Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 99/150

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 99/150

Status of the Olympia Oyster, *Ostrea conchaphila*, in Canada

Graham E. Gillespie

Fisheries and Oceans Canada
Stock Assessment Division
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC, V9R 5K6

ISSN 1480-4883
Ottawa, 1999

ABSTRACT

The Olympia oyster, *Ostrea conchaphila* (= *Ostrea lurida*), is the native oyster of the west coast of North America. They are relatively small oysters, generally found attached to hard substrate or loose on soft substrate in singles or small groups. They are generally distributed from southeast Alaska to Panama, occurring discontinuously in appropriate habitats such as estuaries, lagoons, bays, tidal flats or attached to pilings or floating structures. Maximum reported size is 90 mm diameter, although most individuals are less than 60 mm. Maximum age is unknown, but could be > 10 years. In British Columbia, first maturity is generally achieved one year after settlement. Olympias are larviparous, protandrous, alternating hermaphrodites. Individuals mature first as males, then alternate between male and female phases throughout their lifetime. Fecundity is approximately 250,00-300,000 larvae per spawning. Larvae are retained in the parental mantle cavity for approximately 2 weeks, then are planktonic for 2-4 more weeks. Larvae settle preferentially on the undersurface of hard substrates. In British Columbia, brooding occurs from mid-May to July and settlement occurs from July to September. Dispersal is limited to the planktonic larval phase, once set the adults are sessile. Three to four years growth are required to reach 35-45 mm in size, and little growth occurs after 5 years.

Olympia oysters were commercially fished in British Columbia, Washington, Oregon and California beginning in the mid-1800's. Natural aggregations were overharvested, and largely depleted by the 1930's. The west coast oyster industry unsuccessfully attempted introduction of Atlantic oysters, *Crassostrea virginica*, and is currently dependent on introduced Pacific oysters, *Crassostrea gigas*. Olympia oysters are not commercially fished in British Columbia, and likely hold little recreational value because of their small size.

Olympia oyster distribution is limited by specialized habitat requirements, and relatively low fecundity and dispersal. Olympias are vulnerable to temperature extremes, and are not resistant to harvests on a commercial scale. Habitats which once supported large aggregations in Georgia Strait no longer do, in part due to historic overharvests and environmental stresses, and because development of large oyster reefs may require centuries without disturbance. Small relict populations survive at low tide levels and under floating structures. Olympias are locally common at sites on the west coast of Vancouver Island, and little information exists on populations in Johnstone Strait or in the Central Coast. They do not occur in the Queen Charlotte Islands.

Olympia oysters are not likely facing imminent danger of extinction or extirpation in Canada. Limiting factors have led to significant reductions to population levels in the past. From the limited data currently available, the author recommends a status of Special Concern is appropriate.

RÉSUMÉ

L’huître plate pacifique, *Ostrea conchaphila* (= *Ostrea lurida*), est l’huître indigène de la côte ouest de l’Amérique du Nord. Elle est relativement petite et on la retrouve généralement fixée à un substrat dur ou libre, seule ou formant de petits groupes, sur des substrats mous. Son aire de répartition s’étend du sud-est de l’Alaska jusqu’à Panama mais n’est occupée que dans les habitats adéquats que sont les estuaires, les lagunes, les baies, les fonds intertidaux et les endroits où l’huître peut se fixer tels des pieux ou des structures flottantes. La taille maximale signalée est de 90 mm de diamètre, mais la plupart des individus sont d’un diamètre inférieur à 60 mm. L’âge maximal est inconnu mais pourrait être supérieur à 10 ans. En Colombie-Britannique, la première maturité est généralement atteinte un an après l’étape de la fixation. L’huître plate est un hermaphrodite protérandrique larvipare. Les individus, qui maturent sous la forme mâle, alternent ensuite de mâle à femelle tout au long de leur vie. La fécondité est de l’ordre de 250 000 à 300 000 larves par ponte. Les larves demeurent dans la cavité du manteau pendant deux semaines environ, avant de passer à l’étape planctonique qui dure 2-4 semaines. Les larves se fixent généralement sur les surfaces inférieures de substrats durs. En Colombie-Britannique, la reproduction a lieu de la mi-mai à juillet et la fixation de juillet à septembre. La dispersion est limitée à l’étape de la larve planctonique ; une fois fixés, les adultes sont sessiles. La taille de 35 à 45 mm est atteinte en de trois à quatre ans et la croissance est faible à partir de l’âge de cinq ans.

L’huître plate pacifique a fait l’objet d’une pêche commerciale en Colombie-Britannique, au Washington, en Orégon et en Californie à partir du milieu des années 1800. Les concentrations naturelles ont été surexploitées et étaient en grande partie épuisées au cours des années 1930. L’industrie huîtrière de la côte ouest a tenté sans succès d’introduire l’huître de l’Atlantique, *Crassostrea virginica*, et dépend actuellement de l’huître creuse pacifique, *Crassostrea gigas*. L’huître plate ne fait pas l’objet d’une pêche commerciale en Colombie-Britannique et sa valeur pour la récolte récréative est sans doute faible à cause de sa petite taille.

La répartition de l’huître plate pacifique est limitée par ses besoins spécialisés en matière d’habitats ainsi que par une fécondité et une capacité de dispersion relativement faibles. Cette huître est vulnérable aux extrêmes de température et ne peut résister à une récolte commerciale. Les habitats qui abritaient d’importantes concentrations dans le détroit de Géorgie ne sont plus en mesure de le faire, notamment à cause de la sur-récolte antérieure et de contraintes environnementales et aussi parce que la croissance d’importants récifs à huîtres peut nécessiter plusieurs siècles, cela sans perturbation. De petites populations reliques subsistent encore dans des zones de basse marée et sous des structures flottantes. Cette espèce est localement courante en certains endroits de la côte ouest de l’île de Vancouver, mais on connaît peu les populations de détroit Johnstone et de la côte centrale. Elle est absente des îles de la Reine-Charlotte.

L’huître plate pacifique n’est pas en danger imminent d’extinction ou de disparition au Canada. Des facteurs limitants ont antérieurement donné lieu à des réductions importantes des populations. En se fondant sur les données limitées actuelles, l’auteur recommande que le statut « Préoccupation particulière » est approprié.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Olympia oyster, *Ostrea conchaphila*, is one of four species of oyster found in British Columbia (B.C.), and is the only naturally-occurring oyster (Bourne 1997). Pacific oysters, *Crassostrea gigas*, eastern or Atlantic oysters, *Crassostrea virginica*, and European flat oysters, *Ostrea edulis*, have all been intentionally introduced for aquaculture.

Pacific oysters are sporadically able to breed successfully in the southern waters of B.C., mainly the Strait of Georgia and the west coast of Vancouver Island, and enhanced populations provide recruitment to these areas in years of amenable conditions. Attempts to establish Atlantic oysters were largely unsuccessful, and only a small relict population remains at the mouth of the Nicomekl River, Boundary Bay, Strait of Georgia. European flat oysters have been recovered in Barkley Sound, from a number of sites not known to be areas of direct transplants, implying wild sets from adults involved in intentional transplants. Confirmation of reproducing populations of *O. edulis* in B.C. requires further investigation.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is tasked with reviewing the status of species which might be of particular interest, and which may require special status designations due to declining population levels in Canada. This report summarizes available information on the biology, distribution and population dynamics of Olympia oysters, and evaluates this information to provide a recommendation regarding which category of risk might be appropriate for the species in Canada.

TAXONOMY

Until recently, the Olympia oyster was included in the species *Ostrea lurida*. Harry (1985) synonymized *lurida* with *Ostreola conchaphila*. Coan and Scott (1997) felt that *Ostreola* was not sufficiently different from *Ostrea* to warrant separating the two genera. Turgeon *et al*. (1998) support this arrangement. Phenotypic plasticity, varied habitats where specimens were collected, and the taxonomic tendencies of early naturalists have led to a rather large synonymy (Table 1).

The various English common names reflect either preferred habitats (*e.g.,* rock oyster, shell-loving oyster), geographic locations (*e.g.,* Olympia oyster, California oyster, Yaquina oyster, Shoalwater oyster [Shoalwater Bay was an early name for Willapa Bay, Washington], *etc*.), or distinguish *O. conchaphila* from introduced species (*e.g.,* native oyster). The French common name for the species is huître plate du Pacifique. The name officially recognized by the American Fisheries Association is Olympia oyster (Turgeon *et al*. 1998). The term “native oyster” is commonly used to refer to *O. conchaphila* in areas other than Puget Sound.

DESCRIPTION

The valves are thin, and not chalky as in *Crassostrea*. The valves are unequal, with the lower (left) valve shallowly cupped, and the upper (right) valve generally flat, fitting into the raised margin of the left valve. The lower valve is often attached to a hard substrate, but individuals may be found lying freely on soft substrate as singles or clusters. Free-living individuals often exhibit small scars on the left valve indicating the original point of attachment. The general outline is irregular, tending to be more or less elliptical or circular. The outer surface of the valves may be gray, gray blotched with purple, white, brown, yellow or purplish black; the inner surface grades from white to iridescent green to dark purple. The adductor muscle scar is not much different in color from the rest of the inner surface, unlike the darker scars present in Atlantic or Pacific oysters. The triangular ligament is internal. The shells exhibit a series of 2-12 pits in the lower valve on either side of the hinge, with associated denticles in the upper valve (described as ostreine chomata by Harry [1985]). Both left and right pryomyal chambers are closed (as opposed to *Crassostrea*, in which the right pryomyal chamber is open). Juveniles may have a thin yellow periostracum, which is lacking in adults. After settlement, oysters lack a foot typical of clams and byssus typical of mussels (Quayle 1969; Kozloff 1974; Harry 1985; Couch and Hassler 1989; Baker 1995; Harbo 1997).

Maximum size is approximately 90 mm diameter (Harbo 1997), but individuals in Barkley Sound generally are 60 mm in diameter or less, and other populations (Puget Sound, WA, Humbolt Bay and San Francisco Bay, CA) are generally of a smaller size (Baker 1995).

HABITAT

Olympia oysters are primarily found in the lower intertidal and subtidal zones of estuaries and saltwater lagoons (Quayle 1969, 1988), but 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 50 m depth (Bernard 1983). Olympia oysters require hard substrate for successful settlement, but may settle on very small pieces of hard substrate (Baker 1995).

BIOLOGY

Age and Growth

Maximum age of Olympia oysters is unknown. McKernan *et al*. (1949) recorded approximately 34% annual mortality in adult control groups held for long-term bioassays. Baker (1995) examined fossil Olympia oysters from Coos Bay, OR, that exhibited at least 10 major hinge annuli, which may represent age in years.

Growth of planktonic larvae is relatively rapid (Loosanof and Davis 1963; Strathman 1987). Larvae are released into the water column at shell lengths of approximately 165-189 µm and settle at a length of approximately 300 µm in 2-3 weeks. After settlement, Olympia oysters grow relatively slowly, requiring 4-5 years to reach a marketable size of approximately 50 mm (Sherwood 1931). Three to four years are required to reach shell heights of 35-45 mm in Washington State (Couch and Hassler 1989), and little growth occurs thereafter (Baker 1995).

Feeding

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).

The gill ostia (the passages through which water passes to the branchial chamber) also need to be large enough to allow eggs to pass from the gonad. The larger size of the eggs of Olympia oysters require larger ostia (Elsey 1935), which, in turn, decrease the feeding efficiency of Olympias for smaller particles. Thus, oysters of the genus *Crassostrea*, which have smaller eggs and smaller ostia, may have a competitive advantage over Olympias, because they can take advantage of smaller particles (nannoplankton) when feeding (Elsey 1935; Barrett 1963; Couch and Hassler 1989).

Reproduction

There are four major events in the reproductive cycle of *O. conchaphila*: gonadal development, spawning, swarming and spatting. Gonadal development commences or continues with increased water temperatures in the spring and summer. Male spawning involves release of sperm balls into the mantle cavity, and their subsequent expulsion through pumping contractions of the shell. Upon contact with seawater, the sperm balls disintegrate, releasing spermatozoa. Female spawning occurs when eggs are extruded into the mantle cavity and fertilized by sperm which have been brought into the mantle cavity in the respiratory current. After approximately two weeks of development in the parental mantle cavity, larvae are released into the water column; an event called swarming. Once the larvae have grown and are sufficiently developed, they settle and attach themselves to a hard substrate. This process is called spatting, and the newly settled oysters are referred to as spat.

Olympia oysters are larviparous, protandrous, alternating hermaphrodites. They mature first as males, then undergo alternation of sexes between male and female throughout their life (Coe 1932b). During the male phase, hundreds of thousands of sperm balls are released, each containing approximately 2,000 sperm (Coe 1931). Self-fertilization is not believed to occur, perhaps in part due to the release of sperm in packages that require exposure to seawater to dissociate into active spermatozoa (Strathman 1987).

Stafford (1914) and Coe (1932b) noted retention of larvae in the parental mantle cavity until the larval shell had developed, and Coe postulated that the pelagic larval period was relatively short, limiting potential for dispersal. Brooding and pelagic larval stages were estimated to be 14-17 days each in B.C. (Elsey 1933). Loosanof and Davis (1963) reported spatting after 7 days at 24°C, 10-11 days at 21.5°C and 16 days at 18°C. Hopkins (1937) believed that approximately 30-40 days were required from swarming to spatting for Olympias in Puget Sound. Early embryos and larvae are white, but as the larval shell develops they become dark gray and at the end of gestation appear as a bluish or blackish mass in the mantle chamber (Hopkins 1936). Gravid oysters are referred to as "white sick" or "black sick", referring to the spent condition and the stage of larval development.

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. Egg size is approximately 100-110 µm, larvae are approximately 165-189 µm shell length at swarming, and are approximately 300 µm at settlement (Loosanof and Davis 1963; Strathman 1987; Baker 1995).

Broods are detectable about mid-May in Puget Sound, and mid-May to July in B.C. (Stafford 1914; Hopkins 1936; Heritage and Bourne 1979). Approximately half of the adult broodstock produces a second brood in Puget Sound (Hopkins 1936).

Coe (1932a) noted that spat first appeared in southern California in April, and a late set usually occurred in October or November, for a spawning season of at least seven months. In Puget Sound, spatting occurred in the late summer and fall, usually mid-June to late July (Hopkins 1937). In B.C., the spawning season lasts approximately 3 months (Stafford 1915), and spatting occurs commonly throughout July, August and September (Elsey 1933). Hopkins (1935) showed that larvae settle preferentially on the undersides of objects, and that this was due to preferential settlement rather than differences in mortality.

Age at first reproduction is dependent upon the time of settlement in the summer (Coe 1932b). Given appropriately warm temperatures, the first male phase is complete, ovarian follicles form and first ova are ready for liberation approximately 22-30 weeks after settlement. The ensuing female stage lasts several weeks, encompassing two periods of ovulation and liberation of eggs. The following male phase is achieved 8-12 days later, coincident with release of the developed larvae. Therefore, under appropriate temperature regimes, as many as three sexual phases might occur in the first year of life if they were spawned in early spring (one male and female phase in the fall and a second male phase in the spring). Male and female phases alternate, presumably for the remaining life span of the individual. Because of lower temperatures and later settlement in B.C., first male sexual maturity is not usually achieved until the second breeding season, *i.e.*, at nearly 1 year of age (Elsey 1933).

Olympia oysters require an ambient water temperature of at least 12.5°C to reproduce (Hopkins 1937), but reproduction occurs more commonly at temperatures of 14-16°C (Strathman 1987). Temperature is a critical element in timing of reproductive phases; periods of low temperature can interrupt the alternation of sexes, which resume again when temperatures increase (Baker 1995). 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.

Mortality

Environmental Tolerances

Olympia oysters cannot withstand freezing. Significant mortalities have been attributed to unusually cold weather, including the final depletion (to commercially insignificant levels) of oyster populations (after a history of overfishing) in Ladysmith Harbour in 1929 and Boundary Bay in approximately 1940 (Quayle 1969). Edmonson (1923) attributed an increase in the price for Yaquina Bay oysters in 1917 to increased market demand due to decreased production that resulted from "partial destruction of the beds of the Puget Sound region by freezing during a previous season [1915]". High summer temperatures can also cause considerable mortality in young-of-the-year oysters.

Predation

Olympia oysters suffer some predation from crabs, gastropods, starfish, and birds, as well as possible competition with introduced oyster species and introduced slipper limpets (*Crepidula convexa*). Crabs and slipper limpets are not serious pests, and starfish were generally deterred by the lower salinity in the oyster dikes (Sherwood 1931).

Quayle (1969, 1988) indicated that three species of crabs, Dungeness (*Cancer magister*), red rock (*C. productus*), and slender (*C. gracilis*), had some minor predatory effects on oysters in B.C. All three species were capable of preying on adult Olympia oysters, and the shore crab (*Hemigrapsus oregonensis*) was thought to prey on juveniles. Red rock crabs were specifically mentioned as oyster predators in Oregon (Robinson 1997) and California (Barrett 1963).

Four species of starfish were specifically identified (Quayle 1969, 1988); the ocher star (*Pisaster ochraceus*), pink star (*Pisaster brevispinus*), mottled star (*Evasterias troschelii*) and sun star (*Pycnopodia helianthoides*).

Predatory gastropods can cause significant mortality in oysters. Elsey (1934) stated that "serious inroads are now being made on the native oyster by an oyster-drill imported from the Atlantic coast". The gastropod in question was undoubtedly the Atlantic or eastern oyster drill, *Urosalpinx cinerea*, which was introduced to Boundary Bay and Ladysmith Harbour with Atlantic oysters (Carl and Guiguet 1957; Quayle 1964) and still persists in Boundary Bay (Harbo 1997). Another introduced oyster drill, *Ceratostoma inornatum* from Japan, is a serious predator of Olympia oysters (Hopkins 1937; Chapman and Banner 1949). Both species are present in B.C., 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 species was also curtailed by regulations prohibiting movement of oysters from areas suffering drill predation to drill-free areas. The native drill, *Nucella lamellosa*, was observed to prey on adult Olympias and spat, but tended to prefer mussels to oysters (Hopkins 1937). The moon snail, *Euspira lewisi*, does occasionally prey on adult Olympia oysters, but is not able to penetrate dense oyster beds due to its large soft body and semi-burrowing locomotion (Baker 1995).

White-winged scoters (*Melanitta fusca*), black scoters (*Melanitta nigra*) and greater scaup (*Aythya marila*) have been identified as predators of Olympia oysters (Baker 1995). Anomuran shrimps (*Upogebia pugettensis* and *Callianassa californiana*) can cause direct mortality through smothering oysters during their burrowing activities, and caused oyster dikes to drain, leading to increased mortality from temperature extremes (Baker 1995).

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

Parasitism

Olympia oysters are infected by a parasitic copepod, *Mytilicola orientalis*, 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. Infection appears to cause no pathological effects (Bower *et al*. 1994). In all studies, infestation rates were higher in associated bay mussel populations (*Mytilus* sp.) than in Olympia oysters.

Olympia oysters are host to pea crabs, *Pinnixia littoralis*, with no direct pathology reported (Bower *et al*. 1994).

Large scale mortality of Olympias were reported from systemic infection by the flagellate *Hexamita* sp. in Puget Sound (Stein *et al*. 1959). These flagellates are commonly found in low intensity in the intestinal tract of oysters with no pathological effects (Bower *et al*. 1994). The disease resulted in up to 75% mortality in 2 months.

Olympias 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 1930's could have been responsible for drastic reductions in Olympia oyster populations in B.C., but noted that the disease was yet to be reported from Japan.

Pollution

There is a considerable literature documenting the deleterious effects of sulfite waste liquor, released from pulp mills, on Olympia oysters (*e.g.*, Hopkins *et al*. 1935; McKernan *et al*. 1949; Odlaug 1949; Steele 1957). Local extirpation of oyster populations in Oakland Bay and Budd Inlet, Puget Sound, as well as a general decline in oyster populations throughout southern Puget Sound between 1926 and 1945 were linked to waste from pulp mills. The deleterious effects (lack of growth, decreased condition/meat yield, failure to reproduce and high mortality rates) were induced in oysters in the lab by exposure to sulfite waste liquor.

The anti-fouling compound tributyltin (TBT) has been implicated in failures of the closely related european flat oyster (*Ostrea edulis*) to grow or spawn in France (Thain and Waldock 1986). Anti-fouling paint is common on vessels, and numerous estuarine habitats (*e.g.*, Ladysmith Harbour, Comox Harbour, Nanoose Bay) support marinas and moorages for many vessels. Bright and Ellis (1990) demonstrated high incidence of imposex (development in the female snail of a penis and pallial vas defferens, causing sterility in some species) in three species of neogastropods (*Nucella canaliculata*, *N. emarginata* and *N. lamellosa*) in southern British Columbia, a result of exposure to TBT. Their data suggest that water-borne concentrations of TBT were high enough to induce imposex in nearly all female snails examined in Georgia Strait and the Straits of Juan de Fuca. Incidence of imposex was less severe and more localized on the west coast of Vancouver Island and in the Central and North Coasts. Although chambering in the shells of Pacific oysters has been demonstrated in B.C., there is no published research examining the effects of TBT on *O. conchaphila*.

Competition

Couch and Hassler (1989) felt that the use of major growing areas previously used for Olympia oysters 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. However, Manila clams are fished primarily on the upper third of the intertidal zone, which minimizes impacts on Olympia populations in the lower third of the zone. Similarly, Pacific oyster culture is primarily carried out in the upper and mid-intertidal. Olympia oyster populations in Oregon have not been affected by Pacific oyster culture (J. Johnson, Oregon Department of Fish and Wildlife (ODFW), pers. comm.). Large populations exist in the shallow subtidal zone of oyster culture areas, and Olympias regularly settle on oyster shell left on the beach as cultch.

Barret (1963) believed that under temperature regimes which allow spawning of *Crassostrea*, Olympias would suffer competitive disadvantage both through total fecundity (which is higher in Pacific and Atlantic oysters), and because the larval period for Olympias is longer, exposing them to the hazards of pelagic existence for more extended periods than their exotic competitors. However, the temperature requirement for successful spawning is lower for Olympias (12.5-14°C) than for Pacifics (20-23°C), and the larval periods in B.C. are of similar duration (Quayle 1988). Therefore, Olympia populations (particularly in protected waters) can spawn successfully in most years, whereas Pacific and Atlantic oysters only spawn in warmer water areas (*e.g.*, Pendrell Sound) and only in years with unusually warm temperatures.

Motility

Olympia oysters are motile for only a short planktonic larval period. Adult populations are sessile, regardless of whether all individuals are attached to the substrate, or laying on it. Coe (1932b) felt that opportunities for dispersal were limited due to the short larval stage. Baker (1995) suggested that Olympia oyster larvae stay relatively close to the sites where they were spawned, citing their rarity in nearshore coastal plankton and some large-scale distributional considerations.

Baker (1995) felt that larval dispersal in Olympias was relatively limited, and that little genetic exchange occurred between coastal populations in Washington, Oregon and northern California. As an example, he cited the prehistoric extinction of Olympia oysters in Coos Bay, OR, with recolonization occurring only in recent times, after being re-introduced with Pacific oysters. The time required to re-establish populations may be a function of lack of larval transport from other populations, as well as improvement of Olympia oyster habitat by dredging activities (P. Baker, pers. comm.).

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 1930's. Given that the larval period of Olympia oysters is similar to that of Pacific oysters, then dispersal of at least 56 km can be expected.

Behaviour/Adaptability

Oysters do not exhibit specific behaviours other than selection of a settlement site. From that point on, the physical protection of their shells and their physiological tolerances determine their ability to survive. They cannot move away from predators, nor migrate to areas which offer more suitable temperatures, water quality or food supply.

DISTRIBUTION

Olympia oysters are found only on the west coast of North America, from Sitka Alaska, approximately 57°N, to Panama, approximate 9°N (Harbo 1997). The northern limit is based on a record by Dall (1914), and is somewhat suspect. Although generally distributed between these latitudes, specific habitat requirements limit abundant populations to relatively few locations (Galtsoff 1929). Before *Ostrea lurida* was synonymized with *O. conchaphila*, the southern limit of its distribution was variably reported as southern California, approximately 33°N (Bernard 1983) or Cabo San Lucas, Baja California, approximately 24°N (Haderlie and Abbott 1980).

Most information on distribution of large populations of Olympia oysters can only be derived from discussions of fisheries. Sherwood (1931) stated that natural oyster beds on the Pacific coast had been exhausted by 1930, and that the oyster industry was essentially confined to Puget Sound. Production from B.C. and Oregon was considered insignificant, and the entire Pacific production was less than 1% of the U.S. total. Commercial production from Olympia oyster beds required harvests of huge numbers of animals, considering that approximately 1,600 Olympias were required to produce a gallon of meats, as compared to 150-250 Atlantic oysters or 50-200 Pacific oysters (Hopkins 1937). The overall history of Olympia oyster exploitation on the west coast 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.

Large populations of Olympias still occur in some appropriate habitats in the lower western United States (Baker 1995; Robinson 1997; Shaw 1997). The extent of populations in Mexico and Central America is not well documented

California

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). A small commercial fishery for Olympia oysters began in California in approximately 1840. The fishery was unable to meet local market demand, and Olympia oysters were imported from Willapa Bay, Washington, beginning in the 1850s (Atlantic oysters were imported to San Francisco Bay beginning about 1870). Townsend (1893) complained of heavy spatfall crowding and overgrowing the Atlantic oysters that were the preferred market species. He stated that the species grew "twice as large at Willapa Bay, Washington, as it does at San Francisco". Olympia oysters were only used for "the making of garden walks" or "ground up and scattered about poultry ranches". Natural beds in Elkhorn Slough, Humboldt, Tomales and Newport Bays were depleted in the early 1900s. Olympia oyster stocks continued to decline after the introduction of Pacific oysters in the 1920s and 1930s. Failure of the fishery was attributed to a number of factors, including limited financial resources, lack of experience raising oysters, poor spat collection, 5 years of growth required to reach market size, small meat yield, and limited winter market season.

Baker (1995) reports evidence of historic populations of Olympia oysters that have been extirpated (*e.g.*, Big Lagoon, Elkhorn Slough, Mugu Lagoon, Alamitos Bay, Anaheim Bay, Mission Bay, San Diego Bay and Tijuana Lagoon, CA). He also lists sites (*e.g.*, Agua Hedionda and Los Pensaquitos Lagoons, CA) where dredging and addition of breakwaters resulted in establishment of new populations.

Oregon

Commercial fisheries for Olympia oysters began in Yaquina Bay, Oregon, as early as 1854 (Robinson 1997). By 1899, commercial production had fallen below 60 t, and the oyster industry shifted to imported Atlantic oysters. The Oregon oyster industry was generally unproductive until the importation of Pacific oysters in the 1930s, and is now entirely dependent on cultured Pacific oysters.

Notable populations of Olympia oysters were reported only from Yaquina and Netarts Bays by Marriage (1958), but the population has since disappeared from the latter location (Baker 1995). Olympia oysters were present in Coos Bay, Oregon, in prehistoric times, as evidenced by their presence in native middens (Baker 1995). The cause of their extinction is not known, but local natives believed it was due to a great forest fire that swept the area in the early 1800s (Edmonson 1923), which presumably resulted in siltation problems. Several unsuccessful attempts were made to reintroduce Olympia oysters in the area beginning in the early 1910s (Edmonson 1923), and some were still present in 1988 (Baker 1995). Recent introductions have successfully established Olympia populations in Netarts and Alsea Bays (John Johnson, ODFW, pers. comm.).

Washington

Harvests of natural beds at Willapa Bay, Washington, began in 1850, dwindled, and were essentially finished by 1915 (Galtsoff 1929; Sherwood 1931). Naturally occurring beds had been largely depleted by the 1870s, and the fishery was supported into the early 1900s by enhancement and cultivation (Steele 1957; Lindsay and Simons 1997). Galtsoff (1929) related newspaper reports from the late 1800s that may have indicated unusually high natural mortalities in Willapa Bay in 1867-68, which may have contributed to population declines. Hopkins (1937) indicated that Olympia oyster populations in Willapa Bay had been completely destroyed, and that they were difficult to find, even in local markets.

Production from Puget Sound was more consistent, primarily because greater progress was made in developing dike culture methods (Steele 1957; Lindsay and Simons 1997). Production suffered after 1928, when a pulp mill was opened in Shelton, and discharged sulfite waste liquor into Oakland Bay. By the time the mill closed, which resulted in improved water quality and increased oyster growth, survival and recruitment, most oyster growers had switched to Pacific oyster culture.

Olympia oyster populations still exist at several locations in Puget Sound, in Willapa Bay, and possibly Grays Harbour (Baker 1995).

British Columbia

Olympia oysters were utilized by some First Nations people for food (Ellis and Swan 1981), and Olympia shells were used as ornamentation (Harbo 1997).

Olympia oysters were the only oysters available in B.C. until Atlantic oysters were introduced near Victoria about 1883 (Carlton and Mann 1996), followed by other introductions at Boundary Bay, Esquimalt and Ladysmith (Quayle 1969). Stafford (1913a) was already warning of the demise of the oyster fishery, and of oyster populations, in B.C. Pacific oysters were first introduced to B.C. in 1912 or 1913, but not in large numbers until 1925 (Elsey 1933; Bourne 1997). Commercial landings of Olympia oysters in B.C. began approximately 1884 and continued to about 1930. The fishery was small, and annual landings probably never exceeded 300 t (Bourne 1997). The fishery declined due to overfishing and severely cold winters which caused extensive mortalities. 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 populations (Quayle 1969). Elsey (1933) indicated that increased landings of oysters (primarily Olympias) between 1925 and 1930 was due to increased effort expended in thinly stocked and isolated areas, and in harvesting undersized or inferior oysters.

Stafford (1917) and Sherwood (1931) described oyster culture at Crescent (= White Rock) B.C. in the early 1930s. Low dikes were constructed of concrete or creosoted timbers to provide standing water, which protected the oysters from temperature extremes at low tide (he also mentions that dike culture was not practiced at Ladysmith, implying that no other site in B.C. used dikes). Substrates were altered through the addition of gravel or shell, both to allow easier access by workers and to prevent smothering the oysters by silt and mud. The beds were “seeded” by placing shell and other cultch material in the diked areas to collect natural sets. The oysters were allowed to grow in the diked areas, and harvested when large enough for market; areas were harvested on a rotational basis, not annually.

Stafford (1913b) stated that Olympia oysters were not common in Departure or Hammond Bays, but in Nanoose Bay and Oyster (Ladysmith) Harbour, they occurred “by the thousands, free on the surface, and more or less spotted with barnacles”. Elsey (1933) indicated that the oyster beds of Ladysmith Harbour were seriously depleted, and that the natural populations once contained in the beds were likely at least ten times the then-current population, which was estimated at “not more than five or six thousand bushels”. He also indicated that other beds that were fished (Toquart and Blunden Harbours; Fish Egg, Esperanza and Quatsino Inlets; and the Bardswell Group) produced almost exclusively old oysters. This indicated to him that the beds had been “very slowly built up”, and that intensive fishing would quickly deplete them.

Quayle (1969) indicated that Olympia oysters might be found in numerous places in B.C., but nowhere in abundance. He listed specific sites at the Gorge in Victoria, Ladysmith, Von Donop Creek (Cortes Island) and Pendrell Sound in the Strait of Georgia; Toquart Bay (Barkley Sound) and most other inlets on the west coast of Vancouver Island; Blunden Harbour in Queen Charlotte Straits; and Campbell Island in the Central Coast. Olympia oyster larvae were noted in low abundance in Pendrell Sound during Pacific oyster studies in 1959 and 1963 (Quayle 1974) and from 1971-1977 (Heritage *et al*. 1976,1977; Bourne 1978; Bourne and Heritage 1979; Heritage and Bourne 1979), and Hotham Sound and Ladysmith Harbour in 1976-1977 (Heritage *et al*. 1977; Heritage and Bourne 1979).

Sites in Georgia Strait that were important historically do not currently support large populations of Olympia oysters (Table 2). 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 from earlier descriptions, though scattered individuals of Olympias still occur in Ladysmith Harbour (D. Nikleva, Chemainus First Nation, pers. comm.). An examination of Nanoose Bay yielded only one large Olympia found high in the intertidal near a creek. Local oyster culturists indicated that they had not seen Olympias on their leases for at least 5 years (P. McLellan, Nanoose

Bay Oysters, pers. comm.). Comox Harbour has not been examined recently. Kingzett *et al*. (1995c) did not record Olympia oysters during examination of 93 sites in Okeover Inlet, although records of Olympia oysters would only have been collected incidentally. Olympia oysters can be found in Sooke Basin (E. Helgeson, Coopers Cove Oyster Co., pers. comm.). Relatively large populations are reported to occur in Anderson, Roche and Hutchison Coves.

Olympia oysters are locally common at several sites on the west coast of Vancouver Island (Table 2). In Barkley Sound, notable populations of Olympia oysters occur in Useless Inlet, Effingham Inlet, Pipestem Inlet, Toquart Bay, Congreve Islands, Mayne Bay and Vernon Bay (E. Black, J. Russell, B.C. Ministry of Fisheries, pers. comm.; B. Kingzett, Kingzett Professional Services, pers. comm.; J. Lane, Nuu-chah-nuulth Tribal Council, pers. comm.; N. and M. Truesdell, pers. comm.). Olympia oysters also occur at two sites in the Broken Group Islands (H. Holmes, Parks Canada, pers. comm.). Cross and Kingzett (1993) did not record Olympia oysters from 118 sites examined in Clayoquot Sound, though this may be an artifact of the original objectives of the survey (determination of culture capability for clams and Pacific oysters). In Nootka Sound/Esperanza Inlet, several beaches in Port Eliza supported large populations of Olympia oysters, as did beaches at Canton Creek and Nesook Bay (Kingzett *et al*. 1995a). Olympia oysters occur in Kyuquot Sound, in Amai Inlet (Kingzett *et al*. 1995b). No oysters were noted in examination of 90 sites in Quatsino Sound (Cross *et al*. 1995). Given Elsey's (1933) reported landings of Olympia oysters from the area, additional effort to determine whether or not Olympia oysters still exist in Quatsino is required.

Olympia oysters do not occur in any number in the northern Central Coast or Queen Charlotte Islands (Table 2). Bourne *et al*. (1994) reported Olympias from a lagoon at the head of Watt Bay in Kildidt Sound. Bourne and Heritage (1997) reported Olympia oysters to be common at low tide levels on two beaches in Fish Egg Inlet. Thompson (1914) did not mention Olympia oyster populations from the Central or North Coast areas of B.C. He indicated that they could be found in sparse numbers in Fanny Bay, Strait of Georgia, but that they were of small size. Oysters were not noted in a survey of 127 Central Coast beaches by Peacock *et al*. (1998) or during exploratory surveys reported by Bourne and Cawdell (1992), Bourne *et al*. (1994) and Heritage *et al*. (1998). None were observed during examination of 190 Queen Charlotte Island beaches by Blyth *et al.* (1998) or during surveys of Masset Inlet and Naden Harbour by Gillespie and Bourne (1998). All of these surveys were directed at other species, and Olympia oysters would have only been recorded incidentally

Alaska

Olympia oysters were reported from southeast Alaska, but were seldom encountered in dense aggregations, nor were specific sites reported (Paul and Feder 1976).

POPULATION SIZE AND TREND

Quantitative population estimates (both historic and recent) of Olympia oysters are non-existent. 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 Olympia oyster populations in B.C.

Anecdotal information (both from literature and personal communications) indicates that Olympia oyster populations in the Strait of Georgia are low currently relative to historic levels. It is generally believed that population decreases occurred between the late 1800s and 1930. The decline was mostly due to the disappearance of large oyster populations in specific localities, particularly Boundary Bay and Ladysmith Harbour. Small populations of Olympias still exist in Ladysmith Harbour, and in other suitable habitats. They are locally common in areas on the west coast of Vancouver Island. Limited recent information is available regarding distribution and abundance in Johnstone Straits or the Central Coast. They are presumed to be absent from the Queen Charlotte Islands.

There is less information on population trends. In the absence of other information, the persistence of Olympia oyster populations 50 years or more after significant fishery impacts may be taken as evidence that populations are relatively stable at current low levels of abundance. Whether abundance remains limited in the Strait of Georgia due to habitat alteration, pollution, disease or other causes cannot be assessed with current information.

LIMITING FACTORS

Environmental Extremes

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. That there are few large populations reported in northern B.C. or Alaska is likely a result of physiological temperature requirements for gonadal development and successful spatting.

Small relict populations of Olympias 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. The general distribution of Olympia oysters in southern B.C. may be greater than indicated, simply because these relict populations are rarely observed unless specifically sought out.

Disease

Some members of the U.S. oyster industry believe that disease played a large role in the collapse of some stocks of Olympia oysters (N. Bourne, DFO, pers. comm.) and Bower *et al*. (1997) speculated that the possible introduction Denman Island Disease with imported Pacific oysters could have caused declines in Olympia oyster populations. However, there is no direct proof that this, or any other disease, is a cause of historic population reductions.

Pollution

There is clear evidence that sulfite waste liquor from pulp mills in Puget Sound had a significant deleterious effect on Olympia oyster populations there. It is therefore possible that similar effects occurred in B.C. However, there has been no research to examine the impacts of pulp mill effluent on Olympia oysters in B.C.

Although it is possible that TBT could have an impact on Olympia oyster populations (J. Thompson, 2WE Associates Consulting, pers. comm.) and the spatial correlation of reduced Olympia oyster populations and observed TBT-related effects in other species is compelling, there has been no research that demonstrates a detrimental effect of TBT on Olympia populations.

Human Alteration of Habitat

Galtsoff (1929) understood the sensitivity of large beach and reef populations to human impacts, such as fisheries: "The apparent richness of the natural reef is often misleading because it represents the accumulation of an oyster population that lived undisturbed for a period of possibly several hundred years. Because of the low temperature of northern waters spawning and setting occur only in exceptionally warm years, so that the stock is not replenished regularly. With the beginning of fishing operations the number of adult oysters on such bottoms quickly diminishes, thus decreasing the chance for good setting, and in a few years the whole population of a reef can be wiped out."

Estuarine habitats are limited in B.C., and many estuaries have been adversely affected by human practices. Pollutants and other wastes may be detrimental to oyster populations, as are increased siltation due to changes in forest or land management practices. Estuaries and bays that previously supported Olympia oyster populations (*e.g.*, Ladysmith Harbour) are now heavily impacted by urbanization, pollution and other impacts of commercial and recreational use.

PROTECTION

Commercial oyster fisheries in B.C. are regulated by the Provincial Ministry of Fisheries, and are for Pacific oysters (*C. gigas*) only. Applications for permits are accepted until February each year, and total allowable catches are determined, based on stock assessment surveys and harvest rates of 10-

15% of standing stock in specific areas. Harvests are not allowed if the TAC is less than 1 t, and a maximum of 10 t is allowed in any given area. A maximum of 10 permits are let for an area, and if more than 10 persons apply to fish one area, permits are let by lottery. Fishing is limited to only a few days, and harvest activities are monitored by Provincial Conservation Officers (E. Black, B.C. Ministry of Fisheries, pers. comm.).

Although currently there is no commercial fishing effort directed at Olympia oysters, they are still allowed to be taken under recreational licence in B.C. The recreational fishery is unassessed, and managed only with area closures and a daily bag limit of 15 oysters/person or 0.5 L of shucked meats/person. A daily limit of shucked Olympias might represent 400 oysters, but the same small size that leads to this concern makes Olympias unattractive to recreational fishers. The North Coast is closed to bivalve harvest due to the risks associated with outbreaks of Paralytic Shellfish Poisoning (PSP) and the lack of a monitoring program. The Lower Mainland and other specific areas are closed to bivalve harvest due to sewage contamination.

EVALUATION AND COSEWIC STATUS RECOMMENDATION

The seven categories of risk recognized by COSEWIC are:

1. **Extinct** - a species that no longer exists;
2. **Extirpated** - a species that no longer exists in the wild in Canada, but occurs elsewhere;
3. **Endangered** - a species facing imminent extirpation or extinction;
4. **Threatened** - a species likely to become endangered if limiting factors are not reversed;
5. **Special Concern** - a species of concern because of characteristics that make it particularly sensitive to human activities or natural events;
6. **Not at Risk** - a species that has been evaluated and found not at risk; and
7. **Data Deficient** - a species for which there is insufficient scientific information to support status determination.

Members of COSEWIC also evaluate information contained in the Technical Summary format followed by the International Union for the Conservation of Nature (Table 3). The extent of occurrence of Olympia oysters in Canada is not presently quantifiable. Although Sitka, Alaska, is cited as the northern distributional limit of the species (Dall 1914), the most northerly documented concentrations of significance from other literature are in the Central Coast at Campbell Island, the Bardswell Group, Kildidt Sound and Fish Egg Inlet (Elsey 1933; Quayle 1969, 1988; Bourne *et al*. 1994; Bourne and Heritage 1997). Similarly, area of occupancy is difficult to quantify, as fairly specific conditions are required to support large concentrations of Olympia oysters. The total population size and effective population size in Canada are unknown.

Generation time (defined as average age of parents in the population) is unknown, as no information is available regarding either maximum age or age distribution of Canadian populations. Age at first maturity is approximately 1 year. The population trend is not definitively known, nor is the number of subpopulations which comprise the Canadian population. Because of internal fertilization and brooding behaviours, genetic exchange occurs only through larval dispersal. Adult populations are sessile, thus, Olympia oysters are a classic example of a metapopulation (Hanski and Gilpin 1991). The Canadian population is fragmented due to limited dispersal and specific habitat requirements. The total number of extant sites is not known. Historically large concentrations in the Strait of Georgia have been greatly reduced; Olympia oysters are uncommon there now. Some relatively large concentrations still exist on the west coast of Vancouver Island. The status of populations in Johnstone Strait and the Central Coast are poorly known. Olympia oyster populations do undergo fluctuations, primarily in the form of catastrophic mortality followed by slow recovery.

Populations of Olympia oysters exist in Washington, Oregon, California, Mexico, and possibly Alaska. Immigration is possible only from the closest populations (Puget Sound) because of larval dispersal periods and patterns. The populations in Puget Sound are likely best adapted to conditions in B.C. Sufficient habitat is available in some areas of B.C. for immigrants, but mitigation to repair habitat alteration may be required to ensure that immigrants do not suffer the same fate as the former resident populations.

Olympia oysters are not extinct or extirpated in Canada, nor do existing data indicate that they are facing imminent danger of either fate. However, a number of biological characteristics of the species may increase their vulnerability, and affect their ability to recover from adverse impacts. These include:

- fairly specialized habitat requirements (primarily lagoons, bays and estuaries) for the development of large concentrations;
- relatively low fecundity for bivalve molluscs;
- limited dispersal of larvae relative to distances between suitable habitats (particularly on the outer coasts of Washington Oregon and California); and
- vulnerability to temperature extremes that exceed their physiological tolerances at the northern extreme of their natural range (in B.C.).

As well, a number of limiting factors are apparent that have led to (anecdotally) significant reductions in population levels in the past, including:

- population dynamics and productivity that are not resistant to human harvests on a commercial scale (demonstrated in B.C. and elsewhere throughout their range);
- vulnerability to human pollution (primarily kraft mill effluent) which has been linked to significant declines of populations in Puget Sound, and possibly TBT from antifouling paints, which has had deliterious effects on other oyster species;
- vulnerability to human activities that disturb habitat in locations which historically supported large populations;
- diseases such as Hexamitiasis or Denman Island Disease; and
- vulnerability to exotic predators (*e.g.*, the oyster drills *Urosalpinx cinerea* and *Ceratostoma inornatum*, and the flatworm *Pseudostylochus ostreophagus*) and exotic parasites (the copepod *Mytilicola orientalis*) that have been introduced inadvertently due to aquaculture activities.

Several of these factors are believed to have caused reductions or loss of large concentrations of Olympic oysters in various estuaries; the most visible portion of Olympia oyster populations in B.C. Most important have been human harvests and temperature extremes. There is currently no documentation of competition for space with commercial harvest and/or aquaculture activities. The effects of kraft mill effluent pollution observed in Puget Sound have not been documented in B.C., nor have the effects of exotic predators or parasites been particularly harmful (in part due to the extremely limited distribution of exotic drills in B.C.). Although deliterious effects of TBT have been reported for other species in Georgia Strait, no direct link between TBT levels and Olympia oysters has been explored.

None of these factors appear to be reducing populations of Olympic oysters in B.C. at present. Population declines were recorded historically, but there is no information currently available that indicates that the populations are continuing to decline. The population appears to be stable at low levels relative to historic accounts. Human interest in Olympia oysters as a commercial or recreational species is limited to non-existent at the present. However, recovery of many estuarine populations (particularly in the Strait of Georgia) would require decades of protection in the habitats currently most affected by urbanization, pollution and other human activities.

Given the data currently available, I do not consider Olympia oysters to be Threatened, but feel that there is sufficient justification to recommend that they be classified as a species of Special Concern to COSEWIC.

RECOMMENDATIONS

Current fisheries practices in B.C. do not appear to be causing further decline in Olympia oyster populations. However, other factors could potentially impact oyster populations, and the following recommendations are presented:

1. Information on distribution, abundance and population structure of Olympia oysters in B.C. should be collected and collated, as part of a general approach of utilizing resource inventories and ecosystem-based approaches to resource management.
2. Fishery managers should not support resurrecting or developing a directed commercial fishery for Olympia oysters that depends only on natural stocks. Past experience, both in B.C. and elsewhere on the west coast of North America, indicates that Olympia oyster populations cannot support directed commercial fisheries.
3. DFO managers should endeavor to protect sites of particular significance to Olympia oysters (*i.e.*, sites which support large populations) when considering proposals for aquaculture tenures or other intertidal activities. Large populations of Olympia oysters living freely on the substrate or forming oyster reefs are rare, and require decades or centuries to develop or recover from human or natural impacts. Sites which have historically supported these populations in the Strait of Georgia no longer do, at least in part due to human impacts.

ACKNOWLEDGMENTS

I thank many people who shared information regarding Olympia oyster distribution and biology: Patrick Baker (University of Florida, Gainseville); Edward Black (B.C. Ministry of Fisheries, Courtenay); Neil Bourne (Pacific Biological Station, Nanaimo); Rick Harbo (DFO Operations, Nanaimo); Ed Helgeson (Coopers Cove Oyster Co., Sooke); Heather Holmes (Heritage Canada, Pacific Rim National Park); Glen Irving (Timothy Oysters, Ladysmith); John Johnson (ODFW, Newport); Brian Kingzett (Kingzett Professional Services, Errington); Jim Lane, Nuu-chah-nuulth Tribal Council, Port Alberni); Gordon McLellan (Mac's Oysters, Qualicum); Pete McLellan (Nanoose Bay Oysters, Nanoose); Gary Meyer (Pacific Biological Station, Nanaimo); Dave Nikleva (Chemainus First Nation, Ladysmith); Scott Pilcher (Limberis Seafoods, Ladysmith); Anya Robinson (Oregon State University); Jim Russell (B.C. Ministry of Fisheries, Courtenay); and Norm and Marlene Truesdell (Barkley Sound). Jim Morrison and Margaret Wright (DFO Operations, Nanaimo) and Jeff Thompson (2WE Associates Consulting, Saltspring Island) provided information and literature related to tributyltin effects on bivalves. Theresa Fowler (Environment Canada, Ottawa) and Howard Powles (DFO Fisheries Management, Ottawa) provided guidance in regard to the COSEWIC mandate and process. I thank Neil Bourne, Howard Powles, Rick Harbo and the members of the Invertebrate Subcommittee of the Pacific Scientific Advice Review Committee for their reviews and comments on a draft of this paper.

REFERENCES

Baker, P. 1995. Review of ecology and fishery of the Olympia oyster, *Ostrea lurida* with annotated bibliography. J. Shellfish Res. 14(2): 501-518.

Barrett, E.M. 1963. The California oyster industry. Calif. Dept. Fish Game Bull. 123. 103 p.

Bernard, F.R. 1968. Incidence and effect of the copepod Mytilicola orientalis Mori in the Pacific oyster of British Columbia. Fish. Res. Board Can. Manuscr. Rep. Ser. 993. 14 p. + figs.

Bernard, F.R. 1969. The parasitic copepod *Mytilicola orientalis* in British Columbia bivalves. J. Fish. Res. Board Can. 26: 190-191.

Bernard, F.R. 1983. Catalogue of the living bivalvia of the eastern Pacific Ocean: Bering Strait to Cape Horn. Can. Spec. Publ. Fish. Aquat. Sci. 61. 102 p.

Blyth, C.A., A.M. Peacock, C.A. Horne and B.C. Kingzett. 1998. Shellfish aquaculture capapbility appraisal for the Queen Charlotte Islands region. Report submitted to B.C. Ministry of Fisheries, Victoria, B.C.

Bourne, N. 1978. Pacific oyster breeding in British columbia, 1971, 1972, and 1973. Fish. Mar. Serv. Tech. Rep. 781. 151 p.

Bourne, N. 1997. Molluscan fisheries of British Columbia. NOAA Tech. Rep. NMFS 128: 115-130.

Bourne, N. and G. Cawdell. 1992. Intertidal clam survey of the North Coast area of British Columbia - 1990. Can. Tech. Rep. Fish. Aquat. Sci. 1864: 151 p.

Bourne, N. and G.D. Heritage. 1979. Pacific oyster breeding in Pendrell Sound, 1974. Fish. Mar. Serv. Tech. Rep. 858. 97 p. + app.

Bourne, N.F. and G.D. Heritage. 1997. Intertidal clam surveys in British Columbia – 1992 and 1993. Can. Tech. Rep. Fish. Aquat. Sci. 2168. 95 p.

Bourne, N., G.D. Heritage and G. Cawdell. 1994. Intertidal clam surveys of British Columbia - 1991. Can. Tech. Rep. Fish. Aquat. Sci. 1972. 155 p.

Bower, S.M., D. Hervio and G.R. Meyer. 1997. Infectivity of *Mikrocytos mackini*, the causative agent of Denman Island disease in Pacific oysters, *Crassostrea gigas*, to various species of oysters. Dis. Aquat. Org. 29: 111-116.

Bower, S.M, S.E. McGalddery and I.M. Price. 1994. Synopsis of infectious diseases and parasites of commercially exploited shellfish. Ann. Rev. Fish Dis. 4: 1-199.

Bower, S.M. and G.R. Meyer. 1994. Causes of mortalities among cultured Japanese scallops, *Patenopecten yessoensis*, in British Columbia. P. 85-91. *In*: N.F. Bourne, B.L. Bunting and L.D. Townsend [eds.]. Proceedings of the 9th International Pectinid Workshop, Nanaimo, B.C., Canada, April 22-27, 1993. Volume 1. Can. Tech. Rep. Fish. Aquat. Sci. 1994.

Bradley, W. and A.E. Seibert, Jr. 1978. Infection of *Ostrea lurida* and *Mytilus edulis* by the parasitic copepod *Mytlilicola orientalis* in San Francisco Bay, California. Veliger 21(1): 131-134.

Bright, D.A. and D.V. Ellis. 1990. A comparative survey of imposex in northeast Pacific neogastropods (Prosobranchia) related to tributyltin contamination, and choice of a suitable bioindicator. Can. J. Zool. 68(9): 1915-1924.

Carl, G.C. and C.J Guiguet. 1957. Alien animals in British Columbia. B.C. Prov. Mus. Handbook 24. 103 p.

Carlton, J.T. and R. Mann. 1996. Transfers and world-wide introductions. p. 691-706. *In*: V.S. Kennedy, R.I.E. Newell and A.F. Eble [eds.]. The Eastern Oyster, *Crassostrea virginica*. Maryland Sea Grant College Publication UM-SG-TS-96-01.

Carriker, M.R. and P.M. Gaffney. 1996. A catalogue of selected species of living oysters (Ostreacea) of the world. p. 1-18. *In*: V.S. Kennedy, R.I.E. Newell and A.F. Eble [eds.]. The Eastern Oyster, *Crassostrea virginica*. Maryland Sea Grant College Publication UM-SG-TS-96-01.

Chapman, W.M. and A.H. Banner. 1949. Contributions to the life history of the Japanese oyster drill, *Tritonalia japonica*, with notes on other enemies of the Olympia oyster, *Ostrea lurida*. Wash. Dept. Fish. Biol. Rep. 49A: 168-200.

Coan, E.V. and P.H. Scott. 1997. Checklist of the marine bivalves of the northeastern Pacific Ocean. Santa Barbara Mus. Natur. Hist. Contr. Sci. 1. 28 p.

Coe, W.R. 1931. Spermatogenesis in the California oyster (*Ostrea lurida*). Biol. Bull. 61(3): 309-315.

Coe, W.R. 1932a. Season of attachment and rate of growth of sedentary marine organisms at the pier of the Scripps Institute of Oceanography, La Jolla, California. Bull. Scripps Inst. Oceanogr., Univ. Calif. Tech. Ser. 3(3): 37-86.

Coe, W.R. 1932b. Development of the gonads and the sequence of sexual stages in the California oyster (*Ostrea lurida*). Bull. Scripps Inst. Oceanogr., Univ. Calif. Tech. Ser. 3(6): 119-144.

Couch, D. and T.J. Hassler. 1989. Species Profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) – Olympia oyster. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.124). U.S. Army Corps of Engineers, TR EL-82-4. 8 p.

Cross, S.F., S.J. Gormican and B.C. Kingzett. 1995. Shellfish culture capability appraisal for Quatsino Sound, Vancouver Island. Report submitted to B.C. Ministry of Agriculture, Fisheries and Food, Victoria, B.C.

Cross, S.F. and B.C. Kingzett. 1993. Shellfish culture capability appraisal for Clayoquot Sound, Vancouver Island. Report submitted to B.C. Ministry of Agriculture, Fisheries and Food, Victoria, B.C.

Dall, W.H. 1914. Notes on west American oysters. Nautilus 28(1): 1-3.

Edmondson, C.H. 1923. Shellfish resources of the northwest coast of the United States. Rep. U.S. Commissioner Fish. (1922), App. 3. Bur. Fish. Doc 920. 21 p.

Ellis, D.W. and L. Swan. 1981. Teachings of the Tides: Uses of Marine Invertebrates by the Manhousat People. Theytus Books, Nanaimo, B.C. 118 p.

Elsey, C.R. 1933. Oysters in British Columbia. Bull. Biol. Board Can. 34. 34 p.

Elsey, C.R. 1934. The Japanese oyster in Canadian Pacific waters. Fifth Pacific Science Congress: 4121-4127.

Elsey, C.R.. 1935. On the structure and function of the mantle and gill of *Ostrea lurida* and *Ostrea gigas*. Ttrans. R. Soc. Can. 48(Sect. 5): 131-160.

Galtsoff, P.S. 1929. Oyster industry of the Pacific coast of the United States. Rep. U.S. Commissioner Fish. (1929), App. VIII. Bur. Fish. Doc. 1066: 367-400.

Gillespie, G.E. and N.F. Bourne. 1998. Exploratory intertidal clam surveys in British Columbia - 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2465. 43 p.

Haderlie, E.C. and D.P. Abbott. 1980. Bivalvia: the clams and allies. P. 355-411. *In*: R.H. Morris, D.P. Abbott and E.C. Haderlie [eds.]. Intertidal Invertebrates of California. Stanford Univ. Press, Stanford, CA.

Hanski, I. and M. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. Biol. J. Linn. Soc. 42: 3-16.

Harbo, R.M. 1997. Shells and Shellfish of the Pacific Northwest. Harbour Publishing, Madiera Park, B.C. 270 p.

Harry, H.W. 1985. Synopsis of the supraspecific classification of living oysters (Bivalvia: Gryphaeidae and Ostreidae). Veliger 28(2): 121-158.

Heritage, G.D. and N. Bourne. 1979. Pacific oyster breeding in British Columbia 1977. Fish. Mar. Serv. Tech. Rep. 882. 139 p. + app.

Heritage, G.D., N. Bourne and D.W. Smith. 1977. Pacific oyster breeding in British Columbia, 1976. Fish. Res. Board Can. Manuscr. Rep. 1419. 49 p.

Heritage, G.D., P.A. Breen and N.F. Bourne. 1976. Pacific oyster breeding in Pendrell Sound, 1975. Fish. Res. Board Can. Manuscr. Rep. 1406. 91 p.

Heritage, G.D., G.E. Gillespie and N.F. Bourne. 1998. Exploratory intertidal clam surveys in British Columbia – 1994 and 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2464. 114 p.

Hopkins, A.E. 1935. Attachment of larvae of the Olympia oyster, *Ostrea lurida*, to plane surfaces. Ecology 16(1): 82-87.

Hopkins, A.E. 1936. Ecological observations on spawning and early larval development in the Olympia oyster (*Ostrea lurida*). Ecology 17(4): 551-566.

Hopkins, A.E. 1937. Experimental observations on spawning, larval development and setting in the Olympia oyster *Ostrea lurida*. Bull. U.S. Bur. Fish. 48: 438-503.

Hopkins, A.E., P.S. Galtsoff and H.C. McMillin. 1935. Effects of pulp mill pollution on oysters. Bull. U.S. Bur. Fish. 47: 125-162.

Kingzett, B.C., S.J. Gormican and S.F. Cross. 1995a. Shellfish culture capability appraisal for Nootka Sound, Vancouver Island. Report submitted to B.C. Ministry of Agriculture, Fisheries and Food, Victoria B.C.

Kingzett, B.C., S.J. Gormican and S.F. Cross. 1995b. Shellfish culture capability appraisal for Kyuquot Sound, Vancouver Island. Report submitted to B.C. Ministry of Agriculture, Fisheries and Food, Victoria B.C.

Kingzett, B.C., S.J. Gormican and S.F. Cross. 1995c. Shellfish culture capability appraisal for Okeover Inlet region. Report submitted to B.C. Ministry of Agriculture, Fisheries and Food, Victoria B.C.

Kozloff, E.N. 1974. Keys to the Marine Invertebrates of Puget Sound, the San Juan Archipelago and Adjacent Regions. Univ. of Washington Press, Seattle, WA. 226 p.

Lindsay, C.E. and D. Simons. 1997. The fisheries for Olympia oysters, *Ostreola conchaphila*; Pacific oysters, *Crassostrea gigas*; and Pacific razor clams, *Siliqua patula*, in the state of Washington. NOAA Tech. Rep. NMFS 128: 89-113.

Loosanoff, V.L. and H.C. Davis. 1963. Rearing of bivalve mollusks. Adv. Mar. Biol. 1: 1-136.

Marriage, L.D. 1958. The bay clams of Oregon. Fish. Comm. Oregon Educational Leafl. 2. 29 p.

McKernan, D.L., V. Tartar and R. Tollefson. 1949. An investigation of the native oyster industry in Washington, with special reference to the effects of sulfite pulp mill waste on the Olympia oyster (*Ostrea lurida*). Wash. Dept. Fish. Biol. Rep. 49A: 115-165.

Odlaug, T.O. 1949. Effects of stabilize and unstablilized waste sulfite liquor on the Olympia oyster, *O. lurida*. Trans. Am. Microsc. Soc. 68(2): 163-182.

Paul, A.J. and H.M. Feder. 1976. Clam, mussel and oyster resources of Alaska. Univ. Alaska Inst. Mar. Sci. Rep. 76-4. 41 p.

Peacock, A.M., C.A. Blyth, C.A. Horne, F.A. Williams, S.F. Cross and S.J. Gormican. 1998. Shellfish culture capability appraisal for the northern Central Coast region. Report submitted to B.C. Ministry of Fisheries, Victoria, B.C.

Quayle, D.B. 1964. Distribution of introduced marine mollusca in British Columbia waters. J. Fish. Res. Board Can. 21: 1155-1181.

Quayle, D.B. 1969. Pacific oyster culture in British Columbia. Fish. Res. Board Can. Bull. 169. 192 p.

Quayle, D.B. 1974. Pendrell Sound oyster breeding 1950-1970. Fish. Res. Board Can. Manuscr. Rep. Data Series 1291. 389 p.

Quayle, D.B. 1988. Pacific oyster culture in British Columbia. Can. Bull. Fish Aquat. Sci. 218. 241 p.

Robinson, A.M. 1997. Molluscan fisheries in Oregon: past, present, and future. NOAA Tech. Rep. NMFS 128: 75-87.

Shaw, W.N. 1997. The shellfish industry of California - past, present and future. NOAA Tech. Rep. NMFS 128: 57-74.

Sherwood, H.P. 1931. The oyster industry of North America: a record of a brief tour of some of the centres on the Atlantic and Pacific coasts, and of a summer in Canada. J. Cons. 6(3): 361-386.

Stafford, J. 1913a. Conservation of the oyster. Prov. B.C. Rep. Commerc. Fish. (1912): 71-80.

Stafford, J. 1913b. The Canadian Oyster. Its Development, Environment and Culture. Commission of Conservation Canada, Ottawa. 159 p.

Stafford, J. 1914. The native oyster of British Columbia (*Ostrea lurida*, Carpenter). Prov. B.C. Rep. Commerc. Fish. (1913): 79-102.

Stafford, J. 1915. The native oyster of British Columbia (*Ostrea lurida*, Carpenter). Prov. B.C. Rep. Commerc. Fish. (1914): 100-119.

Stafford, J. 1916. The native oyster of British Columbia (*Ostrea lurida*, Carpenter). Prov. B.C. Rep. Commerc. Fish. (1915): 141-160.

Stafford, J. 1917. The native oyster of British Columbia (*Ostrea lurida*, Carpenter). Prov. B.C. Rep. Commerc. Fish. (1916): 88-120.

Stein, J.E., J.G. Denison and J.G. Mackin. 1959. *Hexamita* sp. and an infectious disease in the commercial oyster, *Ostrea lurida*. Proc. National Sellfisheries Assoc. 50: 67-81.

Steele, E.N. 1957. The Rise and Decline of the Olympia Oyster. Fulco Publ., Co. Elma, WA. 126 p.

Strathman, M.F. 1987. Reproduction and Development of Marine Invertebrates of the Northern Pacific Coast. Univ. of Washington Press, Seattle, WA. 670 p.

Thompson, J. 1996. Snail's pace recovery from restricted toxic paint. IOS Fact Sheet, Inst. Ocean Sciences, Sidney, B.C. 2 p.

Thompson, W.F. 1914. Report on the shellfish beds of British Columbia (clams, mussels and scallops). Prov. B.C. Rep. Commerc. Fish. (1913): 103-125.

Thain, J.E. and M.J. Waldock. 1986. The impact of tributyl tin (TBT) antifouling paints on molluscan fisheries. Wat. Sci. Tech. 18: 193-202.

Townsend, C.H. 1893. Report of observations respecting the oyster resources and oyster fishery of the Pacific coast of the United States. U.S. Comm. Fish and Fisheries, Rep. Comm. (1889 to 1891): 343-372.

Turgeon, D.D., J.F. Quinn, Jr., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson,

M. Vecchione and J.D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Molluscs. 2nd Edition. Amer. Fish. Soc. Spec. Publ. 26.

Woelke, C.E. 1956. The flatworm *Pseudostylochus ostreophagus* Hyman. Proc. Natl. Shellfish Assoc. 47: 62-67.

Table 1. Classification, synonymy and colloquial taxonomy of *Ostrea conchaphila* (Baker 1995; Bernard 1983; Coan and Scott 1997; Couch and Hassler 1989; Edmonson 1923; Carriker and Gaffney 1996Robinson 1997).

CLASSIFICATION

Phylum Mollusca
Class Bivalvia Linnaeus, 1758.
Subclass Pteriomorphia Beurlen, 1944.
Order Ostreioda Férussac, 1822.
Suborder Ostreina Férussac, 1822.
Superfamily Ostreoidea Rafinesque, 1815.
Family Ostreidae Rafinesque, 1815.
Subfamily Ostreinae Rafinesque, 1815.
Genus *Ostrea* Linnaeus, 1758.
Ostrea conchaphila Carpenter, 1857.

SYNONYMY

Ostrea edulis auctt. not Linne, 1758, in part.
Ostreola conchaphila (Carpenter, 1857)
Ostrea lurida Carpenter, 1864.
Ostrea lurida expansa Carpenter, 1864.
Ostrea lurida laticaudata Carpenter, 1864.
Ostrea lurida rufoides Carpenter, 1864.
Ostrea multistriata auctt. not Hanley, 1845, not Deshayes, 1830.
Ostrea palmula auctt. not Carpenter, 1857, in part.
Ostrea procella Lamy, 1929.
Monoeciostrae vancouverensis Orton, 1928, *nomen vanus*.

COLLOQUIAL TAXONOMY

Preferred common name: Olympia oyster.
French common name: huître plate du Pacifique
Other common names: native oyster, California oyster, Yaquina oyster, Yaquina Bay oyster, shell-loving oyster, Shoalwater oyster, rock oyster, western oyster.

Table 2. List of locations in British Columbia known to support Olympia oyster populations.

Geographic Area	Location	Comments	Source
Quatsino Sound	unknown	Historic	Elsey (1933)
Kyuquot Sound	Amai Inlet	Abundant (2 beaches)	Kingzett *et al.* (1995b)
Sidney Inlet	Sidney River Estuary	Present (1976)	RBCM 978-00029-015
Nootka Sound	Cachalot Inlet	Abundant	Pilcher, pers. comm.
	Canton Creek	Present	Kingzett *et al.* (1995a)
	Malksope Inlet	Abundant	Pilcher, pers. comm.
	Nesook Bay	Present	Kingzett *et al.* (1995a)
	Port Eliza	Abundant (6 beaches)	Kingzett *et al.* (1995a)
	Queen Cove	Present (1995)	Kingzett, pers. comm.
Barkley Sound	Ahmah Island	Present (1997)	Truesdell, pers. comm.
	Alma Russell Island	Present (1997)	Truesdell, pers. comm.
	Brabant Island	Present (2 beaches, 1997)	Truesdell, pers. comm.
	Broken Group Islands	Present (3 beaches, 1999)	Holmes, pers. comm.
	Congreve Islands	Present (2 beaches, 1997)	Truesdell, pers. comm.
	Effingham Inlet	Abundant (1997)	Truesdell, pers. comm.
	Harris Point	Abundant (1997)	Truesdell, pers. comm.
	Hillier Island	Abundant (1999)	pers. observ.
	Inner Mary Basin	Abundant (1995)	Kingzett, pers. comm.
	Jacques/Jarvis Lagoon	Present (1973)	RBCM 973-00237-015
	Jacques/Jarvis Lagoon	Present (1997)	Truesdell, pers. comm.
	Julia Passage	Present/Abundant (3 beaches, 1997)	Truesdell, pers. comm.
	Lucky Creek	Abundant (1993)	Meyer, pers. comm.
	Mayne Bay	Abundant (2 beaches, 1997)	Truesdell, pers. comm.
	Nettle Island	Present (2 beaches, 1997)	Truesdell, pers. comm.
	Pinkerton Island	Present (3 beaches, 1997)	Truesdell, pers. comm.
	Pipestem Inlet	Abundant (1995)	Kingzett, pers. comm.
	Snowden Island	Abundant (1993)	Meyer, pers. comm.
	Tofino	Present (1926-36)	RBCM 976-01228-037
	Toquart Bay	Historic	Elsey (1933)
	Toquart Bay	Present (1973)	Truesdell, pers. comm.
	Useless Inlet	Abundant (1995)	Kingzett, pers. comm.
	Vernon Bay	Abundant (1973)	Truesdell, pers. comm.
Sooke Basin	Sooke	Present (1945-63)	RBCM 976-01210-025
	Anderson Cove	Present	Helgeson, pers. comm.
	Hutchison Cove	Present	Helgeson, pers. comm.
	Roche Cove	Present	Helgeson, pers. comm.
Georgia Strait	Boundary Bay	Historic	Stafford (1913-1917)
	Crescent	Present (1933-34)	RBCM 975-00794-003
	Comox Harbour	Historic	Quayle (1969)
	Fanny Bay	Historic	Thompson (1914)
	Gorge (Victoria)	Historic	Quayle (1969)
	Hotham Sound	Present (1976-77)	Heritage *et al.* (1977); Heritage and Bourne (1979)
	Ladysmith Harbour	Historic	Stafford (1913b)
	Ladysmith Harbour	Present (1976-77)	Heritage *et al.* (1977); Heritage and Bourne (1979)
	Ladysmith Harbour	Present (1998)	Nikleva, pers. comm.
	Nanoose Bay	Historic	Stafford (1913b)
	Nanoose Bay	Present, rare (1999)	pers. observ.
	Pendrell Sound	Historic	Quayle (1969)
	Pendrell Sound	Present (1971-77)	Heritage *et al.* (1976, 1977); Bourne (1978); Bourne and Heritage (1979); Heritage and Bourne (1979)
	Von Donop Inlet	Historic	Quayle (1969)
Johnstone Strait	Blunden Harbour	Historic	Elsey (1933); Quayle (1969)

Central Coast	Bardswell Group	Historic	Elsey (1933)
	Campbell Island	Historic	Quayle (1969)
	Fish Egg Inlet	Historic	Elsey (1933)
	Fish Egg Inlet	Abundant (2 beaches)	Bourne and Heritage (1997)
	Watt Bay	Abundant	Bourne *et al.* (1994)

Personal Communnications: E. Helgeson, Coopers Cove Oysters; H. Holmes, Heritage Canada; B. Kingzett, Kingzett Professional Services; G. Meyer, DFO; D. Nikleva, Chemainus First Nation; S. Pilcher, Limberis Seafood Processors; N. and M. Truesdell, Barkley Sound.

Table 3. Technical summary information for Olympia oyster (*Ostrea conchaphila*) in Canada.

DISTRIBUTION

Extent of Occurrence: Not quantified.
Area of Occupancy: Not quantified.

POPULATION INFORMATION

Total number of individuals in the Canadian population: Unknown
Number of mature individuals in the Canadian population: Unknown.
Generation time: Unknown.
Population trend: Populations low relative to historic levels, but appear stable.
Rate of population decline: N/A.
Number of subpopulations: Unknown
Is the population fragmented? Yes
Number of individuals in each subpopulation (give range): Unknown.
Number of extant sites: Unknown.
Number of historic sites from which the species has been extirpated: Population levels greatly reduced in Strait of Georgia, none extirpated.
Does the species undergo fluctuations? Yes.

THREATS

- Susceptibility to environmental extremes
- Overharvest (historic)
- Susceptibility to pollution (particularly sulfite waste liquor, possibly tributyltin)
- Disease (endemic or introduced)

RESCUE POTENTIAL

Does the species exist outside Canada? Yes.
Is immigration known or possible? Not definitively known, but possible.
Would individuals from the nearest foreign population be adapted to survive in Canada? Yes.
Would sufficient suitable habitat be available for immigrants? Yes (unless habitat alteration was cause of extirpation).

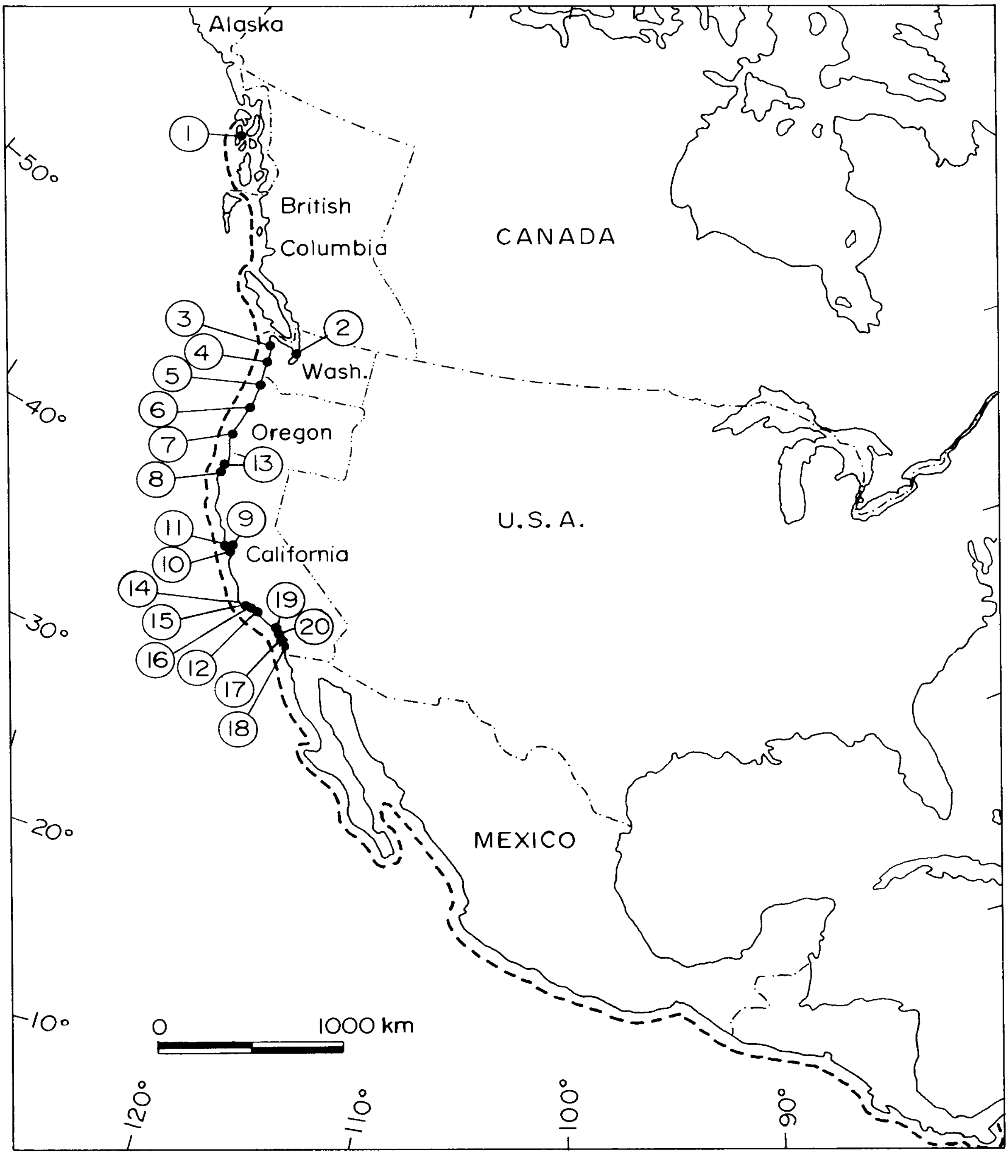

Figure 1. North American distribution of the Olympia oyster, *Ostrea conchaphila.*

Legend: 1- Sitka; 2- Puget Sound; 3- Grays Harbour; 4- Willapa Bay; 5- Netarts Bay; 6- Yaquina Bay; 7- Coos Bay; 8- Humboldt Bay; 9- Elkhorn Slough; 10- San Francisco Bay; 11- Tomales Bay; 12- Newport Bay; 13- Big Lagoon; 14- Mugu Lagoon; 15- Alamitos Bay; 16- Anaheim Bay; 17- Mission Bay; 18-San Diego Bay; 19- Agua Hedionda Lagoon; 20- Los Penasquitos Lagoon.

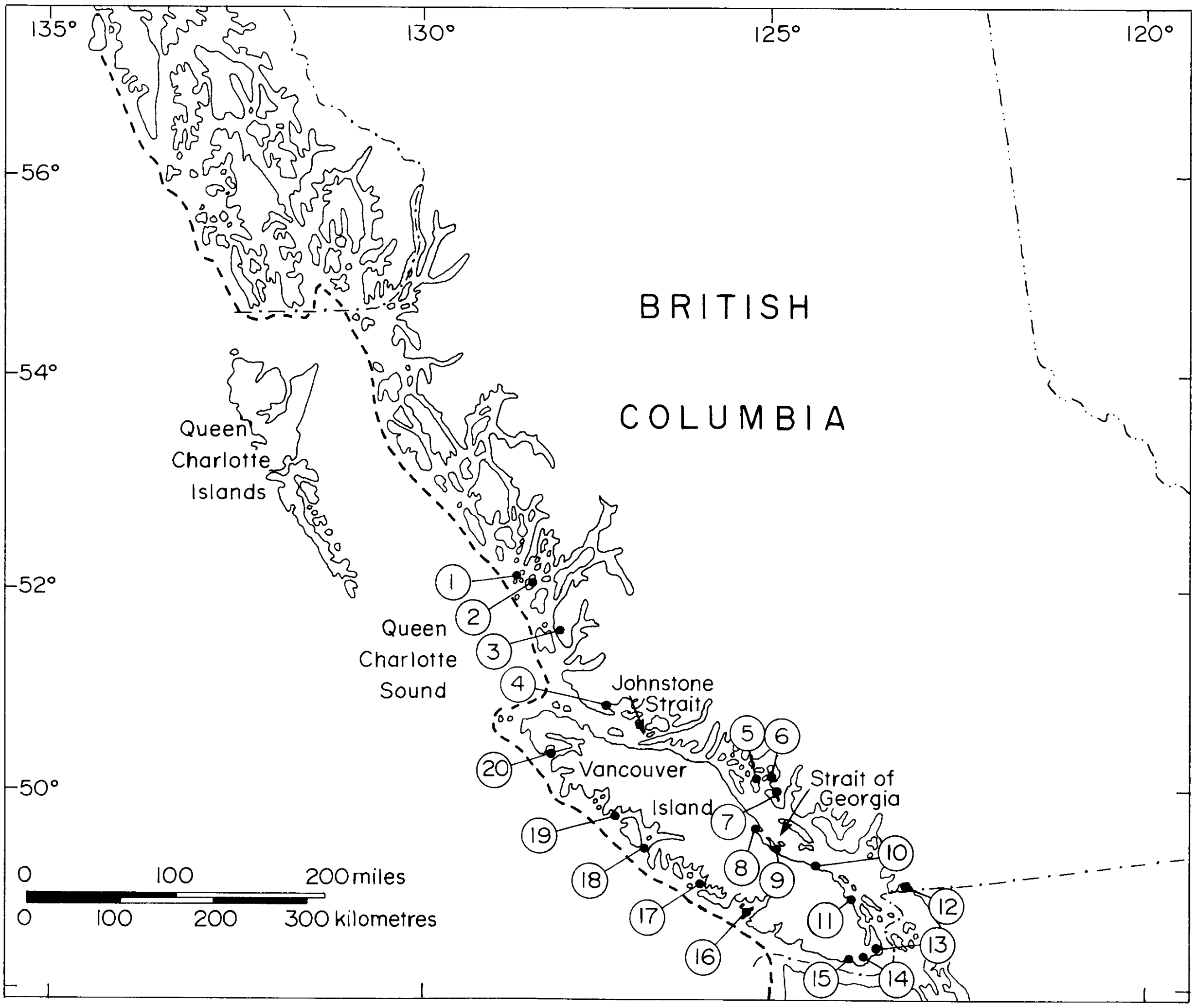

Figure 2. Canadian distribution of the Olympia oyster, *Ostrea conchaphila.*

Legend: 1- Bardswell Group; 2- Campbell Island; 3- Fish Egg Inlet; 4- Blunden Harbour; 5- Von Donop Inlet; 6- Pendrell Sound; 7- Okeover Inlet; 8- Comox Harbour; 9- Fanny Bay; 10- Nanoose Bay; 11- Ladysmith Harbour; 12- Boundary Bay; 13- Victoria; 14- Esquimalt; 15- Sooke Basin; 16- Barkley Sound; 17- Clayoquot Sound; 18- Nootka Sound; 19- Esperanza Inlet; 20- Quatsino Sound.