. The majority of knowledge on the northern abalone population has been in the absence of sea otters.

Sea otter expansion may be a concern in areas where the abalone population is already depleted and may make meeting abalone recovery objectives, as currently defined from areas without sea otters, impossible. Provided sufficient densities of northern abalone remain to be able to reproduce successfully, sea otters may in the longer-term help northern abalone recover by increasing kelp and algae biomass and thereby increasing the food supply available to abalone. This interaction has been highlighted as a knowledge gap (refer to Section 1.8). Refinements to

the abalone population and distribution objectives for areas with sea otters may be necessary with improved knowledge of species interactions.

1.7 Actions Already Completed or Underway

Surveys of Key Index Sites (1978-present) have been conducted every 1-5 years to monitor population abundance and evaluate recovery. These broad scale surveys are considered representative by providing time-series trends of the northern abalone population.

Closures to Commercial Fishing (1971-1990). The Lower Johnstone Strait, Georgia Basin and Strait of Juan de Fuca were closed in 1971 to commercial fishing to provide for recreational fishing opportunities. In addition, there were a number of closures to the commercial fishery to provide for First Nations and recreational harvest (Farlinger, 1990).

Total Fisheries Closures December (1990-present). All B.C. fisheries, including commercial, recreational and First Nations' food, social and ceremonial fisheries, were closed to abalone harvest in 1990. There are currently no commercial fisheries for northern abalone anywhere.

Threatened Status (1999) and Legal Listing (2003-present). Northern abalone were designated by COSEWIC as threatened in 1999 and legally listed under SARA in 2003 (with the Act's proclamation). A re-assessment of northern abalone's status by COSEWIC is in preparation and anticipated to be made in 2009.

Enforcement measures have been undertaken by regular patrols in support of the harvest prohibition and in response to reports of illegal activity. Covert operations and investigations target specific poaching operations. Penalties and court imposed fines have become significant in recent years.

An international **Workshop on Rebuilding Abalone Populations in British Columbia (1999)** was held in February 1999, and convened individuals from local communities, First Nations, international research institutes and government organizations to focus on developing solutions to rehabilitate northern abalone populations (approximate cost $100K). Thirteen peer-reviewed papers were presented (Campbell 2000a) and a Strategy for Rebuilding Abalone Populations in British Columbia was prepared by Dovetail Consulting Inc. The broad approaches and strategies of this Abalone Recovery Strategy were drawn from this workshop.

Pilot Projects in support of rebuilding the wild abalone population (2000-present). In 2000, Fisheries & Oceans Canada in co-operation with several First Nations, coastal communities, and the aquaculture industry, initiated several pilot projects in support of rebuilding wild abalone populations.

Rebuilding Sites: The Haida Fisheries Program and Kitasoo Fisheries Program have established long-term rebuilding sites to improve recruitment by aggregating reproductively mature adults. The Haida Fisheries Program and Pacific Urchin Harvesters Association initiated a joint research project in 2004 to study interactions between northern abalone and red sea urchins, a potential competitor of abalone. The Heiltsuk Abalone and Sea Otter Stewardship Project established rebuilding sites in 2004 and will include studies on the effects of sea otters on the abalone population. These activities are supported also by habitat and population assessment (surveys), community education and awareness and Abalone Coast Watch to protect the abalone population. Fisheries & Oceans Canada and Parks Canada

Agency established research sites in 2002 in and around Pacific Rim National Park to investigate local habitat requirements for recruitment and to test the rebuilding technique of aggregating reproductively mature northern abalone. Current modeling and night surveys by Parks Canada Agency were used to predict and assess juvenile recruitment from the aggregation sites. Preliminary results indicate that aggregation increases localized recruitment. Aggregation studies are authorized under the *Fisheries Act* and section 73 of SARA.

Development of Culture Technology and out-planting: The Bamfield Huu-ay-aht Community Abalone Project was established in 2001 and made the first out-planting to the wild of hatchery-raised northern abalone in 2003. Since then, 2 million abalone larvae and 75,000 young juveniles have been out-planted to the wild. BHCAP made the first sales of cultured northern abalone in 2006. Hatchery-raised abalone are available to research studies (e.g., disease, feeding, effect of finfish farms, interactions with red urchins) that could not previously be conducted with wild abalone. The BHCAP's activities are authorized under the *Fisheries Act* and section 73 of SARA.

An **Abalone Recovery Team (2001)** was formed in November 2001, with representatives from the federal departments of Fisheries and Oceans Canada and Parks Canada Agency, and the Provincial Ministries of Environment (formerly Water, Land and Air Protection) and Agriculture and Lands (formerly Agriculture, Food and Fisheries).

Eight Workshops (2002) for coastal B.C. communities (Bella Bella, Port McNeil, Powell River, Port Alberni, Victoria, Nanaimo, Prince Rupert, and Skidegate) were held in February 2002 as forums to receive input on the recovery strategy from all interested parties. Concurrently, the recovery strategy was reviewed by seven external reviewers representing academia, government, and non-government organizations from Canada, U.S.A., Australia and New Zealand.

A **National Recovery Strategy for the Northern Abalone in Canada (2002)** was adopted under the *Accord for the Protection of Species at Risk* in November, 2002. This was one of the first marine recovery strategies, and the first in the Pacific Region.

Index Sites in southern B.C. (2003-2004) have been established to monitor population abundance and evaluate recovery in Queen Charlotte and Johnstone Straits and the West Coast of Vancouver Island. Limited surveys were conducted also in Georgia Basin in 2005.

Scientific documents and publications produced to increase the knowledge base regarding northern abalone (see References and Additional Reading).

Anti-illegal harvest communications campaign consisted of multiple activities and the production of communications products by Fisheries & Oceans Canada and abalone stewardship projects to raise public awareness of the current status of northern abalone and the harms of continued illegal harvest. Materials produced include an abalone web site, news releases, education curriculums and presentations in local schools, translated articles in the Asian press, posters, stickers, tattoos, t-shirts, water bottles and community brochures, websites, 'Observe-Record-Report' reporting forms, newsletters, and workshops. Numerous newspaper stories, particularly in recent years, and have also supported the campaign.

Abalone Genetics Research (2001). The population structure of northern abalone has been determined in B.C. and a forensic DNA technique has been developed to identify confiscated abalone to species to support enforcement against illegal harvest.

1.8 Knowledge Gaps

Larval Dispersal, Patch Size and Recruitment

Currently very little is known about the relationship between northern abalone adult concentrations, breeding success and subsequent dispersal of larvae and settlement of juveniles. Juvenile northern abalone are cryptic (i.e., hiding in cracks and crevices and unobservable to survey) and difficult to survey effectively until they reach maturity. Low abundance and fragmentation of the population are considered to be impairing the potential reproductive success of northern abalone. The frequency and size of patches of northern abalone required to maintain sufficient recruitment for a healthy population requires further investigation. While a stock-recruitment model was recently developed for the first time for northern abalone (Lessard *et al*. 2006), a better measure for cryptic animals to assess recruitment is still required.

Species Interactions

A better understanding of the ecological interactions between northern abalone and abalone predators (e.g., sea otters) and competitors (e.g., sea urchins) is required. The sea otter, a significant predator of northern abalone, is expanding its range in B.C. following extirpation and re-introduction. Most of the studies on the northern abalone population have been in the absence of sea otters and abalone recovery objectives are based on life history parameters that have been determined without the influence of sea otters. Sea otters affect the size and density of northern abalone, and may also influence factors such as size at maturity and the portion of the population that remains cryptic. Sea otters will also affect the abundance and distribution of other abalone predators, including Dungeness and other crabs, and abalone competitors, particularly red sea urchins. Currently, the factors that facilitate co-existence of sea otters and northern abalone are unknown, and further research on these factors is needed. Recovery objectives in the presence of sea otters need to be determined. In some areas, increased predation from the expanding sea otter population on an already reduced and fragmented northern abalone population poses a concern for northern abalone recovery.

Rebuilding Techniques

Tagged abalone remain relatively close to their transplant site in the first year (B. DeFreitas, Haida Fishery Program, Massett, BC , *pers. comm.*; J. Lessard, *pers. comm.*), which is likely sufficient time to allow for spawning. A preliminary study by Parks Canada Agency and Fisheries & Oceans Canada indicates that aggregating reproductive adults may contribute significantly to local recruitment (Parks Canada Agency, *in preparation*). Out-planting juvenile abalone has had some limited success with other species in other jurisdictions (Seki and Taniguchi 2000; Shepherd *et al.* 2000; Tegner 2000). The recent work in B.C. indicates that shelter from predation and, possibly, selection of sites with lower abundances of predators are important considerations for out-planting, particularly for juvenile northern abalone <12mm SL (Griffiths 2006). Further evaluation of the rebuilding techniques for northern abalone in B.C. is required.

Diseases/Parasites

Abalone disease has severely impacted wild abalone stocks in California (e.g., foot withering syndrome), however it is unknown if the causative agent (a rickettsia-like organism that infects the epithelium of the digestive tract) or other parasites reported in California (e.g., kidney

coccidia) occur in northern abalone in B.C. As random sampling of wild northern abalone in B.C. for a disease survey is not a feasible approach due to low population levels, abalone in culture are being sampled. Broodstock obtained from the wild population will harbour parasites enzootic to the area of collection and these organisms may become evident under culture conditions. Also, hatchery-raised abalone produced in culture will reflect the agents of disease occurring in the vicinity of the culture facility (given the current restrictions with transplanting abalone between different regions of the province, cultured abalone should not develop "exotic" diseases). As well, in the event cultured abalone are used in rebuilding (out-planting) experiments, these animals should have prior disease screening to ensure that only healthy abalone are introduced into the wild population.

Extent of Illegal Harvest

Known quantities of illegally harvested B.C. northern abalone have ranged from <45 to 4500 kg (Jubinville 2000). Prior to the closure of the commercial, recreational, and First Nations fisheries in 1990, and continuing afterwards, there has been illegal harvesting at unknown exploitation rates, and despite the closure, northern abalone has not shown signs of natural recovery. The density of large mature abalone (>100mm SL) has continued to decline at survey index sites, and is reported to be declining at other locations. Anecdotal information suggests that illegal harvesting occurs on a scale significant enough to cause a severe conservation risk to this species.

Clarification of Habitat Concerns

The extent to which works or developments on, in or under the water (e.g., finfish farms, floating camps) may pose a threat to northern abalone by direct and indirect impact(s) in localized areas is unknown. To date, only one study (Lessard *et al*. 2006) has specifically examined the indirect impact from finfish farms on northern abalone, using hatchery-raised abalone. Although the study had some difficulty due to poor survival overall, growth was decreased in proximity to the farm sites in comparison to the controls. A protocol for authorizing works and developments on, in and under the water where abalone are present (Lessard *et al*. (2006)), therefore, adopts a precautionary approach to the authorization of sites in abalone habitat. The protocol includes provisions for monitoring and collection of additional data.

Identification of critical habitat

Although abalone habitat (Section 1.4.1) is not considered to be limiting, there may be certain habitats where juvenile survival is better, or where the reproducing adults contribute to a larger portion of the total recruitment. Identification of this key habitat is included as part of the abalone research and rebuilding plans.

2. RECOVERY

2.1 Recovery Goal

Immediate Goal (over the next five years):

> Halt the decline of the existing wild northern abalone population in B.C. in order to reduce the risk of this species becoming endangered.

Long-term Goal (over the next 30 years):

> Increase number and densities of wild northern abalone to self-sustainable levels in each biogeographic zone of B.C. (Haida Gwaii, Queen Charlotte and Johnstone Strait, North and Central Coast, Georgia Basin, West Coast of Vancouver Island), in order to remove northern abalone from threatened status.

The goal of increasing northern abalone to sustainable levels can be expected to take several decades.

2.2 Recovery Feasibility

Given time, favourable environmental conditions, and reduced mortalities, recovery of northern abalone is feasible, as there remains a reservoir of reproductive adults and high quality habitat is available. Rebuilding techniques are available to improve recruitment. Aggregating reproductive adults appears to improve localized recruitment (Parks Canada Agency, *in preparation*). Out-planting has shown some success in population rebuilding in other jurisdictions (Seki and Taniguchi 2000; Shepherd *et al*. 2000; Tegner 2000; Roberts and Andrew 2003; Cook 2003; de Waal *et al*. 2003 *in press*). Protocols have recently been developed for regulating works and developments on, in and under the water (Lessard *et al*. 2006) to provide for sufficient habitat and spawning aggregations that are important to recovery. Further study is expected to provide guidance towards defining recovery objectives for northern abalone in the presence of sea otters (i.e., how northern abalone can co-exist with sea otters).

However, the approaches for recovery will need to focus on the long-term, given the two main threats; illegal harvesting has continued in spite of the sixteen-year ban on harvesting and low recruitment is influenced by unfavorable environmental and biotic factors that can not be predicted nor controlled. Modeling of collapsed populations gave time periods to recovery of 50-100 years due to subtle ecosystem shifts or the Allee effect (Allee *et al*. 1949) (S. Shepherd, *pers. comm*.).

As more information is gathered, refinement to the recovery goal(s) and assessment of feasibility in some areas of B.C. may be required. In particular, northern abalone densities in the southernmost end of Vancouver Island (see Section 1.3 Populations and Distribution, Georgia Basin) suggest poor potential for recruitment in this area. Predation from the recovering sea otter population may increase mortality to unsustainable levels where the northern abalone population is already depleted from other factors (e.g., illegal harvest and poor recruitment).

2.3 Population and Distribution Objective(s)

The objectives for at least the next five years will be:

1) To observe that mean densities of large adult ($\geq$ 100 mm SL) northern abalone do not decline below 0.1 per m^2 at surveyed index sites in Haida Gwaii and North and Central Coast, and that the percentage of surveyed index sites with large adult ($\geq$ 100 mm SL) northern abalone does not decrease below 40%.

2) To observe that the mean total density estimates at newly established index sites in the Queen Charlotte and Johnstone Straits do not decline below the level observed in 2004

(0.06 northern abalone per m^2 and 0.02 northern abalone per m^2, respectively), and the mean total density estimates for the West Coast of Vancouver Island do not decline below the level observed in 2003 (0.09 northern abalone per m^2).

3) To observe at the index sites (in areas without sea otters) that the annual estimated mortality rate for mature (≥ 70 mm SL) northern abalone is reduced to <0.20 and the mean densities of mature (≥ 70 mm SL) northern abalone are increased to ≥0.32 per m^2.
4) To observe at the index sites (in areas without sea otters) that the proportion of quadrats (m^2) with northern abalone is increased to > 40%.

Objectives #1 and #2 are measures to monitor the halt of the decline in the northern abalone population. Objective #1 is based on 1990 levels when all fisheries were closed. Objective #2 is based on the most recent surveys, as a longer time series is not yet available. Objectives #3 and #4 are a measure of progress towards recovery (i.e., self-sustaining population) based on the northern abalone population model (Lessard *et al*. 2006).

Observing an increase (>40%) in the proportion of quadrats with a single northern abalone (Objective #4) may not be attainable as it requires the current occurrence to double. However, this objective provides the only measure currently available to assess changes in the patchy distribution of northern abalone on a fine scale. Recovery objectives may be refined with improved knowledge, particularly with improved knowledge of the northern abalone patch size required for recruitment and improved knowledge of the effects of sea otters.

2.4 Approaches Recommended to Meet Recovery Objectives

2.4.1 Recovery planning

Table 2. Recovery Planning Table

Priority	Threats addressed	Broad strategy to address threat	Recommended approaches to meet recovery objectives
Recovery Objectives 1, 2, 3 and 4			
High (in place)	Harvest	Protection	Maintain fisheries closures
High (ongoing)	Illegal harvest	Protection	Implement a proactive protection plan
High (ongoing)	Illegal harvest	Education and awareness	Implement a communication campaign
High (in place)	Works or developments on, in and under water	Protection	Use protocols for authorizing works or development on, in and under water

Recovery Objectives 3 and 4			
High (initiated)	Low recruitment	Management	Undertake research and rebuilding
High (to be initiated)	Sea otter predation	Research	Determine northern abalone population and distribution objectives in the presence of sea otters
Recovery Objectives 1, 2, 3, 4			
High (ongoing)	Monitoring	Monitoring	Monitor the population (surveys)

2.4.2 Narrative to support Recovery Planning Table

1) **Maintain the fisheries closures for northern abalone.** A continued prohibition on harvest is necessary to limit human-induced mortalities on the population and allow for natural recruitment and recovery.

2) **Implement a proactive protection plan for the recovery of northern abalone.** Protection is necessary to reduce mortalities of northern abalone from illegal harvest, and to increase community involvement, awareness and fishery officers' support. Protection through habitat management will prevent losses of important habitat and individuals.

   a) Use reactive, preventative and proactive enforcement to curtail illegal harvest and trafficking of northern abalone.

   b) Continue to identify illegal abalone in the marketplace using genetic markers.

   c) Promote communication, awareness, stewardship and policing (e.g., First Nations guardians).

   d) Promote coastal watch programs ("Abalone Coast Watch") to involve communities in protecting the abalone population.

   e) Use 'traceability' protocols to distinguish legally obtained cultured northern abalone from illegally obtained wild northern abalone.

   f) Foster public support of court imposed sentencing that is appropriate to the threatened status of northern abalone. This may be achieved by educating the general public through publications and other communication media.

   g) Continue to apply precautionary protocols (Lessard *et al*. 2006) for authorizing works or developments on, in and under the water.

3) **Implement a communication campaign to stop illegal harvest and raise public awareness for northern abalone.** A communication campaign will help to curb illegal harvest, increase support for enforcement efforts, and encourage community stewardship and public involvement.

   a) Promote northern abalone stewardship projects.

   b) Continue to update a northern abalone web site and newsletter(s) for interested parties and the general public.

   c) Work with First Nations, interested local parties, stakeholders and international agencies.

d) Produce communication materials (e.g., posters, stickers, and brochures) aimed at stopping illegal harvest.

e) Initiate a proactive media relations campaign, and identify and co-ordinate media opportunities.

4) Undertake research and rebuilding experiments for northern abalone. Research and rebuilding may lead to increased breeding success, recruitment and population densities. Rebuilding sites should be established in conjunction with a stewardship program to protect from illegal harvesting.

a) Establish experimental pilot research areas and test rebuilding methods by aggregating reproductive adults.

b) Establish experimental pilot research areas and test enhancement through out-planting hatchery-raised abalone to the wild. Hatchery-raised abalone that are out-planted to the wild become part of the wild population. Investigate the effects of 1) size, 2) habitat type, 3) season, 4) presence/absence of predators and 5) site exposure, on enhancement success by assessing the survival and growth of released juvenile and larval hatchery-raised abalone in small experimental plots of known habitat and species complex.

c) Test the application of recruitment modules to sample and/or protect early life-stages.

d) Establish pilot research areas where sea otters have recovered to determine abalone population parameters under the effects of sea otters and to determine population and distribution objectives in the presence of sea otters.

e) Research the effects of disease and/or parasites.

f) Consult and work co-operatively with First Nations on proposals for projects that are in a First Nations' local area. This includes sharing of information on the abalone population, project goals, rebuilding techniques, impacts, etc.

g) Work co-operatively with coastal communities to share information on the local abalone population and develop rebuilding techniques.

h) Incorporate information on abalone from other jurisdictions where appropriate.

i) Consider a broad ecosystem approach in the research of northern abalone.

5) Monitor the population status of northern abalone. Monitoring is required to determine the progress towards meeting the population and distribution objectives and to determine when recovery has been achieved.

a) Continue index site surveys (every five years). Most recent surveys were conducted in North and Central Coast 2006, Queen Charlotte and Johnstone Straits 2004, West Coast of Vancouver Island 2003, Queen Charlotte Islands 2002.

b) Establish index sites in Georgia Basin.

c) Develop an improved measure for 'patch' size.

2.5 Performance Measures

The success of the recovery actions will be reviewed annually, while the goals, objectives and broad strategies outlined herein will be reviewed within five years of the recovery strategy's acceptance by the Minister. The following performance measures will be used to assess the effectiveness of the objectives and strategies, and to determine whether recovery remains feasible.

Objective-based performance measures:

- Did the mean densities of large adult (≥ 100 mm SL) northern abalone decline below $0.1/m^2$ at surveyed index sites in Haida Gwaii and North and Central Coast? Or did it increase?
- Did the percentage of surveyed index sites with large adult (≥ 100 mm SL) northern abalone decrease (<40%)? Or did it improve (>40%)?
- Did the annual estimated mortality rate for mature (≥ 70 mm SL) abalone drop to < 0.20, and the mean densities of mature (≥ 70 mm SL) abalone increase to greater than $0.32/m^2$?
- Were more than 40% of the quadrats (m^2) occupied by abalone?

Approach-based performance measures:

- Was the coast-wide closure to northern abalone harvesting maintained and enforced? Was the coast-wide closure an effective measure contributing in halting the population decline?
- Was a proactive protective enforcement plan implemented? How many reports relating to abalone harvesting were provided to enforcement officers and the toll free enforcement line (Observe-Record-Report)? To what degree were these reports investigated and resulted in charges and convictions? How many hours were spent on enforcing abalone closures? What were the trends in enforcement hours and resulting charges and convictions over the period before and during implementation of the recovery strategy?
- Was a long-term communications strategy implemented? How many and what kind of communication materials and/or actions were produced and/or undertaken? How many people, and where, did the communications activities reach? What indications for increased awareness (e.g., did visits to the abalone web site increase, what level of participation at workshops?) and/or reductions in illegal harvest were a result of communications efforts?
- What significant new knowledge was gained through research that would directly contribute to the rebuilding of the northern abalone population? How many population rebuilding initiatives were undertaken? Was there an observed increase in juvenile abundance and/or recruitment as a result of rebuilding experiments? Does rebuilding appear to be a viable, or promising strategy to recover the wild abalone population? What reports (technical or primary publications) were prepared that provide results of surveys and biological studies?
- Was baseline abundance data established in each of the biogeographic zones?

2.6 Critical Habitat

2.6.1 Identification of the species' critical habitat

SARA defines critical habitat as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species". While the general habitat requirements for northern abalone can be described (Section 1.4.1), the identification of critical habitat as defined under SARA requires further research.

Critical habitat to northern abalone may exist in certain habitats where juvenile survival is better, or where the reproducing adults contribute to a larger portion of the total recruitment. Identification of these key habitats is an important component to the abalone research and rebuilding plans.

2.6.2 Schedule of studies to identify critical habitat

Further research is needed before critical habitat for northern abalone can be identified. The following schedule for the next five years (2007-2012) outlines the studies that will yield information towards identifying critical habitat for northern abalone. The activities outlined in this schedule are recommendations that are subject to priorities and budgetary constraints of the participating jurisdictions and organizations. Some studies will take longer than five years to complete.

Recovery Activities	Date
Survey juvenile abalone to improve the 'cryptic model' (estimate of the portion of the population that remains cryptic and unavailable to survey).	2007-2012
Compare field observations from known abalone habitat to a predicted abalone habitat suitability model (Jamieson *et al*. 2004).	2007-2012
Determine the habitat characteristics that improve growth rates.	2007-2009
Examine growth, survival and distribution of early benthic stages in relation to local habitat, algal, predator and competitor species. Determine the parameters that contribute to higher juvenile densities (recruitment).	2007-2012
As part of the protocol (Lessard *et al.* 2006), monitor the extent to which works and developments on, in and under the water may impact on abalone habitat and recovery.	2010-2012+
Refine the predicted abalone habitat suitability model based on field observations.	2012+
Examine abalone distribution in relation to local seawater current patterns and computer simulations to determine potential larval dispersal mechanisms.	2012+

The identification of critical habitat is expected to take many years. Juvenile northern abalone are cryptic, making them difficult to find and to study, and dive surveys are intensive. Factors that contribute to localized recruitment (e.g., currents) are complex and may vary annually. A time series of data will be required on which to base assumptions to determine the 'critical' components of the habitat, rather than the habitat that is merely suitable.

2.7 Existing and Recommended Approaches to Habitat Protection

The *Fisheries Act* has provisions to protect northern abalone habitat. A list of existing marine protected areas is summarized in Jamieson and Lessard (2000). Marine Protected Areas may also be established under the *Oceans Act*. Under the *Canada National Marine Conservation Areas Act*, Parks Canada is responsible for the creation of National Marine Conservation Areas (NMCAs) which will be managed for sustainable use, and protected from industrial activities such as marine dumping, mining, and oil and gas exploration and development. A proposed NMCA in the southern Queen Charlotte Islands will extend 10 km offshore from Gwaii Haanas National Park Reserve. As such, it will encompass all the abalone habitat within this area. Consultations on the proposed NMCA are on hold pending negotiations with the Council of the Haida Nation.

Protocols (Lessard *et al*. 2006) are in place for authorizations under the *Fisheries Act* of works or developments on, in and under the water that may impact on abalone or its habitat. The protocols include decision rules to protect important habitat and, as such, adopts a precautionary approach to also protect critical habitat although it has not yet been identified.

Works or developments on, in and under the water that may affect abalone habitat may also be subject to review under the *Navigable Waters Protection Act* and the *Canadian Environmental Assessment Act*.

Movements of abalone to hatchery facilities and to the wild, including enhancement by out-planting to the wild, are subject to review and permitting (*Fisheries Act*) by the federal-provincial Introductions and Transfers Committee. Considerations made by the Committee in permitting transfers include disease transmission, genetic implications, and proper management and control to protect the threatened wild population. Currently, out-planting experiments are restricted to the immediate vicinity of Bamfield, B.C..

2.8 Permitting (SARA)

Refer to the 'Recovery Potential Analysis for Northern Abalone' (Lessard *et al*. 2006) for a review and recommendations on activities that may be permitted under SARA and the impact assessment protocol for proposed works and developments on, in or under the water.

A future amendment to this recovery strategy will be required in the event densities within an established and protected rebuilding area(s) recovers to minimum levels at which a limited First Nation harvest for food, social and ceremonial purposes, as protected under Section 35(1) of the *Constitution Act*, may be considered without jeopardizing survival or recovery of northern abalone.

2.9 Effects on Other Species

Table 3. Effects on other species.

Strategy	Potential Impact	Probability of Impact
1. Fisheries closures	Fisheries closures were anticipated to halt declines in the abalone population to allow for natural stock recovery and were not anticipated to affect other species.	*Low*
2. Communication	Communication may benefit other species associated with abalone communities and other species at risk by raising awareness and increasing reports of illegal harvesting.	*Medium*
3. Proactive Protection Plan	Increased enforcement activities for abalone will benefit other species by increased vigilance for all illegal fishing, possessing, and marketing activities, and can be expected to increase community reporting of illegal activities.	*High*
4. Research and Rebuilding Experiments	Rebuilding experiments may impact other species on a localized scale. Research may provide a better understanding of species and ecological interactions.	*Medium* *High*
5. Population Monitoring	Time series data may help to better understand species population changes of other species and ecosystem processes.	*Medium*

2.10 Recommended Approach for Recovery Implementation

The northern abalone has been considered for the single species recovery approach because it is a distinct species with respect to the issues that threaten its survival. Illegal harvest and low recruitment are the main reasons for a continued decline in the wild population, even though there have been complete fisheries closures for northern abalone since 1990. The northern abalone is the only marine invertebrate listed as threatened or endangered in Pacific Canada. Although being recommended for a single species approach, there are several actions outlined in the approach for recovery that may directly benefit other species within the geographical area that is included within northern abalone habitat. Sea otters (threatened) also exist within this ecosystem within an expanding portion of northern abalone's range, and do interact with northern abalone. Therefore, a shift to an ecosystem approach may be required in the future. This will require an adaptive approach as knowledge of the species and related species interactions improve.

2.11 Statement on Action Plans

One or more action plans, which provide the specific details for recovery implementation, will be completed within three years of completion of the recovery strategy.

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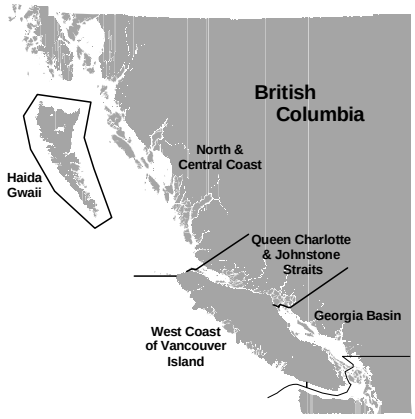
5. GLOSSARY OF TERMS

Abalone: marine gastropod snail of the Family Haliotidae; for the purposes of this document, northern abalone or pinto abalone, *Haliotis kamtschatkana*. This species is the most common and abundant abalone in B.C. *Note:* A mature red abalone, *H. rufescens* was found in the central coast of B.C. (A. Campbell, Fisheries and Oceans Canada, Nanaimo, BC, V9T 6N7, *pers. comm.*). There are numerous unsubstantiated reports of the flat abalone, *H. wallalensis* in the literature with a northern distribution to B.C.
Anthropogenic: involving the impact of humans on nature.

Aquaculture: as defined by the UN Food and Agriculture Organization (FAO) is the culture of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Aquaculture implies some form of intervention in the rearing process to increase production, such as regular stocking, feeding, and protection from predators.

B.C.: British Columbia, Canada.

Biogeographic zones in B.C. - based on environmental, management and/or biological considerations for northern abalone, includes intertidal and sub-tidal waters surrounding the following land areas:



Haida Gwaii (Queen Charlotte Islands): Queen Charlotte Islands.
Queen Charlotte and Johnstone Straits: Quadra Island (Seymour Narrows) north to Cape Caution.
North and Central Coast: Cape Caution north to and including Prince Rupert.
Georgia Basin: San Juan Point to Seymour Narrows near Quadra Island.
West Coast of Vancouver Island: the west coast of Vancouver Island from San Juan Point north to the Scott Islands.

Biomass: the amount of living matter in the form of one or more kinds of organisms present in a particular habitat.

Broodstock: mature adults that are able to produce young.

COSEWIC: Committee on the Status of Endangered Wildlife in Canada (www.COSEWIC.gc.ca).

DFO: Fisheries and Oceans Canada.

Critical Habitat: the habitat necessary for the survival and recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.

Culture: Culture is used to define a variety of techniques or interventions used to assist in an animal's survival and growth. The term "culture" is generic and can be used in the context of either "aquaculture" or "enhancement", and includes use of hatchery technologies and grow-out technologies.

Ecological: of, or having to do with, the environments of living things or with the pattern of relations between living things and their environments; of or relating to the interdependence of organisms.

Ecosystem: an ecological community considered together with the nonliving factors of its environment considered as a unit.

Endangered: facing imminent extirpation or extinction.

Extirpated: no longer existing in the wild in Canada, but occurring elsewhere.

Population rebuilding (or rehabilitation): describes the activities undertaken to restore populations to desired levels of strength or number, and can involve culture, habitat modification, experimental manipulations and aggregating reproductive adults.

Preventative enforcement: active patrols, education and investigations into illegal activity in order to prevent the loss of or illegal harvest of abalone and other species; all of which is done on a continuous and frequent basis throughout the year.

Proactive enforcement: enforcement initiatives undertaken (as for Preventative above) with a long-term view (e.g., education, community development, stewardship and similar effort) aimed at protecting the resource; long-term efforts.

Reactive enforcement: enforcement initiatives undertaken immediately as a result of reported active theft of the resource, happening real time and addressed real time.

Recovery: is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered recovered when its long-term persistence in the wild has been secured.

Recovery Implementation Group: group of people working on specific recovery actions or projects under the umbrella of a recovery team.

Recruitment: for this document, the number of juvenile abalone that enter into the adult population.

SARA: the *Species at Risk Act*.

Self-sustainable population: a population having a <5% probability of becoming extinct over the next 100 years. According to COSEWIC this requires: enough breeding adults to be considered sustainable in the long-term; sufficient quality habitat to available or potentially available to maintain sustainable population numbers; adequate or improving demographic parameters (eg: sex ratio, birth and death rates); and mitigation/control of threats to the population, particularly those that initially caused the species decline.

Threatened: likely to become endangered if limiting factors are not reversed.

Viable: capable of living.

6. RECOVERY TEAM

Abalone Recovery Team (2002)

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Abalone Recovery Team (2007)

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Joanne Lessard, Fisheries and Oceans Canada
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Abalone Recovery Implementation Group (2007)

William Beynon, Metlakatla Fisheries Program
Julie Carpenter, Heiltsuk Fisheries Program / Heiltsuk Abalone Stewardship Project
Laurie Convey (Chairperson), Fisheries and Oceans Canada
Ernie Cooper, TRAFFIC the wildlife trade monitoring network
Bart DeFreitas, Haida Fisheries Program / Haida Gwaii Abalone Stewards
Mike Featherstone (alternate Tim Joys), Pacific Urchin Harvesters Association
Joel Harding (alternate Ernie Mason), Kitasoo Fisheries Program / Kitasoo Abalone Stewardship Project
Heather Holmes, Parks Canada Agency
Russ Jones, Haida Fisheries Program / Haida Gwaii Abalone Stewards
Bryan Jubinville, Fisheries and Oceans Canada
Lynn Lee, World Wildlife Fund Canada / Haida Gwaii Abalone Stewards
Joanne Lessard, Fisheries and Oceans Canada
John Richards, Bamfield Huu-ay-aht Community Abalone Project
Blair Stewart, Nisga'a Fisheries
Tom Tomascik, Parks Canada Agency
Guy Whyte, Pacific Trident Fishing
Ross Wilson, Heiltsuk First Nation

APPENDIX I RECORD OF COOPERATION AND CONSULTATION

Northern abalone are an aquatic species under federal jurisdiction, managed by Fisheries and Oceans Canada: 200-401 Burrard St., Vancouver, B.C. V6C 3S4.

Fisheries and Oceans Canada engaged an Abalone Recovery Team in November 2001 to work cooperatively on drafting a recovery strategy based on *A Strategy for Rebuilding Abalone Populations in British Columbia* (www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/Abalone/default_e.htm) that was developed cooperatively by First Nations, international researchers, aquaculturists, local communities, non-government organizations and federal and provincial governments in 1999. The membership of the Recovery Team and its Recovery Implementation Group that have worked co-operatively in the development and implementation of recovery programs is provided above. The list of participants and the thirteen peer-reviewed papers from the 1999 workshop are available in Campbell (2000a).

In addition, consultations were also undertaken with First Nations and all those interested in the recovery of northern abalone to gain input and advice on an early draft of the recovery strategy through a series of coastal workshops. All coastal First Nations, participants from the 1999 workshop, abalone recovery action groups, commercial fishing representatives and the general public were invited to participate. Over the course of eight workshops held February 1 2002 in Bella Bella; February 5 2002 in Port McNeil; February 8 2002 in Powell River; February 11 2002 in Port Alberni; February 12 2002 in Victoria; February 13 2002 in Nanaimo; February 19 2002 in Prince Rupert; and February 22 2002 in Skidegate, B.C., input on the draft Abalone Recovery Strategy was provided by representatives from: abalone commercial licence holders, Ahousat First Nation, Archipelago Marine Research Ltd., A-tlegay Fisheries Society, Bamfield Huu-ay-aht Community Abalone Project Society, Bamfield Marine Station, BC Ministry of Assets and Lands, BC Ministry of Agriculture, Food, and Fish, Combined North Island Fisheries Center, commercial fishers, Community Futures Development Corporation of the Powell River Region, Council of Haida Nations, Cowichan Tribes, G-N Fisheries, Groundfish Hook and Line Advisory Committee, Haida Fisheries Commission, Haida Gwaii Marine Resources Group Assn., Heiltsuk First Nations, Hemas Council, Kitasoo Fisheries Program, Kitkatla First Nation, Kwakiutl Band, Kwakiutl Nation Development Corp., Lax Kw'alaams Band Council, Living Oceans Society, Malcolm Island Shellfish Cooperative, Metlakatla Band Council, nearshore rockfish fishers, Nuchatlaht Band, Nuu chah nulth Tribal Council, Outer Coast Oysters, Oweekeno First Nations, Parks Canada Gwaii Haanas, Parks Canada Pacific Rim National Parks Reserve, Penelakut Tribes, Prince Rupert Chamber of Commerce, Quatsino Seafood, shellfish biologists, shellfish growers, Sub Sea Products, Tseshaht Band, Tsimshian Allied Tribes, University of Victoria, World Wildlife Canada (marine program), and other interested parties. Written submissions were also provided by Lorne Clayton, IEC International Collaborative Marine Research and Development Ltd.; Erica Boulter, World Wildlife Fund; Larry Golden, Prince Rupert; John Shepherd, Northwest Community College; Stefan Ochman, Fisheries Manager, Huu-ay-aht First Nation, Fred Hawkshaw, nearshore rockfish; Michelle James, Underwater Harvesters' Association; Robert DeVault, Outer Coast Oysters; Mike Featherstone, Pacific Urchin Harvesters' Association; Dawn Renfrew, Bamfield Marine Sciences Center; and

Mark Biagi, Community Futures Development Corporation. Meeting records are available at www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/Abalone/default_e.htm.

Although northern abalone were not specifically identified within the Nisga'a Treaty, the Nisga'a Fisheries Program has an interest in abalone recovery and has been participating in the recovery program.

Input from the workshops and written submissions encouraged the importance of enforcement and deterrents to illegal harvest, adopting an ecosystem approach, consideration for the role of culture and commercial aquaculture, co-operation from commercial urchin and geoduck and horse clam dive fishery associations, research to fill knowledge gaps, incentives for First Nations, and community involvement and education in abalone recovery. In re-drafting the Abalone Recovery Strategy input from public workshops, written submissions and external reviews was adopted wherever possible.

In 2007, the Abalone Recovery Strategy was updated and reformatted to fit the requirements for posting under SARA.

External Reviewers (2002)

Paul A. Breen, Scientist, National Institute of Water and Atmospheric Research
Kon Karpoff, California Department of Fish and Game
Michele Patterson, Marine Program Director, Pacific Region, World Wildlife Fund Canada,
Scoresby Shepherd, Senior Research Fellow, South Australian Research and Development Institute
Norm Sloan, Parks Canada, Gwaii Haanas National Park Reserve
Anne Stewart, Bamfield Huu-ay-aht Community Abalone Project Society
Jane Watson, Malaspina University-College