Species at Risk Act
Action Plan Series

Action Plan for the Northern Abalone (*Haliotis kamtschatkana*) in Canada

Northern Abalone

2012

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

Recommended citation:

Fisheries and Oceans Canada. 2012. Action Plan for the Northern Abalone (*Haliotis kamtschatkana*) in Canada *Species at Risk Act* Action Plan Series. Fisheries and Oceans Canada, Ottawa. vii + 65 pp.

For copies of the action plan, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry (www.sararegistry.gc.ca).

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Également disponible en français sous le titre « Plan d'action pour l'haliotide pie (*Haliotis kamtschatkana*) au Canada »

ISBN: 978-1-100-19459-2
Catalogue no.: CW69-21/4-2011E-PDF

Preface

Northern Abalone is a marine species at risk. The Minister of Fisheries and Oceans is a "competent minister" for aquatic species under the *Species at Risk Act* (SARA). Since Northern Abalone are known to occur in the Gwaii Haanas National Marine Conservation Area and the Pacific Rim National Park Reserve, the Minister responsible for Parks Canada Agency is also a "competent minister" for this species. SARA (Section 47) requires the competent minister to prepare action plans for listed extirpated, endangered or threatened species. The Northern Abalone was listed as threatened under SARA in June 2003.

First Nations along the B.C. coast are playing a lead role in abalone stewardship and recovery within their claimed traditional territories, in collaboration with federal agencies and community partners (see Section 2.6). Although Northern Abalone are not specifically identified within the Nisga'a Treaty, the Nisga'a Fisheries Program is interested in abalone recovery and they participate in the recovery program[1].

Under the *Canada National Marine Conservation Areas Act*, and the *Canada National Parks Act*, Parks Canada Agency is involved in abalone management and protection in National Marine Conservation Areas (NMCAs), NMCA Reserves, and national parks with marine components (e.g. Pacific Rim and Gulf Islands National Park Reserves). Kelp harvesting is subject to licensing under the B.C. *Fisheries Act*[2].

Artificial movements of Northern Abalone into and within coastal waters and to aquaculture facilities are subject to review and licensing by the federal-provincial Introductions and Transfers Committee and SARA.

Success in the recovery of Northern Abalone depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Fisheries and Oceans Canada, Parks Canada Agency or any other party alone. This action plan provides advice to jurisdictions and organizations that are involved in, or wish to become involved in, activities to conserve this species. In the spirit of the *Accord for the Protection of Species at Risk*, the Minister of Fisheries and Oceans and the Minister responsible for Parks Canada Agency invite all Canadians to join Fisheries and Oceans Canada and Parks Canada Agency in supporting and implementing this plan for the benefit of Northern Abalone and Canadian society as a whole. Fisheries and Oceans Canada and Parks Canada Agency will support the implementation of this action plan based on available resources and varying species at risk conservation priorities.

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[1] The Nisga'a Joint Fisheries Management Committee operates within the marine waters of Portland Canal and Observatory Inlet where Northern Abalone may live.

[2] Licensing of aquaculture operations was assumed from the Province of B.C. by the Minister of Fisheries and Oceans in 2010 based on a decision by the B.C. Supreme Court in 2009.

SARA Responsible Jurisdictions[1]

Fisheries and Oceans Canada
Parks Canada Agency

Authors

The 2009-10 Abalone Recovery Team (Appendix 1) led development of this action plan for Fisheries and Oceans Canada. On behalf of the Haida Fisheries Program, Janet Winbourne, Lynn Lee, and Russ Jones provided the Haida traditional knowledge information included in this action plan (see Section 1.4 for source(s)).

Acknowledgements

The development of this action plan was the result of collaborative efforts and contributions from many individuals and organizations. The Recovery Team would like to thank the Haida Fisheries Program for their continued involvement and engagement in ensuring accurate and respectful inclusion of the Haida traditional knowledge information in this 2010 action plan. Fisheries and Oceans Canada also very much appreciates the past and present members of the Abalone Recovery Implementation Group (Ab RIG), and others who provided advice and comments through the November 2009 Abalone Recovery Implementation Group meeting and the 2004 draft National Recovery Action Plan for Northern Abalone.

Many First Nations throughout the coast of B.C. have and continue to participate in recovery efforts for Northern Abalone together with federal agencies (e.g., on the Abalone Recovery Implementation Group) and community partners (e.g., Coast Watch Programs). First Nations are playing a key role in fostering a stewardship ethic for abalone recovery and developing and implementing local recovery programs.

This action plan represents part of a pilot initiative to work with First Nations to incorporate traditional knowledge in SARA recovery planning. Haida Gwaii, North Coast and Central Coast First Nations have been conducting marine traditional knowledge (TK) studies in communities since 2007 as part of the Pacific North Coast Integrated Management Area (PNCIMA) integrated marine use planning initiative. These and other efforts to research and document marine TK are ongoing. To demonstrate the type of knowledge held in many First Nations communities and its potential contribution to marine planning and species recovery initiatives, the Haida Fisheries Program has provided input on how TK may be incorporated within recovery plan documents (specifically within the existing action planning framework). The preliminary abalone TK in Sections 1.4 and 1.5 was provided by the Haida Fisheries Program and reflects a Haida

[1] First Nations consider that they have jurisdiction over the traditional territories that they claim. See 'Associated Plans' section for reference to community-based recovery plans for abalone.

perspective; as such the information may not reflect the federal government's perspective, or those of other First Nations. The Haida TK presented here is neither a comprehensive representation of Haida knowledge of abalone, nor of abalone TK held by other First Nations along the B.C. coast. Traditional knowledge in Section 1.4 is included to characterize how TK information could be incorporated into SARA recovery planning and related documents. This represents a first step by Fisheries and Oceans Canada and First Nations to explore respectful and appropriate incorporation of traditional knowledge into species recovery planning. As new information is gathered from TK and other sources, activities in the action plan may be added, adapted and/ or revised.

Strategic Environmental Assessment Statement

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Action planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that plans 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 upon non-target species or habitats. The results of the SEA are incorporated directly into the plan itself.

This action plan will clearly benefit the environment by promoting the recovery of Northern Abalone. The potential for the plan to inadvertently lead to adverse effects on other species was considered. Refer to the following sections of the document in particular: Section 3.

Executive Summary

This action plan for Northern Abalone (*Haliotis kamtschatkana*) in Canada forms the integral component to implementing the Recovery Strategy for Northern Abalone (*Haliotis kamtschatkana*) in Canada (DFO 2007). Please refer to the recovery strategy for more complete information about Northern Abalone and its recovery in Canada, available on the SARA Public Registry (http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=1342) or by contacting the Abalone Recovery Team Chairpersons listed in Appendix 1.

The Northern Abalone is a patchily distributed marine mollusc that has been declining in numbers and distribution in surveyed areas of British Columbia (B.C.), Canada[1], as documented by regular surveys since the late 1970s. In response to observations of population declines, the Northern Abalone fisheries were closed to all harvest in 1990 and a rebuilding program was initiated in 1999. In April 1999, Northern Abalone was assigned *threatened* status by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). This status was recently changed to *endangered* following an updated status report and reassessment by COSEWIC in April 2009 (http://www.cosewic.gc.ca/eng/sct0/index_e.cfm). The species is legally listed as *endangered* under Canada's *Species at Risk Act*.

The illegal harvesting of Northern Abalone and low recruitment levels have had predominant and widespread impacts and are the most significant threats to Northern Abalone recovery. Predation by Sea Otters is also likely to affect recovery of abalone in areas where abalone is already severely depleted (COSEWIC 2009).

Critical habitat is identified in this action plan to the extent possible using the best available information. Four areas with critical habitat for Northern Abalone are identified (Figure 3). Northern Abalone are mostly found along exposed coastline not suitable for the majority of coastal developments. As such, there are relatively few activities likely to destroy their critical habitat. Finfish aquaculture, log booms and log dumps, and dredging, or the construction of underwater pipes or cable placement, installation of pilings or other developments that may have similar impacts as dredging, may require mitigation measures if they are proposed in areas that contain Northern Abalone (Lessard *et al.* 2007). Lessard *et al.* (2007) rated the relative impact from these works or developments as low, provided an assessment protocol is followed. An assessment protocol has been in place since 2007[2].

The general approaches to reach the population and distribution objectives of the recovery strategy are to: 1) maintain the fisheries closures; 2) promote compliance and enforcement of fisheries closures; 3) continue education and awareness; 4) support research and rebuilding experiments; and 5) monitor the status of the population. Recovery activities are listed in Table 4, along with participating agencies and organizations. Many of these actions were outlined in the the 1999 Workshop for Rebuilding Northern Abalone in B.C, the 2004 draft National Recovery Action Plan for Northern Abalone and the 2007 recovery strategy, and have been

[1] In Canada, Northern Abalone occurs only in British Columbia.

[2] Appendix 4. Lessard, J. and A. Campbell. 2007. Impact assessment protocol for works and developments potentially affecting abalone and their habitat . *In* Lessard *et al.* 2007.

ongoing and improving over several years. To date, these measures continue to be the most comprehensive and extensive means known to recover abalone. Activities may be added, adapted and revised as new information is gathered.

Socio-economic evaluation of this action plan (Section 4) has determined that implementation of this action plan will yield short-term benefits in the form of capacity-building and employment, and longer-term cultural and non-market benefits to First Nations and Canadian society as the abalone population recovers. Many actions to recover Northern Abalone pre-date this action plan and, in some cases, SARA. Since the species was listed in 2003, the majority of the costs of recovery activities related to enforcement, research and population monitoring have been borne by Fisheries and Oceans Canada. Outreach and public education programs and other in-kind costs towards recovery activities have been, and are expected to continue to be, incurred by Environmental Non-Government Organizations (ENGOs) and First Nations participating in the recovery program.

For more information on abalone biology and past recovery initiatives, visit the Fisheries and Oceans Canada Abalone Homepage at http://www.pac.dfo-mpo.gc.ca/fm-gp/commercial/shellfish-mollusques/abalone-ormeau/index-eng.htm

To report suspicious activities or abalone poaching call ***1-800-465-4336***.

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Figures and Tables

1. Synopsis of the 2007 Recovery Strategy and Update

The 2007 Recovery Strategy for Northern Abalone identified key threats contributing to the decline of abalone in Canada. Illegal harvest remains the most significant threat. Low recruitment in an area over a protracted period of several years further threatens the population by not replenishing the reproductive adults that have died from natural causes or illegal harvest. Future threats may include habitat loss in localized areas due 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 goal of the recovery strategy is to achieve self-sustainable densities of abalone within five biogeographic zones[1]; Haida Gwaii, Queen Charlotte and Johnstone Straits, North and Central Coast, Georgia Basin, and West Coast of Vancouver Island, in order to remove Northern Abalone from endangered status. Increasing Northern Abalone to sustainable levels can be expected to take several decades.

Critical habitat for Northern Abalone was not identified in the recovery strategy. Identification of key habitats was flagged as an important component to abalone research and rebuilding plans.

Based on the 2002 Recovery Strategy adopted under the *Accord for the Protection of Species at Risk*, a draft 'National Recovery Action Plan for Northern Abalone' was developed in 2004. Both documents relied heavily on a rebuilding strategy initiated in 1999 and provided guidance and direction for recovery activities for Northern Abalone in B.C. The 2004 draft National Recovery Action Plan for Northern Abalone and draft recovery strategy were posted on the Fisheries and Oceans Canada Abalone Homepage (Abalone: Here and Now – Pacific Region at http://www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/Abalone/default_e.htm), and have been used by members of the Abalone Recovery Implementation Group (Ab RIG) for the purposes of guiding abalone recovery activities. The action plan was updated in 2010 from the earlier draft to reflect knowledge gained and the requirements of the SARA. Appendix 2 provides an evaluation of the action-based performance measures listed in the 2007 recovery strategy and 2004 draft National Recovery Action Plan for Northern Abalone.

1.1 Associated Documents

This action plan implements the Recovery Strategy for Northern Abalone (*Haliotis kamtschatkana*) in Canada, September 2007. The strategy is available at http://www.sararegistry.gc.ca. For more details on description of the species, population and distribution, and threats, please refer to the 2007 Recovery Strategy for Northern Abalone in Canada.

[1] Five biogeographic zones were identified for Northern Abalone in B.C. based on environmental, management and/or biological considerations. These areas include intertidal and subtidal waters surrounding the following land areas: Haida Gwaii; North and Central Coasts (Cape Caution north to and including Prince Rupert); Queen Charlotte and Johnstone Straits (Seymour Narrows near Quadra Island north to Cape Caution); Georgia Basin (San Juan Point to Seymour Narrows near Quadra Island); and West Coast of Vancouver Island (San Juan Point north to the Scott Islands).

1.2 Species Assessment Information from COSEWIC

Date of Assessment: April 2009

Common Name (population): Northern Abalone

Scientific Name: *Haliotis kamtschatkana*

COSEWIC Status: Endangered

Reason for designation:
Highly valued for its meat, this marine mollusc is patchily distributed along the west coast of Canada. Despite a total moratorium on harvest in 1990, the species was designated as Threatened in 2000. Poaching is the most serious threat and continues to reduce population abundance, particularly the larger, more fecund component; however, all size classes have declined significantly over the past three generations (i.e. since 1978) with mature individuals declining an estimated 88-89%. Low densities may further exacerbate the problem by reducing fertilization success in this broadcast spawner (the Allee effect). Although predators such as the recovering Sea Otter population are not responsible for recently observed declines, they may ultimately influence future abundance of abalone populations.

Canadian Occurrence: Pacific Ocean

COSEWIC Status History:
Designated Threatened in April 1999. Status re-examined and confirmed in May 2000. Status re-examined and designated Endangered in April 2009.

1.3 Description of the Species

Abalone are marine molluscs related to snails and whelks. The Northern Abalone, *Haliotis kamtschatkana* (Jonas 1845), is one of approximately 56 species of abalone (*Haliotis* spp.) found world-wide (Geiger 1999). *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).

Northern Abalone have a mottled red to green, lumpy, and ear-shaped shell. The shell has between 3 and 6 holes for respiration, and exterior shell colour can include areas of white and blue. A groove runs parallel to the line of holes. The interior of the shell is faintly iridescent and pearly white. The large foot of the abalone is usually light tan coloured surrounded by tentacle-like structures called epipodium.

Given its widespread range, most coastal First Nations languages have a name for abalone (examples in Table 1). In some cases, such as Haida Gwaii, there are several names for abalone in different Haida dialects, two of which are in Table 1. First Nations also have specific words for abalone shell and for shells of different abalone species.

Table 1. Some First Nations and French names for Northern Abalone in British Columbia.

First Nation	Name for abalone	Reference for names
Haida (Massett)	Gahlyaan	Rhonda Bell
Haida (Skidegate)	GalGahlyan	Skidegate Haida Immersion Program 2007
Huu-ay-aht	ʕapsy'in	Bamfield Marine Sciences Centre 2007 cited in COSEWIC 2009
Heiltsuk	Ğatğ'ni'q	J. Carpenter pers. comm. 2007 cited in COSEWIC 2009
Manhousat	7apts7in	Ellis and Swan 1981 cited in COSEWIC 2009
Nisga'a	Bilaa	Stewart pers. comm. 2007 cited in COSEWIC 2009
Tsimshian[+]	Bilhaa	Sm'algyax Language Committee 2005 cited in COSEWIC 2009
French	Haliotide pie	SARA Public Registry
	ormeau nordique	Clavier and Richard 1986; Foucher and Cochard 2005

[+]Tsimshian Nation includes Kitasoo/Xai Xais (Klemtu), Gitga'at (Hartley Bay), Kitkatla, Metlakatla, Allied Tribes of Lax Kwa'laams, Kitselas and Kitsumkalulm First Nations.

1.4 Role of First Nations Traditional Knowledge in SARA Recovery Plans

The traditional knowledge (TK) of First Nations can provide many insights useful to management and planning initiatives. Typically, oral histories carry knowledge, experience and observations throughout multiple generations, helping to compose time series and trend information that often pre-date scientific research. Many traditional knowledge holders have remarkably detailed ecological observations from lifetimes spent on the land and on the water. Not only can TK often build on, and complement, science in its findings, its respectful inclusion and the meaningful participation of First Nations can bring forth novel ideas and information that greatly enhance cooperative recovery planning and stewardship efforts.

The Haida Marine Traditional Knowledge Study (HMTK) is one example of efforts to document TK to inform integrated management on the B.C. coast (HMTK Study Participants *et al*. 2008)[1]. As part of the project, over 50 Haidas were consulted regarding their knowledge of the marine environment. During the two-year research phase participants discussed approximately 200 marine and maritime species in interviews that totaled 120 hours of audio recordings[2]. Some of the ecological information documented about abalone includes: species distribution and historic fishing areas; population abundance and trends; species associations; spawning observations; and habitat descriptions.

The potential benefits of including this type of information in recovery and action planning are many. The challenges lie in finding a manner of inclusion that is responsive to First Nations cultures and experiences, while also ensuring measures of validity and reliability. In the case of abalone, there is additional sensitivity due to its current COSEWIC status. In some First Nations communities, discussions on abalone are extremely sensitive, with a particular reluctance to share abalone distribution information. Continuing work to bring more comprehensive abalone TK into recovery documents needs to be considerate and respectful of each First Nations' protocols for documenting and sharing TK. Therefore, incorporating localized abalone TK may be more appropriate than trying to generalize for the whole coast of B.C. Efforts to respectfully and effectively incorporate TK in Fisheries and Oceans Canada's species at-risk recovery planning have been initiated, and will assist in informing future planning and recovery activities.

1.5 Cultural Significance

Northern Abalone is a traditional food for many First Nations on the Pacific coast that is not available now due to the coast-wide fisheries closures implemented as a result of significant conservation concerns for the species, i.e., extremely low abundance and unsustainable decline. Abalone were harvested year-round and the meat enjoyed fresh (raw), dried, smoked and/or canned (Haida Marine Traditional Knowledge (HMTK) Study Participants *et al.* 2008). Abalone (*Haliotis* spp.) shells in coastal middens provide evidence of the pre-historic dietary and cultural importance of abalone (Sloan 2006). Shells from california abalone are also used as decoration on ceremonial dress and artwork in many regions of B.C. (Sloan 2003). Like many other species, abalone have been relied upon and taken care of by First Nations, such as the Haida, through a relationship evolving and continuing over countless generations (HMTK Study Participants *et al.* 2008). For thousands of years, Northern Abalone were harvested for food along rocky intertidal shores all around Haida Gwaii (Ellis and Wilson 1981).

In Haida legend, it is said that the Northern Abalone descended from the northwestern toad during *k'áy gang*, the "Time of the Raven." Stories from long ago not only communicate a timeless reciprocal relationship between human and non-human animals, but also portray an understanding of the natural order of the world and teach appropriate actions for maintaining balance in the world (HMTK Study Participants *et al*. 2008; *Kii7iljuus* (Wilson) and Harris 2005). For example, Haida creation stories tell that Haidas came from the sea: their history and

[1] The HMTK study is only one of many marine traditional knowledge studies conducted by First Nations on the North Coast, Central Coast and other places along the B.C. coast.

[2] See HMTK Study Participants *et al.* (2008) for details of study methodology.

experiences are therefore intimately entwined with all sea creatures, and as a result, the harvest of seafoods is underlain with a deep respect. Waste is seen not only as disrespectful but also short-sighted:

> … a lot of times we only took half a sack and…kept that for while we were moving back and forth, doing our gathering, food-gathering there… grandmother used to say, 'Only take enough for what you need. You don't need to take any more than that.' Hence, they were very concerned about preserving things like that, making sure that we had enough. I know grandmother … always told us, 'Never get too greedy about that. If you look after it, it will always be there.' (HMTK Study participant, Mar. 2007).

For abalone, this conservation principle is reinforced by traditional harvesting methods. According to Ellis and Wilson (1981), Haidas traditionally harvested abalone by hand-picking, and by using a two-pronged seafood spear, *kíit'úu*, made by lashing (using spruce root twine) two sharpened pieces of huckleberry stem to each side of a long pole made of spruce or red cedar. Collection of abalone using this spear required practice and skill. If the animal was speared and not twisted off the rock in the same motion it might adhere to the rock with its strong foot and be hard to retrieve, if the animal was speared too lightly, it might be knocked off the rock and fall away to depths beyond reach.

Traditionally, abalone were harvested at extreme low tides, "That was the only time we went to get it was when the tide was down low enough…like a 24-foot high to a zero" (HMTK Study participant, Dec. 2008). "We used to just go pick what was above… the water line, because they'd be crawling around in the kelp. And we wouldn't touch anything else that's in the water… we didn't dive for them" (HMTK Study participant, Feb. 2009). These intertidal harvest methods may have provided a harvest refugia for abalone, as the subtidal portion of the population (>2m depth) was not accessible (Jones *et al.* 2004). As a result, a portion of the population may have been left to regenerate (Ibid).

At one time, historic abalone populations were plentiful enough and of such widespread distribution that they were relied upon both as a source of fresh food and also preserved for storage and for trade (HMTK Study Participants *et al*. 2008; Jones *et al.* 2004). For Haidas, trade with other mainland First Nations brought soapberries, eulachons and eulachon grease in return for the abalone (HMTK Study Participants *et al*. 2008). In the more recent past, people most often spoke about getting just enough abalone for a meal; this may partially be a function of the steady decline of abalone; "To ourselves it was sort of like a treat, and we took care of it. But then they all got wiped out," (HMTK Study participant, Oct. 2008). Many expressed that the widespread decline of abalone is felt as a profound loss:

> Already we can't harvest abalone. And some people could probably say, 'So you've got a lot of other things to harvest.' But I can stand before you and say that in twenty-eight years of working in the health field, I had the honour of being with several elders as they passed on to the next life. Many, many of them, including my late father, one of the last things they asked for or were wishing for was abalone. My birth mother who wasn't even that fond of it before, one of her last requests was to

> have some abalone. And our favourite way of eating it is right out of the water, raw, sliced thinly. [A Haida elder], her last request for traditional food was abalone. And it hurt very much that we couldn't give it to them, I must say. Because we like to fulfill their last wishes, but we could not fill that one, because the [abalone] was overharvested, severely (Haida Elder speaking at Gaaysiigang – An Ocean Forum for Haida Gwaii, January 2009).

The loss of abalone as a part of the traditional diet is both nutritional and socio-cultural (HMTK Study Participants *et al*. 2008). No socio-economic assessment of the loss of abalone as a resource to First Nations has been conducted. The long history of First Nation use and stewardship of abalone, and the socio-cultural and economic costs associated with its decline, should be considered in future[1]. In many First Nations communities, traditional knowledge is passed on to the younger generations through shared experience; opportunities to teach youth traditional methods of finding, harvesting and preparing abalone do not currently exist. Abalone is a traditional food that some of the younger generations have not had an opportunity to experience and enjoy (HMTK Study Participants *et al*. 2008).

1.6 Populations and Distribution

1.6.1 Population

Withler *et al.* (2001) provides the only estimate of Northern Abalone effective population size in B.C.; historically 420, 000 individuals. Surveys at index sites in southeast Haida Gwaii and the Central Coast of B.C. have provided general time-series trends. Both Atkins *et al.* (2004) and Lessard *et al.* (2007) noted that densities of mature and large (≥100mm shell length) abalone have declined at a greater rate than for small abalone.

The recent COSEWIC assessment (2009) shows that mean total abalone density, at index sites declined from 2.40 to 0.40 abalone/m^2 for the Central Coast, between 1978 and 2006 and from 2.22 to 0.43 abalone/m^2 for Haida Gwaii between 1978 and 2007. During the same period, the mean mature (≥70 mm SL) density decreased from 2.13 to 0.23 abalone/m^2 and from 1.28 to 0.15 for the Central Coast and Haida Gwaii, respectively (COSEWIC 2009). Immature densities declined from 0.27 to 0.18 abalone/m^2 and from 1.39 to 0.27 abalone/m^2 for the Central Coast and Haida Gwaii, respectively. Proportionally, the densities of mature and large abalone decreased more rapidly than that for small individuals (Atkins *et al*. 2004; Lessard *et al.* 2007). The declines in density estimates for all size categories were statistically significant between the latest surveys and those completed in 1978; about three generations (COSEWIC 2009). Only the mature and large abalone density estimates from the 2006 and 2007 surveys were significantly lower when compared to the 1989 or 1990 surveys, just before the fisheries closed. The large decrease in mature abalone densities combined with the decline in mean shell length since the fisheries closure suggest size-selective fishing (poaching) mortality (COSEWIC 2009).

[1] Socio-economic evaluation in Section 4 of this action plan is as per SARA s. 49(1)(e), and focuses on evaluation of recovery actions proposed in this document.

First Nations have also witnessed the dramatic decline in abalone abundance. Even formerly very productive and remote areas have been affected. Additional TK research related to abalone population and distribution could complement existing field survey work and inform future surveys.

1.6.2 Distribution

Northern Abalone can be found off the west coast of North America in shallow subtidal waters along exposed and semi-exposed rocky coastlines from Sitka Sound to Turtle Bay, Baja California (McLean 1966; Geiger 1999). In Canada, Northern Abalone occur only on the Pacific coast in patchy distribution on hard substrate in intertidal and shallow subtidal coastal waters.

In the HMTK study, abalone presence was documented throughout many areas of Haida Gwaii: most participants could remember a time when abalone were widespread, "…wherever there's a reef there used to be lots of abalone… pretty hard to find anything nowadays," (HMTK Study participant, Mar. 2007). Harvesting however tended to target areas that were especially productive or convenient; sheltered sites near villages or locations along travel routes were areas most often visited (HMTK Study Participants *et al*. 2008). These sites are known more intimately, and it may be possible to document observations about abalone patch size, density, species associations and habitat descriptions for specific sites.

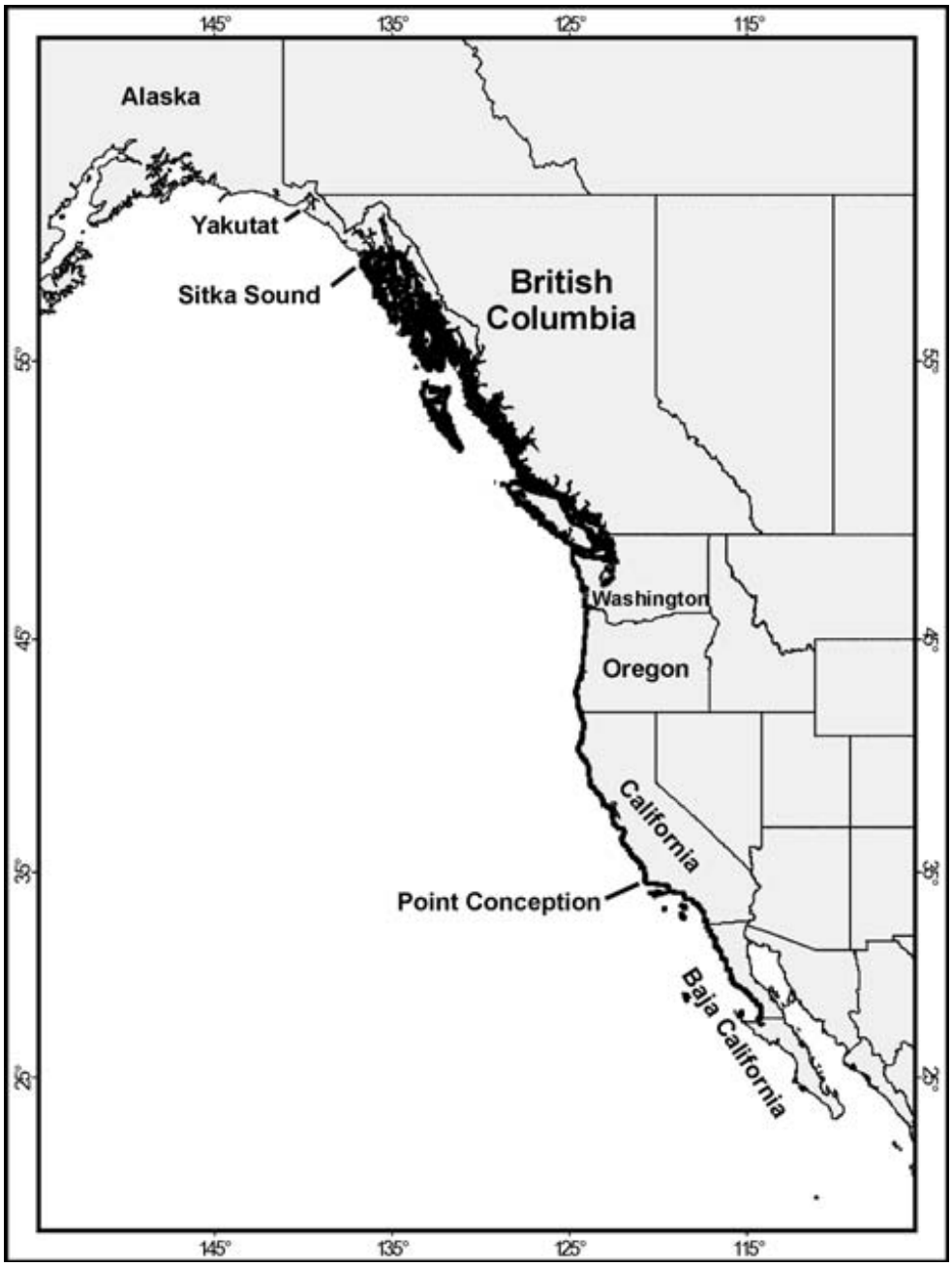

Figure 1. Global distribution of Northern Abalone (map courtesy of COSEWIC 2009). Bolded areas relate to possible distribution.

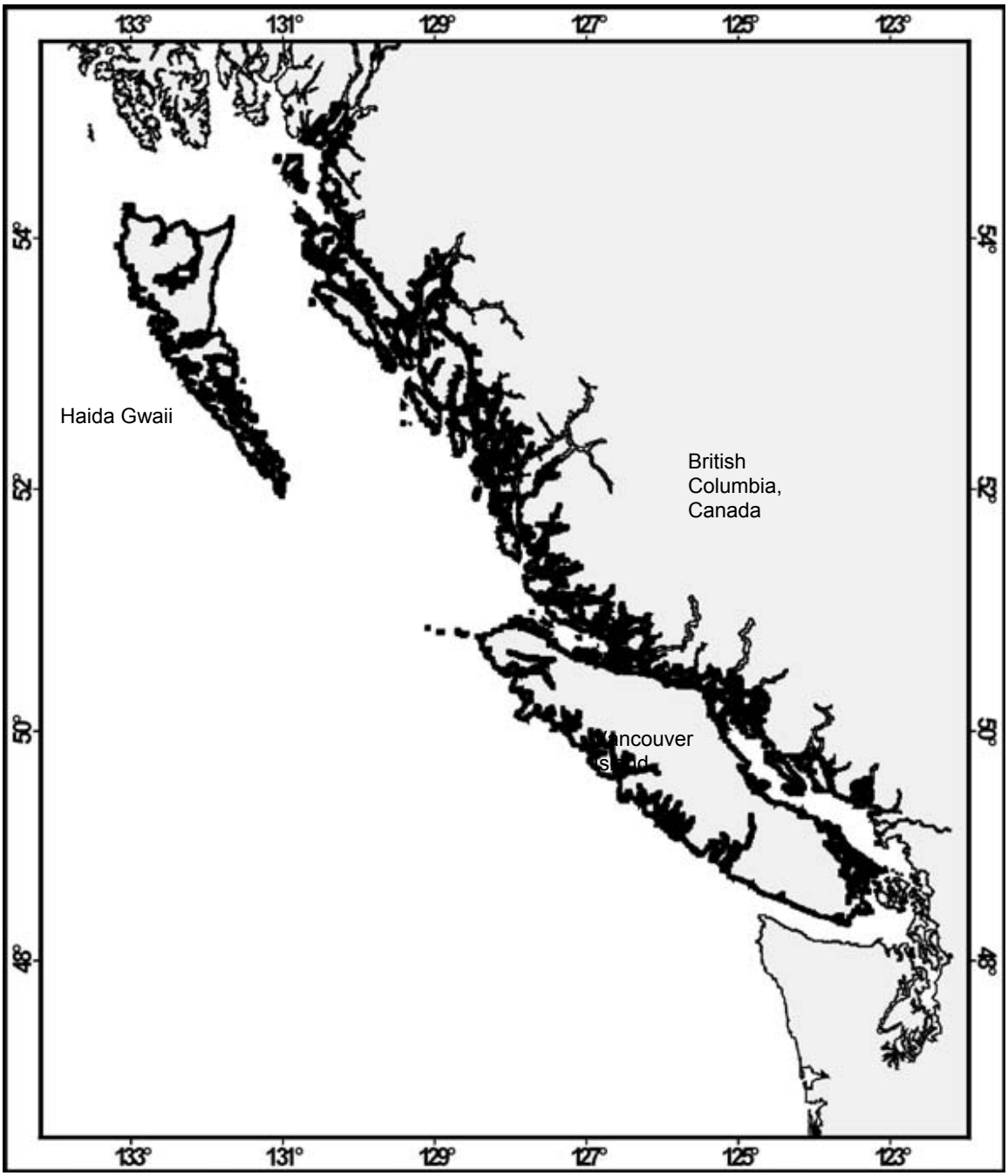

Figure 2. Range of Northern Abalone in Canada (map courtesy of COSEWIC 2009). Bolded areas indicate possible distribution.

1.7 Threats

Continued illegal harvest and low recruitment levels have had predominant and widespread impacts and are the most significant threats to Northern Abalone recovery (DFO 2007, Lessard *et al* 2007, COSEWIC 2009). Preliminary results from joint research by Parks Canada Agency and Fisheries and Oceans Canada indicate that significant mortality events may occur upon settling of larvae, which also contributes to overall low recruitment (Parks Canada Agency and DFO *unpublished*).

Other threats to Northern Abalone include predation by Sea Otters where the two species co-exist, and habitat loss and degradation resulting from underwater works and development, in the event they are unregulated, as well as laundering of wild Northern Abalone in the marketplace. Direct effects from climate change are not expected to occur for several years as BC is well within the global distribution of the species (COSEWIC 2009).

For more detailed description of threats to Northern Abalone, please refer to the Recovery Strategy for Northern Abalone in Canada (2007) and the 2009 COSEWIC status report.

1.8 Goals and Population and Distribution Objectives for the Recovery of Northern Abalone

The goals and objectives outlined in the following subsections are those adopted in the Recovery Strategy for Northern Abalone in Canada (2007).

1.8.1 Goals

From the recovery strategy, the immediate goal is to:

> *halt the decline of the existing wild Northern Abalone population in B.C. in order to reduce the risk of this species becoming endangered;*

and the long-term goal (over the next 30 years) is to:

> *increase number and densities of wild Northern Abalone to self-sustainable levels in each bio-geographic 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 (SARA) status.*

In 2009, COSEWIC reassessed Northern Abalone as endangered, and the species is now legally listed as *endangered* under SARA. The goal of increasing Northern Abalone to self-sustainable levels can be expected to take several decades. Efforts to achieve both the short-term and long-term goals are ongoing and are supported through measures outlined in this action plan (Table 4).

In addition to the recovery goals, some First Nations and community stewardship groups have community-specific goals that support the recovery goals but project further towards sustainable use. The long-term goal in the Nisga'a Community Action Plan (2007) and Haida Gwaii

Northern Abalone Community Action Plan (2008) is to restore local abalone populations to self-sustaining levels that can support First Nations' fishing for food (see Section 5 'Associated Plans' for other recovery plans relevant to the Northern Abalone in Canada).

1.8.2 Population and Distribution Objectives

The population and distribution objectives for the recovery of Northern Abalone as adopted in the recovery strategy are:

1) To observe that mean densities of large adult (≥ 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 (≥ 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 and halt the decline of the Northern Abalone population. Objective #1 is based on population levels in 1990, when all fisheries were closed. Objective #2 is based on the most recent population surveys (at the time the recovery strategy was developed), as a longer time series was not yet available. Objectives #3 and #4 are recovery targets (i.e., self-sustaining population) based on the Northern Abalone population model (*in* Lessard *et al* 2007).

Observing an increase (>40%) in the proportion of quadrats with a single Northern Abalone (Objective #4) is not likely to be attainable within the time frame of this action plan, as it requires current abalone 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.

The population and distribution objectives may be refined with improved knowledge, particularly the Northern Abalone patch size required for recruitment, and improved knowledge of the effects of Sea Otters. Currently, there is insufficient information to set population and distribution objectives for abalone in areas with Sea Otters. Once additional information is available, population and distribution objectives and recovery targets can be re-assessed and revised.

2. Recovery Actions

2.1 Scope of the Action Plan

This Action Plan addresses all the goals and objectives of the Recovery Strategy for Northern Abalone (2007) (see Section 1.8 of this Action Plan).

2.2 Critical Habitat

2.2.1 Identification of Northern Abalone critical habitat

SARA S. 2(1) defines habitat for aquatic species at risk as:
"… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced."

Under SARA S. 2(1), critical habitat is defined 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."*

For the Northern Abalone, critical habitat is identified to the extent possible, using the best information currently available. The critical habitat identified in this action plan describes the geographical area that contains habitat necessary for the survival or recovery of the species. The current area identified is deemed to be sufficient to achieve the population and distribution objectives for the species. As illegal harvest is the most significant threat to Northern Abalone recovery, detailed geospatial information will not be included in the SARA public registry pursuant to SARA Section 124.

2.2.2 Information and Methods Used to Identify Critical Habitat

The geographic locations and biophysical functions, features and attributes of the critical habitat were identified using the best available information, including Northern Abalone, *Haliotis kamtschatkana*, in British Columbia: fisheries and synopsis of life history information (Sloan and Breen, 1988); the *Northern Abalone Case Study for the Determination of SARA Critical Habitat* (Jamieson *et al* 2004); and Describing Northern Abalone, *Haliotis kamtschatkana*, habitat: focusing rebuilding efforts in British Columbia, Canada (Lessard *et al*, 2007).

Northern Abalone occur in a wide variety of habitats from fairly sheltered bays to exposed coastlines, from the low intertidal zone to shallow subtidal depth (DFO 2007). Although the abalone population has declined, there has been no significant reduction in available habitat, and habitat loss is not deemed to be a major threat to the recovery of Northern Abalone (Lessard *et al.* 2007, DFO 2007, COSEWIC 2009). Critical habitat for Northern Abalone is not limited, and the area required for population recovery is less than the area the population currently occupies (COSEWIC 2009).

Critical habitat for Northern Abalone has been identified within four distinct geospatial areas (Figure 3). These four areas constitute the Northern Abalone habitat that is deemed necessary by the Recovery Team and Recovery Implementation Group for the species' survival and recovery: 1) Northern Abalone habitat within the North and Central Coast of the BC mainland; 2) Northern Abalone habitat within the east coast of Haida Gwaii; 3) Northern Abalone habitat in Barkley Sound; and 4) Northern Abalone habitat within the west coast of Haida Gwaii.

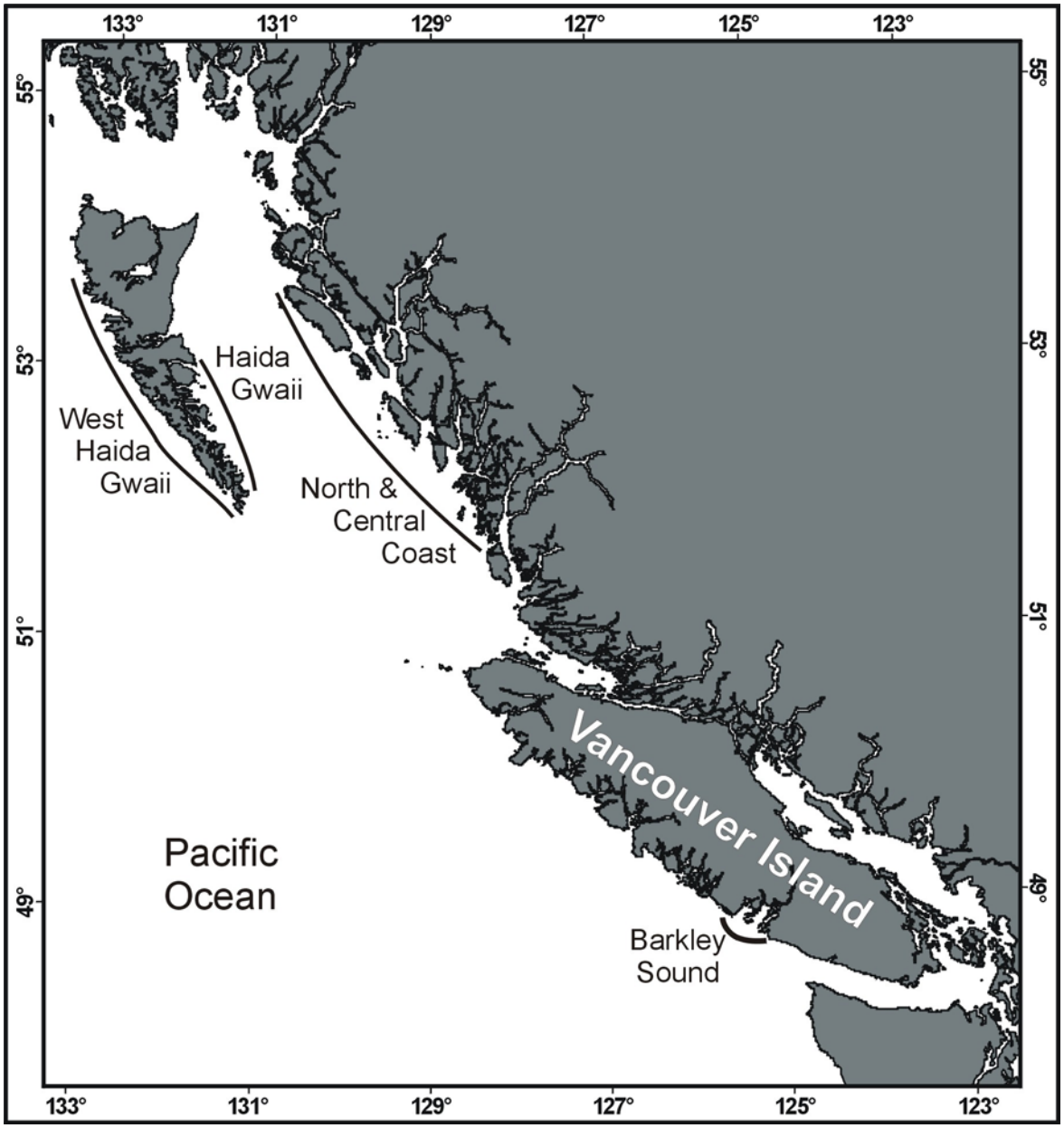

Figure 3. Four distinct geospatial areas of critical habitat for Northern Abalone in Pacific Canadian waters.

The first two areas were identified because these were the historically most productive areas during the former commercial fishery (Farlinger 1990; Harbo and Hobbs 1997). Since 1978,

index site surveys have provided a time series of abalone densities and size frequencies from the Central Coast and Haida Gwaii every 3-5 years (Adkins and Stefanson 1979; Breen and Adkins 1979; Hankewich *et al.* 2008; Hankewich and Lessard 2008). The survey sites were selected because of harvestable commercial abalone abundances. These two areas formed the basis for assessment of Northern Abalone population status. The third area was identified as an important rebuilding area, with several sites established since 2002 (Parks Canada Agency unpublished data; DFO unpublished data). The fourth area demonstrates similar habitat features to those on the east coast of Haida Gwaii based on information from survey sites established in 2008 (DFO unpublished data).

2.2.3 Geospatial Area of Critical Habitat

Within the four areas described above, critical habitat is not comprised of all the area within the identified boundaries but only those areas, within the identified geographic boundaries, where the following specified biophysical attributes occur. Northern Abalone critical habitat is identified at sites at least $20m^2$ in size with ≥ 0.1 abalone/m^2 that contain all of the features and attributes described in Table 2 (Sloan and Breen 1988; Lessard *et al*. 2007; Lessard and Campbell 2007). Density is used to delineate critical habitat, but is not itself considered an attribute of critical habitat. Low densities may exacerbate the decline of the species by reducing fertilization success in this broadcast spawner (the Allee effect).

2.2.4 Functions, Features and Attributes of Northern Abalone Critical Habitat

Abalone are normally found attached to rocks, boulders, bedrock or other stable substrates at depths of < 10m, and in a **water column** that exhibits moderate to high sea water exchange. The presence of a suitable **primary substrate** supports the function of attachment for both the abalone and for **macroalgae**, a feature of critical habitat that provides food and cover for adults. Abalone require a water column with salinity >30 ppt, and are therefore not found near areas of freshwater run-off or in estuarine habitats.

Coralline algae is a feature of critical habitat that serves a number of functions. The presence of coralline algae is the primary settlement cue for larval Northern Abalone, and provides food for the juveniles prior to their transition to a macroalgal diet. It also provides cover and camouflage for adults, both through the incorporation of algal pigments during shell formation, as well as through growth of algal patches on the surface of the shell.

The functions, features and attributes of Northern Abalone critical habitat are summarized in Table 2.

Table 2. Functions, Features and Attributes of Northern Abalone Critical Habitat

FUNCTION	FEATURE	ATTRIBUTE
Attachment Cover	Primary substrate	Bedrock or boulders with adequate rugosity is necessary for attachment. Secondary substrate: some cobble may be present but little or no gravel, sediment, sand, mud, or shell present. ≤10m depth (datum)
Attachment Feeding Larval settling	Water column	Normal salinity (>30 ppt; not low salinity as found close to river run off) Moderate to high water exchange (tidal current or wave action present)
Feeding Larval settling Cover	Coralline algae	Presence of encrusting coralline algae (e.g., *Lithothamnium spp.*)
Feeding Cover	Macroalgae	Presence of *Nereocystis, Macrocystis, Pterygophora or Laminaria spp*

These features and attributes are associated with high quality abalone habitat; however, abalone may not be present in all habitats exhibiting some or all of these features.

2.3 Examples of Activities Likely to Result in Destruction of Critical Habitat

The current statement of what is considered to be destruction of critical habitat is provided in the draft '*Species at Risk Act* Policies: overarching policy framework' (2009) posted on the SARA Public Registry (http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=1916), and describes destruction as follows:

> *"Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time. When critical habitat is identified in a recovery strategy or an action plan, examples of activities that are likely to result in its destruction will be provided".*

Northern Abalone are typically found in exposed and semi-exposed coastal habitat not suitable for the majority of coastal developments. For this reason, there are relatively few types of activities, works or developments, likely to result in critical habitat destruction. A temporary alteration of any combination of the critical habitat features may or may not result in destruction of critical habitat.

Finfish aquaculture, log booms and log dumps, and dredging have the potential to alter the described features and attributes of critical habitat, and may result in loss of function. The construction of underwater pipes or cable placement, installation of pilings or other developments may have similar impacts as dredging (i.e., loss of primary substrate and possible increase in sedimentation), and require mitigation measures if they are proposed for areas within the designated critical habitat (Lessard *et al.* 2007). Concern stems from direct loss of habitat resulting from removal or significant alteration of primary substrate and/or effects on water quality.

Lessard *et al.* (2007) rated the relative impact from these works or developments as low, provided the impact assessment protocol is followed (Appendix 4). Furthermore, the areas potentially affected by such activities are relatively small in the wave-exposed areas of northern B.C. and the west coast of Vancouver Island (COSEWIC 2009) where critical habitat for Northern Abalone is identified (Figure 3). Some examples of activities that are likely to result in the destruction of critical habitat are listed in Table 3.

Table 3. Examples of Activities that are Likely to Result in Destruction of Critical Habitat

Activity	Affect-Pathway	Level of Concern	Function Affected	Feature Affected	Attribute Affected
Dredging Underwater pipe installation Cable placement Piling installation	Direct loss of habitat resulting from removal or significant alteration of primary substrate Effects of sedimentation	Low	Attachment	Primary substrate	Bedrock or boulders with adequate rugosity is necessary for attachment. Secondary substrate: some cobble may be present but little or no gravel, sediment, sand, mud, or shell present.
Finfish aquaculture	Increased sedimentation and physical changes to the substrate	Low	Attachment	Primary substrate	Bedrock or boulders with adequate rugosity is necessary for attachment. Secondary substrate: some cobble may be present but little or no gravel, sediment, sand, mud, or shell present.
Log booms Log dumps	Shading may alter community structure and algal growth	Low	Feeding Larval settling Cover	Coralline algae Macroalgae	Presence of encrusting coralline algae (e.g., *Lithothamnium spp.*) Presence of *Nereocystis, Macrocystis, Pterygophora or Laminaria spp.*

2.4 Proposed Measures to Protect Critical Habitat

Pursuant to subsection 58 (4) of the *Species at Risk Act*, DFO intends to issue an Order to protect Northern Abalone critical habitat.

In addition to the Protection Order, there are various mechanisms that will aid in the protection of critical habitat. Specific criteria to avoid a harmful alteration, disruption or destruction of Northern Abalone habitat are applied through a protocol specifically developed for assessing and protecting Northern Abalone from works or developments in, on or under the water that are proposed in areas of Northern Abalone habitat (Lessard *et al.* 2007; Appendix 4). The protocol applies even in situations where additional measures (to mitigate habitat impacts for other species) prohibiting certain activities (e.g., dredging) are already in place. The protocol also applies to works or developments on, in and under the water that are subject to review under the *Canadian Environmental Assessment Act*. The consistent application of this protocol mitigates impacts to habitat and critical habitat of abalone.

A significant portion of the total critical habitat identified for Northern Abalone falls within the boundaries of National Marine Conservation Areas (NMCAs) and National Marine Conservation Area Reserves (NMCARs). The Gwaii Haanas NMCAR site extends 10 km offshore from Gwaii Haanas National Park Reserve and Haida Heritage Site. This area was established under the *National Marine Conservation Areas Act* and is managed for sustainable use, and protected from industrial activities such as marine dumping, mining, and oil and gas exploration and development.

Pacific Rim National Park Reserve provides protection for abalone critical habitat in Barkley Sound under the *Canada National Parks Act*. Protections in the Park Reserve extend out to 20 metres depth. Parks Canada's protected heritage sites are managed to promote ecosystem integrity, and continued persistence of natural populations by measures to maintain or restore the diversity of genes, species and communities native to the region. Marine Protected Areas may also be established in future under the *Oceans Act*.

Environment Canada's Habitat Stewardship Program (HSP) provides support for Coast Watch, a community-based stewardship program that supports public education, awareness, and abalone patrols to reduce illegal harvest. This program has significant participation from within the First Nations communities.

Habitat and critical habitat for Northern Abalone are also protected under the *Fisheries Act.* Section 35(1) prohibits any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat unless authorized pursuant to Section 35(2).

2.5 Actions and Performance Measures

2.5.1 Measures to be Taken and Implementation Schedule

The specific activities to recover Northern Abalone are summarized in Table 4. Some measures to recover the Northern Abalone population in Canada pre-date the 1990 fisheries closures and the species' legal listing under the SARA. Many of the actions listed below were outlined in the 1999 Workshop for Rebuilding Northern Abalone in B.C. (Dovetail 1999), the 2002 National recovery strategy adopted under the *Accord for the Protection of Species at Risk* (DFO 2002), the 2004 draft National Recovery Action Plan for Northern Abalone, and Recovery Strategy for Northern Abalone (2007), and have been ongoing and improving over several years. To date, these measures continue to be the most comprehensive and extensive means known to recover abalone. New actions or updated approaches have been added to Section 2.4.1 as appropriate. New activities may be added, or those existing activities adapted and revised as new information is gathered.

1. Management

Maintain the fisheries closures for Northern Abalone

Abalone fisheries closures were implemented in 1990 to allow for natural population recovery. However, there is evidence that the reduced abundance and resulting fragmentation of the population (i.e., animals spread too far apart) is hindering recovery. Model simulations from Lessard *et al.* (2007) predict that mortality rates >0.20 would result in further decline in the Northern Abalone population, and recommend that maximum human-induced mortality be near zero. Additional abalone harvest of any kind will significantly hinder recovery. To that end, the following management initiatives will be undertaken:

1.1 Maintain fisheries closures under the *Fisheries Act* and Regulations (1993) to recreational, commercial and First Nations' food, social and ceremonial abalone fisheries to limit mortalities and declines in abundance.

1.2 Restrict release of detailed data on abalone distribution and occurrence collected as a result of monitoring surveys, or proposal reviews conducted under the *Fisheries Act, Canadian Environmental Assessment Act* or SARA, in order to mitigate threats to both individual abalone (illegal harvest) and willful destruction of critical habitat for abalone.

1.3 Continue to employ the monitoring requirements in the impact assessment protocol (Lessard *et al.*2007; Appendix 2) for works and development in abalone habitat and critical habitat.

2. Protection

Implement a compliance promotion and enforcement (proactive and reactive) plan for the recovery of Northern Abalone.

Fisheries and Oceans Canada, Conservation and Protection (C&P) Branch promotes and enforces compliance with legislation that protects Northern Abalone. Efforts are both proactive and

reactive. C&P activities for Northern Abalone are based on: Education and shared stewardship (e.g., public education, media releases, monitoring agreements, presentations to industry, schools and First Nations communities); Monitoring, control and surveillance activities (e.g., land, sea and air patrols, fish inspections, enforcement activities, interagency partnerships, and response to non-compliance); and Management of major cases and special investigations in relation to complex compliance issues (e.g., long-term, intelligence-based investigations that require a high level of specialized investigative skills).

Compliance promotion and enforcement are necessary to reduce mortalities of Northern Abalone from direct illegal harvest (poaching) and to encourage the public to contact C&P when witnessing suspicious activity. Protection of aggregations of abalone and habitats that support them will prevent losses of individuals and important habitat. Detection of abalone in transit disrupts illegal trade between buyers and sellers and allows officers to gather intelligence on individuals and groups involved in the illegal abalone trade. The following compliance and enforcement activities will be undertaken (subject to available resources):

2.1. Education and shared stewardship activities:

- Engage clients, stakeholders and First Nations in compliance decision-making, monitoring agreements, and activities.
- Discuss abalone protection with individuals at wharves, on general patrols, at community events, and at schools.
- Interact with clients and stakeholder groups, First Nations, industry and interested parties on the importance of abalone protection.
- Promote abalone protection and the Observe-Record-Report (ORR) toll-free reporting line (1-800-465-4336).

2.2. Activities to monitor, detect and respond to cases of non-compliance:

- Surveillance of port and offloading sites
- Conduct extensive on-the-water patrols, dive patrols and air patrols (including covert operations) to monitor areas, vessels and persons of interest.
- Build partnerships with other Canadian and international agencies (e.g., Department of Justice, Royal Canadian Mounted Police, Environment Canada, and Canadian Food Inspection Agency).
- Respond to cases of non-compliance (e.g., warnings, alternative measures, orders, prosecutions, community-based justice processes).

2.3. Develop major cases and intelligence-based investigations on illegal abalone trade.

- Build intelligence to disrupt the illegal supply-demand chain.
- Follow up on tips received from the public, informants and partners.
- Work with national and international enforcement agencies to share intelligence and disrupt movement of abalone.

2.4. Continue to review development proposals under the *Fisheries Act* following the impact assessment protocol (Appendix 4) to mitigate harmful alteration, disruption or destruction of abalone habitat and critical habitat.

3. Education and Awareness

Implement a communications campaign to stop illegal harvest and raise public awareness of Northern Abalone.

Communications campaigns are expected to increase support for, and awareness of, enforcement efforts, encourage public involvement and community stewardship of abalone. The communications approach will be used to support an 'anti-poaching' message:

3.1 Continue to raise awareness of the plight of the abalone and the threats to their survival, including, but not limited to:

- Continue to provide communications support to stewardship activities to further the First Nations and community involvement in the abalone action plan.
- Promote delivery of the education tool kit through distribution and use within the public education system.
- Continue to use abalone displays at public events and in public areas, and identify new and upcoming events at which to promote abalone information.
- Engage in media relations to highlight abalone issues, status and stewardship successes.

3.2 Stop or discourage illegal harvesting activities, including but not limited to:

- Continue to promote the Abalone Coast Watch Program and the Observe-Record-Report phone number (e.g., sticker/card with reporting information and phone number).
- Continue to involve First Nations and other coastal communities in monitoring and reporting poaching activities.
- Engage in media relations to deter illegal harvest, and raise awareness of enforcement actions and results (e.g., arrests, convictions, fines).
- Where possible, foster public support of court imposed sentencing that is appropriate to the status of Northern Abalone. This may be achieved by educating the general public through publications, other communication media, and the provision of impact statements to the court.

3.3 Significantly reduce demand for (illegal) Northern Abalone by targeting sales and consumption of Northern Abalone, including but not limited to:

- Engage in media and public relation to explain the distinction between illegal and legal types of abalone in the marketplace.
- Foster restaurant (e.g., "We only use legal abalone" sticker) and consumer-directed awareness programs (e.g., Marine Stewardship Certification, Seafood Watch).

4. Research and Population Rebuilding

Research that leads to improved understanding of threats, life history, recruitment and predator-prey interactions with Sea Otters will assist in developing long-term population and distribution objectives for Northern Abalone recovery. The potential contributions of First Nations traditional knowledge to improved understanding of Northern Abalone habitats is recognized and supported by an ecosystem approach. Evaluation of pilot projects is necessary to prioritize carrying out activities, as well as determine the appropriate rebuilding method(s) to address poor adult recruitment and to fill knowledge gaps on Northern Abalone biology, habitat and ecology. Criteria for evaluating feasibility of pilot projects should include the method's ability to increase abalone abundance in study areas, efficiency, practical application and cost effectiveness. Studies and findings about abalone in other jurisdictions may also be incorporated into B.C. activities as applicable. Some research findings, including abalone traditional knowledge, may overlap and/or complement one another.

a) research on Northern Abalone to improve understanding of abalone recruitment and species interactions:

4.1 If a disease is detected, conduct examinations to identify the cause of disease(s). If the disease is determined to be infectious, investigate the etiological agent to identify the pathogen and determine the biology of the pathogen to find methods of prevention or control.

4.2 Conduct computer simulations to determine potential larval dispersal mechanisms.

4.3 Kinship analyses may be conducted to identify adults to their progeny in support of linking the source of adult concentrations with the proportion of their recruited progeny in an area in (i) wild adult aggregation studies, and (ii) hatchery-raised abalone outplanting studies.

4.4 Investigate ecological interactions with Sea Otters and their role in the recovery of Northern Abalone by establishing pilot research areas where Sea Otters occur to determine abalone population parameters under the effects of Sea Otters and to determine population and distribution objectives in the presence of Sea Otters.

4.5 Evaluate feasibility and effectiveness of pilot aggregation and translocation projects. Aggregating reproductive adult abalone is intended to increase density and improve reproductive success; and translocating "surf" abalone to calmer, kelp abundant habitats, is intended to improve growth rates and reproductive success[1].

4.6 Evaluate the feasibility and effectiveness of outplanting[2] using data from pilot projects conducted between 2000 - 2010. Pilot projects initiated under the rebuilding program have concluded.

[1] This action is subject to review and permitting under SARA (S. 73).

[2] This action is subject to review and permitting under SARA (S. 73).

4.7 Promote additional traditional knowledge research, using appropriate and respectful methods (e.g., HMTK Study Participants *et al.* 2008). Observations regarding habitat requirements and critical habitat areas may be valuable information that First Nations TK can contribute to abalone rebuilding (See Appendix 3 for example interview questions).

b) Continue to promote abalone population rebuilding initiatives in collaboration with First Nations and other coastal communities

First Nations and coastal communities have taken a lead in population rebuilding projects. Without this involvement, contribution and interest, many of the population rebuilding efforts and the associated research activities may not be possible (e.g., cost, time and effort prohibitive). Working co-operatively with coastal First Nations on proposals for projects that are in First Nations' local areas, and with coastal communities and possibly other jurisdictions, will assist in the efforts for abalone population rebuilding.

While wild-to-wild translocations and aggregations of adults and outplanting of hatchery-raised abalone to the wild have shown some promise, their outcomes have often been poor and uncertain (Tegner 2000). In addition, their effects are likely very localized and may not be suited for species recovery on the whole. Evaluation is necessary (see Actions 4.5, 4.6 above) to determine appropriate use of these methods.

4.8 Conduct small scale enhancement of habitat to monitor and increase survival of early abalone benthic stages. Northern Abalone, especially juveniles, are cryptic and hide in rock crevices, which makes monitoring of juvenile survivorship difficult. Currently, contained units (concrete blocks caged in small enclosures (e.g., crab traps), are being used to increase rugosity (i.e., hiding crevices), to monitor juvenile and early life stages' survival and species interactions (e.g., with Sea Otters), and to allow efficient sampling without disrupting the natural environment.

4.9 Examine growth, survival and distribution of early benthic stages in relation to local habitat, algal, predator and competitor species, in order to determine the parameters that contribute to higher juvenile densities (recruitment). Promote the participation of First Nations in identification of habitat requirements for the rebuilding program. Years of observations can potentially provide information on habitat characteristics; previous distribution; particularly productive areas; areas predominated by juveniles or unusually large abalone; and spawning areas.

5. Population Monitoring

Monitor population status of Northern Abalone

Establishing a time series of abundance estimates is needed in the five biogeographic zones[1] to determine the progress (decline or increase) of recovery in the Northern Abalone population compared to the population and distribution objectives. Ongoing monitoring of the abalone population is needed to assess its recovery and long-term viability, and the effectiveness of threat mitigation. Continuation of the current time series is needed to model and study recruitment variation, and population dynamics, in support of rebuilding efforts. The data collected in these surveys will be necessary to evaluate all of the objectives-based performance measures.

5.1 Continue index site surveys every 4-5 years (started 1978) in the North and Central Coast and Haida Gwaii, which includes the collection of habitat information.

5.2 Continue more recently established index surveys every 4-5 years (started 2003) on the West Coast of Vancouver Island, Georgia Basin, and in Queen Charlotte Strait, which includes the collection of habitat information.

5.3 Test new or modifications of existing survey methods to estimate the abundance of abalone of different life stages, aggregation size (patchiness), suitable habitat and habitat mapping.

2.5.2 Performance Measures

The performance measures outlined in Section 2.5 of the Recovery Strategy for Northern Abalone (2007) also apply to this action plan. Some questions from the recovery strategy have been re-framed (shown in *italics*) to focus and support future analyses of performance and progress towards achieving the stated objectives. A report on progress toward addressing each of the action-based performance measures from the recovery strategy is provided (Appendix 2).

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 increase (>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?

[1] Five biogeographic zones were identified for Northern Abalone in B.C. based on environmental, management and/or biological considerations. These areas include intertidal and subtidal waters surrounding the following land areas: Haida Gwaii; North and Central Coasts (Cape Caution north to and including Prince Rupert); Queen Charlotte and Johnstone Straits (Seymour Narrows near Quadra Island north to Cape Caution); Georgia Basin (San Juan Point to Seymour Narrows near Quadra Island); and West Coast of Vancouver Island (San Juan Point north to the Scott Islands).

Action-based performance measures:

Management

- Was the coast-wide closure to northern abalone harvesting maintained and enforced? *Is there evidence for success in detecting and apprehending illegal harvesters?*[1]

Protection

- 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 much effort has been spent on enforcing abalone closures (e.g., months, hours)? What were the trends in enforcement hours and resulting charges and convictions over the period before and during implementation of the recovery strategy? *Has the impact of the illegal harvest been studied further?*

Education and Awareness

- 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?) were a result of communications efforts?

Research and Population Rebuilding

- 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?

Population Monitoring

- *Were regular surveys continued in each of the biogeographic zones*[2]?

2.6 Proposed Implementation Schedule

The specific activities to recover Northern Abalone are summarized in Table 4. Activities are largely ongoing, and implementation dates[3] are given. Where appropriate, partnerships with

[1] In place of, "Was the coast-wide closure an effective measure contributing in halting the population decline?"

[2] Replaces 'Was baseline abundance established in each of the biogeographic zones?' That action has been completed.

[3] Implementation dates may refer to implementation of an improved program rather than a date at which similar activities were started.

specific organizations and sectors have been identified. These partnerships and organizations will provide expertise and capacity to carry out the listed action. In consideration for reducing costs, activities will be combined where appropriate. Fisheries and Oceans Canada encourages groups and individuals other than those listed in Table 4 to participate in the recovery program for Northern Abalone in B.C. The list of organizations below will be adapted as needed.

Many actions in Table 4 were prioritized by the ART and AbRIG during the 2004 action planning process. Ratings and participation were re-confirmed at the 2009 AbRIG meeting. Priority ratings used in 2004 and 2009 were adapted from the criteria established by the national recovery program RENEW (Recovery of Nationally Endangered Wildlife; *A Working Draft - Recovery Operations Manual 20 November 2001*):

"*Urgent*" – an activity addressing the main threats from illegal harvest and low recruitment, with a high predictability of success; or that is mandated under SARA; or

"*Necessary*" – an activity addressing knowledge gaps and/or other threats, for which success may be measured over the long-term; or

"*Optional*" – an activity primarily outside those activities specific to abalone recovery, but which could impact abalone recovery.

Key to Abbreviations used in Table 4:

BMSC	Bamfield Marine Sciences Centre Public Education Program
CC	B.C. coastal communities
CCG	Canadian Coast Guard, Fisheries & Oceans Canada
CFIA	Canadian Food Inspection Agency
DFO	Fisheries and Oceans Canada
DND	Canadian Department of National Defense
EC	Environment Canada - Habitat Stewardship Program for Species at Risk (HSP) and Aboriginal Funds for Species at Risk (AFSAR)
FN	First Nations
HASP	Heiltsuk Abalone Stewardship Project (Heiltsuk Fisheries Program)
HGAbS	Haida Gwaii Abalone Stewards, a partnership of the Haida Fisheries Program, Skidegate Band Council, Old Massett Village Council, Laskeek Bay Conservation Society, Gwaii Haanas National Park Reserve and Haida Heritage Site, World Wildlife Fund Canada, Simon Fraser University (SFU) Centre for Wildlife Ecology, SFU School of Resource and Environmental Management, Environment Canada and Fisheries and Oceans Canada.
KASP	Kitasoo Abalone Stewardship Program (Kitasoo Fisheries Program)
MFP	Metlakatla Fisheries Program
NFD	Nisga'a Fisheries Department
NGOs	Non-governmental Organizations (e.g., Marine Stewardship Certification, Seafood Watch programs)
PCA	Parks Canada Agency
Proponent	Proponent for the works or developments on, in or under the water

PROV	Province of B.C. Ministry of Environment, B.C. Assets and Lands (provincial government), B.C. Conservation Officers Service
RCMP	Royal Canadian Mounted Police
TRAFFIC	Wildlife Trade Monitoring Network
Univ	Universities, e.g., Simon Fraser University, University of Victoria, and Thompson Rivers University

Table 4. Proposed Implementation Schedule. Activities listed are largely ongoing and many recovery measures were implemented prior to SARA's proclamation and to the SARA Recovery Strategy (DFO 2007).

Recovery Activities	Obj.	Priority	Threats or concerns addressed	Responsibility		Start Date
				Lead	Partners[1]	
1. **Management**						
1.1 Aboriginal, recreational and commercial abalone fisheries remain closed	All	U	Harvest Low recruitment	DFO	CCG	Since 1990
1.2 Restrict release of detailed distribution and location to mitigate poaching and destruction of critical habitat	1, 2, 3	U	Harvest Low recruitment Habitat degradation/ loss	DFO	All	Since 1990
1.3 Continue to employ monitoring requirements in Lessard et al (2007) protocol for works and development in abalone habitat and critical habitat	All	U	Habitat degradation/ loss, Critical Habitat destruction, Monitoring	DFO Proponent	PCA	Since 2007
2. **Protection**						
2.1 Promote compliance through education	All	U	Harvest Low recruitment	DFO	CCG, FN, PCA	Since 1990
2.2 Monitor and respond to non-compliance	All	U	Harvest Low recruitment	DFO	RCMP, DND, PCA	Since 1990
2.3 Build major cases and special investigations on illegal abalone trade	All	U	Harvest Low recruitment	DFO	RCMP, CFIA, DND, EC, PCA, PROV, TRAFFIC	Since 1990, new efforts in 2010 are ongoing
2.4 Review works and development proposals in abalone habitat and critical habitat	1, 2, 3	U	Low recruitment Habitat degradation/ loss	DFO	PROV Proponent	Ongoing, as required
3. **Education & Awareness**						
3.1 Raise awareness	All	N	Harvest Low recruitment SARA status	HGAbS, KASP, G-N, HASP, MFP, NFP, BMSC,	DFO	Since 2000

[1] Partnerships do not necessarily identify specific actions or subsidiary actions required to complete the recovery activity.

Recovery Activities	Obj.	Priority	Threats or concerns addressed	Responsibility		Start Date
				Lead	Partners[1]	
				CC & FN, PCA, EC		
3.2 Discourage illegal harvest	All	U	Harvest Low recruitment	DFO	EC, HGAbS, KASP, NFP, MFP, G-N, HASP, BMSC, CC & FN, PCA	DFO since 1990, stewardship efforts since 2000
3.3 Reduce commercial demand of illegal product and target markets	All	N	Harvest Low recruitment	DFO	Restaurants ENGOs	Since 2003
4. **Research & Rebuilding**						
4.1 Disease	All	N	Low recruitment		DFO	Since 2003
4.2 Larval dispersal	All	N	Low recruitment		PCA DFO	Since 2002, again in 2009
4.3 Kinship identification	All	N	Low recruitment	Univ	DFO PCA BHCAP	Since 2002
4.4 Species interactions	3, 4	N	Sea Otters Habitat effects	KASP, HASP, HGAbS, Univ	PCA DFO	Since 2002, new efforts in 2010 ongoing
4.5 Evaluate feasibility and effectiveness of pilot aggregation and translocation projects	All	U	Low recruitment	KASP	HGAbS, MFP, Gitga'at, DFO, EC, PCA	Since 2001 Data analysis in 2010/11
4.6 Evaluate feasibility and effectiveness of pilot out-planting	All	U	Low recruitment Population rebuilding	Univ	BHCAP, Univ, DFO	Outplanting since 2003, surveyed some sites 2000, 2002, 2003 Report expected 2011/12
4.7 Traditional knowledge	All	N	TK, biology, ecology, threats, habitat	FN	AbRIG DFO	2009
4.8 Enhancement to protect early life-stages	All	N	Low recruitment Juvenile Survival	HGAbS, KASP	DFO, EC	Since 2001
4.9 Research on early benthic stages, identify habitat requirements	All	U	Low recruitment Population	Ab RIG, HGAbS, Univ	DFO, PCA	Since 2002, new efforts in 2010 ongoing

Recovery Activities	Obj.	Priority	Threats or concerns addressed	Responsibility		Start Date
				Lead	Partners[1]	
			rebuilding			
5. **Monitoring**						
5.1 Index site surveys • North and Central Coasts • Haida Gwaii	1, 3, 4	U	All (Monitoring)	DFO	HGAbS MFP	Since 1978, 2011 2012
5.2 Baseline abundance surveys in southern B.C. • WCVI • QCS	3, 4	U	All (monitoring)	DFO	PCA	Since 2003, 2013 2014
5.3 Survey methodology for juveniles	All	N	Low recruitment	HGAbS, KASP, Univ	DFO, PCA	Since 2002

3. Effects on Other Species

Table 5. Potential effects of abalone recovery actions on other species.

Broad Strategy	Potential Impact	Probability of Impact
1. Management	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. Recovery of abalone may be beneficial to other species.	*Low - Beneficial*
2. Protection	Increased compliance promotion and 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. Application of the protocol for works and development will mitigate effects to other species and to near-shore habitats.	*High - Beneficial*
3. Education and Awareness	Communications may benefit other species associated with abalone communities and other species at risk by raising awareness and increasing reports of illegal harvesting.	*Medium- Beneficial*
4. Research and Rebuilding	Rebuilding experiments may impact other species on a localized scale.	*Medium - Detrimental*
	Research may provide a better understanding of species and ecological interactions.	*High - Beneficial*
5. Population Monitoring	Time series data may help to better understand species population changes of other species and ecosystem processes.	*Medium - Beneficial*

4. Socio-Economic Evaluation

The Species at Risk Act requires the responsible federal minister to undertake *"an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation"*[1]. This section identifies the anticipated socio-economic impacts associated with the proposed action items in this action plan.

As per section 49(1)(e) of the Act, SARA requires a socio-economic evaluation to assess the costs of the action plan and the benefits to be derived from its implementation. For this action plan, costs of implementation of recovery actions borne by government agencies (e.g., Fisheries and Oceans Canada, Parks Canada Agency, Province of B.C.) are evaluated as a reallocation of existing government funds and are not considered additional costs to society. There are

[1] *SARA* s.49 (1)(*e*).

opportunity costs associated with these government funded actions. However these are not easily quantified.

The combined activities in this action plan are expected to rebuild the Northern Abalone population in the longer term. This will yield benefits for coastal First Nations due to the long history and significant social, cultural and historical use of the species. Recovery is also expected to provide wider societal benefits as abalone is a regionally iconic species likely to have a substantial non-market value.

Actions to recover Northern Abalone, such as coast-wide fisheries closures, pre-date the listing of the species under SARA in 2003. This evaluation considers recovery activities initiated since Northern Abalone was listed as threatened under SARA. It also considers the new and ongoing activities outlined in this action plan. The socio-economic costs of these actions are addressed below under the strategic objective headings of management, protection, education and awareness, research and rebuilding, and population monitoring.

4.1 Management

Complete fisheries closures were implemented under the *Fisheries Act* in 1990 as a result of significant conservation concerns for this species. This Action Plan does not propose changes to existing fisheries closures for abalone. The costs associated with the fisheries closures and foregone ability to harvest the species are a consequence of actions other than those in this action plan or a SARA listing. Consequently, no additional socio-economic impacts to the commercial, recreational or First Nations food, social and ceremonial fisheries are expected as a result of this action plan.

4.2 Protection

Efforts to protect a species-at-risk and to mitigate harmful alteration, disruption or destruction of habitat and critical habitat can result in socio-economic impacts for Canadian society if modifications to existing or future activities are required. However, Northern Abalone is found mostly in environments not suitable for the majority of coastal developments. As such, cost impacts for mitigating habitat threats related to existing development are not expected. In the case of future coastal projects, habitat alterations are expected to be low provided the existing Northern Abalone habitat protection Assessment Protocol is followed (Lessard *et al.* 2007; Appendix 2). However, the assessment protocol requires that a risk assessment be undertaken prior to any new coastal works or for modification to existing developments. This will result in compliance costs for proponents of such works to undertake dive surveys. No additional socio-economic impacts are expected to the broader Canadian public.

Subject to available resources, compliance promotion and enforcement efforts targeting illegal harvest of abalone will continue to be maintained through existing government programs over the timeframe of the action plan and are not expected to result in any additional costs to Canadians.

4.3 Education and Awareness

Illegal harvest is identified as a significant threat contributing to the decline of Northern Abalone in Canada. To address this threat, this action plan calls for the continuation of communications campaigns to increase support for enforcement efforts, encourage public involvement and community stewardship of abalone.

Awareness campaigns targeting illegal harvest of abalone will continue dependent on existing government programs over the timeframe of the action plan and are not expected to result in any additional costs to Canadians. However, in-kind costs related to support to enforcement (e.g., Coast Watch) and stewardship activities have been and will continue to be incurred by First Nations, volunteers and ENGOs involved in activities funded through the Habitat Stewardship Program for Species at Risk (HSP) and the Aboriginal Funds for Species at Risk (AFSAR) programs.

Recovery actions related to patrolling, Coast Watch, education and awareness that further First Nations and community involvement have resulted, and are expected to continue to result, in ongoing capacity building and short-term employment opportunities. Some in-kind costs and funds from partners such as First Nations, and non-government funding organizations (see Table 4) are expected.

4.4 Research and Rebuilding

Identification of key habitats is highlighted as an important component to abalone research and rebuilding plans. This action plan outlines studies (i.e., research and rebuilding experiments) that were initiated since 2003 and continue dependent on existing government programs over the timeframe of the action plan. This component of this action plan will not result in additional cost impacts for the Canadian public. However, the implementation of this component has resulted in some in-kind costs to First Nations for aggregation studies, hatchery operations and out-planting juvenile abalone studies.

As First Nations have been involved in and will continue to participate and lead in implementing government funded research projects; capacity building and some short-term employment benefits resulting from these activities will continue. Some in-kind costs and funds from partners such as universities, First Nations, volunteers and non-government funding organizations (see Table 4) are expected.

4.5 Population Monitoring

Dive survey activities to monitor the status of the population have been ongoing and are expected to continue as outlined in this action plan. The majority of monitoring costs has been and will continue to be borne by Department of Fisheries and Oceans and Parks Canada Agency. Some in-kind support is provided by First Nations organizations, and is expected to continue. Activities related to dive surveys that further First Nations involvement are expected to continue to result in short-term employment opportunities and capacity building.

4.6 Summary

General approaches to reach the population and distribution objectives outlined in the action plan are: maintain existing fisheries closures; implement a compliance promotion and enforcement plan; implement a communications campaign to stop illegal harvest and raise public awareness; undertake research; support rebuilding initiatives and monitor the status of the population. These activities have been on-going prior to this action plan, and some activities precede even the listing of Northern Abalone under SARA. Since the species was listed in 2003, the majority of the costs of recovery activities related to enforcement, research and population monitoring have been borne by Department of Fisheries and Oceans and Parks Canada Agency. These agencies will continue to support these activities based on available resources, expertise, and varying species at risk conservation priorities over the timeframe of this action plan.

The protection and recovery of Northern Abalone in Canada depends upon a meaningful collaboration among the Department of Fisheries and Oceans, Parks Canada Agency, First Nations, ENGOs and others in the implementation of this action plan. In-kind costs have been incurred and are expected to continue for First Nations and ENGOs participating in action plan activities. As well, some in-kind costs related to stewardship activities and enforcement activities outlined in this action plan are also expected for First Nations organizations that are participating in implementation of government funded recovery activities under AFSAR and HSP programs. In terms of benefits, community and First Nations involvement will result in capacity building and short-term employment.

In the longer term, actions to rebuild the population would likely yield benefits for coastal First Nations due to the long history and significant social, cultural and historical use of the species. Abalone recovery would yield wider societal benefits as abalone is a regionally iconic species and is likely to have a substantial non-market value.

5. Associated Plans

First Nations and area-based Community Action Plans have similar goals and objectives which support efforts to achieve the long-term goal of the Recovery Strategy to achieve sustainable population levels in each of the bio-geographic zones.

Recovery Strategy for Northern Abalone (*Haliotis kamtschatkana*) in Canada (2007) http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=1342

Draft National Recovery Action Plan for Northern Abalone (2004) http://www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/Abalone/default_e.htm

Metlakatla Coast Watch. North Coast Community Action Plan for protecting and restoring Northern Abalone (March 2008). *DRAFT*

Nisga'a Abalone Coast Watch. Community Action Plan for protecting and restoring Northern Abalone (October 2007).
http://oceanlink.island.net/Conservation/abalone/BHCAP/Nisga/Nisga_action_plan.pdf

Haida Gwaii Northern Abalone Community Action Plan (March 2008)
http://www.marinematters.org/programs/AbaloneActionPlanMar2008.pdf

Recovery Strategy for the Sea Otter (*Enhydra lutris*) in Canada (2007)
http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=1373

6. References

Adkins, B.E. and A.P. Stefanson. 1979. North coast survey in harvested areas, November 1978. Can. Manuscr. Rep. Mar. Serv. 1500. iii + 15pp.

Atkins, M., J. Lessard, and A. Campbell. 2004. Resurvey of Northern Abalone, *Haliotis kamtschatkana*, populations in Southeast Queen Charlotte Islands, British Columbia, April 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2704:37 pp.

Bergman, C., J. Pattison, and E. Price. 2010. Black Oystercatchers preying on northern abalone in Haida Gwaii. Abstract submitted to the First World Seabird Conference, Victoria, September 2010.

BMSC (Bamfield Marine Science Centre) 2007. CoastWatch Brochure produced by BMSC Education Program.

Breen, P. A., and Adkins, B. E. 1979. A survey of abalone populations on the east coast of the Queen Charlotte Islands, August 1978. Fish. Mar. Serv. MS. Rep. 1490: 125p.

Carpenter, J., personal communication. 2007. Abalone Recovery Implementation Group meeting November 2007. Biologist, Heiltsuk Fisheries Program, Bella Bella, B.C.

Clavier, J., and O. Richard. 1986. Estimation du stock naturel d'ormeaux (*Haliotis tuberculata*) dans la région de Saint-Malo. Revue des Travaux de l'Institut des Pêches Maritimes 48:95-105.

COSEWIC. 2009. COSEWIC assessment and update status report on the Northern Abalone *Haliotis kamtschatkana* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 48 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

DFO (Fisheries and Oceans Canada). 2007. Recovery Strategy for Northern Abalone (*Haliotis kamtschatkana*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. *vi* + 31 pp.

Dovetail. 1999. A Strategy for Rebuilding Abalone Stocks in British Columbia: Report on the Workshop on Rebuilding Abalone Stocks in British Columbia, Nanaimo, B.C., February 23-26, 1999. Prepared for Fisheries and Oceans Canada by Dovetail Consulting Inc., Vancouver, B.C. 39 pp.

Ellis, D.W., and S. Wilson. 1981. The knowledge and usage of marine invertebrates by the Skidegate Haida People of the Queen Charlotte Islands. Queen Charlotte Islands Museum

Monograph Series No. 1:42 p. Queen Charlotte Islands (now Haida Gwaii) Museum Society, Skidegate, B.C.

Ellis, D.W, and L. Swan. 1981. Teachings of the tides. Uses of marine invertebrates by the Manhousat People. Theytus Books, Nanaimo. 118p.

Environment Canada. 2009. *Species at Risk Act* Policies: an overarching framework [DRAFT]. *Species at Risk Act* Policy and Guidelines Series. Environment Canada, Ottawa. 37pp.

Foucher, E., and M.L. Cochard. 2005. Exploitation professionnelle de l'ormeau dans la zone nord du Cotentin. Bilan de la campagne de pêche 2004-2005. 11 pp.

Council of Haida Nation, World Wildlife Fund Canada, Gwaii Haanas National Park Reserve and Haida Heritage Site. 2009. Gaaysiigang: an ocean forum for Haida Gwaii. January 23-24, 2009. Haida Fisheries Program, Council of the Haida Nation: Old Massett.

Geiger, D.L. 1999. A total evidence cladistic analysis of the family Haliotidae (Gastropoda: Vetigastropoda). Ph.D. Thesis, University of Southern California, Los Angeles. xix + 423 pp.

Haida Gwaii Abalone Stewards. 2008. Haida Gwaii Northern Abalone Community Action Plan (updated March 2008). Council of the Haida Nation, Haida Gwaii. 8pp.

Haida Marine Traditional Knowledge Study Participants, J. Winbourne, and Haida Oceans Technical Team of the Haida Fisheries Program. 2008. Haida Marine Traditional Knowledge Study: Phase 1 Progress Report. Unpublished report, Haida Tribal Society, Massett, B.C. 75 pp.

Hankewich, S., and J. Lessard. 2008. Resurvey of Northern Abalone, *Haliotis kamtschatkana*, populations along the central coast of British Columbia, May 2006. Can. Manuscr. Rep. Fish. Aquat. Sci. 2838:40 pp. 42

Hankewich, S., J. Lessard, and E. Grebeldinger. 2008. Resurvey of Northern Abalone, *Haliotis kamtschatkana*, populations in southeast Queen Charlotte Islands, British Columbia, May 2007. Can. Manuscr. Rep.Fish. Aquat. Sci. 2839:37 pp.

Harbo, R. and K. Hobbs. 1997. Pacific commercial fishery updates for invertebrate resources (1994). Can. Manuscr. Rep. Fish. Aquat. Sci. 2369. v + 181pp.

Jamieson, G.S. E.J. Gregr, and C. Robinson. 2004. Northern abalone case study for the determination of SARA critical habitat. Can. Sci. Adv. Secr. Res. Doc. 2004/117. 57 p.

Jones, R., N. Sloan and B. DeFreitas. 2004. Prospects for Northern Abalone *(Haliotis kamtschatkana)* Recovery Through Community Stewardship. *In:* Making Ecosystem Based Management Work, Proceedings of the Fifth International Conference on Science and Management of Protected Areas. Science and Management of Protected Areas Association, Nova Scotia, Canada.

Kii7iljuus (B. J. Wilson) and H. Harris. 2005. Chapter 7: *Tllsda Xaaydas K'aaygang.nga:* Long, Long Ago Haida Ancient Stories. *In:* Fedje DW and RW Mathewes (eds). Haida Gwaii: Human History and Environment from the Time of Loon to the Time of the Iron People. UBC Press: Vancouver. pp 121-139.

Kosmider, G. 2009. personal communication. Recovery Planner. Fisheries and Oceans Canada –

Oceans, Habitat and Enhancement Branch. Nanaimo, B.C.

Lessard, J., A. Campbell, Z. Zhang, L. MacDougall, and S. Hankewich. 2007. Recovery Potential Assessment for the Northern Abalone, (*Haliotis kamtschatkana*,) in Canada. Can. Sci. Adv. Sec. Res. Doc. 2007/061. 107pp. http://www.dfo-mpo.gc.ca/csas-sccs/publications/resdocs-docrech/2007/2007_061-eng.htm

Lessard, J., and A. Campbell. 2007. Describing Northern Abalone, Haliotis kamtschatkana, habitat: focusing rebuilding efforts in British Columbia, Canada. Journal of Shellfish Research 26:677-686.

McLean, J. H. 1966. West American prosobranch gastropoda: Superfamilies Patellacae, Pleurotomariacea, and Fissurellacea. Ph. D. dissertation, Stanford University, CA. 255 p.

Nisga'a Abalone Coast Watch. 2007. Community Action Plan for protecting and restoring Northern Abalone (October 2007). Nisga'a Fisheries Program, Prince Rupert. 4 pp. http://oceanlink.island.net/Conservation/abalone/BHCAP/Nisga/Nisga_action_plan.pdf

Roberts, R. 2001. A review of settlement cues for larval abalone (*Haliotis* spp.). Journal of Shellfish Research 20:571-586.

Rogers-Bennett, L. 2007. Is climate change contributing to range reductions and localized extinctions in northern, (*Haliotis kamtschatkana*), and flat, (*Haliotis walallensis*), abalones? Bulletin of Marine Science 81: 283-296.

Sea Otter Recovery Team. 2007. Recovery Strategy for the Sea Otter (*Enhydra lutris*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Vancouver. vii+56pp.

Skidegate Haida Immersion Program. 2007. Personal communication. 2007. Skidegate, B.C.

Sloan, N.A. 2006. Living marine legacy of Gwaii Haanas. V: Coastal zone values and management around Haida Gwaii. Parks Can. Tech. Rep. in Ecosys. Sci. 042. xxviii + 413 pp.

Sloan, N.A. 2003. Evidence of California-area abalone shell in Haida trade and culture. Canadian Journal of Archaeology 27:273-286.

Sloan, N. A., and Breen, P. A. 1988. Northern Abalone, *Haliotis kamtschatkana*, in British Columbia: fisheries and synopsis of life history information. Can Spec. Publ. Fish. Aquat. Sci. 103. 46 p.

Sm'algyax Language Committee. 2005. Suwilaawksa Sm'algyax: Learning Sm'algyax – A Guide to Accompany Sm'algyax Language CDs. Ts'msyen Sm'algyax Language Authority. School District 52, Prince Rupert, B.C.

Steneck, R.S. 1986. The ecology of coralline algal crusts: convergent patterns and adaptive strategies. Annual Review of Ecology and Systematics 17:273-303.

Stewart, B., personal communication. 2007. Abalone Recovery Implementation Group meeting November 2007. Manager, Nisga'a Fisheries Program, New Aiyansh, B.C.

Tegner, M. J. 2000. Abalone (*Haliotis* spp.) enhancement in California: what we've learned and where we go from here. *In* Workshop on rebuilding abalone stocks in British Columbia. *Edited by* A. Campbell. Can. Spec. Publ. Fish. Aquat. Sci. 130. pp. 61-71.

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. Journal of Shellfish Research 22:831-838.

Withler, R.E., A. Campbell, S. Li, K.M. Miller, D. Brouwer, and B.G. Lucas. 2001. High levels of genetic variation in Northern Abalone *Haliotis kamtschatkana* of British Columbia. Can. Sci. Adv. Secr. Res. Doc. 2001/097. 27 pp.

Zhang, Z., J. Lessard, and A. Campbell. 2009. Use of Bayesian hierarchical models to estimate northern abalone, *Haliotis kamtschatkana*, growth parameter from tag-recapture data. Fish. Res. 95:289-295.

Appendix I: Recovery Implementation Group(s) or Planner(s)

Abalone Recovery Team (2009/ 10) (ART)

Laurie Convey	Fisheries and Oceans Canada (Chair)
Tatiana Lee	Fisheries and Oceans Canada (Co-Chair 2009/10)
Joanne Lessard	Fisheries and Oceans Canada
Louvi Nurse	Fisheries and Oceans Canada
Raquel Roizman	Fisheries and Oceans Canada
Barron Carswell	Province of British Columbia
Heather Holmes	Parks Canada Agency
Jas Sidhu	Fisheries and Oceans Canada
Pauline Ridings	Fisheries and Oceans Canada
Trevor Gray	Fisheries and Oceans Canada
Denise Koshowski	Fisheries and Oceans Canada
Sheila Thornton	Fisheries and Oceans Canada

Resource Personnel:

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Patrick Mahaux	Fisheries and Oceans Canada
Michelle Li	Fisheries and Oceans Canada
Gabriele Kosmider	Fisheries and Oceans Canada
Heather Stalberg	Fisheries and Oceans Canada

Abalone Recovery Implementation Group 2009/10 (AbRIG)

Anne Stewart	Bamfield Marine Sciences Centre, Public Education Program
Bart DeFreitas	Golder and Associates
Blair Stewart	Nisga'a Fisheries Program
Brian Wadhams	'Namgis First Nation
Bruce Clapp	Underwater Harvesters Association
Bryan Jubinville	DFO Conservation & Protection
Chris Pearce	DFO Science (Shellfish Aquaculture)
Chris Picard	Gitga'at Fisheries Program
Denise Koshowksi	DFO Conservation & Protection
Don Rothaus	Washington Dept. of Fish & Wildlife
Ellis Clifton	Gitga'at Fisheries Program
Ernie Cooper	TRAFFIC
Guy Whyte	Pacific Trident Fishing Co. Ltd.
Heather Holmes	Parks Canada Agency, Pacific Rim National Park Reserve
Joanne Lessard	DFO Science (Abalone)
Jody Bissett	World Wildlife Fund Canada
John Richards	Bamfield Huu-Ay-Aht Community Abalone Project
Josh Bouma	University of Washington
Julie Carpenter	Heiltsuk Abalone Stewardship Project
Ken Ridgway	Pacific Urchin Harvesters Association (alternate)
Kristi Straus	University of Washington
Laurie Convey	DFO Resource Management (Abalone & Species at Risk)
Louvi Nurse	DFO Treaties (SARA Aboriginal Coordinator)
Lynn Lee	Haida Gwaii Abalone Stewards & Simon Fraser University
Megan Matthews	Nisga'a Fisheries Program
Mike Featherstone	Pacific Urchin Harvesters Association
Mike Ridsdale	Metlakatla Fisheries Program
Ross Wilson	Heiltsuk Abalone Stewardship Project
Russ Jones	Haida Gwaii Abalone Stewards & Haida Fisheries Program
Sandie Hankewich	Kitasoo Abalone Stewardship Project
Sharon Jeffery	Haida Gwaii Abalone Stewards & Haida Fisheries Program
Tim Joys	Pacific Urchin Harvesters Association
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Trevor Gray	DFO Conservation & Protection, Prince Rupert
William Beynon	Metlakatla Fisheries Program
Sheila Thornton	DFO FAM (SARA Recovery Planner)

Appendix II: Evaluation of Action-Based Performance Measures

Summary of activities outlined in the table below provides an evaluation of efforts that have been conducted since 2004 and relate to the approach-based performance measures outlined in the Recovery Strategy. Information in the table is based on input from ART and AbRIG members as well as information available in annual HSP and AFSAR reports (2005-2008).

Performance Measures	Results	Evaluation and Additional Comments
Management		
Was the coast-wide closure to Northern Abalone harvesting maintained and enforced?	Yes	See comments under 'Protection'.
Was the coast-wide closure an effective measure contributing in halting the population decline?	Yes and No	The coast-wide closure limited mortality on Northern Abalone from legal fishing and the rate of decline in total abalone density has slowed since 1990. However, Lessard *et al.* (2007) found that illegal harvest is still ongoing and is a major source of mortality of Northern Abalone. Densities of mature abalone have declined 44% since 1990.
Protection		
Was a proactive protective enforcement plan implemented?	Yes	Annual compliance promotion work plans are prepared for all abalone-related activities based on C & P's 'three pillars' Coastwide proactive protection measures included the following: - Preventative enforcement patrols and intelligence gathering - Community stewardship and conservation activities, including community-based CoastWatch programs

Performance Measures	Results	Evaluation and Additional Comments
How many reports relating to abalone harvesting were provided to enforcement officers and the toll free enforcement line (Observe-Record-Report)?	>135 calls received	Fishery officers have received over 135 calls pertaining to abalone from the public via the ORR line over the past decade. This also indicates that the secretive and covert nature of abalone harvesting keeps it out of the public sight. Those that partake in abalone harvesting are closely knit and highly secretive. Separate tips to the ORR led to the biggest poaching bust in B.C. in 2006. Additionally, information from the public is often received during patrols and by visiting DFO detachments. Reports from the public are an important source of intelligence that have led to the arrest of abalone harvesters and those involved in illegal buying and selling Northern Abalone. Abalone patrols by stewardship groups directly resulted in 2 reports (2005, 2008).
To what degree were these reports investigated and resulted in charges and convictions?	Extensive	Fishery officers responded to over 90% of the reports received. All other complaints of abalone harvest were investigated by Fishery Officers to determine whether a violation had occurred. Over twenty charges have been laid under various Acts of Parliament. Over twenty-five charges are pending. Alternative approaches including restorative justice-style sentencing applied to half of the charges.
How many hours were spent on enforcing abalone closures?	Thousands	Over 8700 patrol hours have been dedicated to enforcing abalone closures since 2004.
What were the trends in enforcement hours and resulting charges and convictions over the period before and during implementation of the recovery strategy?	Increasing	Prior to the closure of the fishery and the implementation of SARA and the recovery strategy, hours were tracked for species at risk as a whole. The number of occurrences increased during the implementation of the recovery strategy (98 occurrences from 2004 to present, compared to 35 in 1998- 2004). This is likely due to increased public awareness as a result of increased officer presence and education in communities. Coast Watch programs, stewardship groups and patrols have been initiated (using species at risk funding) to assist in outreach regarding reporting of potential incidents, and over 190 on the water monitoring patrols have taken place (2005 to 2008). Fines as high as $35 000 have been ordered in addition to confiscation of vehicles and vessels. This is a rise over smaller fines imposed pre-SARA.
Outreach and Communication		
Was a long-term communications strategy implemented?	Yes	A communications strategy was developed and adopted (see Section 2.4.1)

Performance Measures	Results	Evaluation and Additional Comments
How many and what kind of communication materials and/or actions were produced and/or undertaken?	Yes	Many communications materials and actions have been undertaken, including the examples below: ▪ **3 Abalone Websites**: Fisheries and Oceans Canada Abalone home page http://www.pac.dfo-mpo.gc.ca/fm-gp/commercial/shellfish-mollusques/abalone-ormeau/index-eng.htm; Oceanlink with Bamfield and Nisga'a Abalone projects http://oceanlink.island.net/Conservation/abalone/BHCAP/BCHAP_index.html; Haida Gwaii Abalone Stewards http://www.marinematters.org/programs/abalone.html ▪ **13 news releases** regarding charges and convictions (http://www.pac.dfo-mpo.gc.ca/fm-gp/commercial/shellfish-mollusques/abalone-ormeau/nr-cp-eng.htm) ▪ Promotion of ORR# and Coast Watch - DFO Stop Abalone Poaching brochure, Occurrence reporting forms (DFO and HGAbS), Boat decals (1-800 ORR) (developed by HGAbS, KASP) ▪ **3 School curricula** developed by: HGAbS (Grades 4 & 7) http://www.marinematters.org/programs/abaloneSchoolProgram.html; BMSC http://oceanlink.island.net/Conservation/abalone/abalone_advocates/advocates_activit.pdf; and Nisga'a http://oceanlink.island.net/Conservation/abalone/BHCAP/Nisga/ncw.html ▪ **Annual community TV channel announcements -** developed by KASP ▪ **Annual Newsletters** with updates on stewardship activities and promoting protection of abalone – HGAbS (10 newsletters 2004-2009), HASP, Metlakatla and Abalone Recovery, an update on the recovery of abalone in British Columbia in 2003 and 2004 (http://www.pac.dfo-mpo.gc.ca/fm-gp/commercial/shellfish-mollusques/abalone-ormeau/index-eng.htm) ▪ **33 media stories** (listed in 'Abalone Recovery', an update on the recovery of abalone in British Columbia in 2003 and 2004) ▪ From 2004-2009, HGAbS created and distributed **abalone awareness materials**: ~127 T-shirts, 120 toques, 4 banners, 400 keychains, 108 waterbottles, 100 boat decals, 1000 temporary tattoos, 10,000 glossy brochures, 4 newspaper articles, 10 minute video, stickers, posters and other materials ▪ Public outreach at **annual community events** - HGAbS (2/ year) ▪ **Workshops** - HGAbS (5 Coast Watch); BHCAP (1) ▪ **Presentations**: public - HGAbS (annually in two communities), BHCAP (1); schools - KASP, Metlakatla, HGAbS

Performance Measures	Results	Evaluation and Additional Comments
How many people, and where, did the communications activities reach?	>27,000	Results from HSP project reports submitted for 2006-2008 estimate that over 27,000 people were reached in course of awareness and education stewardship activities Communications materials were developed and distributed to target audiences (e.g. Fishers, Restauranteurs, Public, and Schools)
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?	Positive	February 2006 poaching bust based on tip(s) from the public From Jan 1st, 2009 to March 30, 2010, the DFO Pacific Region Abalone website has been visited 2282 times. HGAbS – 1 Workshop and 4 public presentations had ~161 participants total; BHCAP – 2 workshops 55 participants total Annual AbRIG meetings (hosted by DFO) are attended by representatives from member organizations
Research and Population Rebuilding		
What significant new knowledge was gained through research that would directly contribute to the rebuilding of the Northern Abalone population?	Positive, results being applied	A) Recovery efforts confirmed that transplanted surf abalone increased individual growth rates B) Aggregated, transplanted surf abalone tend to remain at the new sites and spawn successfully.
How many population rebuilding initiatives were undertaken?	~8	A) Transplant of surf abalone to more favourable habitats in terms of exposure. B) Northern Abalone were aggregated to provide threshold numbers for successful spawning HGAbS aggregated 1600 individuals over 8 sites (in 2002) C) Outplanting of hatchery raised Northern Abalone derived from wild brood stock: >107, 000 juveniles, >7.7 million larvae (2003 to 2009) D) From 2006-2008, 5 projects to create 'residences' to aggregate abalone were funded under the federal Habitat Stewardship Program for Protection of Species at Risk
Was there an observed increase in juvenile abundance and/or recruitment as a result of rebuilding experiments?	Yes	There appears to be good representation up to the 10 mm size. There is a gap from 10mm to ~40 mm where mortality appears to be high. Further investigation is needed to confirm mortality (vs. hiding or moving into areas not surveyed) and sources of mortality. A joint research effort is underway to address these issues. Preliminary results from outplanting indicate that survival is low and predator removal does not improve success. Further results from outplanting are pending under a 2009-10 NSERC-funded project lead by Thompson Rivers University.

Performance Measures	Results	Evaluation and Additional Comments
Does rebuilding appear to be a viable, or promising strategy to recover the wild abalone population?	Yes – locally	Aggregation efforts are promising. Further research will help to overcome high post-settlement mortality, possibly from trophic cascades as the result of the removal of a keystone predator from the community.
What reports (technical or primary publications) were prepared that provide results of surveys and biological studies?	Primary publications, DFO Science Reports	See Reference list for published reports and papers on Northern Abalone since 2004. For example; Hankewich, S., and J. Lessard. 2008 Hankewich *et al.* 2008 Jamieson *et al.* 2004. Lessard, J. *et al.* 2007. Lessard, J. and A. Campbell 2007
Population Monitoring		
Was baseline abundance data established in each of the biogeographic zones?	Yes	Index sites were established on the West Coast of Vancouver Island in 2003, Queen Charlotte and Johnstone Straits in 2004, and Georgia Basin in 2009. Index site surveys in the North and Central Coasts and Haida Gwaii have continued every 5 years, the most recent surveys in 2006 and 2007, respectively.

Appendix III: Example Abalone Traditional Knowledge Questions Provided by Haida Fisheries Program

Below are some example TK research topics and questions that could be pursued in future abalone TK work. While specific questions may change depending on the First Nation community and their experience and knowledge of abalone, the questions listed below demonstrate the type of information that this research can access and document. If adequate information protection can be assured, some of this type of information may also be mapped.

Potential Traditional Knowledge Research Questions

Abalone Ecology	**Possible Research Questions**
Habitat Description and Associations	• Where do you tend to find abalone? • What does typical abalone habitat look like? • Does this differ in different areas? • Can you describe the characteristics of areas where you have seen abalone? (abalone size, density, location, environmental conditions, etc.) • Are there some areas that are more productive than others? • Are there any areas that appear to be only juvenile or small abalone? Especially large abalone? Or unique in some way? • What other species do you find associated with abalone? How have you seen these other species interacting with abalone? • What do you see feeding on abalone? • What is the relationship of abalone to kelp? How often do you find abalone in kelp patches? Are they small or large abalone? Are you seeing any changes in kelp patches? How do you think this affects abalone? • Is there anything that might make abalone leave an area?
Spawning/ Mating and Behaviours	• Have you ever seen abalone spawning or mating? If so, can you tell us what you saw and describe the habitat? What time of year did it happen? • Do you have any idea of what might trigger a spawn? Are there any specific conditions you think they need? • Do abalone seem to move seasonally? If so, during what times of the year? Where do they go? How far? What are they doing?
Trends in Abundance	• How is abalone abundance today compared to when you were younger? • If you have seen a decline, can you describe how it happened? (e.g. When do you think it started? Was it sudden or gradual? Over what time span? Was it widespread? Or did it affect different areas differently or at different times?) • What do you think the causes of the decline are? • Did your parents or grandparents ever tell you anything about how abundant abalone used to be in the past? Or anything else about abalone that you remember?
Stewardship	**Possible Research Questions**
Abalone transplanting	• What are traditional ways of looking after seafoods like abalone? Do you know of any rules about harvest or use? • Have you heard of people moving abalone to 'seed' them or try to get them to

	spread to other areas?
Management, monitoring and protection	• Are there any particular areas that you think should be protected or monitored? Any areas that you would consider critical for their survival? • Have you witnessed any illegal harvest of abalone? Are there areas where this is more of a problem than others? • Do you have any ideas about what might most help the abalone to recover? What are some ways they could be protected from further decline?

Appendix IV: Impact Assessment Protocol for Works and Developments Potentially Affecting Abalone and Their Habitat

by

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Definitions

3rd Party Biologist: an established independent third party biological consultant company or an independent third party biologist accredited with a university or college degree in a related biological science that has preferably formed an independent company under his/her own name with experience working with DFO in accomplishing biological research including surveys. Other requirements are outlined in Appendix A.

Abalone Habitat: description of physical and biological features of habitats where abalone are found; includes all abalone habitats as well as critical (not defined for abalone). See Section 5.

Control Site: location outside of the area of influence and within 1000m of the potentially impacted site to minimize differences in current and temperature regimes

Critical Habitat: the habitat that is necessary for the survival or recovery of a listed wildlife species that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species (as defined under SARA)

Impact: unless other wise stated (e.g. impact on habitat) in this document, for the sake of brevity, impact refers to the direct or indirect impacts of works and developments on abalone abundance and distribution only.

Initial Survey: See Section 4.

Monitoring Program: the plot survey repeated at least once a year.

Plot Survey: See Section 8.

Precautionary Approach: Set of measures taken to implement the Precautionary principle. A set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resource, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the potential consequences of being wrong. (Garcia S.M. (1996) The precautionary approach to fisheries and its implications for fishery research, technology and management: An updated review. FAO Fish. Tech. Paper, 350.2: 1-76)

Recruitment: for this document, juvenile abalone with a shell length <70 mm.

SARA: Species at Risk Act

Site: proposed site, unless otherwise stated (e.g. control site).

SL: Shell length, the maximum measurement of an abalone shell.

Transect Survey: See Section 6.

Background

The provisions of SARA that were implemented on June 1, 2004 include:

- prohibitions on killing, harming, harassing, possessing, buying or selling an individual of a species listed as an extirpated species, an endangered species or a threatened species etc. (section 32).
- prohibitions on damaging or destroying residences of individuals (section 33).
- prohibitions on destroying the critical habitat of a listed endangered or threatened species or listed extirpated species (section 58).
- provisions for effective enforcement measures and significant penalties where needed to serve as a deterrent.

These prohibitions will apply to aquatic species that are listed under SARA as extirpated, endangered or threatened. There is a provision in SARA (section 73) that allows the competent minister (DFO for listed aquatic species) to authorise a person to engage in an activity that affects a listed wildlife species, its critical habitat or residence. However, this provision also includes a series of strict criteria that must be met prior to doing so.

Currently there is ample habitat available in BC for the northern abalone population. In general, abalone populations have declined; however, 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. Although good abalone habitat is not believed to be limiting, there may be certain habitat 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 being included as part of the abalone research and rebuilding plans.

The abalone recovery strategy identified several knowledge gaps (Abalone Recovery Team 2002). The recovery strategy identified the need to clarify the extent of threat of works and developments on, in and under the water to northern abalone populations and habitat. The recovery strategy also identified the need for monitoring and regulation of projects to prevent losses to important spawning aggregations and maintain ecosystems in which abalone can recover. Once 'critical habitat' for northern abalone is defined (e.g., abalone beds or important spawning aggregations), specific criteria to protect it under the Fisheries Act and Regulations (1993) and SARA (2003) may be better developed and applied. Until then, it is recommended that the best science available be used, and where science is lacking that a precautionary approach be adopted in considering and approving location(s) for works and developments on, in, and under the water.

Determining impacts on a site by site basis is impractical and will not provide meaningful data as other factors may affect abalone populations. However, when all sites with abalone are combined it may be possible to determine the impact(s) if a proper scientific method is followed. It is the intention of the monitoring program described in Section 8 to evaluate what these impacts are. Given DFO abalone stock assessment limited budget, no large scale studies are planned to determine the impacts of works and developments on, in or under the water on abalone populations. Therefore, the proponents will have to either pay for a DFO certified 3rd party biologist

and/or give money to DFO to carry out the work, which will include field survey, analysis and reporting.

This impact assessment protocol applies to any proposed works and developments where abalone habitat is present and the area affected will be larger than $20m^2$. The amount of abalone habitat necessary to trigger this protocol is arbitrary and is purposely small as the shape of the area impacted is important. For example, $20m^2$ distributed as a 1m vertical swath to a depth of 10m with a moderate slope is not equal to 20m wide 1m horizontal swath parallel to shore at 3m depth because abalone prefer shallow depths and more abalone preferred habitat is impacted in the second scenario. If abalone are present in a small area (i.e. $<20m^2$) expected to be impacted, the individual abalone shall be relocated, under a SARA permit, to suitable abalone habitat nearby. The SARA permit will include the following conditions (some conditions may vary depending on the available abalone habitat nearby):

1. The dive surveys of the area to be impacted must take place at night and search successive depth contours in a systematic and thorough manner.
2. All abalone observed within the survey area must be removed from the substrate by hand only, with the assistance of a *Pycnopodia helianthoides* (sunflower sea star) if necessary; prying abalone from the substrate is not permitted;
3. The shell length (to the nearest mm), depth located, substrate type and dominant algae species must be recorded for each abalone observed;
4. The abalone must be relocated underwater to a location of cover in rocky subtidal habitat no deeper than 6m depth (chart datum) and a minimum of 50 metres away from the construction footprint; taking abalone from the water is not permitted;
5. Plastic totes may be used to move the abalone underwater and abalone may be relocated in close proximity of another abalone to improve chance of spawning success;
6. As a requirement to report information under this project, the authorized persons must submit a written record containing the following summary information:
    i. Dates in which relocation surveys took place;
    ii. Number of abalone observed and relocated;
    iii. Shell length, depth located, substrate type and dominant algae cover for each abalone observed;
    iv. Overall perspective on the success or difficulties in conducting the work.

How to Determine Impact on Abalone

Except for surveyed sites, there is a general lack of data on abalone distribution and abundance throughout the BC coastline. Site specific information for proposed works and developments must be acquired before any decision can be made. In order to determine impacts of works and developments on abalone populations and make inference to their habitat, abalone will have to be present at some sites. Only abundance, and possibly distribution, data will be used to determine impacts in the short term (2-5 years) as other parameters of abalone population health are more difficult to measure (e.g. change in reproductive output, growth, disease incidence, etc.). Impacts may be determined by changes in density before and after the project is completed in conjunction with the continuous monitoring of control site(s) outside of the area of influence. For example, there may be a statistically significant changes (increases or decreases) in total abalone density within the site, but no change at the control site(s) or the total density does not change, but one of size category (juvenile, mature, etc.) becomes more dominant when compared with the control site(s). Observing changes in

abalone spatial distribution will be more difficult unless some animals are uniquely identified (tagged), particularly if density decreases and few or no shells are recovered. Nevertheless, changes in depth distribution and aggregation will be possible under the proposed monitoring approach described in Section 8.
To obtain information necessary to make a decision on the site and evaluate impacts if approved, we recommend a four phased approach:

Phase 1: Initial Survey

The site is assessed to determine the extent of abalone habitat present using nearshore swims. The abalone habitat is then mapped.

Phase 2: Transect Survey

A quantitative survey is conducted to estimate abalone densities within the abalone habitat identified in Phase 1 as well as in an area outside the area of influence.

Phase 3: Monitoring program – Plot survey

If the site is accepted and abalone are present, an intensive survey is conducted at 1-3 plots within the impacted site as well as within a control site, outside the area of influence.

Phase 4: Feed Back

After 5 years, an analysis of abalone abundance and distribution data combining several sites of a given type of work or development should be completed to evaluate the impacts and determine if mitigation actions are required.

Each phase is described in detail in the sections below. We recommend that Phase 1 to 3, if not done by DFO staff, be completed by a certified 3rd party biologist (see Appendix A for requirements).

Phase 1: Initial Survey

The objectives of this phase are to (1) establish the area of Abalone Habitat present at the site, and (2) delineate these habitats on a chart. Although all habitats are important, for the purpose of this document, only abalone habitat is described in Section 5.

Site definition

The site is defined by using landmarks and geographic coordinates. The 'site width' is the linear distance between the two furthest points.

Nearshore-swims

Two divers swim (a few metres apart from each other) in a zigzag pattern (generally parallel to shore) between depths of 0-10 m chart datum. Very good notes need to be taken throughout the swim so that the GPS coordinates can be related to what was observed underwater. Habitat changes including changes in primary substrate (e.g., bedrock to boulders or sand), and algal community (e.g., from a *Macrocystis* to a *Nereocystis* kelp forest or understorey algae only), should be marked using one of two methods described below.
Method 1: Floats can be deployed at the edges of each change in habitat. The boat can then use a GPS to obtain the coordinates. Because the edges of habitats do not

usually form a straight line, several floats need to be release to accurately map the habitats.
Method 2: One person is put on shore at a location where most of the surface water of the site would be visible and records his/her position using a portable GPS. Two divers swim throughout the site during several dives carrying a metal float. At a change in habitat, one of the divers pulls on the float several times while the other diver records the time, depth and other habitat information. Upon seeing the float bob at the surface, the shore person measures the distance to the float using a laser range finder and the magnetic bearing of the float using a compass and records the time which will be matched with the time recorded underwater.

Desired results

The end product of this phase should be a digital map with depth contours and the important habitats delineated. Although all habitats should be outlined, for the purpose of this document, only abalone habitat is described here in detail (see next section).

Data Management

The GPS shore positions are imported into ArcView 3.2 or another GIS software.
Method 1: The GPS positions from the boat are matched with the divers notes to digitize (create a polygon) abalone habitat.
Method 2: From the shore positions, the measured distances and bearings are plotted using an extension from Jenness Enterprises called "Distance & Azimuth tool" (http://www.jennessent.com/arcview/arcview_extensions.htm). Polygons delineating abalone habitat are created using the plotted positions.
The digital map, electronic file containing the GPS points and copies of the field notes must be sent to the Shellfish Data Unit, PBS, Nanaimo.

Decision rule for next step

If abalone habitat, as described in the next section, is present and the area of the abalone habitat is > $20m^2$, then the next phase is necessary to assess the abalone density at the site as well as in surrounding areas.

Abalone Habitat

Physical factors include:

i. Primary Substrate: bedrock and/or boulders
ii. normal salinity (not low salinity as found close to river run off)
iii. Depth: ≤10m depth (datum)
iv. Good water exchange (tidal current or wave action present)
v. Secondary Substrate: some cobble may be present and little or no gravel, sediment, sand, mud, or shell present.

Biological factors include:

i. Presence of encrusting coralline algae (e.g. *Lithothamnium*)
ii. Presence of sea urchins *Strongylocentrotus franciscanus* and/or *S. droebachiensis, Lithopoma (Astraea) gibberosa*, sea stars.

iii. Presence of kelp in surrounding area (e.g., *Nereocystis, Macrocystis, Pterygophora*).
iv. Presence/absence of abalone

Physical and biological factors are listed in order of importance.

Phase 2: Transect survey

The objective of the transect survey is to get quantitative estimates of abalone density and distribution within the abalone habitat delineated in the initial survey (Phase 1). This is necessary to evaluate if the work or development proposal will be accepted based on the 0.1 abalone/m^2 criteria (see "Decision Rules" this section). The method described in this section is identical to Lessard *et al.* (2002) with two exceptions: (1) the **higher** confidence interval is used for the density calculation, and (2) the population size is not calculated as it is unnecessary to evaluate the site. The 0.1 abalone/m^2 threshold was originally based on the measurable short-term goal of the National Recovery Strategy (see "Background" section). Although, this threshold in the recovery strategy is for the size category ≥100 mm SL, the higher confidence interval of the mean is used here.
Transect survey(s) outside the area of influence is also necessary to assess possible control site(s). The transect survey at the control site(s) may be done after the transect survey at the proposed site is completed and the site is given approval to go ahead. However, to minimize seasonality effects, transect survey(s) at possible control sites should be conducted within a month, two at the most. For information on where the control site should be, see Section 7. Control Site.

Transect placement

Transect positions are marked on nautical charts before the survey begins. The positions are selected randomly using the 'abalone habitat width' defined as the linear distance between the two furthest points of the abalone habitat. Transects are perpendicular to the shoreline at these positions. If the abalone habitat is discontinuous, separated by large areas of unsuitable abalone habitat (e.g., area of sand), the process to select the transect positions is repeated for each area of abalone habitat. At least ten transects should be surveyed in each abalone habitat area. If the width of the abalone habitat is shorter than 300m, a lesser amount of transects may be considered.

Transect layout

The primary sampling unit is a transect, made up of a variable number of secondary units: quadrats. Each transect is one meter wide and variable in length, depending on the slope of the substrate. Prior to entering the water, a lead line, the transect, is laid perpendicular to the shore, from the boat. If this is not possible, because of thick kelp beds or other environmental factors, then the divers should sample along a compass bearing perpendicular to the shore. The compass bearing must be strictly followed to avoid possible bias in the density estimate(s). Transects begin at 10 m chart datum and extend all the way into the shore, or to the point where the surge makes it impossible for the divers to work effectively.

Underwater survey (Filling out the "Abalone Field Sheet - Transect" Appendix B)

The secondary sampling unit consists of a 1 m x 1 m square quadrat that is placed beside the transect, 1 m away to avoid the area potentially disturbed by the lead line placement. Divers flip the quadrat parallel to the transect line, from deep to shallow. One diver records the data while the other measure the abalone and flips the quadrat. In each quadrat, the recording diver writes down 1) the shell length (SL in mm) of each abalone, 2) the depth, 3) the time, 4) the substrate type, 5) the number of urchins, 6) the number and relative size of abalone predators (sunflower starfish, Dungeness and red rock crabs, octopus, etc.) and 7) the % cover and dominant species of algae. The % cover of all algae combined is recorded by category: 1) canopy (kelp taller than 2m), 2) understorey (algae between 15cm and 2m in height), 3) turf (erect algae less that 15cm in height) and 4) encrusting (carpet-like algae). The dominant algal species (1-2) are recorded for the first 3 categories only. Appendix D lists the substrate and algae species codes to be used. The measuring diver must exercise caution when measuring abalone to ensure that the longest shell length is measured and the abalone is returned right side up on the rocks outside and behind of the quadrat. In order to minimize habitat damage, algae are not to be removed. Boulders are not to be moved to search for cryptic abalone. Caution must be exercised to ensure that abalone in upcoming quadrats are not disturbed.

Where the transect length is greater than 20 m, only every second quadrat needs to be sampled completely. If transects are longer than 60 m, abalone and depth can be sampled every second quadrat, and substrate and algae cover can be sampled every fourth quadrat. The frequency of sampling must be written on the underwater sheet.

Analytical methods

Calculations are included here for information only. The analysis will be performed by DFO Stock Assessment.

For each site, the estimated mean density, $\bar{d}_s$ (number/m^2), of abalone is calculated as:

$$\bar{d}_s = \frac{\sum_t ((c_t / q_t) * L_t)}{\sum_t L_t} \qquad (1)$$

The standard error of the mean density, se_s, is calculated as:

$$se_s = \sqrt{1 - \frac{n}{T}} * \sqrt{\frac{\sum_t ((c_t / q_t) * L_t - d_s * L_t)^2}{n * (n-1) * \bar{L}^2}} \qquad (2)$$

where n is the number of transects,

c_t is the number of abalone counted in transect t,

q_t is the number of quadrats sampled in transect t,

L_t is the length of transect t,

$\bar{L}$ is the mean transect length,

T is the total possible number of transects that can be sampled in the surveyed area and is equal to the 'abalone habitat width'.

This method accounts for the variable length of transects and for the variable proportion of quadrats surveyed along each transect.

To estimate the mean density (Equation 1) and standard error (Equation 2) for a specific size group (*i*) (*i.e.* ≥100 mm SL), the value c_t is substituted with c_{ti}, the counts of size group *i* in transect *t*.
At each site, the higher 90% confidence intervals of the mean density (*H90CI*), for all sizes or for a particular size group (≥100 mm SL) of abalone, are calculated using bootstrapping (Davidson and Hinkley, 1997).

Data Management

All the data must be entered using the "Transect Data Entry" form in the Access database provided by DFO Stock Assessment. The fields that need to be filled on the field sheets and in the database are described in Appendix E. The original field data sheets as well as the electronic version in Access must be sent the Shellfish Data Unit, PBS, Nanaimo.
At PBS, a S-Plus script exists to analyze the data using the data directly from the database.

Decision rule for next phase

If the H90CI for all sizes is ≥0.1 abalone/m^2, the site is automatically rejected. If the H90CI for all sizes is <0.1 abalone/m^2, the responsibility of the decision to go ahead with permitting rests with the Habitat Management Program. If the site is accepted and an authorization is issued in accordance with section 35 of the *Fisheries Act*, the next phase is initiated.

Control Site

Proposed control site(s) should be outside of the area of influence and within 1000m of the impacted sites to minimize differences in current and temperature regimes. For aquaculture proposals, the area of influence is determined by DEPOMOD. The control site must be within abalone habitat as described in Section 5. In general, the control site should have the same relative exposure, current regime and habitat characteristics. For example, it would be unsuitable to have smooth bedrock substrate within the abalone portion of the impacted site and boulders at the control site. It may also be unsuitable to have the control 'around the corner' where exposure to wave action would be different.

Phase 3: Monitoring program – Plot Survey

The objective of this phase is to survey abalone within a small geographic area in order to calculate reliable density estimates with minimal variation. A density estimate with high precision is essential to detect impacts on abalone abundance as abalone density estimates have inherently high variance due to their aggregating behaviour. It is not rare to have standard deviations equal to or larger than the mean density estimates. For example, if the mean density estimate from the transect survey is 0.05 abalone/m^2 with a pooled standard deviation of 0.025 abalone/m^2, 34 samples would be necessary to detect a change in abundance of at least 50% with 95% confidence 80% of the time (17 impacted sites and 17 control sites). To increase precision, more plots can be placed in both the impacted and control sites; this would add a strata (high/low density

areas) to the sampling design. In addition, more random transects can be added within each depth strata. The number of samples (transects) and strata can be determined using the transect survey results.

The plot survey is based on a stratified random sampling design. The current plot survey design is based on past survey results and builds on the Parks Canada and Haida Fisheries Program survey designs. Figure 1 gives a schematic diagram of the plot survey design. A better design would involve using the quadrats as the primary sampling unit and have each quadrat randomly placed within the plot. Strata (e.g. deep/shallow and/or high/low density areas) could also be used. However, the underwater logistics of such a design are impractical. The sampling design described below is for the minimum number of strata and samples required: one plot at each of the impacted and control sites with 2 depth strata in each plot and 10 or 8 transects for the shallow or deep reference lines, respectively.

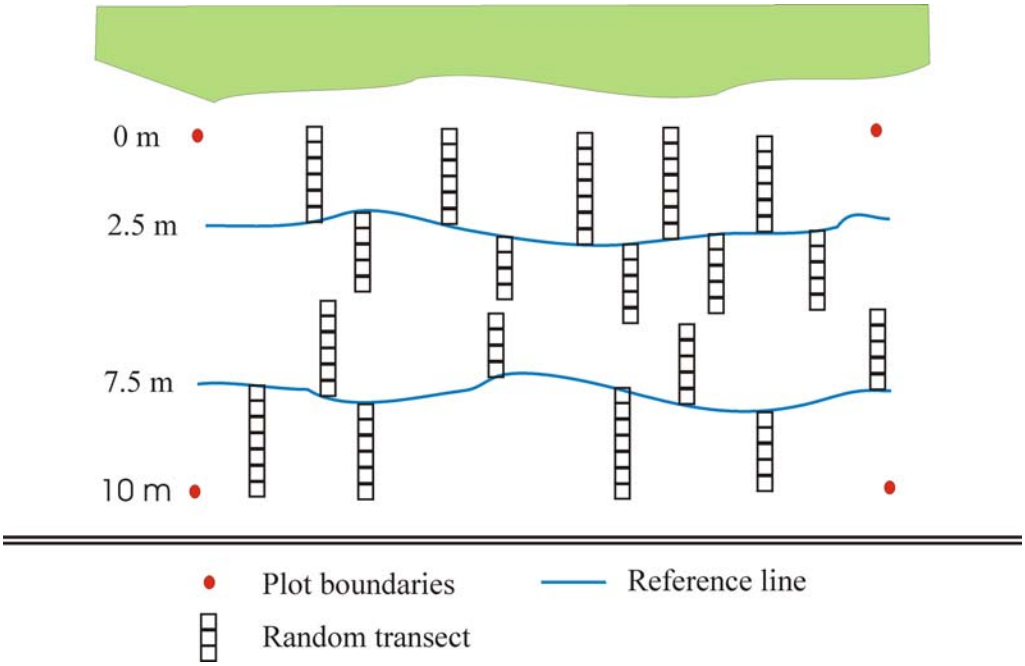

Figure 1. Schematic view of the plot survey design. Numbers on the left side are depths in metres (datum).

Reference line placement (in consultation with DFO Stock Assessment)

Two reference lines, 40m long each, are placed at 2.5m and at 7.5m below chart datum. The location of the reference lines are the middle of the 2 depth zones (0-5m and 6-10m) that are going to be sampled (the 2 strata in a stratified random sampling design). On each of the reference lines, several short perpendicular 1 m wide transects are surveyed, alternating on either side of the reference lines to minimize disturbance. The start location of each transect is chosen randomly prior to the start of the survey. Choose 10 starting positions (out of 40 m) along the shallow reference line (2.5m) and 8 along the deep reference line (7.5m). Additionally, randomly choose the side of the transect where the first transect is placed and alternate thereafter (marked as “Start Down” or Start Up” on the field sheet).

Underwater survey (Filling out the "Abalone Field Sheet - Plot" Appendix C)

Each transect starts off the reference line at the randomly chosen location and the quadrat is flipped perpendicular to the reference line until the top, or bottom, of the depth zone is reached. No lead line is laid out for the random transects (a compass bearing can be taken, but this is not necessary as the transects are usually short, 4-8 quadrats long). One diver records the data while the other measures the abalone and flips the quadrat. In each quadrat, the recording diver writes down 1) the shell length (SL in mm) of each abalone, 2) the depth, 3) the time, 4) the substrate type, 5) the number of urchins, 6) the number and relative size of abalone predators (sunflower starfish, Dungeness and red rock crabs, octopus, etc.) and 7) the % cover and dominant species of algae. The % cover of all algae combined is recorded by category: 1) canopy (kelp taller than 2m), 2) understorey (algae between 5cm and 2m in height), 3) turf (erect algae less that 5cm in height) and 4) encrusting (carpet-like algae). The dominant algal species (1-2) are recorded for the first 3 categories only. The measuring diver must exercise caution when measuring abalone to ensure that the longest shell length is measured and the abalone is returned right side up on the rocks outside and behind of the quadrat. In order to minimize habitat damage, algae are not to be removed. Boulders are not to be moved to search for cryptic abalone. Caution must be exercised to ensure that abalone in upcoming quadrats are not disturbed. All quadrats are sampled completely. Once the transect is completed, the divers move to the random location and repeat the procedure until all locations have been completed within the depth strata.

Analytical methods

To calculate the mean and standard error within each strata *a*, the analysis is identical to the Transect Survey in Section 6.
For each site, the estimated mean density, d_s (number/^{2}), of abalone is calculated as:

$$d_s = (1/N)\sum n_a d_a \qquad (3)$$

The standard error of the site mean density, se_s, is calculated as:

$$se_s = (1/N)\sum n_a se_a \qquad (4)$$

where N is the total number of transects in all strata

n_a is the number of transects in strata *a*

d_a is the estimated mean density in strata *a*

se_a is the estimated standard error of the mean in strata *a*

The data will probably not be normally distributed and a nonparametric test such as the Wilcoxon paired-sample test should be used to look at differences between control and impacted sites.

Data Management

All the data must be entered using the "Plot Data Entry" form in the Access database provided by DFO Stock Assessment. The fields that need to be filled on the field sheets and in the database are described in Appendix E. The original field data sheets as well

as the electronic version in Access must be sent to the Shellfish Data Unit, PBS, Nanaimo.

Decision rule for next phase

Once the monitoring is initiated at more than one site, the next phase should be instigated after 2-5 years depending on the extent of the changes. For example, if densities decrease at all impacted sites, but not at the control sites, by >50% within 2 years, then Phase 4 should be initiated.

Phase 4: Feedback

In phase 4 all monitoring data for a given type of work or development are pooled to determine overall impacts of this given type of work or development on abalone populations. Due to natural variation in abalone density and the low initial densities at approved sites (<0.1abalone/m^2), a small change in abundance or distribution will be difficult to detect. Detecting changes less than 50% is therefore impractical because of the high variance and a much larger number of samples would be required. Because of the possible implications of such an analysis, the results should be presented at PSARC.

References

Davidson, A.C., and Hinkley, D.V.. 1997. Bootstrap Methods and their Application. Cambridge University Press, Cambridge. 578 p.

Lessard, J, Campbell, A, and Hajas, W. 2002. Survey protocol for the removal of allowable numbers of northern abalone, *Haliotis kamtschatkana*, for use as broodstock in aquaculture in British Columbia. CSAS 2002/126: 41 p.

Sloan, N.A., and Breen, P.A.. 1988. Northern abalone, *Haliotis kamtschatkana*, in British Columbia: fisheries and synopsis of life history information. Can. Spec. Public. Fish. Aquat. Sci. 103: 46 p.

Appendix A. Third party biologist requirements

The minimum requirements for biological expertise for an independent third party biologist to conduct abalone surveys are:

an established independent third party biological consultant company with experience working with DFO in accomplishing biological research including surveys; or

an independent third party biologist accredited with a university or college degree in a related biological science that has preferably formed an independent company under their own name and has experience working with DFO in accomplishing biological research including surveys.

And

meets a reference check for experience, competency, and demonstrated independent 'arms length' work experience;

And

has passed a training session with DFO-Stock Assessment Division on conducting abalone surveys, including data collection and reporting. Training will be given by DFO-Stock Assessment Division and may be expected to include dive surveying.

And

SCUBA dive certification, meeting WCB requirements

And

bonded (to ensure confidentiality)

And

knowledge of common algae, invertebrates and fish species.

And

has access to Microsoft Access database software

Appendix B. Field data sheet for the transect survey

See Appendix E for field descriptions.

Abalone Field Sheet - Transect

Page ____ of _____

Site Name:_____File number:_____Date:_____
Measurer: _____Recorder: _____Time in:_____Out:_____
LAT:_____LONG:_____Direction (bearing in °):_____
Transect number:_____ Quadrat Frequency:_____

Quad #	Depth ft.	Time	Substrate	Abalone Shell Length (mm)	Urchin Count	Predators	Canopy	Understory	Turf	En %

Substrate codes: 1 bedrock smooth 3 boulders 5 gravel 7 sand 9 mud
2 bedrock crevices 4 cobble 6 pea gravel 8 shell

General Algae codes:
EN encrusting (flat)
AC articulated coralline
KK kelp
B other brown
R red algae
G green algae

F foliose (leaf-like)
B branched (tree-like)
H filamentous (hair-like)

Grasses (GR)
PH *Phyllospadix*

Specific algae codes:
AG *Agarum* IR *Iridea* PT *Pterygophora*
AL *Alaria* LA *Laminaria* SA *Sargassum*
CO *Costaria* MA *Macrosystis* UL *Ulva*
CY *Cymathere* NT *Nereocystis*
DE *Desmarestia* PL *Pleurophycus*
EG *Egregia* PO *Porphyra*

Appendix C. Field data sheet for the plot survey

note: Numbers/text in **bold** in the heading section of the field sheet are chosen randomly for each reference line for each period surveyed.
See Appendix E for field descriptions.

Abalone Field Sheet - Plot

Page ____ of _____

Site Name:_____File number:_____Date:_____
Measurer: _____Recorder:_____Time in:_____Out:_____
LAT:_____LONG:_____Direction (bearing in °):_____
Reference Line:_____(shallow or deep) Plot number:_____
Transect start locations: **2, 6, 13, 19, 21, 25, 31, 32, 34, 38** Start **Down**
Tide height (height@time):_____

Quad #	Depth ft.	Time	Substrate	Abalone Shell Length (mm)	Urchin Count	Predators	Canopy	Understory	Turf	En %

Substrate codes: 1 bedrock smooth 3 boulders 5 gravel 7 sand 9 mud
2 bedrock crevices 4 cobble 6 pea gravel 8 shell

General Algae codes:
EN encrusting (flat)
AC articulated coralline
KK kelp
B other brown
R red algae
G green algae

F foliose (leaf-like)
B branched (tree-like)
H filamentous (hair-like)

Grasses (GR)
PH *Phyllospadix*

Specific algae codes:
AG *Agarum*
AL *Alaria*
CO *Costaria*
CY *Cymathere*
DE *Desmarestia*
EG *Egregia*
IR *Iridea*
LA *Laminaria*
MA *Macrosystis*
NT *Nereocystis*
PL *Pleurophycus*
PO *Porphyra*
PT *Pterygophora*
SA *Sargassum*
UL *Ulva*

Appendix D. Dive Codes

Table D1. Substrate codes

Code	Substrate
1	Bedrock - smooth
2	Bedrock - crevices
3	Boulders (rock bigger than a basketball)
4	Cobble (basketball down to 3 inches)
5	Gravel (3 inches down to 3/4 inch)
6	Pea gravel (3/4 inch down to 1/8 inch)
7	Sand
8	Shell
9	Mud

Table D2. Algae Codes

Code	Species
AA	Alaria nana
AB	Agarum cribosum
AC	Articulated corallines
AF	Agarum fimbriatum
AG	Agarum sp
AL	Alaria sp
AM	Alaria marginata
BB	brown branched
BF	brown foliose
BH	brown filamentous
CA	Callophyllis sp
CF	Codium fragile
CN	Constantinea sp.
CO	Costaria costata
CR	Cryptopleura sp
CS	Codium setchellii
CY	Cymathere triplicata
DB	Dictyota binghamiae
DE	Desmarestia sp
DF	Desmarestia foliacea
DL	Desmarestia ligulata
DU	Desmarestia munda
DR	drift algae
DS	Delesseria sp.

Code	Species
DV	Desmarestia viridis
EG	Egregia menziesii
EI	Eisenia arborea
EN	encrusting algae
ET	Enteromorpha sp
FU	Fucus gardneri
GA	Green Algae
GB	green branched
GE	Gelidium sp
GF	green foliose
GG	eelgrass & surfgrass
GH	green filamentous
GI	Gigartina sp
GR	Gracilaria pacifica
GS	Gastroclonium subarticulatum
HA	Halosaccion glandiforme
HE	Hedophyllum sessile
IR	Iridea sp
KK	Kelp
LA	Laminaria sp
LB	Laminaria bongardiana
LE	Leathesia difformis

Code	Species
LO	Lessoniopsis littoralis
LR	Laurentia spectabilis
LS	Laminaria saccharina
LT	Laminaria setchellii
MA	Macrocystis integrifolia
MI	Microcladia sp
NO	No Algae Present
NT	Nereocystis luetkeana
OD	Odonthalia sp
PH	Phyllospadix sp
PL	Pleurophycus gardneri
PO	Porphyra sp
PR	Prionitis sp
PT	Pterygophora californica
PV	Pelvetiopsis sp.
RB	red branched
RF	red foliose
RH	red filamentous
SA	Sargassum muticum
UL	Ulva sp, Monostroma sp or Ulvaria sp
UN	Unknown
ZO	Zostera sp

Appendix E. Database Field Descriptions

Field Name	Description
Site Name	The name of the proposed tenure as stated on the application
File Number	File number of the application *if available
Date	YYMMDD
Measurer	The name of the diver measuring and counting
Recorder	The name of the diver recording
Time In	The time (hh:mm) the diver leaves the surface *note: do not round to 5 mins.
Time Out	The time (hh:mm) the diver reaches the surface
LAT	Latitude of site in degrees and decimal minutes
LONG	Longitude of site in degrees and decimal minutes
Direction (bearing in º)	The bearing in which the transect is laid, in degrees
Reference Line	(shallow or deep)
Plot Number	Number assigned to the plot
Transect start locations	Randomly selected points along the transect to lay reference lines
Start	The direction from the main transect line to start the first quadrat, either shallow or deep
Tide height (height @time)	Several tide height to add to maximum depth to reach for strata (e.g., 4.5ft@10:30, 5ft@11:00, etc)
Quad#	The number of the quadrat being sampled
Depth (ft)	The gauge depth, in feet, for the quadrat being sampled
Time	The time (hh:mm) at which the diver was in that quadrat
Substrate	up to three codes for the most prominent substrate types in that quadrat (see sheet for codes)
Abalone Shell length (mm)	The measured shell length in mm of each abalone measured
Urchin Count	The number of urchins counted in that quadrat
Predators	(count/size/species) eg. 2MPy = 2 medium *Pycnopodia*
Canopy	% and species of the most dominant canopy species (kelp taller than 2m) (e.g., 50 MA = 50% *Macrocystis*)
Understory	% and species of the most dominant understorey species (algae between 5cm and 2m in height)
Turf	% and species of the most dominant turf species (erect algae less that 5cm in height)
En%	% (only) of cover of encrusting (carpet-like algae)