PROPOSED

SPECIES AT RISK ACT
Management Plan Series

Management Plan for the Olympia Oyster (*Ostrea conchaphila*) in Canada

Olympia Oyster

May 2009

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

About the *Species at Risk Act* Management Plan Series

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

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is "*to manage species of special concern to prevent them from becoming endangered or threatened*."

What is a species of special concern?

Under SARA, a species of special concern is a wildlife species that could become threatened or endangered because of a combination of biological characteristics and identified threats. Species of special concern are included in the SARA List of Wildlife Species at Risk.

What is a management plan?

Under SARA, a management plan is an action-oriented planning document that identifies the conservation activities and land use measures needed to ensure, at a minimum, that a species of special concern does not become threatened or endangered. For many species, the ultimate aim of the management plan will be to alleviate human threats and remove the species from the List of Wildlife Species at Risk. The plan sets goals and objectives, identifies threats, and indicates the main areas of activities to be undertaken to address those threats.

Management plan development is mandated under Sections 65–72 of SARA (http://www.sararegistry.gc.ca/approach/act/default_e.cfm).

A management plan has to be developed within three years after the species is added to the List of Wildlife Species at Risk. Five years is allowed for those species that were initially listed when SARA came into force.

What's next?

Directions set in the management plan will enable jurisdictions, communities, land users, and conservationists to implement conservation activities that will have preventative or restorative benefits. Cost-effective measures to prevent the species from becoming further at risk should not be postponed for lack of full scientific certainty and may, in fact, result in significant cost savings in the future.

The series

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

To learn more

To learn more about the *Species at Risk Act* and conservation initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/).

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2009-2013

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

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PREFACE

The Olympia oyster is a marine species and is under the responsibility of the federal government. The *Species at Risk Act* (SARA, Section 65) requires the competent minister to prepare management plans for species listed as special concern. The Olympia oyster was listed as a species of special concern under SARA in June 2003. The development of this management plan was led by Fisheries and Oceans Canada – Pacific Region, in cooperation and consultation with many individuals, organizations and government agencies, as indicated below. The plan meets SARA requirements in terms of content and process (SARA sections 65-68).

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Fisheries and Oceans Canada or any other party alone. This plan provides advice to jurisdictions and organizations that may be involved 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 invites all responsible jurisdictions and Canadians to join Fisheries and Oceans Canada in supporting and implementing this plan for the benefit of the Olympia oyster and Canadian society as a whole. The Minister will report on progress within five years.

RESPONSIBLE JURISDICTIONS

Fisheries and Oceans Canada
Government of British Columbia
Parks Canada Agency

The Province of BC licences commercial oyster harvest on vacant provincial crown land. Artificial movements of aquatic species into and within coastal waters and to aquaculture facilities are subject to review and licensing by the federal-provincial Introductions and Transfers Committee. Under the *Canada National Parks Act* and the *Canada National Marine Conservation Areas Act*, Parks Canada Agency has involvement in Olympia oyster management and protection in National Parks with marine components and National Marine Conservation Areas (NMCAs).

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STRATEGIC ENVIRONMENTAL ASSESSMENT

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.

Recovery 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 on non-target species or habitats. The results of the SEA are incorporated directly into the plan itself, but are also summarized below.

This management plan will clearly benefit the environment by promoting the conservation of the Olympia oyster. The potential for the plan to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this plan will clearly benefit the environment and will not entail any significant adverse effects. Refer to sections 1.3 Population and Distribution, 1.4 Needs of the Olympia oyster, 1.5 Threats and 2.3 Management Actions.

EXECUTIVE SUMMARY

Of the four species of oyster currently found in British Columbia (BC), the Olympia oyster is the only native species. The Olympia oyster is a relatively small oyster with a deeply cupped lower (left) valve and a flat upper (right) valve that fits within the margins of the lower valve. Maximum size is approximately 90 mm in diameter (Harbo 1997), though most individuals are smaller than 60 mm.

Large-scale Olympia oyster culture occurred in Boundary Bay from the early 1900s through the 1930s (Stafford 1917; Sherwood 1931). It is generally believed that population decreases occurred between the late 1800s and 1930. The overall history of Olympia oyster exploitation on the west coast was of overharvest and replacement with more marketable species, first with unsuccessful attempts to introduce Atlantic oysters, and finally with the development of Pacific oyster culture.

Historically, the most important threat to Olympia oysters was human harvests and temperature extremes. Alteration of habitat by land use practices (urbanization and industrialization), introduction of non-indigenous predators and parasites inadvertently by aquaculture and harvesting activities and, possibly, persistent pollutants are current concerns for management of the remaining populations.

While population declines were recorded historically, there is no indication, currently, that the population is continuing to decline. In consideration that BC is likely at or near the northern end of the global distribution of Olympia oysters and that the population appears to be stable at low levels relative to historic accounts, the management goal is to maintain stable populations of Olympia oysters in BC. The indicator to be used to measure whether the goal is being attained will be that the relative abundance of Olympia oysters at index sites is maintained over the next six years (2008-2013).

Recommended management actions over the next six years (2008-2013) are to maintain current restrictions on commercial and recreational harvest; address concerns for habitat alteration and transfer of non-indigenous predators and parasites; clarification of threats to support protection measures; population monitoring, including the establishment of index sites through collaborative effort; and communication about the detrimental effects of predator and parasite transfers.

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1.1. Species Assessment Information from COSEWIC

Date of Assessment: November 2000

Common Name (population): Olympia oyster

Scientific Name: *Ostrea conchaphila*

COSEWIC Status: Special Concern

Reason for Designation: This species is the only native oyster along the west coast of Canada. Currently the population is apparently stable but decline in the historic past may re-occur due to rapidly expanding farming of non-native oysters, pressure from recreational and commercial activities, and continued introduction of exotic species of oysters.

Canadian Occurrence: Pacific Ocean

COSEWIC Status History: Designated Special Concern in November 2000. Assessment based on a new status report.

1.2. Description

The Olympia oyster, *Ostrea conchaphila* (= *O. lurida*), is a relatively small oyster with a deeply cupped lower (left) valve and a flat upper (right) valve that fits within the margins of the lower valve. They are often attached to hard substrate, but may occur free on the substrate, as singles or in clusters. The shell margin is more or less elliptical, and the outer surfaces of the valves range in colour from white to purplish-black. The inner surfaces of the valves range from white to iridescent green to purple, with the adductor muscle scar similar in colour to the rest of the valve, not darker as in Atlantic or Pacific oysters. Maximum size is approximately 90 mm diameter (Harbo 1997), though most individuals are smaller. Individuals in BC are generally 60 mm in diameter or less (COSEWIC 2000, Gillespie *et al*. 2004, Gillespie and Bourne 2005a).

The term “native oyster” is commonly used to refer to *O. conchaphila* in areas other than Puget Sound, Washington (COSEWIC 2000). This distinguishes *O. conchaphila* from the more abundant Pacific oyster, *Crassostrea gigas*, which was introduced to BC around 1925.

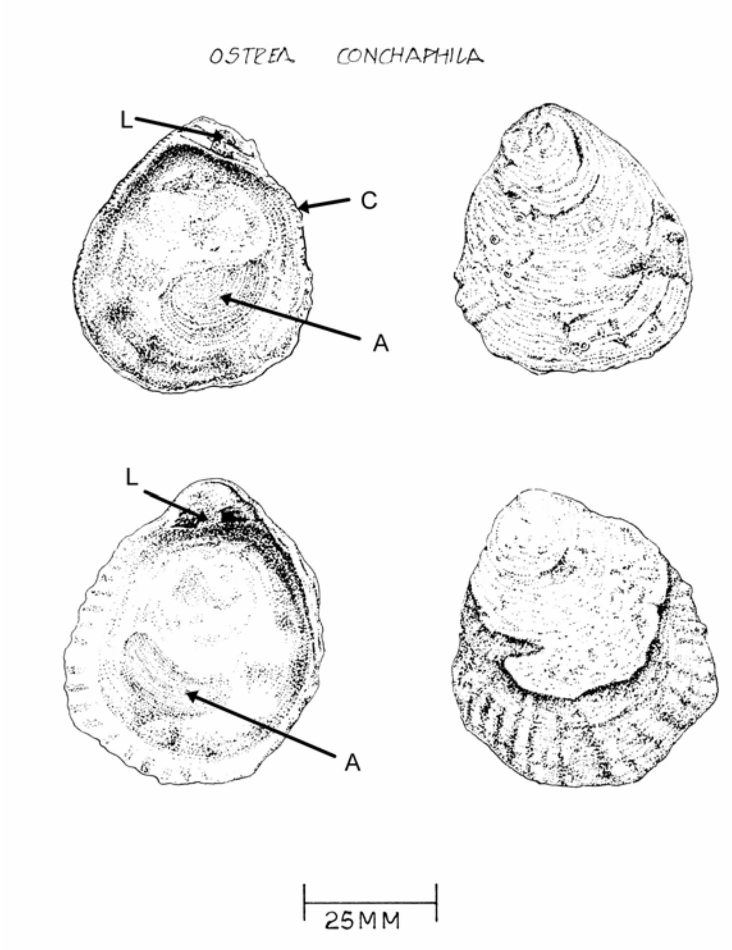

Figure 1. The Olympia oyster, *Ostrea conchaphila* Carpenter, 1857. Top row is upper (right) valve, bottom row is lower (left) valve, left column is interior of valve, right column is exterior. A = adductor muscle scar, C = chomata, L = ligament.

1.3. Populations and Distribution

Global

Olympia oysters are found only on the west coast of North America, reported from Sitka, Alaska, to Panama (Harbo 1997). However, the northern limit is based on a record by Dall (1914) and is somewhat suspect. Specific habitat requirements limit abundant populations to relatively few locations (Galtsoff 1929).

Olympia oyster populations still exist at several locations in Washington, including Puget Sound, Willapa Bay, and possibly Grays Harbour (Baker 1995). Oregon populations include Yaquina, Coos, Netarts and Alsea Bays, the last three as a result of successful introductions (Gillespie 1999). In California, there is evidence that many historic populations have been extirpated but populations persist in Humbolt, Tomales, San Francisco, Newport and Morro Bays, Elkhorn Slough, Drakes Estero, Agua Hediondo and Los Pensaquitos Lagoons (Baker 1995, Friedman *et al*. 2005, Moores 2005). Olympia oysters were reported from southeast Alaska, but were seldom encountered in dense aggregations, nor were specific sites reported (Paul and Feder 1976). Recent reports of their occurrence in southeast Alaska have not been substantiated despite investigation (Scott Walker, Alaska Department of Fish and Game, Ketchikan, Alaska; pers. comm.).

The extent of populations in Mexico and Central America is not well documented (Baker 1995).

<u>Canada (Pacific) – BC</u>

With the exception of anecdotal information that describes locations supporting populations of Olympia oysters that were large enough to attract commercial fisheries, little attention has been directed at the Olympia oyster population in BC and quantitative population estimates (both historic and recent) are non-existent. In the absence of other information, the persistence of Olympia oyster populations 50 years or more after significant impacts had occurred may be taken as evidence that populations are relatively stable at current low levels of abundance (COSEWIC 2000). Table 1 provides the most recent information on the known populations of Olympia oysters in BC and will require updating with the COSEWIC reassessment anticipated in 2010.

It is generally believed that population decreases occurred between the late 1800s and 1930. The decline was mostly due to the disappearance of large Olympia oyster populations in specific localities, particularly Boundary Bay and Ladysmith Harbour. Populations in Boundary Bay may have been established and maintained primarily through the efforts of culturists (Stafford 1916), and the combination of significant losses due to cold winter temperatures in 1940 and the shift in market preference to Pacific oysters led to cessation of culture efforts there. Populations in Ladysmith Harbour, Nanoose Bay and Comox Harbour are greatly reduced. Occasional scattered individuals of Olympia oysters still occur in Ladysmith Harbour (J. Morrison, Fisheries & Oceans Canada, Nanaimo, BC, pers. comm.). The population at Nanoose Bay appears to be mostly gone. Comox Harbour has not been examined recently (COSEWIC 2000).

Olympia oysters are still locally common at several sites on the west coast of Vancouver Island in Barkley Sound, Clayoquot Sound, Nootka Sound, and Kyuquot Sound (Table 1). Whether Olympia oysters still exist in Quatsino Sound is unknown. Simple density estimates were made for populations at three sites on the west coast of Vancouver Island; mean density ranged from 109 oysters m^{-2} at Klaskino Inlet to 360 oysters m^{-2} at Port Eliza (Gillespie *et al*. 2005a).

Olympia oysters do not occur in any number in northern BC or the Queen Charlotte Islands, with the exception of a small number of locations in the Central Coast (Bourne *et al.* 1994, Bourne and Heritage 1997, Gillespie 2000, Gillespie *et al.* 2004, Gillespie and Bourne 2005b).

Table 1. Localities in B.C. where Olympia oysters have been documented (updated from COSEWIC 2000).

Geographic Area	Location	Comments
North Coast		
Milbanke Sound	Bardswell Group	Historic[1]
	Campbell Island	Historic[2]
	Gale Passage	Present [3]
Queen Sound	Watt Bay	Abundant 1991[4], 2004[5]
Fitz Hugh Sound	Fish Egg Inlet	Historic[1], Abundant 1991[6], 2001[7]
Smith Inlet	Boswell Inlet	Abundant[8]
Queen Charlotte Strait		
Queen Charlotte Strait	Blunden Harbour	Historic[1,2, 9]
	Bradley Lagoon	Historic[10]
West Coast Vancouver Island		
Quatsino Sound	unknown	Historic[1]
Brooks Bay	Klaskino Inlet	Abundant 2001[7], 2002[11], 2007[8]
	Klaskino Anchorage	Present 2007[8]
Checleset Bay	Johnson Lagoon	Present 2000[12]
	Ououkinsh Inlet	Present 2002[11]
Kyuquot Sound	Amai Inlet	Abundant 1995[16], 2002[11]
	Cachalot Inlet	Abundant 2002[11], 2007[14]
	Kashutl River	Present 2007[8]
	Malksope Inlet	Abundant 2007[14]
Nootka Sound	Canton Creek	Present 1995[13]
	Espinosa Inlet	Present 2006[8]
	Hisnit Inlet	Present 2007[8]
	Inner Mary Basin	Abundant 1995[15]
	Little Espinosa Inlet	Present 2006[8]
	Nesook Bay	Present 1995[11], 2007[8]
	Port Eliza	Abundant 1995[13], 2002[11]
	Queen Cove	Present 1995[15], 2006[8]
	Tlupana Inlet	Present 1995[13]
Clayoquot Sound	Bottleneck Cove	Abundant 2003[14]
	Darr Island	Present 2007[8]
	Heelboom Bay	Present 2006[8]
	Lemmens Inlet	Present 2006[8]
	Mosquito Harbour	Abundant 2000[7], Present 2006[8]
	Pretty Girl Cove	Abundant 2003[14], Present 2006[8]
	Sydney Inlet	Abundant 2005/2006[17]
	Sydney River	Present 1976[18]
	Sulphur Pass	Possibly present[17]
	Tofino	Present 1926-1936[19]
	Vargas Island	Present 2006[20]
	Whitepine Cove	Present 2002[11], 2006[8]
	Young Bay	Present[14]

Barkley Sound	Ahmah Island	Present 1997[21]
	Alma Russell Island	Present 1997[21]
	Brabant Island	Present 1997[21]
	Broken Group	Present 1999[22]
	Congreve Islands	Present 1997[21]
	Effingham Inlet	Abundant 1997[21]
	Fatty Basin	Present[12]
	Harris Point	Abundant 1997[21]
	Hillier Island	Abundant 2002[11], 2006/2007[8]
	Jacques/Jarvis Lagoon	Present 1973[23], 1997[21], 2006[8]
	Joes Bay	Present 2006[8]
	Julia Passage	Present/Abundant 1997[21]
	Lucky Creek	Abundant 1993[22], 2002[11]
	Mayne Bay	Abundant 1997[21]
	Nettle Island	Present 1997[21]
	Pinkerton Island	Present 1997[21]
	Pipestem Inlet	Abundant 1995[15], Present 2006[8]
	Snowden Island	Abundant 1993[24]
	South Stopper Island	Abundant 2007[14]
	Toquart Bay	Historic[1], Present 1997[21]
	Useless Inlet	Abundant 1995[15], Present 2006[8]
	Vernon Bay	Abundant 1997[21], 2006/2007[14]
Strait of Georgia		
Desolation Sound	Pendrell Sound	Historic[2], Present 1971-1977[25-29], 2007[8]
Northern Gulf Islands	Talbot Cove	Present 2000[30]
	Von Donop Inlet	Historic[2], Present 2007[8]
East Coast Vancouver	Comox Harbour	Historic[2]
Island	Fanny Bay	Historic[31]
	Goldstream	Present 1996[8]
	Ladysmith Harbour	Historic[9,32], Present 1976/1977[24,29], 1998[33], 2006[34]
	Nanaimo	Present 1999[8]
	Nanoose Harbour	Historic[2], Present 1999[8]
Mainland Inlets	Hotham Sound	Present 1976/1977[26,29]
	Malaspina Inlet	Historic[9]
	Sargeant Bay	Present[35]
Boundary Bay	Boundary Bay	Historic[9,36], Present 1997/1998[37]
	Crescent	Present 1933/1934[38]
Strait of Juan de Fuca		
Victoria	Esquimalt Harbour	Historic ca. 1858[39], ca. 1960[9]
	Gorge Waterway	Historic[2], Present 2000[40]
Sooke	Anderson Cove	Present 1999[41]
	Ayum Creek	Present 2007[42]
	Hutchinson Cove	Present 1999[41]

	Roche Cove	Present 1999[41], 2007[42]
	Sooke	Present 1945-1963[43]

References: 1 – Elsey (1933), 2 – Quayle (1969), 4 – Bourne *et al*. (1994), 5 – Gillespie and Bourne (2005b), 6 – Bourne and Heritage (1997), 7 – Gillespie *et al*. (2004), 9 – Quayle (1960), 10 – Taylor (1895), 11 – Gillespie and Bourne (2005a), 13 – Kingzett *et al*. (1995a), 16 – Kingzett *et al*. (1995b), 25 – Heritage *et al*. (1976), 26 – Heritage *et al*. (1977), 27 – Bourne (1978), 28 – Bourne and Heritage (1979), 29 – Heritage and Bourne (1979), 31 – Thompson (1914), 32 – Stafford (1913b), 35 – Lamb and Hanby (2005), 36 – Stafford (1913a, 1913b, 1914, 1915, 1916, 1917), 39 – Lord, *in* Carpenter (1864), 40 – Archipelago Marine Research (2000).

Personal communications: 3 – T. Johansson, DFO; 8 – G. Gillespie, DFO, unpublished data; 12 – J. Watson, Malaspina University-College; 14 – S. Pilcher, BC Ministry of Agriculture and Lands; 15 – B. Kingzett, Blue Revolution Consulting; 17 – F. Bruhwiler, Parks Canada; 20 – B. Campbell, Parks Canada (ret.); 21 – N. and M. Truesdell, Barkley Sound; 22 – H. Holmes, Parks Canada; 24 – G. Meyer, DFO; 30 – D. Plested, Desolation Sound; 33 – D. Nikleva, Chemainus First Nation; 34 – J. Morrison, DFO; 37 – R. Forsyth, RBCM; 41 – E. Helgeson, Coopers Cove Oysters; 42 – A. McNaughton, T'Sooke First Nation.

Museum materials: 18 – RBCM 978-00029-015, 19 – RBCM 976-01228-037, 23 – RBCM 973-00237-015, 38 – RBCM 975-00794-003, 43 – RBCM 976-01210-025.

1.4. Needs of the Olympia Oyster

1.4.1. Habitat and biological needs

Olympia oysters are primarily found in the lower intertidal and subtidal zones of estuaries and saltwater lagoons (Quayle 1969, 1988), but are also found on mud-gravel tidal flats, in splash pools, near freshwater seepage, in tidal channels, bays and sounds, or attached to pilings or the undersides of floats (Couch and Hassler 1989; Harbo 1997). On the outer coast, they are found only in protected locations. They have been found from the intertidal zone to 50m depth (Bernard 1983). Olympia oysters require hard substrate for successful settlement, but may settle on very small pieces (Baker 1995). Hopkins (1935) showed that larvae settle preferentially on the undersides of objects. Olympia oysters will settle successfully on the shells of Pacific oysters.

Olympia oysters are filter feeders. Larvae are planktotrophic; they swim actively and feed on organic material in the water column. Adults rely on suspended organic materials and planktonic organisms. Diatoms and dinoflagellates are preferred food items, and other food types include detritus from disintegrating marine plant and animal matter, bacteria, minute flagellates, other protozoa, and gametes of marine algae or invertebrates (Barrett 1963).

Temperature is critical to Olympia oyster survival and reproduction. This species does not survive freezing, and high summer temperatures can also be lethal (see Section 1.4.3 Limiting Factors).

1.4.2. Ecological role

Olympia oysters have an important ecological role as filter feeders and as prey to crabs, snails, sea stars and birds. Native predators include Dungeness crab (*Cancer magister*), red rock crab (*C. productus*), slender crab (*C. gracilis*), green shore crab (*Hemigrapsus oregonensis*), ochre star (*Pisaster ochraceus*), pink star (*Pisaster brevispinus*), mottled star (*Evasterias troschelii*), sun star (*Pycnopodia helianthoides*), native drill (*Nucella lamellosa*), moon snail (*Euspira lewisi),* (occasionally preys on adult Olympia oysters but is not able to penetrate dense oyster beds), white-winged scoters (*Melanitta fusca*), black scoters (*M. nigra*) and greater scaup (*Aythya marila*) (Quayle 1969, 1988; Baker 1995; Hopkins 1937). In 1998, European green crabs (*Carcinus maenas*) spread north into BC from established populations in Washington, Oregon and California (Gillespie *et al*. 2007). Where they become established, *C. maenas* can, have substantial negative impacts by preying on the young of species such as oysters and the Dungeness crab, or competing with them for resources (Lafferty and Kuris 1996).

Like other species of oysters, Olympia oysters are a substrate for colonization by barnacles.

1.4.3. Limiting factors

A number of biological traits may increase the Olympia oyster's vulnerability and inability to withstand adverse impacts. These limiting factors include: vulnerability to temperature extremes that, in BC, exceed their physiological tolerances at the northern extreme of their natural range; fairly specialized habitat requirements, primarily lagoons, bays and estuaries; relatively low fecundity; and limited dispersal of larvae relative to distances between suitable habitats.

Temperature extremes
Historically, the most important limiting factor leading to decline was temperature extremes. Olympia oysters cannot withstand freezing. A severe winter in 1929 destroyed much of the Ladysmith Harbour population, and another severe frost in about 1940 destroyed most of the remaining Boundary Bay population (Quayle 1969). Freezing in 1915 also had severe impacts on the beds in the Puget Sound region (Edmondson 1923).

That there are few large populations reported in northern BC or Alaska is likely a result of physiological temperature requirements for gonadal development and successful spatting. Olympia oysters require an ambient water temperature of at least 12.5^{o}C to reproduce (Hopkins 1937), but reproduction occurs more commonly at temperatures of 14-16^{o}C (Strathman 1987). Although oysters may mature in their first year and more than one generation might be produced in favourable seasons in southern California (Coe 1932b), cooler temperatures further north may result in only one or two spawnings in mid summer (Couch and Hassler 1989), later age at maturity, and generally less productive populations. Temperature is also a critical element for Olympia oysters in timing of reproductive phases; periods of low temperature can interrupt the alteration of sexes, which resume again when temperatures increase (Baker 1995). High summer temperatures can also cause considerable mortality in young-of-the-year oysters. Broad environmental changes, such as global climate change which has been predicted to influence temperature extremes, may influence the future distribution of Olympia oysters.

Specialized habitat requirements

The vulnerability of Olympia oysters to freezing or high summer temperatures likely explains the limitation of large populations to low tidal levels, lagoons, or other habitats that have standing water, which serves to insulate the oysters from extremes in air temperature. Small relict populations of Olympia oysters survive at low tidal levels, which are not often exposed to freezing air temperatures; and in instances where they have attached to the undersides of floating structures which are constantly submerged.

Limited dispersal and relatively low fecundity

Adult oysters are sessile, regardless of whether individuals are attached to the substrate, or laying on it. They cannot move away from predators, nor migrate to areas which offer more suitable temperatures, water quality or food supply. Their survival is highly dependent on the site in which they first settle. From the time of post-larval settlement, the physical protection of their shells and their physiological tolerances determine their ability to survive.

Olympia oysters are motile for only a short planktonic larval period. Growth of planktonic larvae is relatively rapid (Loosanof and Davis 1963; Strathman 1987) with larvae settling in 2-3 weeks. Coe (1932b) felt that opportunities for dispersal were limited due to this short larval stage. Baker (1995) suggested that Olympia oyster larvae stay relatively close to the sites where they were spawned. Quayle (1969) reported transport of Pacific oyster larvae over a distance of 56 km (35 mi) from a breeding population in Ladysmith Harbour in the 1930s. Given that the larval period of Olympia oysters in BC is similar to that of Pacific oysters (2-3 weeks, depending on temperature), then dispersal of 56 km can be expected. Within such a relatively limited area, the specific habitats, such as lagoons and standing water (see above), that will support an adult population may not exist.

Total fecundity before fertilization has not been documented (Baker 1995), but Hopkins (1937) indicated that brood size for marketable oysters ranges from 250,000 to 300,000 larvae. In southern California (Coe 1932a), the spawning season lasts at least seven months from April to October or November. In BC, the spawning season lasts only about three months (Stafford 1915), with spatting occurring commonly from July through September (Elsey 1933). Male and female phases alternate, presumably for the life span of the individual. Age at first reproduction is dependent upon the time of settlement in the summer (Coe 1932b). Under appropriately warm temperatures, such as those found further south in California, as many as three sexual phases and release of gametes might occur in the first year of life. However, because of lower temperatures and later settlement in BC, first male sexual maturity is not usually achieved until the second breeding season, *i.e.*, at nearly one year of age (Elsey 1933).

1.5. Threats

1.5.1. Threat classification

Table 2. Threat Classification Table.

1	**Human Alteration of Habitat**	**Threat Information**		
Threat Category	Habitat Loss or Degradation	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Burying and loss of habitat from land use or harvesting practices	**Occurrence**	Current	
		Frequency	Recurrent	
Specific Threat	Alteration of habitat characteristics	**Causal Certainty**	High	
		Severity	High	
Stress	Increased mortality and loss of reproductive success	**Level of Concern**	High	
2	**Introduction of Non-indigenous Predators and Parasites inadvertently by Aquaculture and Harvesting**	**Threat Information**		
Threat Category	Exotic or Invasive Species	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Inadvertent introduction or transfer by aquaculture and harvesting	**Occurrence**	Unknown	
		Frequency	Recurrent	
Specific Threat	Predation (*e.g.*, green crabs), parasites (*e.g.*, Denman Island Disease)	**Causal Certainty**	Medium	
		Severity	Moderate	
Stress	Increased mortality and loss of reproductive success	**Level of Concern**	Medium	
3	**Pollution**	**Threat Information**		
Threat Category	Pollution	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Pulp mills or anti-fouling paint of Canadian and international oceangoing vessels (>25m)	**Occurrence**	Historic	
		Frequency	Continuous	
Specific Threat	Sulphite waste or TBT	**Causal Certainty**	High (sulphite waste) Medium (TBT)	
		Severity	Moderate	
Stress	Increased mortality or loss of reproductive success	**Level of Concern**	Medium	

4	**Harvest**	**Threat Information**		
Threat Category	Consumptive Use	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Harvest (historic)	**Occurrence**		Historic
		Frequency		Continuous
Specific Threat		**Causal Certainty**		High
		Severity		High
Stress	Increased mortality	**Level of Concern**	Low	

1.5.2. Description of threats

Anthropogenic threats to Olympia oysters that have led to population declines in the past include human alteration of habitat, inadvertent introduction of non-indigenous predators and parasites, vulnerability to human pollution (pulp mill effluent and possibly antifouling paints), and over harvesting. See section 7 for definition of threat categories.

Human alteration of habitat
Estuarine habitats are limited in BC, and many estuaries have been adversely affected by human practices. Burying and increased siltation due to foreshore development, forestry practices and land management practices (urbanisation and industrialization) can be detrimental to oyster populations. Estuaries and bays that previously supported Olympia oyster populations (*e.g.*, Ladysmith Harbour) are now heavily impacted by urbanisation, pollution and other effects of commercial and recreational use.

Couch and Hassler (1989) felt that the use of major growing areas previously used for Olympia oysters and now used for growing Pacific oysters, contributed to the decline of Olympia oyster production in the western U.S.; it is also possible that disturbance of former Olympia oyster growing areas by intertidal clam harvests may be sufficient to prevent recolonization by oysters. Manila clams, *Venerupius philippinarum*, are fished primarily on the upper third of the intertidal zone, which minimizes impacts on Olympia oyster populations in the lower third of the zone. While the information is anecdotal, the closure of the intertidal clam fishery north of Brooks Peninsula in the early 1990's may have allowed Olympia oysters to occupy more of the intertidal zone in Klaskino Inlet (S. Pilcher, pers. comm.). Similarly, Pacific oyster culture is primarily carried out in the upper and mid-intertidal zones. In the shallow subtidal zone of some oyster culture areas, Olympia oysters regularly settle on oyster shell left on the beach as cultch. Olympia oyster populations in Oregon have not been affected by Pacific oyster culture (J. Johnson, Oregon Department of Fish and Wildlife, pers. comm.).

Inadvertent introduction or transfer of non-indigenous predators and parasites by aquaculture and harvesting

Intentional introductions of species for aquaculture and routine transfers of cultured or wild harvested species such as oysters and clams from one locality to another can result in inadvertent introduction or transfer of non-indigenous predators and parasites of Olympia oysters.

Predatory gastropods can cause significant mortality in oysters. The Atlantic or eastern oyster drill, *Urosalpinx cinerea*, was introduced to Boundary Bay and Ladysmith Harbour with Atlantic oysters (Carl and Guiguet 1957; Quayle 1964) but has not been observed in recent history (Forsyth, pers. comm.; Harbo 1997). The Japanese oyster drill, *Ocinebrellus inornata* (= *Ceratostoma inornatum*), introduced with Pacific oysters from Japan, is also a serious predator of Olympia oysters (Hopkins 1937; Chapman and Banner 1949). The Japanese drill is present in BC (Boundary Bay and Ladysmith Harbour, R. Harbo, pers. comm.; Useless Inlet, Barkley Sound, G. Gillespie, pers. comm.), though their distributions are relatively limited, and dispersal is nearly negligible, due to the lack of a pelagic larval stage and patchiness of available habitat (Carl and Guiguet 1957; Quayle 1964, 1969, 1988). Early spread of these two species was also curtailed by regulations prohibiting movement of oysters from areas suffering drill predation to drill-free areas. The extremely limited distribution has probably limited their impact in BC to date (Gillespie 2000).

The Japanese oyster leech (a flatworm), *Pseudostylochus ostreophagus*, which was introduced with Pacific oysters, has been accused of causing large mortalities in Olympia oyster spat in Puget Sound (Woelke 1956), and “assumes pest proportions” in some years (Quayle 1988). It is well established also in southern BC and has caused significant mortality in juvenile Pacific oysters (N. Bourne, DFO, pers. comm.) and Japanese scallops, *Mizuhopecten yessoensis* (Bower and Meyer 1994).

Olympia oysters are also susceptible to Denman Island disease, caused by the intracellular parasite *Mikrocytos mackini*. The disease is known only from the Georgia Strait and other specific localities on Vancouver Island (Bower *et al*. 1994). The disease causes mortality of larger oysters at low tide levels in the spring, following a 3-4 month period of temperatures less than 10°C. It is associated primarily with Pacific oysters, but Olympia oysters may be more susceptible to infection and the resulting disease (Bower *et al*. 1997). Bower *et al*. (1997) speculated that arrival of the disease with imported Pacific oyster seed in the 1930s could have been responsible for drastic reductions in Olympia oyster populations in BC, although the disease was yet to be reported from Japan.

Olympia oysters are infected by a parasitic copepod, *Mytilicola orientalis*, introduced with Pacific oysters, which lives in the lower intestinal tract of bivalve molluscs (Bernard 1968, 1969; Bradley and Siebert 1978). Although some early reports indicated that infestation led to reduced condition factor, little evidence was found in Bernard’s studies. Bower *et al.* (1994) more recently determined that this infection appears to cause no pathological effects.

The European green crab (*Carcinus maenas*) arrived in BC as pelagic larvae during the 1998/99 El Niño event. They have established local populations in most of the inlet systems on the west coast of Vancouver Island (Gillespie *et al*. 2007). Green crabs are a well-documented predator on small bivalves and may have additional impact on Olympia oyster populations wherever they become established (Jamieson *et al*. 1998, Palacios and Ferraro 2003).

Atlantic oysters, *C. virginica*, were introduced for culture near Victoria about 1883 (Carlton and Mann 1996), followed by other introductions at Boundary Bay, Esquimalt and Ladysmith (Quayle 1969). Currently, Atlantic oysters are only found at Boundary Bay and upstream in the Nikomekl River (Harbo, 1997). Pacific oysters were first introduced to BC for culture in 1912 or 1913, but not in large numbers until 1925 (Elsey 1933; Bourne 1997). Pacific oysters are now abundant in the south coast of BC and are routinely transferred and beach cultured. More recently, European flat oysters, *Ostrea edulis*, have been intentionally introduced for aquaculture (Gillespie 2000). Some European oysters have been found in the wild (Barkley Sound; R. Harbo, pers. comm.) originating from spawning stock on aquaculture tenures. Olympia oysters may be susceptible to many of the diseases and parasites of these related species.

In addition to oysters, there is a risk that mussels, scallops, and clams could be accidental carriers of shellfish diseases. Aquatic animal diseases can be spread through transport of infected products. Transferring shellfish from one body of water to another for biological cleansing ("relaying") could contribute to disease transfer. Another, larger concern is the inadvertent movement of disease through wet storage or holding shellfish in seawater systems that flow into the open environment.

Pollution (sulphite waste and TBT)

There is considerable literature documenting the deleterious effects on Olympia oysters of sulphite waste liquor released from pulp mills (*e.g.*, Hopkins *et al.* 1935; McKernan *et al.* 1949; Odlaug 1949; Steele 1957). Local extirpations as well as a general decline in oyster populations throughout southern Puget Sound between 1926 and 1945 were linked to waste from pulp mills. Deleterious effects (lack of growth, decreased condition/meat yield, failure to reproduce and high mortality rates) were induced in oysters in the laboratory by exposure to sulphite waste liquor (McKernan *et al*. 1949). It is possible that similar effects occurred near pulp mills in BC (Gillespie 2000).

There is only one sulphite pulp mill operating in western Canada and it discharges into Neroutsos Inlet near Port Alice, BC. Four other BC mills used the sulphite process historically but have long since changed processes or shut down (at Woodfibre, Skeena, Powell River and Ocean Falls). The Port Alice mill conducts environmental effects monitoring (EEM) as a condition of deposit under *Pulp and Paper Effluent Regulations* of the *Fisheries Act*. Their EEM pre-design review of historical information did not show Olympia oysters among the resources documented in Neroutsos Inlet (J. Boyd, pers. comm., Environment Canada, Vancouver).

While there is no published research examining the effects of the anti-fouling compound tributyltin (TBT) on Olympia oysters, chambering (abnormal shell growth characterized by large empty chambers in the shell matrix) of Pacific oysters as a result of TBT exposure has been demonstrated in BC and elsewhere (Paul and Davies 1986, DFO 1996, Alzieu 1998, Gillespie 2000), and TBT has been implicated in failures of the closely related European flat oyster to grow or spawn in France (Thain and Waldock 1986). In BC, water-borne concentrations of TBT were found to be high enough in the Georgia Strait and the Strait of Juan de Fuca to affect reproduction in three species of snails (Bright and Ellis 1990), and possibly to cause extirpation of these species from highly contaminated waters around Vancouver (Horiguchi *et al*. 2003). The impact was less severe and more localized on the west coast of Vancouver Island and in the central and north coasts of BC (Bright and Ellis 1990).

In the Georgia Basin, elevated levels of butyltin compounds were detected in surface waters, bottom sediments, fish, aquatic invertebrates, and/or fish-eating birds collected in the vicinity of some marinas, harbours, shipyards, recreational boating areas, and salmon farms in the late 1980s and early 1990s. Environmental levels of TBT have decreased in coastal marinas (and likely salmon farms and recreational boating areas) since 1989, when Canada prohibited the use of TBT-based antifouling paints on small vessels (<25 m). However, levels in harbour areas remained elevated in 1995 due to the continued release of TBT-based antifoulants from vessels over 25 m in length and from foreign vessels. In some areas, surface water concentrations greatly exceeded the Canadian water quality guideline for the protection of marine life (Garrett and Shrimpton 1997). While recovery of neogastropods in some low and moderate traffic boating areas in south coastal BC was observed, recovery was not observed in large harbours, such as Vancouver Harbour, where environmental concentration of butyltin compounds remained elevated (Horiguchi et al. 2003; Reitsema et al. 2002; Tester et al. 1996). As of 2003, sediment samples collected from Vancouver, Victoria and Esquimalt harbours still contained elevated concentrations of butyltins (Thompson et al. 2005). There is, however, little option for remedial action as dredging would re-release butyltins from the sediments.

More recently, Canada prohibited the use of TBT in antifouling paints on January 1, 2003 and in 2007 the Minister of Environment has proposed to add TBT to the list of toxic substances under the *Canadian Environmental Protection Act*.

Water quality was historically considered to be a negative factor in Puget Sound, but is not considered to be a factor currently hindering recovery (Schafer 2004).

Harvest (historic)
Olympia oysters were a source of food for natives in California, and populations may have declined before historic times, based on evidence from middens (Shaw 1997). Lord (*in* Carpenter 1864) reported that native oysters were found in Esquimalt Harbour, BC, and were "dredged-up by Indians in small handnets with long handles, in 2-3 fm., on mud-flats". Olympia oysters were not noted from middens at Yuquot, Nootka Island and Ozette, Wa (Clarke and Clarke, 1980; Wessen 1988) but have been found in middens at numerous other localities, including the Victoria area (G. Keddie, pers. comm.). They were found in middens at False Narrows, Gabriola Island (Royal BC Museum collections), but the source location is unknown.

The overall commercial history of Olympia oyster exploitation on the west coast, in California, Oregon, Washington and BC, was one of overharvest and replacement with more marketable species, first with unsuccessful attempts to introduce Atlantic oysters, and finally with the development of Pacific oyster culture. Commercial production from Olympia oyster beds required harvests of huge numbers of animals, approximately 1,600 Olympia oysters were required to produce a gallon (3.78 L) of meats (Hopkins 1937).

Commercial landings of Olympia oysters in BC began in approximately 1884 and continued to about 1930. The fishery was small, and annual landings probably never exceeded 300 t (Bourne 1997). Elsey (1933) indicated that increased landings of oysters (primarily Olympia oysters) between 1925 and 1930 was due to increased effort expended in thinly stocked and isolated areas, and in harvesting undersized or inferior oysters. By 1913, Stafford (1913a) was already warning of the demise of the oyster fishery, and of oyster populations, in BC.

By 1930, natural Olympia oyster beds on the Pacific coast had been exhausted, and the oyster industry was essentially confined to Puget Sound. Production from BC and Oregon was considered insignificant. The entire Pacific production of Olympia oysters was less than 1% of the U.S. total oyster production (Sherwood 1931), which by then had become reliant on Pacific oysters.

There is currently no targeted commercial fishing for Olympia oysters in BC. Olympia oysters likely hold little recreational interest because of their small size (Gillespie 2000). In 2007, the recreational bag limit for Olympia oysters was reduced to zero under the *Fisheries Act* (*BC Sport Fisheries Regulations*). The level of food, social and ceremonial harvest by First Nations is unknown and is not restricted. Olympia oysters may be cultured on aquaculture tenures under provincial regulation; however, there are currently only five sites licensed for Olympia oyster culture and none of these sites have reported any culture activities or harvest to-date.

The Province of BC licences the harvest of oysters under Section 9 of the BC *Fisheries Act* Regulations on vacant Crown land. Harvest permits are issued only in areas where stock assessment has been carried out and determined that a harvestable surplus is available. Although licences are not specific as to the species of oyster, stock assessment and harvest is currently directed to Pacific oysters (*Crassotrea gigas*). Toquart Bay is the only area where commercial harvest is currently licensed and there is an overlap between Pacific oyster and Olympia oysters (S Pilcher, pers. comm.).

1.6. Actions Already Completed or Underway

The following management actions are already completed or underway in BC.

- Commercial harvest of Olympia oysters ended ~1930. The current stock assessment and market demand is for the Pacific oyster.

- The recreational harvest limit for Olympia oysters was reduced to zero in May 2007 and included in the BC Tidal Waters Sport Fishing Guide 2007-2009.

- Under authority of the *Fisheries Act*, authorization by a permit or a licence is required from the federal-provincial Introductions and Transfers Committee to release live fish, including aquaculture species, into any fish habitat or to transfer live fish, including aquaculture species, to fish rearing facilities or fish habitat.

- Under authority of the BC *Fisheries Act* permission is also required to plant or introduce oysters, oyster seed, cultch or oyster shells from outside the Province.

- Under authority of the BC *Fisheries Act*, there are restrictions in the movement of oysters and oyster culture and harvesting equipment to prevent the spread of drills and Denman Island disease.

- An industry advisory to prohibit the transfer of green crabs from the west coast of Vancouver Island was issued in 2007.

- Aquaculture sites and leases with allowable harvest of Olympia oysters were reviewed in 2007.

- Canada prohibited the use of TBT in antifouling paints January 1, 2003, and has proposed in 2007 to add TBT to the list of toxic substances under the *Canadian Environmental Protection Act*.

- COSEWIC designated Olympia oysters a species of Special Concern (2000) and Olympia oysters are legally listed as Special Concern under SARA (2003). SARA's purpose is to manage species of Special Concern to prevent them from becoming endangered or threatened, although it does not add additional prohibitions as it does for threatened or endangered species.

- Existing marine protected areas and fisheries closures are summarized in Jamieson and Lessard (2000), and include the Pacific Rim National Park Reserve and BC Provincial Parks and Ecological Reserves, also affording some levels of protection to Olympia oysters.

- Provincial Map Reserves established under the *Land Act* (BC) for Pacific oyster spat collection (Hotham Sound, Pendrell Sound, Pipestem Inlet, Nesook Bay) may provide refuge for Olympia oysters.

- A number of non-indigenous predators, diseases and parasites of concern to Olympia oysters have been identified (see Section 1.5 Threats).

- Localities known to support Olympia oysters have been compiled (2000; 2007) (see Section 1.3 Populations and Distribution).

1.7. Knowledge Gaps

Following are the most important knowledge gaps in the management of Olympia oysters in BC.

Threat clarification
An identification of the sites where non-indigenous predators and parasites have already become established, and for which there may be concern for Olympia oysters, will assist in the management of aquaculture and wild harvest (*e.g.*, wet storage) transfers. In cases where there is a high risk, mitigation options may be developed to reduce the risk of predator or parasite

transfer to the wild. Ongoing monitoring for new predators, diseases and parasites will be needed.

Population monitoring
Few estimates have been made in BC of Olympia oyster abundance (see Section 1.3 Populations and Distribution). Further consultation and surveys will be required to document the current distribution of Olympia oysters in BC.

Food, social, ceremonial harvests
Further information is needed on the level of harvest of Olympia oysters by First Nations for food, social and ceremonial purposes.

Aquaculture
The few licensed aquaculture sites with Olympia oysters report no sales to-date. Further, consultation with the aquaculture industry may assist to determine if the limiting factors to interest in Olympia oyster culture to-date are related to markets, site suitability, and/or access to brood stock, seed or spat.

2. MANAGEMENT

Population declines were recorded historically, but there is no current information to indicate that the population is continuing to decline. From the information that is available the population appears to be stable at low levels relative to historic accounts.

2.1. Goal

In consideration that BC is likely at or near the northern end of the global distribution of Olympia oysters and that the population appears to be stable at low levels relative to historic accounts, the management goal is, therefore, to maintain stable populations of Olympia oysters in BC.

2.2. Objective

The objective will be to ensure maintenance of the relative abundance of Olympia oysters at index sites over the next six years (2008-2013).

2.3. Actions

2.3.1. Protection

1. As index sites are identified (Section 2.3.4), consider establishing a notation of interest or map reserve through the existing provincial process to protect index sites that are not already protected (*e.g.*, within federal or provincial parks or provincial ecological reserves).

2. Where possible, develop and undertake protection measures by identifying Olympia oysters in coastwide mapping initiatives and land/marine-use planning processes, such as the Quatsino Sound Coastal Plan, in order for the relevant authorities to take into account the presence of Olympia oysters.

2.3.2. Management

1. Seek agreement with the Province of BC to mitigate potential impacts on Olympia oysters populations from provincially regulated oyster harvesting activities.

2. Maintain the recreational harvest limit of zero.

3. Continue to limit, under the *Fisheries Act* and BC *Fisheries Act*, the commercial and recreational harvest of Olympia oysters.

4. Develop mitigation measures in key areas to reduce potential impacts on Olympia oyster populations from non-indigenous predators and parasites.

5. Continue to regulate through the habitat referral process, activities that may disrupt or alter Olympia oyster habitat, particularly nearshore developments where populations of Olympia oysters are known to occur. For nearshore development projects, avoid impacts to Olympia oyster beds through project relocation or design mitigation if possible. If impacts are unavoidable, adhere to like-for-like principles when designing and constructing compensatory habitat.

2.3.3. Research

1. Identify beaches where intertidal clam harvesting co-occurs with Olympia oysters through discussion with clam harvesters and First Nations.

2. Review the success of restoration efforts in Washington, Oregon, and California.

3. Collate information on the distribution of non-indigenous predators (*e.g.*, green crabs) and parasites (*e.g.*, Denman Island Disease) of concern to Olympia oysters and provide this information to the federal-provincial Introductions and Transfers Committee to assist in decisions on the permitting of aquaculture- and harvest-related transfers.

2.3.4. Monitoring and Assessment

1. Gather resource maps using local and traditional knowledge to identify and establish index sites in collaboration with First Nations, governments, oyster harvesters and aquaculturists for the purpose of collaborative monitoring of known locations with Olympia oysters (Table 1). Review relative abundance at each index site at least once every five years.

2. Develop survey protocols for making relative abundance (maximum density) estimates at established index sites.

3. Undertake baseline histopathological examinations as well as preserve tissue samples for future pathogen specific studies.

2.3.5. Outreach and Communication

1. Communicate about the potential detrimental effects of predator and parasite transfers on Olympia oysters to aquaculturists, the BC Shellfish Grower's Association, wild clam and oyster harvesters (commercial, recreational and First Nations), BC Ministry of Agriculture and Lands and the Introductions and Transfers Committee.

2.4. Performance Measures

The following performance measures will be used to assess implementation and to determine whether management objectives are being met. As more information is gathered through the establishment of index sites, survey protocols and regular monitoring, more prescriptive performance measure(s) can be developed.

Objective based performance measure:

- Has the relative abundance of Olympia oysters at identified index sites changed over the period 2008-2013?

Approach based performance measures:

- Have index sites been identified and protected?
- Have anthropogenic threats been managed through existing management tools?
- Have resource maps been created?
- Have survey protocols been adopted?
- Have tissue samples been collected for baseline analysis?
- Have stakeholders been engaged in implementing management actions?

2.5. Proposed Implementation Schedule

Fisheries & Oceans Canada encourages other agencies and organizations to participate in the conservation of the Olympia oyster through the implementation of this management plan. The agencies in Table 3 have been identified as partners for implementing the recommended actions. The table summarizes those actions that are recommended to support the management goals and objectives. The activities implemented by Fisheries & Oceans Canada will be subject to the availability of funding and other required resources. Where appropriate, partnerships with specific organizations and sectors will provide the necessary expertise and capacity to carry out the listed action. However, this identification is intended to be advice to other agencies, and carrying out these actions will be subject to each agency's priorities and budgetary constraints.

Table 3. Proposed Implementation Schedule

Action	Obj.	Priority	Threats addressed	Participating Agencies*	Timeline
Protection					
Inventory, establish and protect index sites	1	H	Human alteration of habitat	DFO, BC MAL, PC, BCSGA	2008-2009
Marine-use planning	1	M	Human alteration of habitat; Introduction of non-indigenous predators and parasites	*e.g.*, QS CMA, PNCIMA, Cooperators in the integrated management area	2008-2013+
Management					
Mitigate commercial harvest activities	1	H	Vulnerability to harvest	BC MAL, DFO	2008-2013+
Maintain recreational bag limit of zero	1	H	Vulnerability to harvest	DFO	2008-2013+
Limit commercial and recreational harvest	1	H	Vulnerability to harvest	DFO, BC MAL	2008-2013+
Develop mitigation measures for non-indigenous predators and parasites	1	H	Introduction of non-indigenous predators and parasites	DFO, BC MAL, BCSGA, ITC	2008-2013+
Mitigation/ compensation (project review process)	1	H	Human alteration of habitat	DFO, As identified	As identified
Research					
Identify clam harvesting beaches	1	M	Human alteration of habitat	DFO, BC MAL, Clam Boards	2009
Review success of restoration	1	L	Human habitat alteration, historic harvest	DFO, BC MAL, Researchers	As appropriate
Collate information on non-indigenous	1	H	Introduction of non-indigenous predators and	DFO, BC MAL, ITC	2008 (update as needed)

* Identification of government agencies and non-governmental organizations is intended to be advice and does not commit the agency or organization to implementing the listed action. Implementing actions will be contingent upon each organization's or agency's priorities and budgetary constraints.

predators & parasites, provide to ITC			parasites		
Monitoring& Assessment					
Establish & monitor index sites	1	H	Monitor status	DFO, BC MAL, PC, To be identified	2009 & once/5 yrs.
Develop abundance protocols	1	M	Monitor status	DFO	2008-2013
Undertake histopath-ological studies	1	M	Monitor status	DFO, ITC	2008-2013
Communication					
Communicate about transfers of non-indigenous predators and parasites	1	H	Introduction of non-indigenous predators and parasites	DFO, BC MAL, BCSGA	2008-2013+

Key to abbreviations:
DFO - Fisheries & Oceans Canada
BC MAL - British Columbia Ministry of Agriculture and Lands
BCSGA - BC Shellfish Growers' Association
ITC – federal/provincial Introductions and Transfers Committee
PNCIMA - Pacific North Coast Integrated Management Area
PC – Parks Canada Agency
QS CMA - Quatsino Sound Coastal Management Area

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APPENDIX II. GLOSSARY

Ambient: surrounding.

Anti-fouling (anti-foulant): a substance that prevents an accumulation of deposits. In the context of marine vessels, an anti-foulant paint prevents marine organisms, such as barnacles and algae, from growing and accumulating on the vessel's hull.

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

BC: British Columbia, Canada.

Bivalve: an animal having a shell composed of two movable valves that open and shut (e.g., oysters, clams).

Butyltins: organotin substances, to which tributyltin belongs.

Chomata: series of fine teeth. The shell edges of Olympia oysters have a series of tiny teeth near the hinge called chomata that are not present on *Crassostrea spp.*

Copepod: a minute aquatic crustacean.

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

Cultch: a material (e.g., oyster shell) laid down on oyster grounds to furnish points of attachment for the spat.

DFO: Fisheries & Oceans Canada.

Diatoms: a group of unicellular or colonial algae, having a silicified cell wall that persists as a skeleton after death.

Dinoflagellates and flagellates: a microscopic organism that drifts in the water.

Ecological: of or having to do with the environments of living things or with the pattern of relations between living things and their environments.

Fecundity: number of eggs produced by one female.

fm. (fathom): a unit of length equal to 6 feet based on the distance between fingertips of a man's outstretched arms and used especially for measuring the depth of water.

Gametes: a mature germ cell (as a sperm or egg).

Gastropod: a mollusc of the class Gastropoda with a univalve shell which is not divided into chambers and is usually spiraled or coiled (e.g., snails and whelks), and some (e.g., slugs) with the shell greatly reduced or lacking.

Gonadal: a primary sex gland (ovary or testis)

Intertidal: of, relating to, or being the part of the littoral zone that is above low-tide mark.

Intracellular: being or occurring within a body cell.

Invertebrates: animals without backbones.

Map Reserve: a designation under the *Land Act* (B.C.) used to remove specific areas of Crown land from further disposition.

Mollusc: a large group (phylum) of invertebrate animals that include snails, mussels and other bivalves, octopuses and related forms and that have a soft unsegmented body lacking segmented appendages and commonly protected by a calcareous shell.

Mortality: death.

Neogastropod: a subgroup of gastropods comprised of modern marine snails.

Non-indigenous: introduced directly or indirectly into a particular land, region or environment from outside.

Oyster seed: see 'spat'.

Oyster cultch: see 'cultch'.

Pathological: diseased, altered by disease.

Physiological: characteristic of or appropriate to an organism's healthy or normal functioning.

Plankton: the passively floating or weakly swimming animal and plant life of a body of water.

Planktotrophic: swim actively and feed on organic material in the water column.

Protozoa: a group of animals that have essentially an acellular structure (e.g., amoebas).

Post-larva (post-larval): immature, before it has attained the appearance of a miniature adult.

SARA: the *Species at Risk Act*.

Spat: a young oyster (or other mollusc) either before or after it first becomes adherent.

Spatting: spawning.

Special Concern (Species of Special Concern): a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.

Subtidal: of, relating to, or being the part of the zone that is underwater below the low-tide mark.

TBT: Tributyltin.

APPENDIX III. ANTHROPOGENIC THREAT CLASSIFICATION TABLE DEFINITIONS

The following definitions are taken from the draft Guidelines on Identifying and Mitigating Threats to Species at Risk, February 1, 2007, prepared by Environment Canada.

Threat category – Broad category indicating the type of threat. The threat categories are:

- Habitat Loss or Degradation
- Exotic or Invasive Species

- Changes in Ecological Dynamics or Natural Processes
- Pollution
- Accidental Mortality
- Consumptive Use
- Disturbance or Persecution
- Climate and Natural Disasters
- Natural Processes or Activities

General threat – Typically the general activity causing the specific threat. To be determined by status report author or recovery team/planner.

Specific threat – The specific factor or stimulus causing stress to the population. To be determined by status report author or recovery team/planner. Note that not every threat can be specified to all three levels in this classification hierarchy. Thus, in these situations, specify either a general or specific threat.

Stress – Indicated by an impairment of a demographic, physiological, or behavioural attribute of a population in response to an identified or unidentified threat that results in a reduction of its viability. To be determined by status report author or recovery team/planner.

Extent – Indicate whether the threat is widespread, localized, or unknown across the species range.

Occurrence – Indicate whether the threat is historic (contributed to decline but no longer affecting the species), current (affecting the species now), imminent (is expected to affect the species very soon), anticipated (may affect the species in the future), or unknown. If applicable, also indicate whether the occurrence differs between 'local' populations or smaller areas of the range and the full 'range-wide' distribution.

Frequency – Indicate whether the threat is a one-time occurrence, seasonal (either because the species is migratory or the threat only occurs at certain times of the year – indicate which season), continuous (on-going), recurrent (reoccurs from time to time but not on an annual or seasonal basis), or unknown. If applicable, also indicate whether the frequency differs between 'local' populations or smaller areas of the range and the full 'range-wide' distribution.

Causal certainty – Indicate whether the best available knowledge about the threat and its impact on population viability is high (evidence causally links the threat to stresses on population viability), medium (correlation between the threat and population viability, expert opinion, etc), or low (assumed or plausible threat only). This should be a general reflection of the degree of evidence that is known for the threat, which in turn provides information on the risk that the threat has been misdiagnosed. If applicable, also indicate whether the level of knowledge differs between 'local' populations or smaller areas of the range and the full 'range-wide' distribution.

Severity – Indicate whether the severity of the threat is high (very large population-level effect), moderate, low, or unknown. If applicable, also indicate whether the severity differs between 'local' populations or smaller areas of the range and the full 'range-wide' distribution.

Level of concern – Indicate whether managing the threat is an overall high, medium, or low concern for recovery of the species, taking into account all of the above factors.

Local – indicates threat information relates to a specific site or narrow portion of the range of the species.

Range-wide – indicates threat information relates to the whole distribution or large portion of the range of the species.

APPENDIX IV. RECORD OF CONSULTATION AND COOPERATION

The Olympia oyster is an aquatic species under federal jurisdiction, managed by Fisheries and Oceans Canada: 200-401 Burrard St., Vancouver, B.C. V6C 3S4. The draft Olympia oyster management plan was made available publicly via the Fisheries and Oceans Canada webpage: (http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/olympiaoyster/default_e.htm). DFO also requested comments directly from coastal First Nations, the Province of BC and other government departments. Input was also provided by the BC Shellfish Growers Association and the Introductions and Transfers Committee. Information was provided to the Sports Fish Advisory Board, the West Coast Vancouver Island Aquatic Management Board, the Boundary Bay Shared Waters Alliance and to interested parties at the fall session of the DFO community dialogue sessions.