Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the North Pacific Humpback Whale (*Megaptera novaeangliae*) in Canada

Humpback Whale (North Pacific Population)

2013

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

Recommended citation:

Fisheries and Oceans Canada. 2013. Recovery Strategy for the North Pacific Humpback Whale (*Megaptera novaeangliae*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. x + 67 pp.

Additional copies:

Additional copies can be downloaded from the SAR Public Registry (www.sararegistry.gc.ca).

Cover photo: Brian Gisborne, Fisheries and Oceans Canada

Également disponible en français sous le titre
« Programme de rétablissement du rorqual à bosse du Pacifique Nord (*Megaptera novaeangliae*) au Canada »

ISBN 978-1-100-19053-2
Catalogue no. En3-4/115-2013E-PDF

PREFACE

The North Pacific Humpback Whale is a marine mammal that when in Canadian waters is under the responsibility of the Canadian federal government. The Minister of Fisheries and Oceans is a "competent minister" for aquatic species under the *Species at Risk Act* (SARA). North Pacific Humpback Whales also enter the Gwaii Haanas National Marine Conservation Area and the Pacific Rim National Park Reserve. These areas are administered by the Parks Canada Agency; therefore, the Minister of the Environment is also a "competent minister" under SARA for Humpback Whales. The *Species at Risk Act* (SARA, Section 37) requires the competent ministers to prepare recovery strategies for listed extirpated, endangered and threatened species. The North Pacific Humpback Whale was listed as threatened under SARA in January 2005. The development of this recovery strategy was led by Fisheries and Oceans Canada (DFO) – Pacific Region, in cooperation and consultation with many individuals, organizations and government agencies, including the Parks Canada Agency.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by DFO, the Parks Canada Agency or any other party alone. This strategy provides advice to jurisdictions and organizations that may be involved or wish to become involved in the recovery of the species. In the spirit of the National Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans and the Minister of the Environment invite all responsible jurisdictions and Canadians to join DFO and the Parks Canada Agency in supporting and implementing this strategy to benefit North Pacific Humpback Whales and relevant ecosystem attributes on behalf of Canadians. Fisheries and Oceans Canada and the Parks Canada Agency will support implementation of this strategy to the extent possible, given available resources and its overall responsibility for species at risk recovery.

The goals, objectives and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new information. The competent ministers will report on progress within five years. This strategy will be complemented by an action plan, a document that will provide details on specific recovery measures to be taken to support recovery of the species. The Minister of Fisheries and Oceans and the Minister of the Environment have taken steps to ensure that, to the extent possible, Canadians interested in or affected by these measures have been consulted. Please refer to Appendix F for details.

RESPONSIBLE JURISDICTIONS

The Minister of Fisheries and Oceans and the Minister of Environment, responsible for the Parks Canada Agency, are the competent ministers for Humpback Whales in Pacific Canadian waters. The North Pacific population of Humpback Whales occurs off the coast of the Province of British Columbia and within the Pacific Rim National Park Reserve, National Marine Conservation Area Reserve off the Gwaii Haanas National Park Reserve and Haida Heritage Site and to a lesser extent within the Gulf Islands National Park Reserve. Parks Canada Agency cooperated in the development of this recovery strategy.

AUTHORS

Andrea Rambeau, John Calambokidis and the 2009-10 DFO Humpback Whale Technical Team developed this recovery strategy for Fisheries and Oceans Canada.

ACKNOWLEDGMENTS

Fisheries and Oceans Canada would like to thank Andrea Rambeau (contractor) for developing initial drafts of this recovery strategy and contributing important local information on the population. John Calambokidis (Cascadia Research Collective), Ian Perry, Jake Schweigert (DFO Science) and Cliff Robinson (Parks Canada Agency) provided valuable technical advice and support to the DFO Team, as well as review and input on drafts. Chris Picard shared preliminary results from current Gitga'at Lands and Resources Stewardship Society research programs on the North Coast, which provided insight into aspects of local occurrences and distribution. Participants of the 2009 Humpback Whale Recovery Planning Workshop provided technical input on the draft recovery strategy and presenters contributed new information to assist in developing the draft recovery strategy.

STRATEGIC ENVIRONMENTAL ASSESSMENT

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

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

This recovery strategy will clearly benefit the environment by promoting the recovery of the North Pacific Humpback Whale. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. It has been determined that this strategy will clearly benefit the environment and will not entail any significant adverse effects. Refer to the following sections of the document in particular: Section 2.4 Broad Strategies and Approaches to Recovery, and Section 2.9 Effects on Other Species.

RESIDENCE

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

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

EXECUTIVE SUMMARY

In 2003, North Pacific Humpback Whale population status was assessed as 'threatened' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and in 2005 the population was listed as 'threatened' under Canada's *Species at Risk Act* (SARA) affording it legal protection. The population's status was re-assessed as 'special concern' in 2011 by COSEWIC. Following public consultation regarding the re-classification of the species, the Department of Fisheries and Oceans has referred the assessment of 'special concern' back to COSEWIC for further consideration and the SARA status of North Pacific Humpback remains unchanged at the publication of this document.

A recent estimate of 18,302 individuals indicates a dramatic increase, suggesting the population is recovering at a moderate rate of 4.9 to 6.8% annually (Calambokidis *et al.* 2008). Additional information in Section 1.3.3 outlines rationale for the lingering conservation concerns, which includes the potential for genetically distinct regional feeding groups.

It is estimated that as of 1905, there was at minimum 4,000 humpbacks off the west coast of Vancouver Island. Recent analysis of photo-identification data suggests currently the local B.C. population is between 1,428 and 3,856, with a best estimate of 2,145 animals (95% confidence limits 1,970 -2,331; Ford *et al.* 2009). The range of the Canadian North Pacific population runs along the entire length of the west coast of B.C. from Washington to Alaska and includes inshore coastal inlets and offshore waters. The greatest numbers of humpbacks are found between May and October; however, individuals are observed during all months of the year (Ford *et al.* 2009).

Habitat use in B.C. is primarily for foraging and migrating to higher latitude feeding areas. B.C.'s highly productive waters (Ware and Thomson 2005) serve as important summer feeding habitat (Gregr *et al.* 2000), and during this critical time, humpbacks must build up their fat reserves to sustain them over the winter months (Chittleborough 1965). In B.C., humpbacks consume a variable diet of zooplankton (e.g. euphausiids [krill] and copepods) and small schooling fish (such as herring and sardine). Current threats to humpbacks are vessel strikes, entanglement, toxic spills, prey reduction, and acoustic disturbance.

Critical habitat for Humpback Whales in B.C. has been identified to the extent possible, based on the best available information (Figure 4). At present, there is insufficient information to identify other areas of critical habitat or to provide further details on the features and attributes present within the boundaries of identified critical habitat. Activities likely to destroy or degrade critical habitat include vessel traffic, toxic spills, overfishing, seismic exploration, sonar and pile driving (i.e., activities that cause acoustic disturbance at levels that may affect foraging or communication, or result in the displacement of whales). A schedule of studies has been included to address uncertainties and provide further details on the critical habitat feature(s), as well as identify additional areas of critical habitat. It is anticipated that results from these studies will also assist in development of relevant protection measures for the critical habitat feature(s).

The two goals of this recovery strategy are: in the short term, to *maintain at minimum, the current abundance of humpbacks*[1] *in B.C.;* and in the longer-term, to *observe continued growth*

[1] Using best estimate of 2,145 animals (95% confidence limits 1,970 - 2,331 as presented in Ford *et al.* 2009).

of the population and expansion into suitable habitats throughout B.C. To meet these goals, threat and population monitoring, research, management, protection and enforcement, stewardship, outreach and education activities are recommended. Based on the need to assess population-level effects of threats and develop appropriate mitigation measures, activities to monitor and assess threats are given higher priority. An action plan to implement this recovery strategy will be completed within five years of final posting of this recovery strategy on the SAR Public Registry. When feasible and appropriate, recovery efforts will be coordinated with implementation of other SARA marine mammal recovery plans.

TABLE OF CONTENTS

FIGURES AND TABLES

1. BACKGROUND

This recovery strategy is in part based on the information used in the 2003 COSEWIC assessment of the Humpback Whale (North Pacific population). The development of this recovery strategy was initiated and completed prior to the 2011 COSEWIC re-assessment of the population, which recommended a change of status from “threatened” to “special concern”. However, DFO has referred the 2011 assessment back to COSEWIC due to information brought up during public consultations regarding the structure of the population in Canada. Some species experts expressed concerns that key data justifying the designation of two designatable units in Canada had not been considered by COSEWIC (List of Wildlife Species at Risk (referral back to COSEWIC) Order 2013).

1.1. Species Assessment Information from COSEWIC

Date of Assessment:	May 2003
Common Name:	Humpback Whale (North Pacific population)
Scientific Name:	*Megaptera novaeangliae*
COSEWIC Status:	Threatened
Reason for Designation:	Heavily reduced by whaling, the North Pacific population appears to be increasing. The number of animals that use British Columbia waters is probably in the low hundreds. The high-level of feeding ground fidelity suggests that if animals are exterminated from a particular area, it is unlikely that the area will be rapidly repopulated from other areas. Two extirpated British Columbia populations have shown no sign of rescue. Humpbacks are occasionally entangled in fishing gear, though the number entangled is not thought to threaten or limit the population. In summary, humpback whales that use British Columbia waters appear to be well below historical numbers and have not returned to some portions of their former range.
Canadian Occurrence:	Pacific Ocean
COSEWIC Status History:	The "Western North Atlantic and North Pacific populations" were given a single designation of Threatened in April 1982. Split into two populations in April 1985 (Western North Atlantic population and North Pacific population). The North Pacific population designated Threatened in 1985. Status re-examined and confirmed in May 2003. Last assessment based on an update status report.

1.2. Description

Humpback Whales are easily identified among the baleen whales by their very long pectoral flippers, which are the largest of any whale species. Notably, their Latin genus name, *Megaptera*, means “large wings” in reference to the fact that their flippers may measure up to one third of their body length (True 1904). Other names for Humpback Whales are; yayačim (Nuu-chah-nulth, Stonham (2005), gviýeṃ (R. Carpenter, 2009, Heiltsuk Fisheries Program, pers. comm.), baleine à bosse (French), humpback, hump whale, or hunchbacked whale. Average length of a mature humpback is 13 m for males, and 14 m for females with the maximum recorded length being 17.4 m (Chittleborough 1965). Adult Humpback Whales weigh an average of 34,000 kg, and up to 45,000 kg. Also unique to Humpback Whales are a series of distinct round bumps called ‘tubercles’, which line their upper and lower jaw, their rostrum, and the front edge of their flippers. Humpbacks are rorqual whales (Family Balaenopteridae), and thus share the common characteristics of possessing both a dorsal fin and ventral throat grooves (allowing them to take in large volumes of water while feeding). The dorsal fin of Humpback Whales is quite variable, ranging from rounded to falcate, and the throat grooves are wide and relatively few (between 14 and 22) (Leatherwood *et al.* 1976). Dorsal skin colouration is a dark blue-black, progressing to variable black through white colouration ventrally. The variable colouration continues onto the ventral surface of the tail flukes and this, in combination with the serrated patterning of the flukes’ trailing edge, can be used to identify unique individuals (Katona and Whitehead 1981). Humpback Whales are considered the most acrobatic of the large whales and can often be seen breaching, flipper-slapping, and lob-tailing. The species is also well known for their rich and varied “songs” (Payne and McVay 1971), sung only by males and which differ between populations from different oceanic basins (Winn *et al.* 1981). Although the purpose of song has not been determined, it is thought to be a form of courting and mating display (Tyack 1981) as songs are primarily heard on their winter breeding grounds. However, songs have also been heard on summer feeding grounds (Mattila *et al.* 1987, McSweeney *et al.* 1989, Ford *et al.* 2009).

As with most baleen whales, breeding is strongly seasonal. Courting and mating takes place in tropical and sub-tropical breeding grounds. Humpback Whales in the North Pacific breed in the Hawaiian Islands, Mexican coastal waters, Central America, the Philippines, and Japan (Calambokidis *et al.* 2008) from approximately September to May (Urbán and Aguayo 1987). Calving takes place on the wintering grounds the following year, after a gestation period of 11-12 months (Chittleborough 1958). Females give birth to a single calf, generally every 1-5 years and female humpbacks show an estimated calving rate of 0.37 calves per mature female per year (for Humpback Whales in southeast Alaska, Baker *et al.* 1987). Newborn calves have a mean length of 4.5 m (Chittleborough 1965). Sexual maturity occurs at about 9 years of age for both sexes, and at an average length of 12m; physical maturity is not reached for another 3-9 years. The oldest documented age of a harvested Humpback Whale was estimated at 48 years old (Chittleborough 1965); however, commercial hunting is expected to have removed most of the oldest individuals from the global population, and humpbacks likely live much longer. Average longevity is unknown for Humpback Whales, and sources of natural mortality are not well understood. There is no evidence of reproductive senescence in humpbacks or other baleen whales.

During the breeding and calving season, there is limited feeding (Baraff *et al.* 1991) on the relatively unproductive tropical wintering grounds, as the whales presumably invest the majority of their energy to breeding while subsisting off their blubber reserves. In spring and summer, Humpback Whales migrate long distances to high latitude feeding grounds where they feed mostly on dense patches of krill and small schooling fishes in temperate coastal and shelf waters. Humpback Whales, like all rorquals, are "gulp feeders", which means that they engulf discrete mouthfuls of food one mouthful at a time, in contrast to "skimmers", such as bowhead whales, which continuously filter their food from the water. Humpback Whales show a wide variety of specific feeding behaviours, such as lunge-feeding, flick-feeding, and bubblenet feeding. Humpback Whales exhibit rather loose social associations, and can forage alone or in coordinated groups that exploit the same prey patch (Leighton *et al*. 2004). Bubblenet feeding, a behaviour that is unique to Humpback Whale, is used to cooperatively trap or confuse fish and other small prey by encircling them in a cylinder of bubbles and then swimming up through the centre, mouth agape (Leighton *et al*. 2004).

1.3. Population and Distribution

1.3.1 Global

The Humpback Whale has a global cosmopolitan distribution and inhabits all of the world's major ocean basins, though it is less common in Arctic waters. Humpback Whales have a history of being hunted for both commercial and subsistence purposes throughout the world. The pre-exploitation global population is estimated at over 120,000 humpbacks (Johnson and Wolman 1984). In the Southern Ocean alone, approximately 71,000 Humpback Whales were killed between 1904 and 1938 (Chittleborough 1965, Perry *et al.* 1999). The International Whaling Commission (IWC) banned commercial hunting of humpbacks in 1955 in the North Atlantic, in 1964 in the Southern Hemisphere, and in 1966 in the North Pacific (Best 1993). There is some evidence that the global population was reduced by as much as 90-95% during that time (Johnson and Wolman 1984).

Current global population estimates show considerable variation. In the 1980s and early 1990s, global abundance can be estimated as roughly 38,000 individuals: divided between the North Atlantic population with 10,600 individuals (Smith *et al*. 1999), the Southern Hemisphere population (south of 30°S) 20,000 individuals (Butterworth *et al*. 1993), and the North Pacific population 6,000-8,000 individuals (Calambokidis *et al*. 1997). However, summation of stock estimates from the 1990s (which have been assessed in some detail; IWC 2007), produces conservative minimum global estimates that are closer to 54,000-75,000.

Humpback Whales have an extensive worldwide range, but because of their historical over-exploitation, they remain depleted and considered vulnerable to entanglement, vessel strikes, prey limitation and disturbance, among other threats. As such, they are listed as Vulnerable under the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List, and Endangered under the U.S. Endangered Species Act (ESA). In Canada, there are two separate populations: the western North Atlantic population on the east coast listed as 'Special Concern' under the SARA (Schedule 3), and the North Pacific population on the west coast, listed as Threatened under the SARA (Schedule 1).

1.3.2 North Pacific

The total pre-industrial harvest population for the North Pacific was estimated at 15,000 by Rice (1978); however, this was based on whaling data which might have been inaccurate. From 1905 to 1965, about 28,000 humpbacks were killed in the eastern North Pacific (Rice 1978) and by the end of commercial whaling this population was estimated to have dropped to 1,600 individuals (Gambell 1976), although there remains much uncertainty regarding the estimation methods used (Calambokidis and Barlow 2004).

In 2003, the status report on Humpback Whales in Canada (Baird 2003), published by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), provided the most up to date information to assess the conservation status of North Pacific Humpback Whales. This report contained a population abundance estimate of between 6,000 and 8,000 individuals (not including calves; Calambokidis *et al.* 1997). This COSEWIC status report (Baird 2003) contributed to listing of the North Pacific population as Threatened under the SARA. Since the 2003 COSEWIC report, there have been significant advances in our understanding of North Pacific Humpback Whale abundance. The three-year SPLASH project ('Structure of Populations, Levels of Abundance, and Status of Humpbacks') conducted from 2004 through 2006, was one of the largest international scientific collaborations on Humpback Whales ever conducted and involved researchers from Russia, Japan, Mexico, the U.S. and Canada. Its goal was to estimate the population size, structure, and migratory patterns of Humpback Whales throughout the North Pacific, and a final report was completed in May of 2008 (Calambokidis *et al.* 2008). The best overall abundance estimate for the North Pacific was determined to be 18,302 individuals (excluding calves; Calambokidis *et al.* 2008). This dramatic increase from previous estimates suggests that the population is recovering at an annual rate of increase ranging from 4.9 to 6.8% (Calambokidis *et al.* 2008). When this new information is compared with the earlier estimate of 6,000 to 8,000 for the North Pacific population (Calambokidis *et al.* 1997), and Rice's (1978) estimate of pre-industrial whaling abundance (15,000) it suggests that this North Pacific population is largely recovered. However, there remains uncertainty surrounding methods used to estimate pre-whaling abundance (Calambokidis and Barlow 2004). Additional information contained in Section 1.3.3 'Population and Distribution – British Columbia' outlines the rationale for the lingering conservation concerns for the population, specific to B.C. waters.

Humpback Whales in the eastern and central North Pacific are thought to comprise a single 'structured stock', which is made up of geographically-isolated feeding aggregations (Baker *et al.* 1986). Individuals from the various isolated feeding aggregations migrate and intermingle together on one or more separate breeding grounds (Baker *et al.* 1986). The United States recognizes three Humpback Whale stocks within the U.S. Exclusive Economic Zone of the North Pacific (Angliss and Outlaw 2005, Baker *et al.* 1998, Calambokidis *et al.* 1997). The Eastern North Pacific stock consists of whales that feed along the coast of California to southern B.C. in the summer and fall, and migrate primarily to coastal Central America and Mexico in the winter and spring (Steiger *et al.* 1991, Calambokidis *et al.* 1996, Angliss and Outlaw 2005). The Central North Pacific stock spends summer and fall off the coast of central and northern BC, southeast Alaska, and Prince William Sound west to Unimak Pass, and migrates to the Hawaiian Islands, Mexico and Central America for the winter and spring (Baker *et al.* 1990, Perry *et al.* 1990, Calambokidis *et al.* 1997, Angliss and Outlaw 2005). The Western North Pacific stock includes winter populations in Japan, which likely migrate to the Bering Sea and Aleutian

Islands in the summer and fall (Nishiwaki 1966). Sightings data in Figure 1 depict general migration patterns between feeding and breeding grounds. The concept of three stocks is supported by observations of sequential sightings of the same individuals in feeding and breeding grounds.

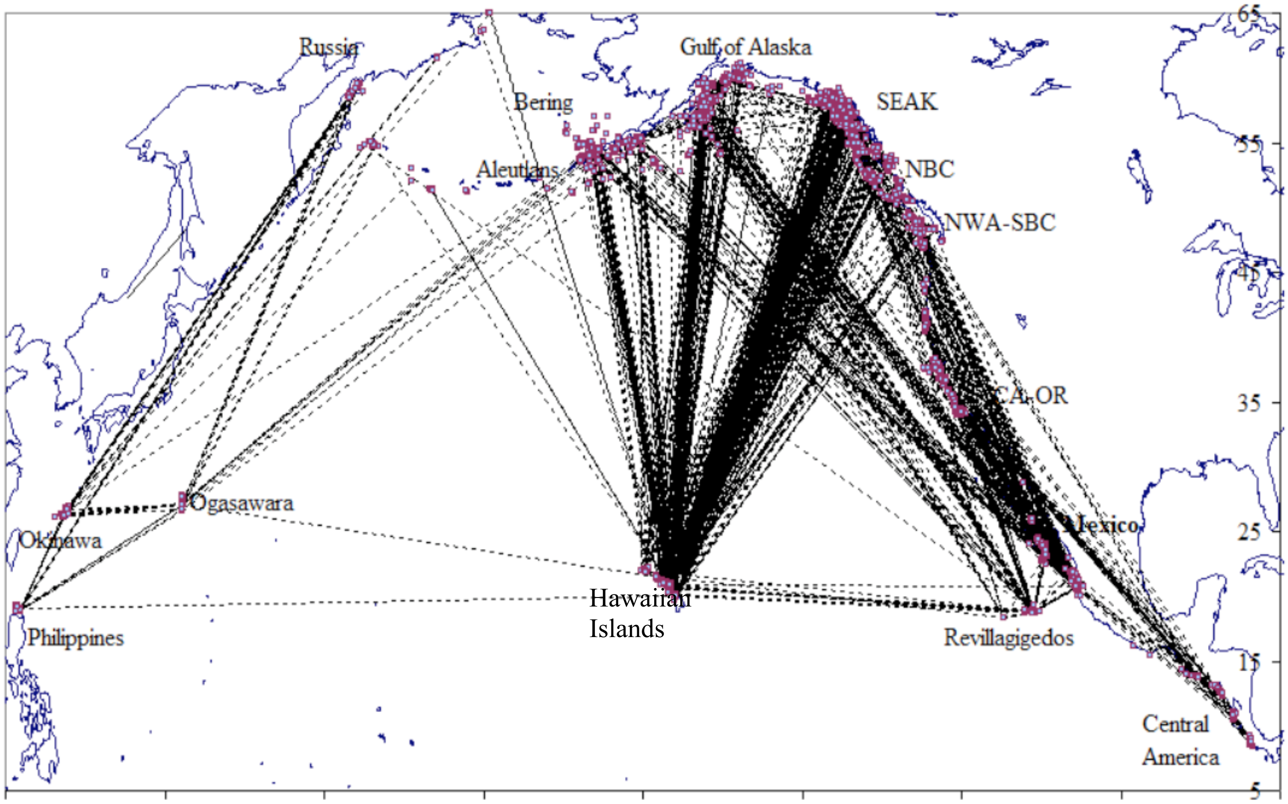

Figure 1. Locations of 873 photo-identified Humpback Whales in the North Pacific documented in the SPLASH project, 2004-2006. Lines connect sequential sightings of the same individual, but do not necessarily reflect actual migratory paths between breeding grounds and feeding areas. 'SEAK' refers to southeast Alaska, 'NBC' to northern British Columbia, 'NWA-SBC' refers to the northern Washington-southern B.C. area, 'CA-OR' the northern California-Oregon area. This map has been reproduced from Calambokidis *et al*. (2008).

1.3.3 British Columbia

The pre-industrial whaling abundance of Humpback Whales off the west coast of Canada is unknown. However, it is estimated that as of 1905 (the beginning of an intense period of whaling), there was a minimum abundance of 4,000 humpbacks using the waters off the west coast of Vancouver Island (Ford *et al.* 2009).

Sightings off B.C. were rare in the 1980s (Whitehead 1987; G. Ellis 2009, Fisheries and Oceans Canada, pers. comm.); however, in recent decades, Humpback Whales appear to be re-colonizing B.C. waters. Recent work analyzing photo-identification data of humpbacks sighted in the Canadian Pacific (from 1992-2006) suggests that the population utilizing B.C. waters, either as a migration corridor or for feeding, consists of between 1,428 to 3,856 individuals with a current best estimate of 2,145 animals (95% confidence limits 1, 970-2,331; Ford *et al.* 2009). Line transect surveys for cetaceans conducted over the summers of 2004 and 2005 in a portion of the coastal waterways of B.C. (excluding all waters off the west coast of Vancouver Island and the west coast of Haida Gwaii [the Queen Charlotte Islands]) provided an abundance estimate of 1,313 Humpback Whales (95% confidence limits, 755-2,285; Williams and Thomas 2007).

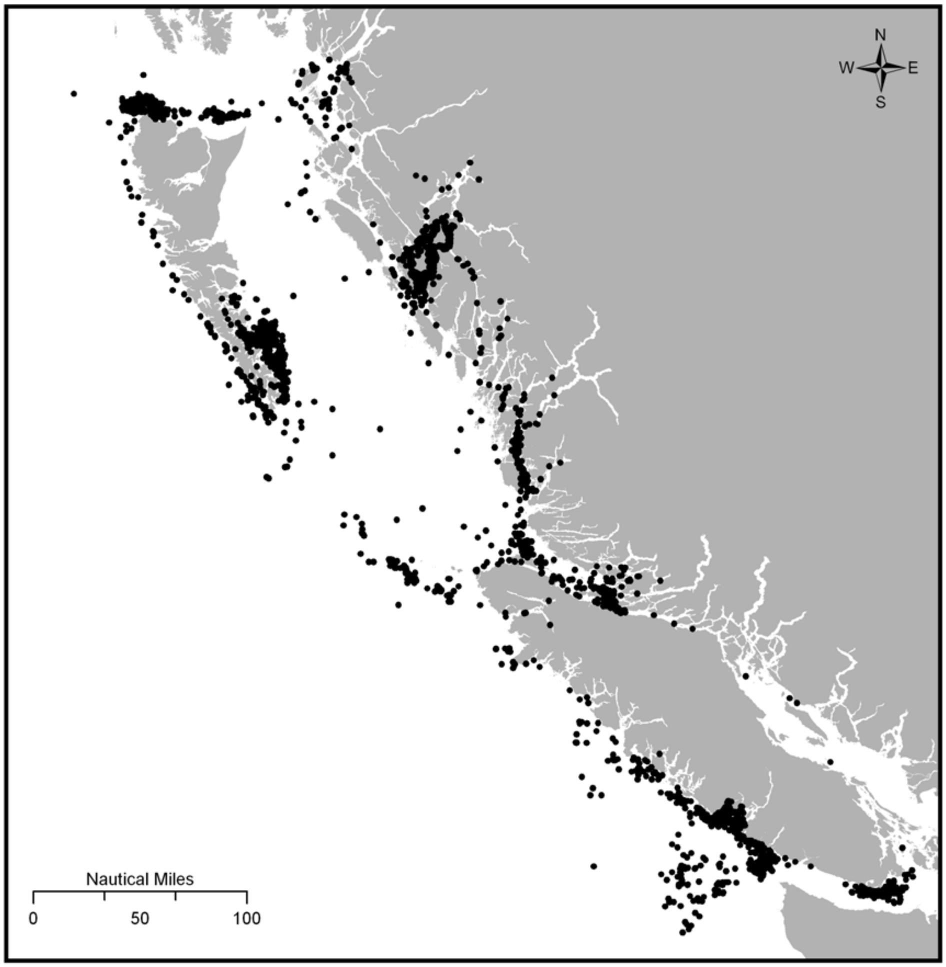

Figure 2. Locations of 6401 Humpback Whale photo-identifications in B.C. collected during 1984-2007 (Ford *et al.* 2009).

The range of the Canadian North Pacific population runs along the entire length of the west coast of B.C., from Washington to Alaska borders and includes both inshore coastal inlets, and offshore waters (Figure 2). It is likely that these whales belong to the U.S. Eastern and Central North Pacific stocks and also use U.S. waters to the north or south. Studies reviewed in the COSEWIC status assessment for this population (Baird 2003) provided evidence that two distinct regional feeding groups may exist within B.C.; a southern B.C. – northern Washington (WA) group and a northern B.C. – southeast Alaska (SEAK) group. Calambokidis *et al.* (1996, 2001) noted little interchange between regional feeding areas, suggesting some degree of isolation between these feeding aggregations. At the time of the COSEWIC assessment, no abundance estimate was available for B.C. waters only. Preliminary data provided a minimum of 115 unique animals for the southern B.C.-north WA group and over 500 animals in the northern B.C. – SEAK group (Baird 2003). As this unpublished information was part of ongoing research efforts, there was insufficient information for recommending regional population sub-units for assessment as ‘designatable units’ by COSEWIC.

Building on information in the COSEWIC status report, recent genetics and photo-identification research provides supporting evidence for the two sub-populations, further distinguishing their site fidelity, and indicating genetically distinct feeding groups (Calambokidis *et al*. 2008, Ford *et al*. 2009, Baker *et al*. in prep). The SPLASH program estimated regional abundances of 3,000 to 5,000 and 200 to 400 for the north B.C. - SEAK and southern B.C. - northern WA regions, respectively (Calambokidis *et al.* 2008). There may be overlap in habitat use between these potential sub-populations, and there is currently insufficient evidence to delineate specific geographic boundaries of the distinct sub-populations. Preliminary data suggest that the division may be somewhere off northern Vancouver Island (Ford *et al.* 2009). SARA recognizes a single North Pacific Humpback Whale population, thus the current recovery strategy conforms to this classification.

The greatest numbers of Humpback Whales in B.C. waters are found between May and October; however, individuals are observed during all months of the year (Ford *et al.* 2009). Distribution of Humpback Whales in British Columbia occurs in aggregations that likely reflect the patchy, mobile distribution and abundance of their prey (Whitehead and Carscadden 1985, Piatt *et al.* 1989, Payne *et al.* 1990). The waters off the north coast of Graham Island, the east coast of Moresby Island, channels and inlets on the north mainland coast, and areas off the north and southwest coasts of Vancouver Island (Ford *et al.* 2009) are areas of particularly high whale density. As in other parts of the world, individual animals show very strong site fidelity and are known to return to the same general area across years (Ford *et al.* 2009).

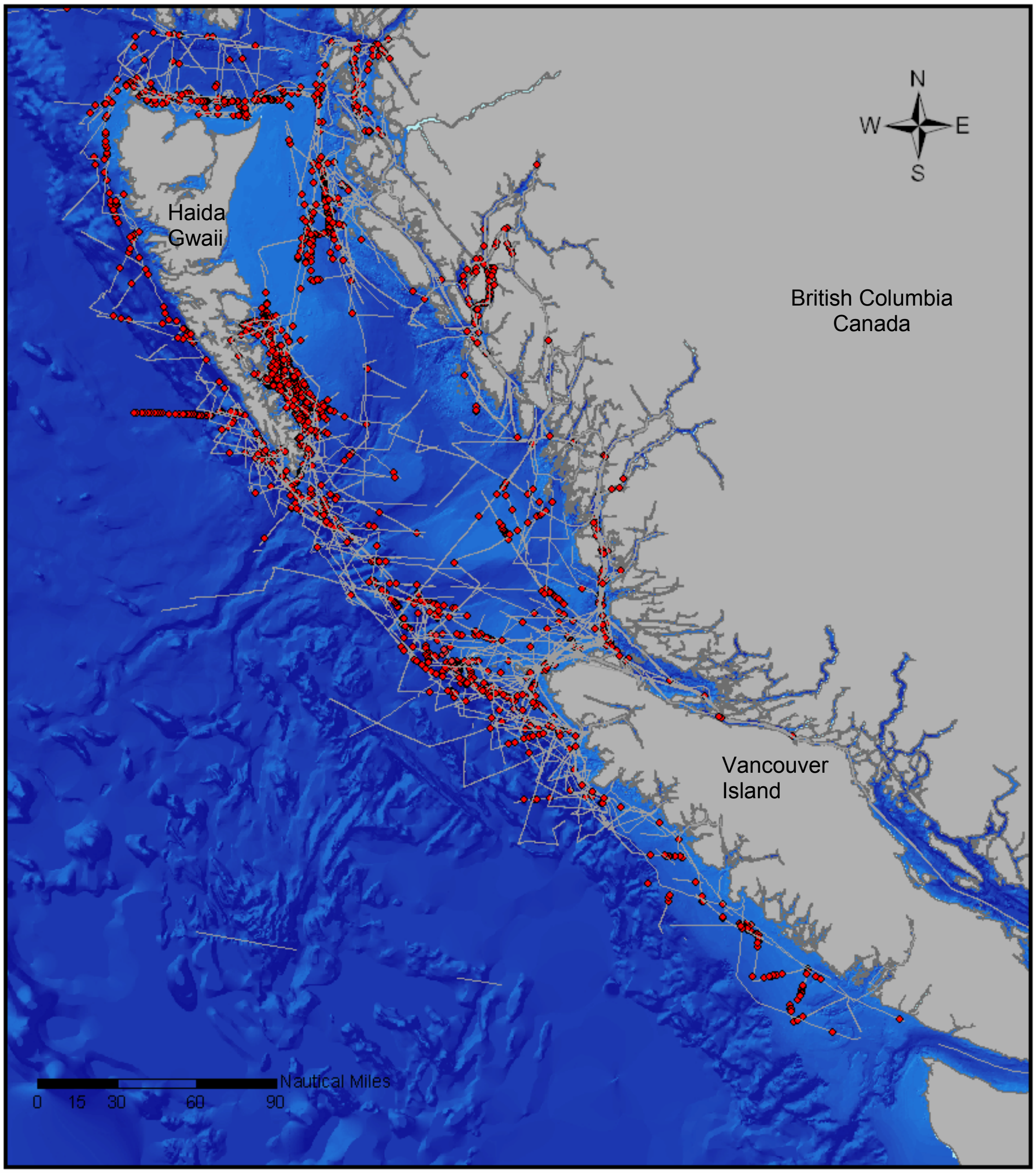

Figure 3. Sightings of Humpback Whales made during multi-species cetacean surveys by Fisheries and Oceans Canada, Cetacean Research Program (Ford *et al.* 2009). Sightings do not reflect actual distribution of humpbacks as survey effort throughout B.C. does not cover the whole coast either within or across years. This map shows effort lines (in light grey) from 26 surveys conducted during 2002-08 and the locations of 1810 sightings of one or more Humpback Whales.

1.4. Habitat and Biological Requirements, Ecological Role and Limiting Factors for Humpback Whales

1.4.1 Habitat and Biological Needs

Humpback Whales are a migratory species requiring tropical habitats for breeding and temperate habitats for feeding. The marine waters of B.C. not only offer productive feeding habitat to humpbacks, but likely also provide migratory pathway for whales travelling to Washington or Alaska to feed.

The highly productive waters of B.C. (Ware and Thomson 2005) serve as important feeding habitat for a portion of the Humpback Whale population during summer months (Gregr *et al.* 2000). Whales fast during their seasonal migrations and on their winter breeding grounds (Chittleborough 1965), therefore, they must build up their fat reserves during the feeding season in order to sustain them over the winter months (Chittleborough 1965). In the eastern Atlantic, summer distribution of Humpback Whales is closely tied to their prey (Whitehead and Carscadden 1985, Piatt *et al.* 1989, Payne *et al.* 1990) and there is evidence that this is maternally-directed, with whales showing strong site fidelity to areas they visited with their mothers (Whitehead and Carscadden 1985, Piatt *et al.* 1989, Payne *et al.* 1990). If similar imprinting occurs in B.C., visiting calves would be expected to use B.C. waters as their primary feeding area throughout their lives.

As Humpback Whales use B.C. waters mainly as feeding grounds, their habitat needs are closely linked with biological and oceanographic parameters affecting their prey. Humpback Whales feed in nearshore protected waters as well as in offshore coastal waters associated with the continental shelf (Gregr and Trites 2001, Ford *et al.* 2009).

Diet in British Columbia and Alaska
Humpbacks are "gulp feeders" and are able to consume large quantities of prey by expanding their throat pleats. Thus they benefit from large aggregations of prey. They may also form loose social associations for the purposes of cooperative feeding (e.g., bubblenet feeding) which likely vary in response to shifts in geographical location and size of prey schools (Clapham 1996).

North Pacific Humpback Whales consume a diverse diet of zooplankton (particularly euphausiids [krill] and copepods), small schooling fish (such as herring, sardine, sand lance, smelts, juvenile salmonids, cod, mackerel, and anchovies), as well as pteropods (small pelagic sea snails) and some cephalopods (Johnson and Wolman 1984). In Frederick Sound, Alaska, 50-80% of a Humpback Whale's diet is comprised of krill, principally *Thysannoessa raschi* and *Euphausia pacifica* (Dolphin 1987b).

In B.C., Humpback Whales have been observed to forage on sardine, herring and euphausiids. This may be only a partial description of their diet in B.C., as no dedicated studies have yet been undertaken (G. Ellis and J. Ford 2009, Fisheries and Oceans Canada, Science Branch, pers. comm.). Additional information on population trends and harvests of euphausiids, herring and sardine in B.C. waters is provided in Appendix E.

Whaling data from 1949-65 provide information on stomach contents of humpbacks taken by B.C. whalers during that time period[1]. Analyses show that euphausiids were the most common prey of Humpback Whales in B.C. (DFO-CRP, unpublished data). Ford *et al*. (2009) noted that of the stomachs containing prey remains (n = 287), 92% contained only euphausiids, 4% only copepods, and 0.7% had only fish. The remaining stomachs contained mixtures of these prey types and 1 stomach was full of small squid (<5 cm). Two species of euphausiids were identified: *Euphausia pacifica* and *Thysanoessa spinifera*.

Humpback Whale-euphausiid foraging studies in Alaska have focussed on the associations between prey density, prey depth and energetic feasibility (Bryant *et al.* 1981; Dolphin 1987b). For North Atlantic humpbacks, Piatt and Methvan (1992) found that thresholds of prey density affected humpbacks' foraging on capelin. These studies demonstrate that not all potential prey aggregations provide equal foraging opportunities. When considered in association with site fidelity, Humpback Whales may be dependent on specific prey at specific feeding regions.

Changes in distribution and abundance of local prey species may have varying effects on Humpback Whales' use of habitat in B.C. The linkage between abundance of prey species and distribution of Humpback Whales indicates that variations in prey abundance or distribution may be reflected in a shift in humpback distribution (Whitehead and Carscadden 1985, Piatt *et al.* 1989, Payne *et al.* 1990, Benson and Trites 2002). More information is needed on diet composition, prey availability and other habitat features of Humpback Whales in B.C. waters.

1.4.2 Ecological Role

Marine mammals may have a large impact on structure and function of marine communities as a result of their large size, current abundance, and consumptive abilities, but limited empirical evidence makes it difficult to quantify their effects (Bowen 1997). As with many other species of whales, humpbacks are carnivorous and have few predators, making them apex predators on their feeding grounds (Pauly *et al.* 1998). Humpback Whales consume large quantities of multiple types of prey and may compete with other marine mammals and fish species for prey resources, as well as with fisheries. Marine mammals may also have important ecological functions of recycling nutrients into the water column via urination, defecation, and decomposition.

Although there is little information on the energetic and foraging requirements of Humpback Whales, Sigurjónsson and Víkingsson (1997) estimated forage requirements for an Icelandic population of 1,796 individuals. They estimated that approximately 230,000-280,000 tonnes of prey (calculated ratio of 52% fish and 48% crustacea) were consumed during a forage season of approximately 4 months, which corresponds to average annual estimates of 128-156 tonnes of prey per whale. Their results are useful for considering prey requirements on individual and population levels, particularly as the Icelandic population estimate is similar to that for B.C. By applying Sigurjónsson and Víkingsson's average forage consumption rates per whale to the recent estimates of the Canadian Pacific population (2,145 animals; 95% confidence limits 1,970

[1] Whales were taken 10 nautical miles from shore or farther.

- 2,331; Ford *et al.* 2009), annual consumption rates for humpbacks in B.C. can be calculated at approximately 250,000 – 360,000 tonnes per annum.

1.4.3. Biological Limiting Factors

Biological factors which limit population growth or maximum potential abundance are typically two-fold: bottom-up processes mediated, for example, by the availability and quality of prey; and top-down processes such as predation. These limiting factors are intrinsic to the biology of a species and can not be mitigated or managed directly. However, pressures from human activities may alter the influence of limiting factors on a population. In such cases, actions may be warranted to ensure that human activities do not tip the balance of biological limiting factors and trigger population decline. See Section 1.5 'Threats' for further details.

Humpback Whales are long-lived animals with few predators and a diverse prey base. Their reproductive parameters can lead to relatively high rates of population growth, while natural limiting factors act on a species' intrinsic or maximum rate of growth. The maximum potential abundance that a species can attain in a certain habitat is called "carrying capacity". As a population approaches carrying capacity, its growth rate approaches zero. Currently the North Pacific population is likely below its carrying capacity because no slowing of the growth rate has been observed.

Three potential limiting factors on the population in B.C. waters are prey availability, site fidelity behaviour and natural mortality. Of these, prey availability could be a significant factor as it is likely tied closely to carry capacity. Site fidelity behaviour may act with prey availability to influence population growth and the rate of habitat re-occupation. When the estimated annual population growth rate is considered (4.9 – 6.8%; Calambokidis *et al.* 2008), prey availability, site fidelity and natural mortality do not appear to be limiting population growth at present. Each of these potential factors is discussed in more detail below.

Prey Availability
Changes in oceanographic conditions that affect Humpback Whale prey populations have been documented along the west coast of North America. Some of these changes may be associated with cyclical variability, regime shifts or broader climate change that compromise the production of forage species. For example, abundances of some euphausiid species off southern California have been correlated with the Pacific Decadal Oscillation (PDO) (Brinton and Townsend 2003). Humpback Whale prey selection off the coast of California has shifted from a krill-based diet in the 1990s toward fish as the primary prey species since 1999 (Calambokidis *et al*; unpublished data). Changes in oceanographic conditions and prey availability off the California coast have impacted populations of krill-feeding seabirds (Hyrenbach and Veit 2003). In addition, low levels of reproduction in Cassin's auklets in 2005 and 2006 was attributed to reduced krill stock in some areas of the U.S. West Coast (Sydeman *et al.* 2006).

Evidence from other species, such as Grey Whales, indicates that large whales can be limited by ocean productivity and access to feeding areas. For Grey Whales, persistent ice cover limiting access to key Arctic feeding grounds has been linked to subsequent decrease in calf production, increase in mortalities and reduced body condition (Le Boeuf *et al*. 2000; Moore *et al*. 2001; Perryman *et al.* 2002). In 2005, a significant decrease in abundance of summer resident Grey Whales off the Oregon coast was associated with an altered upwelling regime and subsequent recruitment failure of mysid shrimps (*Crustacea: Mysidae*; Newell and Cowles 2006).

Prey switching may be a strategy used by Humpback Whales. Observations of prey switching from krill to forage fish species have been explained as a response to changes in relative abundance of the two prey types (J. Calambokidis 2009, Cascadia Research Collective, pers. comm.; Calambokidis *et al* unpublished). Weinrich *et al.* (1992) hypothesized that as Humpback Whales switch food sources they may develop new feeding behaviours, which are culturally transmitted within the 2-3 year period after weaning. Grey Whales have also been reported to compensate for changes in productivity of certain feeding grounds by moving to other feeding areas, or by switching to alternative prey (Moore *et al*. 2007). Given the uncertainty regarding propensity for prey switching, potential target prey species, and impacts of distributional shifts in prey abundance, it is difficult to predict shifts in use of foraging habitat for Humpback Whales. Changes in abundance of important prey species and subsequent prey switching could potentially lead to consumption of 'lower quality' prey[1] which could result in their inability to meet energetic demands.

If availability of key forage species is low, Humpback Whales may show a range of physiological responses including reduced growth rate and fat storage, reduced reproductive success/or delayed maturation, as well as changes in normal seasonal distribution patterns. Due to the large quantities of food consumed by an individual humpback (see 'Habitat and Biological Needs' and 'Ecological Role'), continued population growth or maximum potential abundance of this population could, in future, be constrained by environmental factors affecting food availability and distribution.

Site Fidelity

Humpbacks show very strong site fidelity to traditional feeding grounds in both the North Atlantic (Clapham *et al.* 1993) and the North Pacific oceans (Darling and McSweeney 1985, Baker *et al.* 1986, Craig and Herman 1997, Calambokidis *et al*. 2008, Ford *et al*. 2009). Distinct differences in Humpback Whale mtDNA between regions indicate limited interchange of animals among regions within the eastern North Pacific (Baker *et al*. in prep). In B.C., when individual Humpback Whales are re-sighted in multiple years, the majority of these sightings occur within 100km of previous sightings (Ford *et al*. 2009), and there is limited interchange between regional feeding areas (e.g. between north B.C. and south B.C.; Calambokidis *et al*. 2008). This suggests that humpbacks may be very slow to re-colonize areas from which they have been removed and that anthropogenic actions and impacts to foraging habitat could have large effects on the population in B.C., even if activities occur in highly localized areas.

Natural Mortality

Sources of natural mortality specific to the North Pacific population and B.C. include predation, disease, parasitism, biotoxins, and accidental beaching (Baird 2003). Humpbacks undergo extensive annual migrations which are energetically very costly. During this time cow-calf pairs are at potentially greater risk of predation. Based on the prevalence of scarring on humpbacks

[1] Prey quality refers to its nutritional value (caloric content, nutrients, etc.)

(Steiger *et al.* 2008) and records of predatory events (Jefferson *et al.* 1991) predation by killer whales may be a significant source of mortality to calves. The first-year natural mortality rate of 0.182 (95% CI: 0.023-0.518) was estimated for humpback calves in the Central North Pacific (Gabriele *et al.* 2001). Cookie cutter sharks and lampreys are thought to cause damage to skin (Jones 1971), and humpbacks have numerous external and internal parasites, yet these have not been shown to have any serious effects (Matthews 1978, cited in Johnson and Wolman 1984).

1.5 Threats

The population of Humpback Whales in Canadian Pacific waters is affected by a variety of human activities that, if unmitigated, could pose potential threats to long-term recovery, or potentially contribute to a population decline. For the purposes of this Recovery Strategy, a threat to recovery of humpbacks in B.C. is identified as any activity that negatively affects the survival or reproduction of an individual, and may include disturbances that impact an animal's ability to conduct its normal life processes. These may be of anthropogenic origin (e.g. vessel traffic), or natural ecosystem processes (e.g. killer whale predation), or cumulative effects of both. Limiting factors are environmental or biological factors that may naturally limit population size or slow population growth, and are typically not considered a threat unless altered by human activities (EC 2007). As per SARA Section 41(1)(b) the following threats to individuals, populations and habitat of Humpback Whales in B.C have been identified in this recovery strategy: *vessel strike; entanglement, toxic spills; prey reduction (i.e., declines in prey quantity and/or quality);and acoustic disturbance*.

Other potential threats to the North Pacific population of Humpback Whales in BC and throughout their range include bioaccumulation of persistent toxins, biotoxins, and resumption of whaling practices. Based on current knowledge, these threats are not yet considered significant or imminent with respect to the population levels (refer to Appendix D for more detailed background information on these threats).

The Potential Biological Removal (*PBR*) for the humpback population in B.C. was calculated to be 21 animals (Ford *et al.* 2009). *PBR* estimates the maximum number of animals, excluding natural mortality, which may be removed annually without triggering unsustainable population declines (Wade 1998). Not enough is known about prevalence and severity of some threats to draw conclusions on population-level risks. Assessing current information against the calculated *PBR* is not possible at this time.

1.5.1 Threat classification

The relative risk for each identified current or imminent threat affecting North Pacific Humpback Whales in B.C. was determined for impacts to the individual, population and habitat (Table 1). Each threat is considered in terms of a general activity and the stress it causes to the identified habitat, to individuals, and on the population as a whole. Potential demographic, physiological, and behavioural effects are considered with respect to relative certainty regarding the linkage between the activity and each potential effect on Humpback Whales and their environment. Relative risk includes consideration of the relative geographic extent, frequency and occurrence of the threat, as well as the severity of impacts to Humpback Whale behaviour, physiology and other life processes and relative certainty of those impacts (see Appendix B – 'Glossary of Terms'). Detailed descriptions of the five identified threats as they pertain to human activities are provided in Section 1.5.2 and in Appendix C.

Table 1. Relative risk rating for each of the threats identified to affect Humpback Whales and their habitat in B.C. Detailed risk assessments for these threats are outlined in Appendix C. Other potential threats are described in Appendix D. Order of threats presented in this table is not prioritized.

General Threat	Specific Threat	Relative Risk		
		Individual Humpbacks (IN)	Population Wide (PW)	Habitat (HB)
Physical Disturbance	IN - Potential for risk of vessel strikes to increase to High; further study required to clarify uncertainties	Moderate	Low	n/a - does not directly affect habitat
Entanglement	IN/PW – Risk to individuals is moderate; population numbers may be sufficient to support associated mortality rates; further studies are required to clarify uncertainties	Moderate	Low	n/a – does not directly affect habitat
Toxic spills	IN/PW - Risk of occurrence is low; risk of individual morbidity and mortality related to a spill is unknown but expected to be significant HB - risk for degradation of prey population varies depending on the rate of dissipation/dispersion	Low	Low	Moderate
Prey Reduction	IN/PW - Risk likely to increase as food requirements increase for growing population; further studies are required to clarify uncertainties HB – as foraging is one of the primary activities undertaken by Humpback Whales in BC waters, reduction in quality or quantity of prey is detrimental and degrades the habitat	Unknown	Unknown	Moderate
Acoustic Disturbance	IN/PW - Further studies are required to clarify uncertainties HB – in narrow channels, fjords and other areas where sound pressure level dissipation is restricted	Unknown	Unknown	Low to Moderate*

*Relative risk varies depending on the specific location and features of the habitat.

It should be noted that accurate ranking of relative risk can be difficult for threats having considerable knowledge gaps regarding significance of effects. Prey reduction has the greatest potential to influence population growth rate; however, significant knowledge gaps prevent the ranking of this threat. As the population continues to grow, and increasing numbers of whales are found in B.C. waters, it is anticipated that in future, the influence of identified and unidentified threats will affect abundance and density-dependent effects may become more prevalent. Although the relative risk of some threats are presently identified as unknown or low, it is important to note that many data gaps still exist, and that the level of risk for threats will be re-assessed against population trends and changing conditions in B.C. Therefore, future assessments of Humpback Whales may identify additional threats, or yield differing results and relative risk ratings.

Given that North Pacific Humpback Whales are listed under the SARA as Threatened, monitoring of the population and clarification of knowledge gaps is necessary to determine impacts of threats and support recovery of the population. Additionally, the absence of scientific certainty should not preclude preventive measures for protection of this population.

1.5.2 Description of Threats

Vessel Strike

Individuals and Population - The tendency of Humpback Whales to occupy shelf-break and coastal locations means their use of habitat may frequently coincide with both large and small vessel traffic. Globally, Humpback Whales are second only to fin whales with respect to the number of vessel strikes (Jensen and Silber 2003). In B.C. waters, Humpback Whales are the most common species of cetacean struck by vessels, as reported to the Marine Mammal Response Network. Between 2001 and 2008, there were 21 reports of vessel strikes involving Humpback Whales. Of these, 15 were witnessed collision events while the remaining 6 were of live individuals documented with fresh injuries consistent with recent blunt force trauma or propeller lacerations from a vessel strike (Ford *et al*. 2009).

Overall, vessel strikes can cause injuries ranging from scarring to direct mortality of individual whales. Some stranded Humpback Whales that showed no obvious external trauma, have been shown from necropsy to have internal injuries consistent with vessel strikes (Wiley *et al.* 1995). Evidence of ship-strike mortalities on the U.S. Atlantic Coast was apparent in 30% (6 animals out of 20 examined) of stranded humpbacks (Wiley *et al*. 1995), whereas in Washington State there has been only one record of a stranded sexually-immature Humpback Whale that was deemed possibly ship-struck (Douglas *et al*. 2008). However, a study by Laist *et al.* (2001) found that a high proportion of struck humpbacks appear to be calves or juveniles. It is unknown how many whales have died as a result of vessel strikes in B.C. waters. To date, only one reported dead Humpback Whale presented with evidence consistent with blunt force trauma and lacerations resulting from a vessel strike (DFO unpublished data).

According to Laist *et al*. (2001), vessels traveling at speeds of more than 14 knots (26km/hr) provide the greatest threat of collision with cetaceans. Reported humpback-vessel strike incidents in B.C. waters have mainly involved small vessels (<10m long), typically capable of speeds up to 25-30 knots (46-55 km/hr).

There are no confirmed reports of Humpback Whale collisions in B.C. waters attributed to shipping, cruise ship or ferry traffic. However, larger ships are far less likely to detect the physical impact of a collision than smaller vessels, and this could account for the lack of reported strikes. Collisions with large vessels may be more common than reported, especially in areas where larger vessel traffic is concentrated.

Despite the fact that collisions may only affect a small proportion of the overall Humpback Whale population, vessel strikes may be a cause for concern for some local and seasonal areas of high ship traffic. Laist *et al.* (2001) identified shipping lanes as an area where humpbacks are more likely to be hit. Areas with high occurrences of Humpback Whales (Ford *et al.* 2009, Williams 2008, Sandilands 2008) especially during summer months, accompanied by intense vessel traffic, may be of particular concern. In B.C., areas of high probability of humpback-vessel interaction include Johnstone Strait off northeast Vancouver Island, Juan de Fuca Strait off southwest Vancouver Island, Dixon Entrance and the "Inside Passage" off the northern B.C. mainland (Williams 2008) which include portions of two of the identified critical habitat areas (See Section 2.7 for detail on identified critical habitats).

As the numbers of vessels and whales increase, and as boats get faster and larger, the frequency of collision events is likely to increase. Container and cruise ship traffic through British Columbia ports has increased by over 200% in the past 20 years (Transport Canada 2005) and is expected to continue to rise.

Given that reports of strikes often contain few details regarding impacts to the animal (e.g., focus remains on damage to property), it is difficult to draw conclusions regarding population-level effects from this threat. While impacts to individuals can be severe, current population growth trends for North Pacific Humpback Whales and apparent frequency of vessel strikes in B.C. indicate that vessel strikes are not affecting overall population viability at this time. Continued reporting of strikes and consideration of indirect methods for assessment of vessel strikes are important as a means of addressing knowledge gaps to ensure long-term recovery this population.

Entanglement

Individuals and Population - Entanglement in fishing gear has proven to be a threat to numerous baleen whale species around the world, including Humpback Whales (Volgenau *et al*. 1995, Clapham *et al.* 1999). Entanglements have been documented within the North Pacific Humpback Whale population on both its winter breeding and summer foraging grounds (Mazzuca *et al.* 1998, Neilson *et al.* 2007, Ford *et al.* 2009).

The B.C. Marine Mammal Response Network has 40 reports of entangled Humpback Whales between 1987 and 2008, including four confirmed mortalities (Ford *et al.* 2009). These reports involved entanglements in various types of fishing gear including unknown gear (30%), gillnets (27.5%), traps (22.5%), herring pond (7.5%), aquaculture gear (5%), longline gear (2.5%), seine nets (2.5%) and anchor lines(2.5%) (Ford *et al*. 2009). Three of the entanglement-related mortalities documented in B.C. resulted from interactions with herring pond anchoring systems, and the fourth resulted from entanglement in a gillnet (Ford *et al.* 2009). Similar fishing gear, specifically gillnets and various trap gear, have also posed entanglement risks to the Western Atlantic and southeast Alaska Humpback Whale populations (Johnson *et al.* 2005, Neilson *et al.* 2007). Additionally, the gear types involved in 12 Humpback Whale entanglement reports from 2009 are consistent with those from previous years (L. Spaven 2009, Fisheries and Oceans Canada, pers. comm.).

In some regions, there are estimates that reported entanglements reflect 10% of actual events. These figures suggest that our understanding of entanglement rates may be limited (Robbins and Mattila 2004). Methods to analyze scarring patterns have estimated non-lethal entanglement rates for several humpback stocks. In Southeast Alaska between 2003-04, 52% of photographed humpbacks showed clear evidence of previous entanglement (Neilson *et al*. 2007). Similar analyses on SPLASH data are currently underway and suggest that non-lethal entanglements of humpbacks using northern B.C. are consistent with rates found in Southeast Alaska (J. Robbins, Provincetown Center for Coastal studies; D. Mattila, NOAA, pers. comms. cited in Ford *et al.* 2009). The sample size of photographs from southern B.C. was too small for meaningful results, although data does indicate that animals in southern B.C. show evidence of entanglement wounds.

Gillnet fisheries (salmon, herring roe), crab and prawn trap float lines, groundfish long line fisheries, spawn on kelp, herring bait ponds, aquaculture facilities, and seine fisheries all pose entanglement risks to humpbacks within B.C. These fisheries are present year round on the B.C. coast with the gillnet fisheries concentrated March through October, commercial and recreational prawn fisheries are concentrated in May and June and in the summer months, respectively, (2008a through g, DFO 2010). During these months, the presence of humpbacks along the Pacific coast overlaps with fisheries activities (particularly the salmon gillnet fishery), increasing the probability of humpbacks foraging and navigating around concentrations of fishing boats and gear. Entanglements of Humpback Whales in gillnets have been observed and reported coast-wide by researchers and fishers (G. Ellis 2009, pers. comm.; DFO-CRP unpublished data), and salmon gillnetting may represent the most significant entanglement risk for humpbacks in B.C.

The size and remoteness of the British Columbia coast limits the ability of researchers to determine the extent of entanglements in this region and current data represent a minimum occurrence rate. The continued population growth rate of humpbacks suggests that no population level effects currently result from entanglements. Although mortalities appear limited, neither the long-term survival nor reproductive success of animals that have been released from entanglement are known. Preliminary data from ongoing work by Sandilands (2008) suggests that entanglement risks may be higher in northern B.C. waters, hence increasing likelihood of impacts to northern B.C. feeding aggregations.

Adaptive management and gear modifications present promising mitigation potential. It is anticipated that risk of entanglement will increase as the Humpback Whale population grows and expands its use of B.C. coastal habitats. As with vessel strikes, continued monitoring and increased reporting of incidents are considered important to assessment of this threat to Humpback Whales.

Toxic Spills

Individuals and Population – While toxic spills are not considered an imminent or current threat to the North Pacific Humpback Whale population while they are in B.C. waters, this threat cannot be ruled out. The future development of coastal and offshore areas has the potential to increase this risk in both northern and southern B.C. This may be significant on a finer-scale should distinct regional sub-populations be identified in B.C. Proactive measures to reduce likelihood of spills in key feeding areas, and development of spill response measures (specific for cetaceans) should be considered.

The recent oil platform blowout in the Gulf of Mexico released an estimated 5.2 million barrels of oil (Crone and Tolstoy, 2010) is a poignant reminder of the potential for failure in engineered infrastructure in the marine environment. Even with very low odds and excellent safety records, catastrophic events can lead to undesirable outcomes. Proposed pipeline projects, associated tanker traffic, and possible offshore oil and gas exploration and development in coastal British Columbia all increase the likelihood of toxic spills in Humpback Whale habitat in the future, and underscore the importance of protecting critical habitat and supporting mitigation measures and plans.

In 1989 and 1990, following the *Exxon Valdez* oil spill, Humpback Whales in Prince William Sound were monitored for resulting effects. A change in abundance could not be determined, no change in calving rate was observed, and distribution varied by year, possibly related to changing prey abundance or distribution. Since there were no reports of Humpback Whales directly exposed to the spill (i.e. swimming through oil slicks), or of dead stranded whales (Dahlheim and von Ziegesar 1993), it is difficult to conclude whether Humpback Whales are vulnerable to oil spills or whether there were simply no whales in the vicinity at the time of the spill. However, other cetaceans such as Killer Whales do not appear to avoid toxic spills, and the *Exxon Valdez* oil spill was associated with unprecedented mortality of both Resident and Transient Killer Whales, likely resulting from inhalation of petroleum vapours (Matkin *et al.* 2008).

Toxic spills have occurred impacting marine habitat along the B.C. coast. For example, the Nestucca oil spill (1988) resulted in 875 tonnes of oil spilled in Gray's Harbor, Washington. Oil slicks from this spill drifted into Canadian waters, including Humpback Whale habitat. In 2006, a tanker ruptured in Howe Sound, B.C. spilling approximately 50 tonnes of bunker fuel into coastal waters. In 2007, a barge carrying vehicles and forestry equipment sank near the Robson Bight-Michael Bigg Ecological Reserve within the critical habitat for Northern Resident Killer Whales, spilling an estimated 200 litres of fuel. The barge and equipment (including a 10,000L diesel tank) were recovered without incident. When the Queen of the North sank on March 22, 2006, with 225,000 L of diesel fuel, 15,000 L of light oil, 3,200 L of hydraulic fluid, and 3,200 of stern tube oil, it did so on the tanker route to Kitimat, which is currently the subject of a pipeline and port proposal and within the current boundaries of Humpback Whale critical habitat (see Figure 5, Critical Habitat Gil Island).

Habitat – Increased vessel traffic, increased development of ports and pipelines, as well as spills that occur in Humpback Whale habitat all increase the risk of prey contamination and degradation of the resource. Effects on prey species, either through direct contact with a toxic spill within the habitat, or reduction in overall prey population within the Humpback Whale feeding grounds would decrease prey availability. Herring, an important prey item for Humpback Whales, was heavily impacted during the Exxon Valdez Oil Spills (EVOS), with effects being attributed to morphological deformities, reduced survival in newly-hatched embryos, failure of the 1989 year class, and a long-term failure of the Prince William Sound population to recover (Brown *et al*. 1996; Hose *et al*. 1996; Norcross *et al*. 1996). The physical presence of a toxin within the habitat may also result in disruption of access and avoidance of the area by individuals. Development of ports and pipelines will increase the risk of spills in Pacific waters and specifically in areas where Humpback Whales are known to aggregate. Review of projects and proposals with consideration for Humpback Whale habitat, distribution, and seasonal occurrences will assist in mitigating this potential threat.

Prey Reduction

Individuals and Population - Humpback Whales have numerous feeding strategies, a wide prey base, and require large amounts of prey, but they may also have localized and seasonal prey preferences. See Sections 1.4.2 and 1.4.3 for additional information. Spatial, seasonal and annual variability in Humpback Whale diet composition and biomass consumption rates in B.C. are not well understood.

In addition to changes in oceanographic conditions, which may affect prey availability, there may be specific human activities that could reduce prey abundance. These include fishing (direct harvests), aquaculture (disease, competition), and coastal habitat degradation (loss of prey habitat). DeMaster *et al*. (2001) predict that localized depletion of commercially important fish stocks will have negative effects on marine mammals over the next century, in particular for coastal species. This is of particular significance for humpbacks due to their extremely high site fidelity to local foraging habitats (Rambeau 2008, Baker *et al*. 1986). Background information on legal protection and other management respecting humpback prey resources is provided in Section 1.6 (Actions Already Completed or Underway). Information related to abundance, distribution and catch composition is only available for some important Humpback Whale prey species, but generally not in a context directly related to Humpback Whale ecology. Some background information related to population trends and harvests of important prey species for humpbacks in B.C. waters (euphausiids, herring and sardine) is provided in Appendix E.

Prey reduction due to human activities does not currently appear to limit the population growth or viability of the North Pacific Humpback Whale population. Fluctuations with overall downward trends and unstable regional abundances of prey species due to natural factors or anthropogenic activities could, in future, lead to nutritional stress in this growing population, and potentially alter Humpback Whale distributions. Clarification of flexibilities in terms of prey preference (i.e. localized dependence on prey species, prey 'switching'), and overall caloric needs of humpbacks will assist in determining the level of risk that this threat may pose to humpbacks in B.C. in the future.

Habitat –Anthropogenic events that would impact the density and availability of prey species in foraging areas constitute threats to Humpback Whale habitat. Project proposals in these areas need to be examined as to their impact on prey populations.

Acoustic Disturbance

Individuals and Population - Hearing is the primary sensory system used by cetaceans to communicate, navigate, locate prey, detect and avoid predators. The frequency range of baleen whale vocalizations and estimates of their hearing sensitivity suggest these species have greatest sensitivity to sounds from tens of Hz to about 10 kHz, although Humpback Whales may be able to detect and produce signals with harmonics that extend up to 24 kHz (Au *et al.* 2006; Southall *et al.* 2007).

Depending on the source, underwater noise pollution may be chronic or intermittent in nature. Commercial shipping is the major contributor to chronic underwater noise at low frequencies (5 to 500 Hz). From 1950 and 2000, low frequency noise in the oceans increased 16 dB, corresponding to a doubling of noise power (3 dB) every decade, or a 7% annual increase in noise power (NRC 2003, IWC 2004). Sources of underwater noise that may be intermittent but more intense include sounds produced during seismic surveys, during the use of sonar, military sonar and noise associated with industrial activities (e.g., pile driving, cable laying, drilling).

Airgun arrays used in seismic surveys to map subsurface seabed features produce sounds with pressure levels between 200 to 250 dB re 1 µPa at 1 m from their source. The pulse signals are broadband in frequency but most energy is concentrated in the 10-300 Hz range with some higher frequency components extending to 15 kHz (Hildebrand 2006, Nowacek *et al*. 2007). Military low-frequency active sonar (LFA) produces sounds below 1 kHz, and mid-frequency active sonar produces higher frequency sounds between 1 and 20 kHz. Sound pressure levels of these military sonars range from 180 to 235 dB re 1µPA at 1m (Evans and England 2001; IWC 2004).

Evidence of disturbance and displacement due to underwater noise has been observed in several baleen whale species including Humpback Whales at received sound pressure levels of 160 to 170 dB re 1 µPa and lower. Observed reactions include avoidance of the noise area, interrupting of feeding and moving away from the sound source, rapid swimming away from source, and changes in respiration and dive patterns (Anon 2005; Frankel and Clark 2000; McCauley *et al.* 2000; Richardson *et al.* 1995; Stone and Tasker 2006; Weir 2008). Recent studies of the behavioural response of singing Humpback Whales in Hawaiian waters indicate that individuals exposed to LFA pulses at received levels of 150 dB re 1 µPa responded by increasing the length of their songs, perhaps in response to masking effects of these signals (Miller *et al.* 2000; Fristrup *et al.* 2003).

Globally, cases of lethal effects of high intensity underwater sounds to humpbacks are few. Two Humpback Whales that died following exposure to underwater blasting sounds had inner ear damage consistent with blast exposure (Ketten *et al.* 1993). In 2002, an unusual increase in the number of stranded adult Humpback Whales in an area along the coast of Brazil used by breeding Humpback Whales occurred coincidently with seismic surveys in the area for oil exploration. Although seismic was not a confirmed factor in these strandings, the Brazilian government put in place regulations for seasonal and geographic closures with respect to further marine seismic operations (IWC 2004).

The long-term and cumulative effects of sub-lethal exposures and the linkage between exposures of individuals to potential population level impacts are of increasing concern, particularly as intermittent industrial noise events and chronic ocean noise levels are expected to continue to rise (NRC 2005). The consequences of noise exposure may include masking of communication signals for breeding or socializing (Miller *et al*. 2000; Fristrup *et al*. 2003; Parks and Clark 2007), and interference with prey detection or predator avoidance. These effects may have greater consequences than a short-term behavioural response might suggest. At this time, linking short-term behavioural response (e.g. avoidance, moving away, changes in respiration) by individuals to larger consequences and population impacts is a significant knowledge gap (NRC 2005).

Not only is it difficult to determine the consequences of behavioural reactions to underwater noise, but the absence of a behavioural reaction as an indication of no or low impact may be misleading. Todd *et al*. (1996) found that Humpback Whales exposed to underwater explosions in Trinity Bay Newfoundland, showed no alteration in surface behaviour or distribution, but a coincident increase in the occurrence of Humpback Whale entanglement in fishing nets was observed and the authors speculated that exposure to the explosions may have affected the ability of some humpbacks to orient and navigate. This example also serves to demonstrate the potential synergistic or compounding effects of exposure to multiple threats (noise and entanglement).

Applications for seismic operations in the Pacific Region are reviewed by DFO and mitigation protocols are required. Since 2001, the Province of B.C. has supported lifting the provincial and federal moratoriums on oil and gas exploration (Province of British Columbia, 2004) and the issue is currently in the Government of Canada review process. At present, no decision has been made. A full lifting of the moratorium would likely result in an increase in seismic survey activity in B.C. waters. The Canadian Navy uses active sonar during training exercises and equipment testing in designated marine ranges. However sonar operations may also take place in other waters along the Pacific Coast. Canadian marine ranges are also used by other navies to test equipment and train personnel. To mitigate potential impacts of sonar use, DND ship personnel receive training in marine mammal identification and detection. Mitigation protocols for military sonar use, seismic operations and impact assessments for some underwater industrial activities attempt to avoid exposing animals to intense sound by reducing or ceasing sound transmission when marine mammals are observed within specified ranges of the sound source. See Actions Already Completed or Underway (Section 1.6) for details on sonar mitigation protocols.

Given the current estimated population growth rate of humpbacks in B.C., present levels of activities producing underwater noise in the region do not appear to be negatively affecting population viability at this time. The potential future effects of acoustic disturbances may be greater when considered coincidently with other threats, and as the occurrence and frequency of underwater noise activities are anticipated to increase in B.C., future level of risk to individuals and the population may need to be reassessed. Further studies on the behavioural and displacement effects of noise on Humpback Whales are recommended.

Habitat – Increased acoustic disturbance in Humpback Whale habitat, especially in narrow channels and fjords, may reduce the likelihood of the animal entering the area and utilizing the resource due to sound propagation. Strong avoidance reactions to underwater noise by Grey, Humpback and Bowhead Whales has been observed at received levels of 160-170 dB re 1 µPa (Richardson *et al*. 1995; Frankel and Clark 2000; McCauley *et al*. 2000; Stone and Tasker 2006). The level of noise from a tanker may be as high as 190 dB re 1 µPa, and bathymetric features that reduce sound dissipation would further increase the level of disturbance. For this reason, fjords or channels may be particularly sensitive to noise propagation from vessel traffic. The disruption of access to these areas would limit or reduce foraging opportunities or alter behaviours that support other life processes, such as resting, socializing, and vocal interaction. Humpback Whales exhibit strong site fidelity for feeding along the B.C. coast (DFO 2009; Ford *et al.* 2009) and increased acoustic disturbance in these areas may be detrimental to the quality and accessibility of the feeding grounds.

Cumulative Effects

At present, none of the identified threats are likely affecting population viability. Some threats are known to have specific effects on individuals, and the potential for cumulative effects should not be overlooked. Not enough is known about prevalence and severity of many of these threats to draw conclusions surrounding level of risk to this population, and assessing current information against the calculated *PBR* for the B.C. population (21 animals, Ford *et al*. 2009) is not possible at this time given data constraints.

1.6 Actions Already Completed or Underway

The conservation of Humpback Whales in the North Pacific has been ongoing since the 1960s and extensive international effort has been undertaken to protect and recover this population. The information provided below represents some examples of recent efforts relevant for the North Pacific population.

Legal Protection

In Canada, Humpback Whales are managed by DFO and legally protected through the Marine Mammal Regulations under the *Fisheries Act*, 1985. These regulations make it an offence to disturb, kill, fish for, move, tag, or mark marine (ss. 5, 7, 11) without a valid licence. Since 2005, humpbacks have been protected under the federal *Species at Risk Act* (2002) which makes it an offence to kill, harm, harass, capture or take a listed species (Section 32(1)).

In the United States, Humpback Whales are legally protected and managed under a variety of legislation, including the *Marine Mammal Protection Act*, the *Endangered Species Act*, and the *Marine Protection, Research and Sanctuaries Act* of 1974, which protects whales present in designated sanctuary areas (such as the Hawaiian Islands Humpback Whale National Marine Sanctuary, and Olympic Coast National Marine Sanctuary). Since 1998, whale watching in Mexico has been legally regulated under the *Norma Oficial Mexicana NOM-131-SEMARNAT-1998* which sets out guidance for behaviour around whales.

Existing legal protection for Humpback Whales also includes two international conventions. The International Convention for the Regulation of Whaling 1946 (IWC) banned commercial hunting of Humpback Whales in the North Pacific in 1965. However, Canada has not been a member of the IWC since 1982. The Humpback Whale is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Species (which includes their parts and derivatives) included in Appendix I are those which are "threatened with extinction which are or may be affected by trade." As a result of its inclusion in Appendix I of CITES, commercial trade of Humpback Whales, their parts, and derivatives is banned among all countries that are parties to CITES. Canada is a party to the CITES Convention.

Research

DFO, along with many collaborators and contributors, has been collecting photo-identifications of Humpback Whales in B.C. since 1984. This has resulted in a catalogue of nearly 2,000 unique whales. Photo-identification studies can be used to assess population size, trends, and distribution. During the summers of 2004 and 2005, photographs and biopsies from DFO were collected and analysed as part of the international SPLASH project. The development of the DFO Recovery Potential Assessment filled in some of the knowledge gaps concerning possible pre-industrial whaling abundance of humpbacks in B.C., population size, potential biological removal, and trends for the Canadian Pacific population of Humpback Whales (Ford *et al.* 2009). A DFO Research Document analyzed information on critical habitat for humpbacks in B.C. (Nichol *et al.* 2009), and formed the basis for peer-reviewed science advice relevant for the identification of critical habitat in this Recovery Strategy (DFO 2009).

Current research efforts on North Pacific Humpback Whales in B.C. include spatial modelling of the risks of entanglement (in marine debris and in fishing gear) and ship-strikes for several cetacean species (Sandilands 2008, Williams and O'Hara 2010). Organizations such as the Gitga'at Lands and Resources Stewardship Society, and CetaceaLab have field programs collecting both acoustic and visual data to clarify local abundances and distribution of humpbacks on B.C.'s North Coast. OrcaLab collects acoustic data on cetacean species frequenting the Johnstone Strait. Sightings information on cetaceans is collected by the B.C. Cetacean Sightings Network, a collaboration of the Vancouver Aquarium Marine Science Centre and DFO (B.C. CSN). Information on incidents, such as vessel strikes, entanglements, strandings, as well as injured or dead marine mammals is collected in B.C. by the Marine Mammal Response Network (MMRN), coordinated through DFO's Cetacean Research Program.

Aboriginal Traditional Knowledge

Projects to collect preliminary data on aboriginal traditional knowledge for the North Coast are underway (e.g. Heiltsuk Fisheries Program, Gitga'at Fisheries Program) and information may become available to DFO for future recovery planning for Humpback Whales and other marine mammal species found in B.C.

Additionally, a request for technical and/or traditional knowledge on Humpback Whales to include in this recovery strategy was sent to all coastal First Nations groups at the start of developing this document (Spring 2008). See Appendix F for further details.

Management

There are several existing measures to mitigate acute underwater noise stress on marine mammals. The DFO *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment* (DFO 2007) outlines minimum measures to reduce potential impacts of seismic sounds on marine life, including on Humpback Whales.

The Canadian Department of National Defence (DND) 'Maritime command order 46-13: marine mammal mitigation procedures' (DND 2007) aims to avoid transmission of sonar any time a marine mammal is observed within the defined mitigation avoidance zone specific to each type of sonar. However, an evaluation of the effectiveness of the Maritime Command Order, particularly the ability of observers to detect marine mammals in the zone of influence, has not been completed to date. These zones are determined using the interim National Marine Fisheries Service (NMFS) thresholds for potential behavioural disturbance (160 dB) and physical injury (180 dB) (D. Freeman, DND, personnel communication 2007). Concerns remain that some impacts may occur beyond the visible horizon, and these will be difficult or impossible to observe or mitigate. Canadian test ranges are also used by other navies to test equipment and train personnel. They follow Canadian procedures for use of these ranges, which includes marine mammal impact assessment and mitigation (D. Freeman, DND, personal communication 2005). When conducting joint exercises in Canadian waters, other navies are provided direction (including sonar mitigation protocols), prior to and during exercises.

To mitigate physical and acoustic disturbance effects DFO, in collaboration with many other organizations, including the U.S. National Ocean and Atmospheric Administration – National Marine Fisheries Service and Pacific Whale Watch Association, has developed the trans-boundary '*Be Whale Wise: Marine Wildlife Guidelines for Boaters, Paddlers and Viewers*' (http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/mammals-mammiferes/view-observer-eng.htm). These guidelines are being used province-wide as best practices for all marine mammal viewing situations. In Washington State, these guidelines have recently become a regulation under state law.

Other efforts to date also include raising awareness of whale distribution, encouraging reporting of collision events to help inform vessel traffic management policies and mitigation efforts. It is currently unknown to what degree these measures have reduced the number of Humpback Whale-vessel interactions in B.C., and continued data collection and analysis is needed.

In B.C. waters, the management of fisheries targeting Humpback Whale prey species is guided by Integrated Fishery Management Plans (IFMPs) and fishery enforcement is largely directed by the Canadian *Fisheries Act* and its related statutes. The implementation of the DFO Policy on New Fisheries for Forage Species (http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/forage-eng.htm) may assist in the management of fisheries targeting potential humpback prey species. The policy objectives focus on conservation-based fisheries management considering ecological relationships, such as predator-prey dynamics, in the management of fisheries on forage species.

Recovery Planning

The DFO Technical Team for North Pacific Humpback Whales was established in April 2008 to develop a recovery strategy for the population. The Team is comprised of representatives from Parks Canada Agency and Fisheries and Oceans Canada, and meets regularly to discuss recovery planning, research needs and management for North Pacific Humpback Whales. A workshop was held in January 2009 to solicit expertise to assist in recovery planning for the North Pacific population, participants included representatives from the international scientific community, First Nations, Parks Canada Agency, U.S. National Oceanic and Atmospheric Administration and Hawaiian Islands Humpback Whale Sanctuary (see Appendix F for additional details).

In 1991, the U.S. National Oceanic and Atmospheric Administration published a recovery plan for both North Atlantic and North Pacific humpbacks outlining threats and recovery actions (NMFS, 1991).

1.7 Knowledge Gaps

Humpback Whales have been the focus of substantial research efforts throughout the world. However, there is still a need for more detailed analyses concerning local populations, in particular the Canadian Pacific population.

Population Structure
Currently, there remains some uncertainty regarding the structure of the humpback population in B.C. Further genetic analyses supported by photo-identification surveys will clarify whether distinct sub-populations exist within Canadian Pacific waters and will assist with the development of appropriate management measures.

Diet and Foraging Requirements
In future, diet is likely to be the primary factor limiting population growth for humpbacks in B.C. Addressing knowledge gaps regarding diet composition, localized prey preferences, prey 'switching' and foraging requirements (i.e., caloric needs) is necessary. Influences from both anthropogenic and natural factors have potential to impact the population growth rate and a more detailed understanding of diet and foraging requirements will support assessment of the likelihood of competition between humpbacks and local fisheries for prey resources, and in development of appropriate mitigation measures for other threats to prey availability in B.C.

Threats and Cumulative Effects
The effects from human activities such as production of underwater noise, vessel strikes and entanglements on a population level are poorly understood and continued reporting, monitoring and response to these types of incidents will assist in clarifying the extent of anthropogenic mortality rates against the calculated *PBR*. Robbins and Mattila (2004) provide estimates that reported entanglements may account for only 10% of actual events. Continued efforts to analyze scarring patterns for northern B.C. whales will provide additional information to determine the extent of this threat. Efforts to model spatial risk for entanglement and vessel strike may assist in identifying potential problem areas and assist in developing protection measures for the identified critical habitat. At this time, linking short-term behaviour responses of individuals to

underwater noise disturbance to larger population level consequences is a significant knowledge gap.

Critical Habitat
Clarification of habitat requirements, seasonal use, migratory corridors, and biophysical characteristics of habitat will aid in further identification of critical habitat, and contribute information to determine important biophysical features of critical habitat. See Section 2.7 Critical Habitat and the Schedule of Studies (Table 4) for further information.

2. RECOVERY

2.1 Recovery Goal

The short-term goal of this recovery strategy is to:

"Maintain at minimum, the current abundance of humpbacks[1] in British Columbia"

The long-term goal of this recovery strategy is:

"To observe continued growth of the population and expansion into suitable habitats throughout British Columbia"

2.2 Recovery Feasibility

Recovery of the B.C. Humpback Whale population is feasible, given its strong population growth rate, the absence of any apparent population-level effects of known threats, and that its habitat does not appear to be limiting (Ford *et al*. 2009). Furthermore, the North Pacific population of Humpback Whales has been growing since whaling ended in the 1960s and this is also true for the component of this population that occurs in B.C. waters (Calambokidis *et al.* 2008, Ford *et al*. 2009). The overall North Pacific population has exhibited considerable reproductive capacity, with an estimated annual rate of increase ranging from 4.9 to 6.8% (Calambokidis *et al.* 2008). In B.C., habitat use in coastal waters is associated with prey availability, and regional changes in prey abundance and/or distribution could contribute to a decline in habitat suitability. It is unclear whether the population is nearing carrying capacity in B.C. waters. Measures currently exist to mitigate several threats; however, the efficacy of some techniques has not been determined to date.

The determination of recovery feasibility for North Pacific Humpback Whales is consistent with the criteria outlined in the draft 'Policy on the Feasibility of Recovery' (Government of Canada, 2005).

[1] Using best estimate of 2,145 animals (95% confidence limits 1,970 - 2,331) as presented in Ford *et al.* 2009

2.3 Population and Distribution Objective

As per SARA Section 41(1)(d), the following population and distribution objective that will assist the recovery and survival of the species has been identified:

> Maintain the distribution of humpbacks along the B.C. coast and the abundance of humpbacks in B.C. at or above the current best estimate of 2,145 (CI 95% 1,970 – 2,331) by measures that support forage habitat access and use, and by undertaking measures to reduce mortality rates.

2.4 Broad Strategies and Approaches to Recovery

The approach to recovery will focus on two main activities: 1) conduct research to further understand life processes and distribution of Humpback Whales; and 2) gather data on the scope of identified threats to Humpback Whales to assist in mitigation. Addressing questions related to these objectives will guide adaptive management measures.

1. Resolve uncertainties regarding north and south B.C. sub-populations delineations (e.g. geographic distributions, migratory behaviour, and genetics).

2. Improve understanding of anthropogenic mortality rates to assess whether the calculated potential biological removal of 21 animals per annum (Ford *et al.* 2009) is exceeded for the humpback population in B.C.

3. Improve understanding of diet, particularly versatility in prey consumption within and between regions.

4. Improve understanding of the scope of influences from human activities, mainly related to: prey reduction and competition from fisheries, entanglement, vessel traffic, and disturbance; and clarify uncertainty regarding potential effects on recovery, habitat and individuals.

5. Develop appropriate mitigation measures to address entanglement, vessel traffic, disturbance and potential prey limitation in B.C.

2.5 Recovery Planning

A wide variety of approaches are required to meet the objectives of this recovery strategy. Monitoring identified threats and population abundance is the primary focus of this strategy. Stewardship, research, outreach and legal protection and management measures are also beneficial to supporting recovery. Many approaches listed have several avenues, techniques or methods to assist recovery of Humpback Whales. In some cases specific detailed methods are not listed in order to allow for maximum use of all available methods and techniques to conduct each general approach, and to meet the population and distribution objectives of this strategy. Studies addressing habitat and diet of humpbacks while in B.C. are captured in Table 4 Schedule of Studies to identify Critical Habitat.

Meeting population and distribution objectives will require the involvement of many individuals and organizations in implementing the various approaches listed in Table 2, including Non-Governmental Organizations (NGOs), First Nations, academic institutions, as well as other government agencies. Fisheries and Oceans Canada and the Parks Canada Agency encourage other agencies and organizations to participate in the conservation of North Pacific Humpback Whales through implementation of this recovery strategy. Implementation will be subject to DFO's capacity, availability of funding and other required resources. Where appropriate, partnerships with specific organizations and sectors will be necessary to provide the expertise and capacity to carry out activities.

Table 2. Recovery Planning Table

Priority	Obj. No.	Threats addressed	Recommended approaches to meet the population and distribution objective
Broad Strategy: Threat Monitoring			
Necessary	2, 4, 5,	All five	• Assess mortality rates due to these threats and consider cumulative effects • Contribute to and collaborate on, global threat assessments for humpbacks (e.g. vessel strike, entanglement) • Model spatial and temporal risk for threats
Necessary	4, 5	Prey Limitation	• Analyze catch reporting data for fisheries on known prey species, in the context of potential impacts on prey availability for humpbacks in B.C.
Broad Strategy: Management			
Necessary	2, 4, 5	All five	• Continue to support and promote the Marine Mammal Incident Response Program and associated network of responders
Necessary	2, 4, 5	Entanglement	• Mandatory reporting of entangled marine mammals in fishing and aquaculture gear
Necessary	5	Entanglement	• Determine fisheries management mitigation measures (e.g. of fishing and gear-types)
Beneficial	5	Acoustic Disturbance	• Fisheries and Oceans Canada to continue to review project proposals with potential to impact humpbacks in B.C. Provide advice for mitigation or avoidance with respect to habitat needs and direct impacts to individuals.
Beneficial	5	All five	• As new information becomes available, consider separate management options for northern and southern regional feeding aggregations within B.C.
Beneficial	5	Vessel Traffic	• Determine appropriate measures for shipping corridors within the identified critical habitat
Beneficial	CH	All five	• Contribute data on Humpback Whale occurrence for inclusion into Parks Canada Agency Marxan analysis for the proposed Gwaii Haanas National Marine Conservation Area (NMCA) to support management of the identified critical habitat
Beneficial	5	Prey Limitation	• Implement DFO's Policy on New Fisheries for Forage Species
Broad Strategy: Research			
Beneficial	n/a	n/a	• Determine whether available genetics data can contribute to additional clarification of pre-industrial whaling abundance in B.C.
Broad Strategy: Monitoring and Inventory			
Beneficial	1	All	• Continue supporting sightings network(s), and management of sightings data for Humpback Whales
Beneficial	4	All	• Continue outreach and communications to promote submission of sightings data by mariners to the B.C. Cetacean Sightings Network
Broad Strategy: Legal Protection & Enforcement			
Beneficial	5	All	• Continue to enforce protection measures for marine mammals in the existing *Fisheries Act*, Marine Mammal Regulations • Complete amendments to *Fisheries Act*, Marine Mammal Regulations and implement the amended regulations

2.6 Performance Measures

In the short term, analyses indicating B.C. Humpback Whale abundance is sustained over a period of five years, within or above the Ford *et al*. (2009) best estimate's 95% confidence interval (1,970-2,331 animals), will indicate that the population objective is met. Continued widespread usage of coastal B.C. waters by humpbacks will indicate maintenance of distribution.

In the longer-term, abundance estimates indicating a continued increasing trend in numbers of humpbacks using B.C. waters (compared to the Ford *et al.* 2009 estimate) at B.C. feeding grounds will provide an indication of continued recovery of the local population and progress towards achieving the goal. Additionally, analyses indicating new locations of persistent seasonal Humpback Whale aggregations will indicate expansion into suitable habitats.

Studies to clarify current population structure and historic abundance of humpbacks in B.C., as well as the potential for prey limitation, and scope of human-induced threats are important components necessary to assess future impacts to population growth and recovery. It is unlikely that information gaps can be completely addressed before action planning. However, studies will contribute to an improved understanding of anthropogenic and ecological processes affecting Humpback Whales in B.C.

2.7 Critical Habitat

2.7.1 General identification of Humpback Whale Critical Habitat

SARA defines habitat for aquatic species at risk as:

> *"… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced."* [s. 2(1)]

Under SARA S. 2(1), critical habitat is defined as *"the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or action plan for the species."*

For the North Pacific Humpback Whale, critical habitat is identified to the extent possible, using the best information currently available. The critical habitat identified in this recovery strategy describes the geographical area within which the habitat necessary for the survival or recovery of the species is found. The current area identified may be insufficient to achieve the population and distribution objectives for the species and will need to be further refined in terms of its biophysical functions/features/attributes and/or its spatial extent. The schedule of studies outlines the activities required to refine the description of critical habitat to further support its protection.

2.7.2 Information and methods used to identify Critical Habitat

The geographic locations and biophysical functions, features and attributes of the critical habitat were identified using the best available information, including the Recovery Potential Assessment (Ford *et al*. 2009), which identified several areas of potentially important habitat for humpbacks in B.C. To confirm the long-term usage and relative importance of these areas for humpbacks, a more detailed analysis on available data was completed (Nichol *et al.* 2009) and provided advice relevant to the identification of SARA critical habitat in this Recovery Strategy (DFO 2009).

Use of coastal and offshore habitats along the B.C. coast, is both for foraging and for migrating to higher latitude feeding areas. While Humpback Whales do not appear to be habitat-limited, they do appear to preferentially use certain inlets and bays along the B.C. coast (Ford *et al.* 2009). Humpbacks have been observed foraging close to shore in areas which exhibit steep bathymetry and shorelines (DFO-CRP unpublished data). Predictable, persistent hot spots of Humpback Whale aggregations are found off Langara Island, southeast Moresby Island, Gil Island and southwest Vancouver Island (Figures 3 and 4). Based on the best available information, these four areas are identified as critical habitat under SARA and are depicted in Figure 4. In areas adjacent to the shore, critical habitat boundaries extend to the low tide mark.

As local areas of occupancy in B.C. are largely dependent on oceanographic processes contributing to seasonal abundances and distribution of prey, other undiscovered areas of critical habitat for Humpback Whales in B.C. may exist. Temporal variation and behavioural changes (e.g. prey switching) may result in shifts in the pattern of distribution; therefore, monitoring of current areas, as well as identification of new possible critical habitat will be an ongoing process.

The significance of the Langara and Southeast Moresby critical habitat areas is highlighted by the fact that over 50% of all whales photo-identified in B.C. have been encountered in these two areas. Sighting rates from DFO line transect surveys (tracks shown on Figure 2) indicated that Southeast Moresby had a significantly higher springtime sighting rate than all areas of the coast. A lower proportion of the photo-identified animals have been encountered in the southwest Vancouver Island area. Over the past two decades, the southwest portion of this area was included in a U.S.-led line-transect and small boat photo-identification survey of waters off Washington (Calambokidis *et al.* 2004). Based on their data from ship surveys (1995-2002) and small boat surveys (1989-2002), consistent small-scale concentrations of Humpback Whales were recorded near the mouth of Barkley Canyon and over Swiftsure Bank. Approximately 44% of photo-identified animals were re-sighted in their study area in more than one year. Taking into account both the DFO and Calambokidis *et al* (2004) data, this area meets the requirements for designation as critical habitat. Growing evidence of distinct sub-populations of humpbacks increases the relative importance of this area, as it represents the only area for Humpback Whales that may occupy southern B.C. and northern Washington waters.

Humpback Whales frequent the Gil Island critical habitat area predominantly in the late summer and fall. Sighting data indicate that the fjords located within this critical habitat area appear to be utilized more than other mainland inlets, and whaling records suggest this area may have historical relevance (DFO 2009).

Taking all four of these areas together, almost three-quarters of the Humpback Whales photo-identified in B.C. (from 1984-2007) have been encountered in these areas (Figure 4; Ford *et al* 2009; DFO 2009). Low rates of inter-matches among the four critical habitat areas suggests that each area supports different parts of the population and underlines the high degree of site fidelity to feeding grounds exhibited by this species. It also suggests that factors influencing the habitat in these areas would affect different parts of the North Pacific Humpback Whale population.

While all four areas show some seasonality with respect to increased usage by humpbacks, the available data indicate humpbacks are present in all four critical habitat areas throughout all seasons (DFO 2010) and thus, critical habitat is a year-round designation.

2.7.3 Geographic Area of Critical Habitat

North Pacific Humpback Whale critical habitat is comprised of four distinct geographic areas; the locations of critical habitat are shown in Figure 4. Critical habitat consists of all of the area within the identified geographic boundaries, and includes the biophysical features and attributes that are necessary for the species to carry out specific functions associated with its life processes.

The four identified critical habitat areas have particularly high and persistent seasonal abundance of whales. The boundaries to delineate these areas were drawn to include the majority of sightings in areas used habitually over many years. Finer scale delineation of boundaries is not feasible at this time given spatial resolution of current information; therefore, all boundary lines include buffers around highest density of sightings in order to ensure that management measures adequately protect critical foraging grounds and the associated humpback behaviour required for successful foraging (Figure 5).

Based on recommendations of the North Pacific Humpback Whale recovery team, the Minister of Fisheries and Oceans has concluded that these are the areas considered necessary for the species' survival and recovery. All four areas presented meet the definition of critical habitat under Canada's *Species at Risk Act*, and constitute a portion of the total critical habitat for humpbacks in B.C. In addition to these four areas, recent DFO survey data (unpublished) suggests that north Hecate Strait and east Dixon Entrance are potential areas of critical habitat. However, further research is needed to clarify their seasonal importance with respect to potential SARA critical habitat designation.

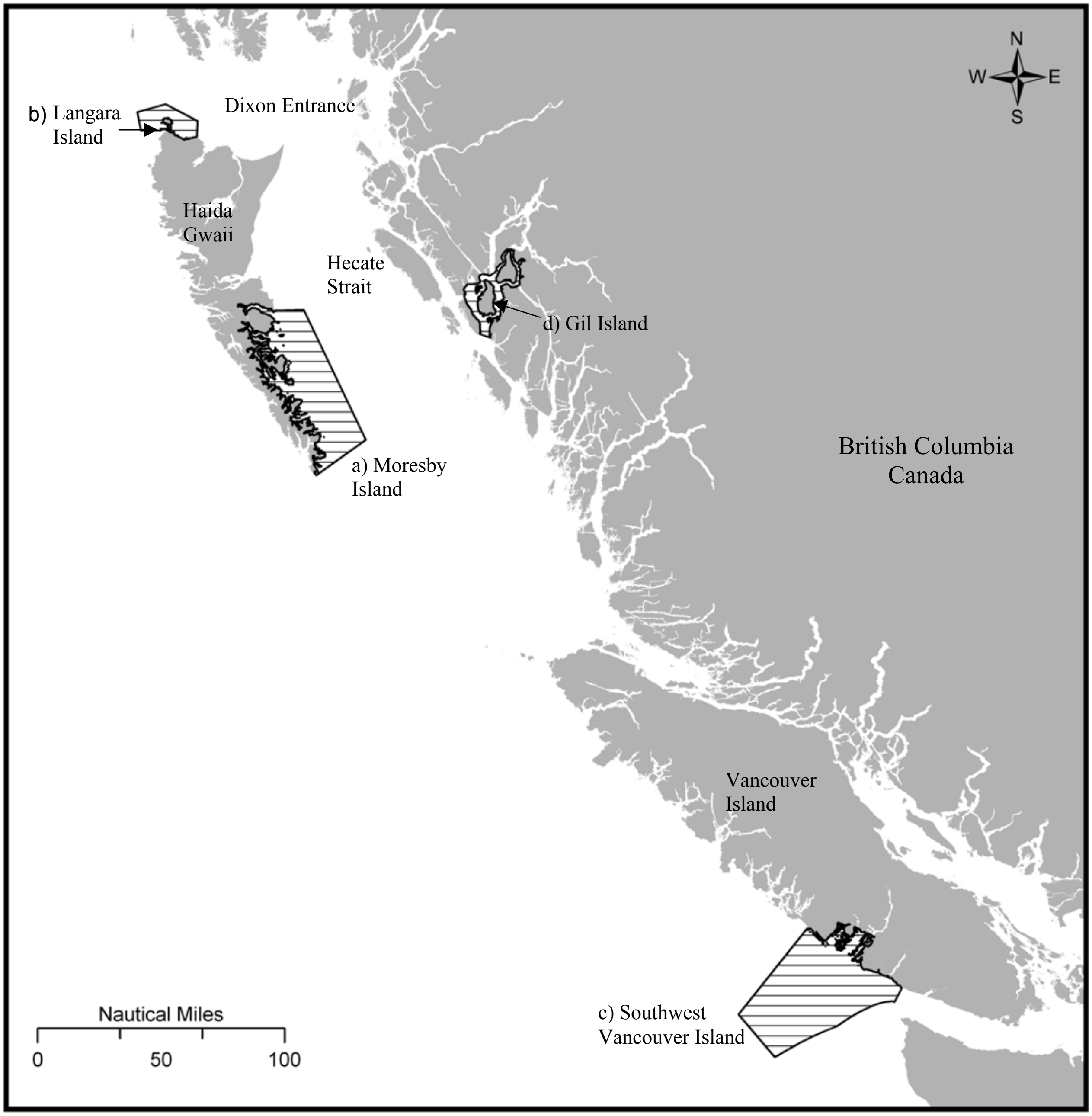

Figure 4. Locations of the four critical habitat areas a. Southeast Moresby Island, b. Langara Island, c. Southwest Vancouver Island, d. Gil Island (DFO 2009). The existence of other areas of critical habitat for Humpback Whales in B.C. is likely.

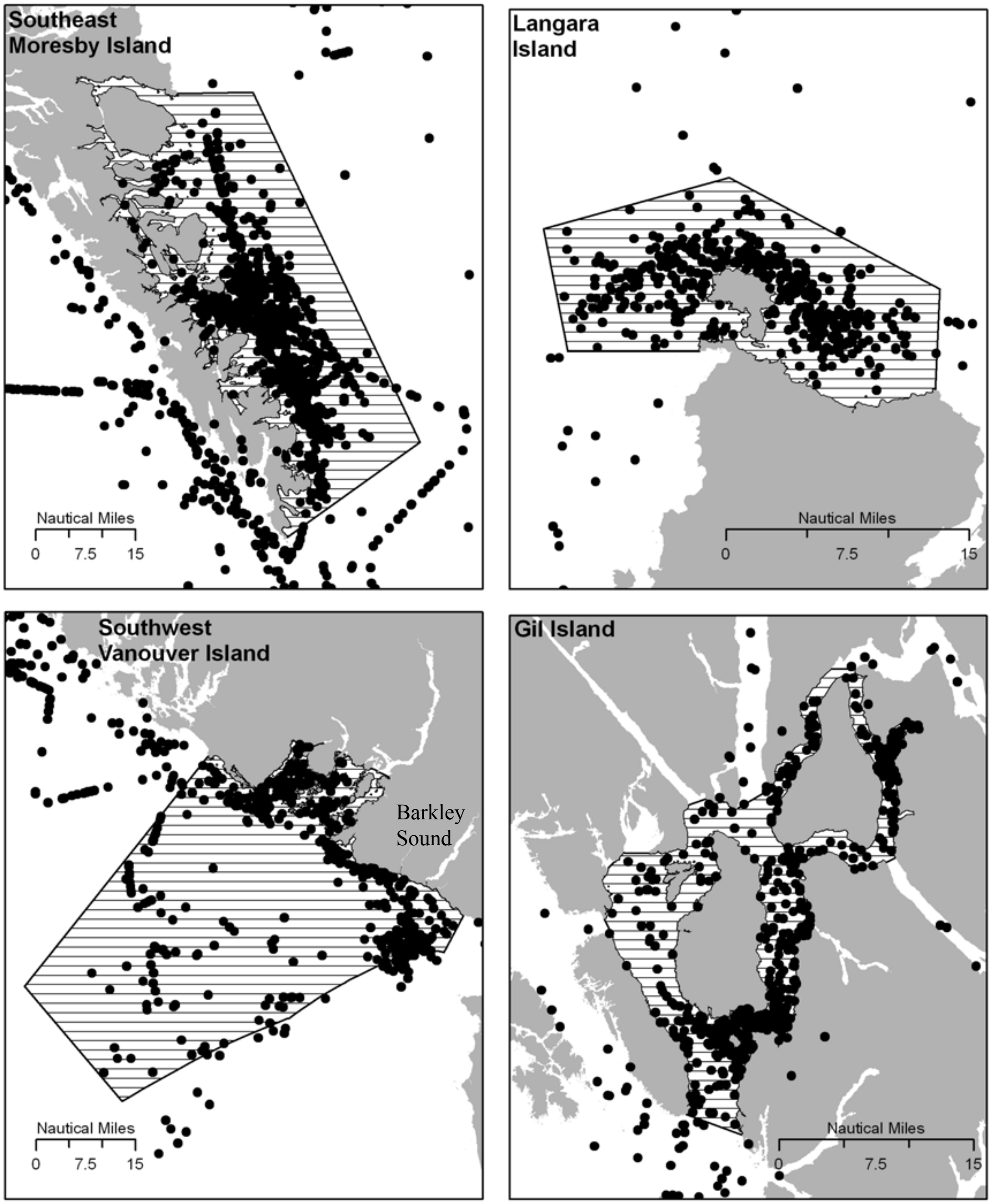

Figure 5. Each of the four critical habitat areas showing distribution of sightings from line transect surveys and photo-identifications in relation to area boundaries (DFO 2009).

2.7.4 Biophysical Functions, Features and Attributes of Critical Habitat

The majority of British Columbia's Humpback Whale population migrate long distances from their southern tropical wintering grounds to the waters off the Pacific coast of Canada and the US. These high latitude locations serve primarily as feeding grounds, where animals replenish their depleted blubber reserves after an energy-intensive breeding and calving season. However, in some high-latitude feeding areas, humpbacks remain well into the breeding season, leading to individual variation in timing of the migration and the presence of individuals in Canadian waters during all months of the year. In addition, there is some evidence that juveniles may remain in mid-latitude areas after the adults have left for the breeding grounds. Within the geographical boundaries identified in Section 2.7.3, the identified areas of critical habitat support **feeding and foraging** behaviour of Humpback Whales, and play an important role in providing resources necessary for the survival and recovery of the species.

In addition to feeding and foraging behaviour, critical habitat also provides an opportunity for **resting and socializing**. When not actively engaged in feeding, Humpback Whales require an environment that is free from disturbance in order to rest and conserve energy for metabolically costly processes. The identified areas of critical habitat provide the resources necessary to undertake these important functions and support the survival and recovery of the species.

2.7.4.1 Features that support Feeding and Foraging

Humpback Whales enter temperate and polar waters to engage in feeding and foraging behaviour, and four key features that support and facilitate this function have been identified. A primary feature within critical habitat is the availability of **prey**. Identified attributes that define this feature are a sufficient quantity of suitable prey species. Current estimates indicate that the concentration of zooplankton required to support Humpback Whale foraging is > 50 euphausiids/m^3 (Dolphin 1987b). No estimates have been published on the required stock levels of sardine, herring, or sand lance that are required to supplement Humpback Whale dietary needs. Further research is needed to define prey requirements for this species, and studies addressing this knowledge gap are identified in the Schedule of Studies (Section 2.7.5).

Other features that support feeding and foraging include an **acoustic environment** that is conducive to the successful detection and capture of prey species. Predation on schooling fish may involve bubble net feeding, a cooperative behaviour that is dependent on vocal communication between whales.

An unimpeded **physical space** is considered to be a vital feature of critical habitat. Humpback Whales require a minimum of 100m of unimpeded space around them to undertake actions related in support of life processes. In order to provide an unimpeded path for movement, this limit is extended to 400m along the direct path of travel (both the leading and trailing edge).

The **water and air** within the critical habitat must be of sufficient quality so as not to cause adverse health effects. As a significant proportion of the population utilizes the designated areas of critical habitat, degradation of the quality of water and/or air in critical habitat has the potential to cause population-level effects.

2.7.4.2 Features that support Resting and Socializing

When not actively engaged in feeding and foraging events, Humpback Whales also require habitat that provides a suitable environment for resting and socializing. As Humpback Whales fast during the winter breeding season and along the migratory route to the feeding grounds, a successful foraging season is required in order to replenish depleted fat reserves and prepare for the migration back to the breeding grounds. An environment that is free from disturbance is required in order to rest, socialize and conserve energy for metabolically costly processes. To support these important behaviours and fulfill this required function, the necessary features and associated attributes are identified as **physical space**, **water and air**, and **acoustic environment**. As social interactions between Humpback Whales involve a significant amount of vocalization, acoustic disturbance may lead to masking of these signals, interfere with predator detection and avoidance, and disrupt important social behaviours.

Table 3. Functions, Features, and Attributes of Humpback Whale Critical Habitat

FUNCTION	FEATURE	ATTRIBUTE
Feeding and foraging	Prey	Sand lance levels TBD (SoS) Sardine stock levels TBD (SoS) Herring stock levels TBD (SoS) Zooplankton biomass > 50 euphausiids/m^3
Feeding and foraging Resting and socializing	Acoustic environment	Received chronic sound levels TBD (SoS) Received levels of acute acoustic noise below 160 dB re 1 μPa
Feeding and foraging Resting and socializing	Physical space	A 100m radius of unimpeded physical space around a whale A 400m area of unimpeded physical space in the path of a traveling whale
Feeding and foraging Resting and socializing	Water and Air	Water and air quality of a sufficient level so as not to cause adverse health effects (SoS)

TBD – to be determined
SoS – Schedule of Studies

2.7.5 Schedule of Studies to Identify Critical Habitat

Studies on ecological processes and cetacean biology require continuous and long-term research programs to elucidate trends. The following studies will assist in further describing the features of identified critical habitat, and to identify other areas of critical habitat for Humpback Whales in B.C. It is likely that research after 2016 will be required to provide additional information on critical habitat.

Table 4. Schedule of Studies to assist in Identification of Critical Habitat for North Pacific Humpback Whales in British Columbia

Description of Activity	Outcome/Rationale	Timeline
Cetacean surveys to monitor and clarify seasonal presence and distribution Passive acoustic monitoring to support determination of seasonal presence Seasonal habitat surveys to clarify critical habitat features	• Abundance and distribution in B.C. monitored to assess usage of identified critical habitats in B.C.; identify other areas of critical habitat in B.C. waters • Trends in occurrence of local feeding aggregations analysed • Data on biophysical characteristics of habitat with respect to Humpback Whale habitat use collected to assist in understanding habitat utilization in B.C. and important features of critical habitat	Seasonal, Ongoing 2011-2016[1]
Visual surveys to identify potential additional critical habitat in B.C. with complementary acoustic monitoring	• Clarification of importance of north Hecate Strait, east Dixon Entrance, and other areas with respect to potential identification as critical habitat in B.C.	2011-2016
Studies on foraging requirements of humpbacks in B.C.	• Identification of uncertainties and specific requirements of the population with respect to the prey feature of critical habitat • Results will also support development of relevant protection measures for this identified critical habitat feature	2011-2016
Genetic studies to clarify population structure within B.C.	• Determination of population structure will identify whether additional critical habitat must be considered to support recovery and survival of two distinct population sub-units • Clarification of distinct sub-populations, or regional feeding aggregations in B.C. will support relevant management of the four identified critical habitat areas	2011-2016
Research on levels of acute and chronic acoustic disturbance	• To provide guidance on the acoustic thresholds for disturbance of humpbacks	2011-2016
Identify pollutants of concern in critical habitat and investigate potential affects on humpbacks	• To provide guidance on the pollutant thresholds that result in harm to Humpback Whales	2011-2016

[1] Studies will likely be ongoing after 2016

2.8 Examples of Activities likely to result in Destruction of Critical Habitat

Concerns regarding detrimental impacts to the identified critical habitat stem from the likelihood of occurrence as well as the likelihood to destroy either a feature or attribute of the identified critical habitat such that it cannot serve the identified functions of feeding, foraging, resting, and socializing.

Intensive vessel traffic or increased vessel density has the potential to impact whales' ability to successfully navigate and forage within the designated critical habitat areas. Watercraft or vessels that approach an animal within the 100m radius (or within 400m in the path of a traveling whale) degrade the physical space by impeding the animal's ability to effectively undertake its life processes. It is recognised that whales may alter course and place themselves in closer proximity to a vessel; therefore, for the purposes of this recovery strategy, approach is defined as a deliberate movement undertaken with the intent to place a vessel in closer proximity to a whale; or to deliberately place a vessel in the path of a traveling whale.

An increase in commercial vessel traffic and/or a higher proportion of vessels carrying potentially toxic cargo would also elevate the risk of toxic spills, potentially contaminating air, water, and prey species present at the time of a spill. In addition, chronic underwater noise is on the increase. Commercial shipping is a major contributor to low frequency chronic underwater noise, and the effects of this disturbance on Humpback Whales are currently unknown. Sonar and seismic surveying, if inadequately mitigated, may lead to habitat degradation or destruction by way of reduced foraging success (i.e. affecting communication or prey detection) or direct displacement of animals from the four critical habitat areas. Significant levels of acoustic disturbance may interfere with vocal communications and result in decreased foraging success. Large scale projects involving pile driving, seismic surveying, and sonar noise within or in the vicinity of critical habitat may also have a potential impact on the ability of the species to access sufficient quantities of prey that are associated with the habitat. Humpback Whales have demonstrated avoidance behaviour in response to sound pressure levels of 160 – 170 dB. The presence of acoustic disturbance within areas of critical habitat may result in altered behaviour or avoidance of the area. Research initiatives to further understand the effect of chronic noise have been added to the Schedule of Studies.

Given the uncertainties regarding Humpback Whale diet composition, the likelihood of overfishing resulting in prey reduction is difficult to assess. Further study is required to clarify potential effects of forage fish harvesting on humpbacks and their use of the identified critical habitat.

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. For North Pacific Humpback Whale critical habitat, it is anticipated that this will be accomplished through the establishment of a Ministerial Order as required by subsections 58(4) and (5) of SARA that will invoke the section 58(1) prohibition against the destruction of the identified critical habitat. The examples of activities likely to destroy critical habitat as described in Table 5 are neither exhaustive nor exclusive and have been guided by the threats described in Section 1.5 (Threats). The absence of a specific human activity does not mean that, when carried out, it will not destroy critical habitat. Furthermore, the inclusion of an activity does not result in its automatic prohibition, since it is destruction of critical habitat that is prohibited. The prohibition against the destruction of critical habitat is engaged if a critical habitat protection order is made. Since habitat use is often temporal in nature, every activity is assessed on a case-by-case basis and site-specific mitigation measures are applied where they are reliable and available. In every case, where information is available, thresholds and limits are associated with attributes to better inform management and regulatory decision-making. However, in many cases the knowledge of a species and its critical habitat may be lacking. In particular, sometimes information associated with a species' or habitat's threshold of tolerance to disturbance from human activities, is lacking and must be acquired.

Table 5. Examples of Activities that May Result in the Destruction of Critical Habitat

Activity	Affect- Pathway	Level of Concern	Function Affected	Feature Affected	Attribute Affected
Prey Reduction: Commercial, recreational and Aboriginal fisheries	Reduction in the availability of prey species resulting in nutritional stress	Moderate	Feeding and foraging	Prey	Herring stock Sardine stock Euphausiid stock
Toxic Spills: Large-scale offshore or near shore industrial development Land-based outflows	Reduction in water and/or air quality causing direct contamination Alteration of whale behaviour resulting in displacement or avoidance of the critical habitat. Prey contamination leading to decrease in quality and/or quantity of food supply.	Moderate	Resting and Socializing Feeding and Foraging	Water and Air Prey	Water and air quality of a sufficient level so as not to cause adverse health effects Herring stock Sardine stock Euphausiid stock
Acoustic Disturbance: Seismic exploration, Pile driving, dredging, construction Sonar	Alteration of whale behaviour resulting in displacement or avoidance of the critical habitat. Interference with communication resulting in displacement or avoidance of resting/socialising areas or inability to feed.	Low to Moderate	Resting and Socializing Feeding and Foraging	Acoustic Environment Physical space Prey	Receivedlevels of acoustic noise below 160 dB re 1 μPa

Physical Disturbance Commercial and recreational vessel traffic	Displacement or avoidance of critical habitat resulting in reduced foraging efficiency Displacement or avoidance of critical habitat resulting in a loss/decrease in foraging Opportunities.	High	Resting and Socializing Feeding and Foraging	Acoustic Environment Physical space	A 100m radius of unimpeded physical space around a whale A 400m area of unimpeded physical space in the path of a traveling whale

2.9 Effects on Other Species

Efforts to complete identification of critical habitat and to promote recovery of this species will likely result in increased data on other marine mammals and on oceanographic processes. Measures to protect Humpback Whales and their identified critical habitat from effects of threats will likely have positive benefits for protection of other marine species and their habitats.

Increasing use of B.C. waters by Humpback Whales as foraging grounds is likely to influence abundance of prey species in the future. However, the extent of potential impacts to specific prey populations is unknown at present. Continued monitoring of both predator and prey populations will assist in characterizing potential negative effects to both the Humpback Whale population, as well as potential predation effects on their prey populations.

2.10 Statement on Action Plans

The conservation status North Pacific Humpback Whales is currently being re-assessed by COSEWIC. Following completion of this re-assessment, a change in SARA status for the population may or may not be recommended. Should the SARA status of Humpback Whales remain unchanged, an action plan to implement this recovery strategy will be completed within five years of final posting of this recovery strategy on the SAR Public Registry. When feasible, Canadian recovery efforts for this population will be coordinated with those actions outlined in other SARA marine mammal recovery strategies, action and/or management plans.

3. REFERENCES

Alcock, R. E. and K.C. Jones. 1996. Dioxins in the environment: A review of trend data. Environmental Science and Technology. 30: 3133-3143.

Angliss, R. P. and R. B. Outlaw. 2005. Alaska marine mammal stock assessments, 2005. NOAA Technical Memorandum. U.S. Dept. Commerce. 250 pp.

Anon 2005. Assessment of acoustic exposure on marine mammals in conjunction with *USS Shoup* Active Sonar Transmissions in the eastern Strait of Juan de Fuca and Haro Strait, Washington, May 5, 2003. 13pp. Accessed October 10, 2008 at: www.nmfs.noaa.gov/pr/pdfs/acoustics/assessment.pdf

Au, W. W. L., A.A. Pack, M.O. Lammers, L.M. Herman, M.H. Deakos and K. Andrews. 2006. Acoustic properties of humpback whale songs. Journal of Acoustical Society of America. 120: 1103-1110.

Baird, R. W. 2003. Update COSEWIC status report on the humpback whale *Megaptera novaeangliae* in Canada *in* COSEWIC assessment and update status report on the humpback whale *Megaptera novaeangliae* in Canada. Committee on the Status of Endangered Wildlife in Canada,, Ottawa. 1-25 pp.

Baker, C. S., L. Medrano-Gonzalez, J. Calambokidis, A. Perry, F. Pichler, H. Rosenbaum, J. M. Straley, J. Urban-Ramirez, M. Yamaguchi and O. Von Ziegesar. 1998. Population structure of nuclear and mitochondrial DNA variation among humpback whales in the North Pacific. Molecular Ecology 7: 695-707.

Baker, C. S., S. R. Palumbi, R. H. Lambertsen, M. T. Weinrich, J. Calambokidis and S. J. O'Brien. 1990. Influence of seasonal migration on geographic distribution of mitochondrial DNA haplotypes in humpback whales. Nature 344: 238-240.

Baker, C. S., A. Perry and L. M. Herman. 1987. Reproductive histories of female humpback whales (*Megaptera novaeangliae*) in the North Pacific. Marine Ecology Progress Series 41: 103-114.

Baker, C. S., L. M. Herman, A. Perry, W. S. Lawton, J. M. Straley, A. A. Wolman, G. D. Kaufman, H. E. Winn, J. D. Hall, J. M. Reinke and J. Ostman. 1986. Migratory movement and population structure of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. Marine Ecology Progress Series 41: 103-114.

Baraff, L. S., P. J. Clapham, D. K. Mattila and R. S. Bowman. 1991. Feeding behavior of a humpback whale in low-latitude waters. Marine Mammal Science 7: 197-202

Baumgartner, T., A. Soutar, and V. Ferreira-Bartrina. 1992. Reconstruction of the history of the Pacific sardine and northern anchovy populations over the past two millennia from sediments of the Santa Barbara Basin, California. California Cooperative Oceanic Fish. Invest. Rep. 33:24-40.

Benson, A.J. and A. W. Trites. 2002. Ecological effects of regime shifts in the Bering Sea and eastern North Pacific Ocean. Fish and Fisheries. 3(2): 95-113.

Best P.B. 1993. Increase rates in severely depleted stocks of baleen whales. ICES Journal of Marine Science 50: 169–186.

Bowen, W. D. 1997. Role of marine mammals in aquatic ecosystems. Mar. Ecol. Prog. Ser 158: 267-274.

Brinton, E., and A. Townsend. 2003. Decadal variability in abundances of the dominant euphausiid species in southern sectors of the California Current. Deep-Sea Research Part II: Topical Studies in Oceanography 50:2449-2472.

Brown, E.D., T.T. Baker, J.E. Hose, R.M. Kocan, G.D. Marty, M.D. McGurk, B.L. Norcross, J. Short. 1996. Injury to the early life history stages of Pacific herring in Prince William Sound after the Exxon Valdez oil spill. Am. Fisheries Society Symposium 18: 448-462.

Bryant, P., G. Nichols, T. Bryant and K. Miller. 1981. Krill availability and the distribution of humpback whales in Southeastern Alaska. Journal of Mammalogy 62(2): 427-430.

Butterworth, D. S., D. L. Borchers and S. Chalis. 1993. Updates of abundance estimates for Southern Hemisphere blue, fin, sei and humpback whales incorporating data from the second circumpolar set of IDCR cruises. Reports of the International Whaling Commission: 43:530.

Calambokidis, J., E.A. Falcone, , T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn , A. Havron, J. Huggins, N. Maloney, J. Barlow, and P.R. Wade. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078. U.S. Dept of Commerce. 57 pp.

Calambokidis, J. and J. Barlow. 2004. Abundance of blue and humpback whales in the eastern North Pacific estimated by capture-recapture and line-transect methods. Marine Mammal Science 20: 63-85.

Calambokidis, J., J.M. Straley, L.M. Herman, S. Cerchio, D. R. Salden, J. Urbán R., J.K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C.M. Gabriele. 2001. Movements and population structure of humpback whales in the North Pacific. Marine Mammal Science. 17(4): 769-794.

Calambokidis, J., G. H. Steiger, J. M. Straley, T. J. Quinn II, L. M. Herman, S. Cerchio, D. R. Salden, M. Yamaguchi, F. Sato, J. Urbán R., J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, N. Higashi, S. Uchida, J. K. B. Ford, Y. Miyamura, P. L. de Guevara P., S. A. Mizroch, L. Schlender and K. Rasmussen. 1997. Abundance and population structure of humpback whales in the North Pacific basin. *in* C. R. Collective (ed.) Final Contract Report. Southwest Fisheries Science Center. 72 pp.

Calambokidis, J., G. H. Steiger, J. R. Evenson, K. R. Flynn, K. C. Balcomb, D. E. Claridge, P. Bloedel, J. M. Straley, C. S. Baker, O. von Ziegesar, M. E. Dahlheim, J. M. Waite, J. D. Darling, G. Ellis and G. A. Green. 1996. Interchange and isolation of humpback whales off California and other North Pacific feeding grounds. Marine Mammal Science 12: 215-226.Chittleborough, R. G. 1965. Dynamics of two populations of the humpback whale. *Megaptera novaeangliae* (Borowski). Australian Journal of Marine and Freshwater Research 16: 33-128.

Chittleborough, R. G. 1958. The breeding cycle of the female humpback whale, *Megaptera novaeangliae* (Borowski). Aust. J. Mar. Freshwat. Res 9: 1-18.

Clapham, P.J., and S.B. Young, R.L. Brownell, Jr. 1999. Baleen whales: conservation issues and the status of the most endangered populations. Mammal Review. 29 (1): 35-60.

Clapham, P. J. 1996. The social and reproductive biology of humpback whales: An ecological perspective. . Mammal Review 26: 27-49.

Clapham, P.J., L.S. Baraff, C.A. Carlson, M.A. Christian, D.K. Mattila, C.A. Mayo, M.A. Murphy and S. Pittman. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Canadian Journal of Zoology 72: 440-443.

Craig, A.S., and L.M. Herman. 1997. Sex differences in site fidelity and migration of humpback whales (*Megaptera novaeangliae*) to the Hawaiian Islands. Canadian Journal of Zoology 75: 1923-1933.

Crone, T.J., and M. Tolstoy. 2010. Magnitude of the 2010 Gulf of Mexico oil leak. Science 330: 634.

Dahlheim, M. E. and O. von Ziegesar. 1993. Effects of the *Exxon Valdez* oil spill on the abundance and distribution of humpback whales (*Megaptera novaeangliae*), in Prince William Sound. *Exxon Valdez* Oil Spill State/Federal Natural Resource Damage Assessment Final Report (Marine

Mammal Study Number l), U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, Washington. 28 pp.

Darling, J.D., and D.J. McSweeney. 1985. Observations on the migrations of North Pacific humpback whales (*Megaptera novaeangliae*). Canadian Journal of Zoology 63: 308-314.

DeMaster, D. P., C. W. Fowler, S. L. Perry, and M. F. Richlen. 2001. Predation and competition: The impact of fisheries on marine-mammal populations over the next one hundred years. Journal of Mammalogy. 82(2): 641-651.

DFO (Fisheries and Oceans Canada). 2009. Advice relevant to the identification of critical habitats for North Pacific Humpback Whales (*Megaptera novaeangliae*). DFO Can. Sci. Advis. Sec. Sci. Resp. 2009/016.

DFO. 2008a. Pacific Region Integrated Fisheries Management Plan - Salmon Northern B.C. June 1, 2008 – May 31, 2009.

DFO. 2008b. Pacific Region Integrated Fisheries Management Plan - Salmon Southern B.C. June 1, 2008 – May 31, 2009.

DFO. 2008c. Pacific Region Integrated Fisheries Management Plan - Roe Herring. February 10, 2008 to April 30, 2008.

DFO. 2008d. Pacific Region Integrated Fisheries Management Plan 2008 - Spawn-On-Kelp Herring.

DFO. 2008e Pacific Region Integrated Fisheries Management Plan - Prawn and Shrimp By Trap. May 1, 2008 to April 30, 2009.

DFO. 2008f. Pacific Region Integrated Fisheries Management Plan - Crab by Trap. January 1, 2008 to December 31, 2008.

DFO. 2008g. Pacific Region Integrated Fisheries Management Plan - Groundfish. March 8, 2008 to February 20, 2009.

DFO. 2007. Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment. Available from: http://www.dfo-mpo.gc.ca/oceans/management-gestion/integratedmanagement-gestionintegree/seismic-sismique/index-eng.asp

DND [Department of National Defence]. 2007. Maritime command order: marine mammal mitigation procedures [MARCORD]. unpublished. 46-13 (3A). 10p.

Dolphin, W. F. 1987a. Ventilation and dive patterns of humpback whales, *Megaptera novaeangliae*, on their Alaskan feeding grounds. Canadian Journal of Zoology 65: 83-90.

Dolphin, W. F. 1987b. Prey densities of humpback whales, *Megaptera novaengliae*. Experientia 43: 468–471.

Douglas, A.B., J. Calambokidis, S. Raverty, S.J. Jeffries, D.M. Lambourn and S.A. Norman. 2008. Incidence of ship strikes of large whales in Washington state. J Mar. Biol. Assoc of UK. Published online by Cambridge University Press. 17 March 2008.

EC (Environment Canada) 2007. Guidelines on identifying and mitigating threats to species at risk (Draft). Government of Canada: Ottawa. 29pp.

Evans D.L. and G.R. England. 2001. Joint interim report Bahamas marine mammal stranding event of 15-16 March 2000. NOAA, US Dept. of Commerce and Dept. of the Navy.

Ford J.K.B., A.L. Rambeau, R.M. Abernethy, M.D. Boogaards, L.M. Nichol, and L.D. Spaven . 2009. An Assessment of the Potential for Recovery of Humpback Whales off the Pacific Coast of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/015. iv + 33 p.

Ford, J.K.B., R.M. Abernethy, A.V. Phillips, J. Calambokidis, G.M. Ellis, and L.M. Nichol. 2010. Distribution and relative abundance of cetaceans in Western Canadian Waters from ship surveys, 2002-2008. Canadian Technical Report of Fisheries and Aquatic Sciences. 2913. 51 pp.

Frankel A.S. and C.W. Clark. 2000. Behavioural response of humpback whales (*Megaptera novaeangliae*) to full scale ATOC signals. Journal of the Acoustical Society of America, 108(4):1930-1937.

Fristrup K.M., L.T. Hatch, and C.W. Clark. 2003. Variation in humpback whale (*Megatpera novaeangliae*) song length in relation to low-frequency sound broadcasts. Journal of the Acoustical Society of America. 113(6): 3411-3424.

Hildebrand, J. 2006. The contribution of seismic sources to the anthropogenic ocean noise budget. Impacts of seismic survey activities on whales and other marine biota. International Workshop, Dessau, Germany. Accessed February 2008 at: www.umweltdaten.de/publikationen/fpdf-l/3159.pdf

Fulton, J., M.N. Arai and J.C. Mason. 1982. Euphausiids, coelenterates, ctenophores, and other zooplankton from the Canadian Pacific Coast ichthyoplankton survey, 1980. Canadian Technical Report of Fisheries and Aquatic Sciences. 1125. 75 pp.

Gabriele, C. M., J. M. Straley, S. A. Mizroch, C. S. Baker, A. S. Craig, L. M. Herman, D. Glockner-Ferrari, M. J. Ferrari, S. Cerchio, O. V. Ziegesar, J. Darling, D. Mcsweeney, T. J. Q. Ii and J. K. Jacobsen. 2001. Estimating the mortality rate of humpback whale calves in the central North Pacific Ocean. Canadian Journal of Zoology 79: 589-600.

Gambell, R. 1976. World whale stocks. Mammal Review 6: 41-53.

Geraci, J. R., D. M. Anderson, R. J. Timperi, D. J. St. Aubin, G. A. Early, J. H. Prescott, and C. A. Mayo. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. Canadian Journal of Fisheries and Aquatic Science. 46: 1895-1898.

Government of Canada, 2013. List of Wildlife Species at Risk (referral back to COSEWIC) Order. Canada Gazette, Part II, March 27, 2013, Vol. 147, No. 7. (SI/2013-28). Available from: http://www.gazette.gc.ca/rp-pr/p2/2013/2013-03-27/html/si-tr28-eng.html

Government of Canada, 2005. Policy on the feasibility of recovery [Draft]. 3pp. *In:* National Recovery Working Group. 2007. Recovery Handbook (ROMAN) Endangered Wildlife, Ottawa, Ontario.

Gregr, E. J. and A. W. Trites. 2001. Predictions of critical habitat for five whale species in the waters of coastal British Columbia. Canadian Journal of Fisheries and Aquatic Science. 58: 1265–1285.

Gregr, E. J., L. Nichol, J. K. B. Ford, G. Ellis and A. W. Trites. 2000. Migration and population structure of northeastern Pacifc whales off coastal British Columbia: An analysis of commercial whaling records from 1908-1967. Marine Mammal Science 16: 699-727.

Hildebrand, J. 2006. The contribution of seismic sources to the anthropogenic ocean noise budget. Impacts of seismic survey activities on whales and other marine biota. International Workshop, Dessau, Germany. Accessed Februaury 2008 at: www.umweltdaten.de/publikationen/fpdf-l/3159.pdf

Hill, K., E. Dorval, N. Lo, B. Macewicz, C. Show, and R. Felix-Uraga. 2008. Assessment of the Pacific sardine (*Sardinops sagax caerulea*) resource in 2008 for U.S. management in 2009. NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC. 147 p.

Hose, J.E., M.D. McGurk, G.D. Marty, D.E. Hinton, E.D. Brown, T.T. Baker. 1996. Sublethal effects of the Exxon Valdez oil spill on herring embryos and larvae: morphological, cytogenetic and histopathological assessments 1989-1991. Can. J. Fish. Aquat. Sci. 53: 2355-2365.

Hoyt, E. 2005. Marine protected areas for whales, dolphins and porpoises: a world handbook for cetacean habitat conservation. Earthscan: London, U.K. 492p.

Hyrenbach, K.D., and R.R. Veit. 2003. Ocean warming and seabird communities of the southern California Current System (1987-98): response at multiple temporal scales. Deep-Sea Research Part II: Topical Studies in Oceanography 50:2537-2565.

Ikonomou, M. G., S. Rayne, R. F. Addison. 2002. Exponential Increases of the Brominated Flame Retardants, Polybrominated Diphenyl Ethers, in the Canadian Arctic from 1981 to 2000. Environ. Sci. Technol. 36:1886-1892.

IWC (International Whaling Commission). 2007. Whale Population Estimates. International Whaling Commission. Available at: http://www.iwcoffice.org/conservation/estimate.htm#assessment. Accessed April 17, 2008.

IWC. 2004. Annex K. Report Group on Environmental Concerns. Report of the Scientific Committee of the International Whaling Commission. Meeting held in Sorrento Italy, 22-29 July 2004.

Jefferson, T. A., P. J. Stacey and R. W. Baird. 1991. A review of killer whale interactions with other marine mammals: predation to co-existence. Mammal Review 21: 151-180.

Jensen, A. S., and G. K. Silber. 2003. Large Whale Ship Strike Database. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-OPR-, 37 pp.

Johnson, A.J G. Salvador, J. Kenney, J. Robbins, S. Kraus, S. Landry, and P. Clapham. 2005. Fishing gear involved in entanglements of right and humpback whales. Mar. Mam. Sci. 21(4), 635-645.

Johnson, J. H. and A. A. Wolman. 1984. The humpback whale, *Megaptera novaeangliae*. Marine Fisheries Review 46: 30–37.

Jones, E. C. 1971. *Isistius brasiliansis*, a squalid shark, the probable cause of crater wounds of fishes and cetaceans. Fisheries Bulletin U.S. 69: 791-798.

Kannan, K., J. Koistinen, K. Beckmen, T. Evans, J. F. Gorzelany, K.J. Hansen, P.D. Jones, E. Helle, M. Nyman, and J.P. Giesy. 2001. Accumulation of Perfluorooctane Sulfonate in Marine Mammals. Environ. Sci. Technol. 35:1593 – 1598.

Katona, S.K., and H.P. Whitehead. 1981. Identifying humpback whales using their natural markings. Polar Record 20: 439-444.

Ketten, D.R., J. Lien and S. Todd. 1993. Blast injury in humpback whales: evidence and implications. (Abstract only) Journal of the Acoustical Society of America 94: 1849-1850.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17: 35-75.

Le Boeuf, B. J., M. H. Pérez Cortés, J. Urbán Ramirez, B. R. Mate and U.F. Ollervides. 2000. High gray whale mortality and low recruitment in 1999: Potential causes and implications. Journal of Cetacean Research and Management 2: 85-99.

Leatherwood, S., D.K. CALDWELL, H.E. Winn, W.E. Schevill and M.C. Caldwell. 1976. Whales, Dolphins, and Porpoises of the western North-Atlantic - A Guide to their Identification –. NOAA technical report NMFS CIRC, 396. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service

Lee, T.S., Galbraith, R., Joyce, M., Ross, P.S. and Ford, J.K.B. 2007. Preliminary risk assessment of threats to the proposed critical habitat of northern and southern resident killer whales (*Orcinus orca*) in British Columbia (unpublished report). Fisheries and Oceans Canada, Pacific Biological Station, Cetacean Research Program.

LeBrasseur, R.J. and J.D. Fulton. 1967. A guide to zooplankton of the north-eastern Pacific Ocean. Circular of Biological Station. 84. 34pp.

Leighton, T.G., S.D. Richards and P.R.White. 2004. Trapped within a wall of sound. Acoustics Bulletin, 29: 24-29.

Lu, B.., D.L. Mackas and D.F. Moore. 2003. Cross-shore separation of adult and juvenile euphausiids in a shelf-break alongshore current. Progr. Oceanogr. 57: 381-404.

Mackas, D., M. Galbraith, and D. Faust. 2008. Zooplankton community returns to 'cool-ocean' patterns off Vancouver Island in 2007, *in* J. Irvine and B. Crawford [eds.] State of physical, biological, and selected fishery resources of Pacific Canadian marine ecosystems. Fisheries Oceanography Working Group. Canadian Science Advisory Secretariat Research Document 2008/013.

Mackas, D., A. Pena, D. Johannessen, R. Birch, K. Borg and D. Fissel. 2007. Appendix D: Plankton. *In* B.G. Lucas, S. Verrin and R. Brown [eds.] Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA). Canadian Technical Reports of Fisheries and Aquatic Sciences 2667.

Mackas, D.L., W.T. Peterson and J.E. Zamon. 2004. Comparisons of interannual biomass anomalies of zooplankton communities along the continental margins of British Columbia and Oregon. Deep-Sea Research II 51: 875-896.

Mackas, D.L., R. Kieser, M. Saunders, D.R. Yelland, R.M. Brown and D.F. Moore. 1997. Aggregation of euphausiids and Pacific hake (*Merluccius productus*) along the outer continental shelf off Vancouver Island. Canadian Journal of Fisheries and Aquatic Sciences 54(9): 2080-2096.

Matkin, C.O., G. M. Ellis, E. L. Saulitis, L. G. Barrett-Lennard, and D. R. Matkin. 1999. Killer Whales of Southern Alaska. North Gulf Oceanic Society, Homer, Alaska. 99 pp.

Matkin, C.O., E.L. Saulitis, G.M. Ellis, P. Olesiuk, and S. D. Rice. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* sixteen years following the *Exxon Valdez* oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series 356: 269-281.

Matthews, L.H. 1978. The natural history of the whale. Columbia Univ. Press: New York. 219 pp.

Mattson, C.R. and B.L. Wing. 1978. Ichthyoplankton composition and plankton volumes from inland coastal waters of southeastern Alaska, April-November 1972. NOAA Technical Report NMFS. SSRF-723. 55pp.

Mattila, D., L.N. Guinee and C.A. Mayo. 1987. Humpback whale songs on a North Atlantic feeding ground. Journal of Mammalogy 68: 880-883.

Mazzuca, L., S. Atkinson, and E. Nitta. 1998. Deaths and entanglements of humpback whales, Megaptera novaeangliae, in the main Hawaiian Island, 1972-1996. Pacific Science 52(1):1-13.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch and K. McCabe. 2000. Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Report for Australian Petroleum Production Exploration Association. Available from Centre for Marine Science and Technology, Curtin University of Technology, Western Australia 6102. 198 pp.

McSweeney, D.J., K.C. Chu, W.F. Dolphin and L.N. Guinee. 1989. North Pacific humpback whale songs: A comparison of southeast Alaskan feeding ground songs with Hawaiian wintering ground songs. Marine Mammal Science 5: 139–148.

Metcalfe, C., B. Koenig, T. Metcalfe, G. Paterson and R. Sears. 2004. Intra- and inter-species differences in persistent organic contaminants in the blubber of blue whales and humpback whales from the Gulf of St. Lawrence, Canada. Marine Environmental Research. 57: 245-260.

Miller, P.J.O., N. Biassoni, A. Samuels, and P.L. Tyack. 2000. Whale songs lengthen in response to sonar. Nature 405: 903.

Moore, S. E., J. Urbán Ramirez, W.L. Perryman, F. Gulland, H. Pérez Cortés, P.R. Wade, L. Rojas Bracho and T. Rowles. 2001. Are gray whales hitting "K" hard? Marine Mammal Science. 17: 954-958.

Moore, S. E., K.M. Wynne, J.C. Kinney and J.M. Grebmeier. 2007. Gray whale occurrence and forage southeast of Kodiak, Island, Alaska. Marine Mammal Science. 23: 419-428.

Muir, D., B. Braune, B. DeMarch, R. Norstrom, R. Wagemann, L. Lockhart, B. Hargrave, D. Bright, R. Addison, J. Payne., and K. Reimer. 1999. Spatial and temporal trends and effects of contaminants in the Canadian Arctic marine ecosystem: a review. Sci. Total Environ., 230, 83-144.

Newell, C. L. and T.J. Cowles. 2006. Unusual gray whale *Eschrichtius robustus* feeding in the summer of 2005 off the central Oregon Coast. Geophysical Research Letters. p. 33.

Neilson, K.L., C.M. Gabriele, and J.M. Straley. 2007. Humpback whale entanglement in fishing fear in northern southeastern Alaska,.*in* Piatt, J.F., and S.M. Gende. (eds) Proceedings of the Fourth Glacier Bay Science Symposium, October 26-28, 2004: U.S. Geological Survey Scientific Investigations Report 2007-5047, p. 204-207.

Nichol, L.M., R. Abernethy, L. Flostrand, T.S. Lee and J.K.B. Ford. 2009. An assessment of Critical Habitats of North Pacific Humpback Whales (*Megaptera novaeangliae*) in British Columbia (DRAFT). DFO Can. Sci. Advis. Sec. Res. Doc. 2009/nnn. iv + 27 pp.

Nishiwaki, M. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. Pages 172-191 *in* K. S. Norris (ed.) Whales, Dolphins and Porpoises. University of California Press, Berkeley, CA.

Norcross, B.L., J.E. Hose, M. Frander, E.D. Brown. 1996. Distribution, abundance, morphological condition, and cytogenetic abnormalities of larval herring in Prince William Sound, Alaska, following the Exxon Valdez oil spill. Can. J. Fish. Aquat. Sci. 53: 2376-2387.

Nowacek, D. P., L. H. Thorne, D. W. Johnston, and P. L. Tyack. 2007. Response of cetaceans to anthropogenic noise. Mammal Review, 37:81-115.

NMFS (National Marine Fisheries Service). 1991 Recovery plan for the humpback whale (*Megaptera novaeangliae*). Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 105pp.

NRC (National Research Council). 2005. Marine mammal populations and ocean noise. Determining when noise causes biologically significant effects. National Academic Press, Washington, DC. 126pp. Available from www.nap.edu

NRC. 2003. Ocean Noise and Marine Mammals. National Academic Press, Washington, D.C.

O'Shea, T. J., and R. L. Brownell, Jr. 1994. Organochlorine and metal contaminants in baleen whales: a review and evaluation of conservation implications. The Science of the Total Environment 154:179–200.

Parks, S. E., and C. W. Clark. 2007. Short- and long-term changes in right whale calling behaviour: the potential effects of noise on acoustic communication. Journal of the Acoustical Society of America, 122: 3725-3731.

Pauly, D., A.W. Trites, E. Caputi and V. Christensen. 1998. Diet composition and trophic levels of marine mammals. ICES J. Mar. Sci. 55: 467-481.

Payne, P.M., D.N. Wiley, S.B. Young, S. Pittman, P.J. Clapham, and J.W. Jossi. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in selected prey. Fish. Bull. 88: 687–696.

Payne, R., and S. McVay. 1971. Songs of humpback whales. Science 173: 583-597.

Perry, A., C. S. Baker and L. M. Herman. 1990. Population characteristics of individually identified humpback whales in the central and eastern North Pacific: A summary and critique. Report of the International Whaling Commission (Special Issue 12): 307-317.

Phillips, C. 1996. Conservation in practice: agreements, regulations, sanctuaries and action plans. *In* The conservation of whales and dolphins. M.P. Simmonds and J.D. Hutchinson (eds). John Wiley and Sons, Ltd. Chichester, UK. 476 pp.

Perry, R.I. 1984. Plankton blooms of the British Columbia northern shelf: seasonal distributions and mechanisms influencing their formation. Thesis (Ph.D.). University of British Columbia: Vancouver, BC. 218pp.

Perry, S.L., D.P. DeMaster and G.K. Silbec. 1999. The great whales: History and status of six species listed as endangered under the US Endangered Species Act of 1973. Marine Fisheries Review 61 99-110.

Perryman, W. L., M.A. Donahue, P.C. Perkins and S.B. Reilly. 2002. Gray whale calf production 1994-2000: Are observed fluctuations related to changes in seasonal ice cover? Marine Mammal Science. 18: 121-144

Phillips, C. 1996.Conservation in practice: agreements, regulations, sanctuaries and action plans. *In:* The conservation of whales and dolphins. M.P. Simmonds and J.D. Hutchinson (eds). John Wiley and Sons Ltd.: Chichester, UK.

Piatt, J.F. and D. A. Methven.1992. Threshold foraging behavior of baleen whales. Marine Ecology Progress Series. 84: 205-210.

Piatt, J. F., D. A. Methven, A. E. Burger, R. L. McLagan, V. Mercer and E. Creelman. 1989. Baleen whales and their prey in a coastal environment. Canadian Journal of Zoology 67: 1523-1530.

Porte C, G. Janer, L.C. Lorusso, M. Ortiz-Zarragoitia, M.P. Cajaraville, M.C. Fossi, and L. Canesi. 2006. Endocrine disruptors in marine organisms: approaches and perspectives. Comp Biochem Physiol C Toxicol Pharmacol. 143:303-315.

Province of British Columbia. 2004. The Province of British Columbia's perspective on the federal moratorium on oil and gas activities, offshore British Columbia.

Rambeau, A.L. 2008. Determining abundance and stock structure for a widespread migratory animals: the case of humpback whales (*Megaptera novaeangliae*) in British Columbia, Canada. M.Sc Thesis. University of British Columbia.

Rayne, S., M. G. Ikonomou, P. S. Ross, G. M. Ellis and L. G. Barrett-Lennard. 2004. PBDEs, PBBs, and PCNs in three communities of free-ranging killer whales (*Orcinus orca*) from the Northeastern Pacific Ocean. Environ. Sci. Technol. 38:4293-4299.

Rice, D. W. 1978. The humpback whale in the North Pacific: Distribution, exploitation and numbers. Pages 29-44 *in* K. S. Norris and R. S. Reeves eds. Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. . U.S. Dept. of Commerce.

Richardson, W. J., C. R. Greene Jr, C. I. Malme, and D. H. Thompson. 1998. Marine mammals and noise. Academic Press, San Diego. pp. 576.

Robbins, J. and D. Mattila. 2004. Estimating humpback whale (*Megaptera novaeangliae*) entanglement rates on the basis of scar evidence. Report to the Northeast Fisheries Science Center, National Marine Fisheries Service, Woods Hole, MA. Order Number 43EANF030121

Ross, P.S. 2006. Fireproof killer whales (*Orcinus orca*): flame-retardant chemicals and the conservation imperative in the charismatic icon of British Columbia, Canada. Journal of Fisheries and Aquatic Science. 63: 224-234.

Sandilands, D. 2008. B.C. Cetacean Sightings Network - unpublished data. Vancouver Aquarium Marine Sciences Centre: Vancouver, B.C.

Schweigert J, Christensen LB, Haist V. 2009. Stock Assessment for British Columbia Herring in 2008 and Forecasts of the Potential Catch in 2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/019. iv + 61 pp.

Schweigert, J., McFarlane, G., and Hodes, V. 2009b. Pacific sardine (*Sardinops sagax*) biomass and migration rates in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/088.

Sigurjónsson, J. and G. A. Víkingsson. 1997. Seasonal abundance of and estimated food consumption by cetaceans in Icelandic and adjacent waters. . Journal of Northwest Atlantic Fisheries Science 22: 271-287.Smith, T. D., J. Allen, P. J. Clapham, P. S. Hammond, S. Katona, F. Larsen, J. Lien, D. Mattila, P. J. Palsbøll, J. Sigurjónsson, P. T. Stevick and N. Øien. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaengliae*). Marine Mammal Science. 15: 1-32.

Simard, Y. and D.L. Mackas. 1989. Mesoscale aggregations of euphausiid sound-scattering layers on the continental shelf of Vancouver Island. Canadian Journal of Fisheries and Aquatic Sciences 46: 1238-1249.

Smith, T.D., Allen, J., Clapham, P.J., Hammond, P.S., Katona, S., Larsen, F., Lien, J., Mattila, D., Palsboll, P.J., Sigurjonsson, J., Stevick, P.T. and N. Oien. 1999. An ocean basin-wide mark-recapture study of the north Atlantic humpback whale (*Megaptera novaengliae*). Marine Mammal Science. 15:1-32.

Steiger , G. H., J. Calambokidis, J. M. Straley, L. M. Herman, S. Cerchio, D. R. Salden, J. Urbán-R., J. K. Jacobsen, O. V. Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, J. K. B. Ford, P. Ladrón De Guevara, M. Yamaguchi and J. Barlow. 2008. Geographic variation in killer whale attacks on humpback whales in the North Pacific: Implications for predation pressure. Endangered Species Research 4: 247–256.

Steiger, G. H., J. Calambokidis, R. Sears, K. C. Balcomb and J. C. Cubbage. 1991. Movement of humpback whales between California and Costa Rica. Marine Mammal Science 7: 306-310.

Stone, C. J., and M. L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. Journal of Cetacean Research and Management, 8: 255-263.

Stonham, J.T. (ed.) 2005. A concise dictionary of the Nuuchahnulth language of Vancouver Island. Native American Studies. 17. Edwin Mellen Press: Queenston, ON. 537pp.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. J. Greene, D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals.. 33(4): 410-522.

Sydeman, W.J., Bradley, R.W., Warzybok. P., Abraham, C.L., Jahncke, J., Hyrenbach, K.D., Kousky, V., Hipfner, J.M. and M.D. Ohman. 2006. Planktivorous auklet *Ptychoramphus aleuticus* reponses to ocean climate, 2005: unusual atmospheric blocking? Geophysical Research Letters. 33(22).

Tanasichuk, R. W. 2001. An evaluation of a recruitment forecasting procedure for Strait of Georgia herring. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/101. 29p.

Tanasichuk, R.W. 2000. Age-specific natural mortality rates of adult Pacific herring (*Clupea pallasi*) from southern British Columbia. Canadian Journal of Fisheries and Aquatic Sciences. 57(11): 2258-2266.

Therriault, T.W. 2003. Are offshore summer herring distributions useful predictors of recruitment strength for northern herring stocks? DFO Can. Sci. Advis. Sec. Res. Doc. 2003/081. 27p.

Thompson, M. and Therriault, T.W. 2006. Central coast juvenile herring survey, August 2004. Can. Manuscr. Rep. Fish. Aquat. Sci. 2758. vii + 55p.

Thompson, M. and Therriault, T.W. 2007. Queen Charlotte Islands juvenile herring survey, August 2005. Can. Manuscr. Rep. Fish. Aquat. Sci. 2822: vi + 24 p.

Todd, S., P. Stevick, J. Lien, F. Marques and D. Ketten. 1996. Behavioural effects of exposure to underwater explosions in humpback whales (*Megaptera novaeangliae*). Canadian Journal of Zoology 74: 1661-1672.

Transport Canada. 2005. Statistics from T-FACTS. http://www.tc.gc.ca/eng/policy/anre-menu.htm. Accessed October 28, 2008.

True, F. W. 1904. The whalebone whales of the western North Atlantic compared with those occurring in European waters: with some observations on the species of the North Pacific. Smithson. Contr Knowl. 33: 1-318.

Tyack, P. 1981. Interactions between singing Hawaiian humpback whales and conspecifics nearby. Behavioral Ecology and Sociobiology. 8: 105-116.

Urbán, R. J. and L. A. Aguayo. 1987. Spatial and seasonal distribution of the humpback whale, Megaptera novaeangliae, in the Mexican Pacific. Marine Mammal Science 3: 333-344.

Volgenau, L., S.D.Kraus, and J. Lien. 1995. The impact of entanglements on two substocks of the western North Atlantic humpback whale, *Megaptera novaeangliae*. Can. J. Zool. 73, 1689-1698.

Wade P.R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mamm. Sci. 14: 1-37.

Ware, D. M. and R. E. Thomson. 2005. Bottom-Up Ecosystem Trophic Dynamics Determine Fish Production in the Northeast Pacific. Science 308: 1280-1284.

Ware, D. M. and R. E. Thomson. 1991. Link between long-term variability in upwelling and fish production in the northeast Pacific Ocean. Can. J. Fish. Aquat. Sci. 48:2296-2306.

Weinrich, M. T., M. R. Schilling and C. R. Belt. 1992. Evidence for acquisition of a novel feeding behaviour: lobtail feeding in humpback whales, Megaptera novaeangliae Animal Behaviour 44: 1059-1072.

Weir, C.R. 2008. Overt response of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter Macrocephalus*), and Atlantic spotted dophins (*Stenella frontalis*) to seismic exploration off Angola. Aquatic Mammals, 34(1): 71-83.

Whitehead, H., R.R. Reeves and P.L. Tyack. 2000. Science and the conservation, protection and management of wild cetaceans. In Cetacean societies: fields studies of dolphins and whales.

Edited by J. Mann, R. Connor, P. Tyack and H. Whitehead. University of Chicago Press, Chicago, IL.

Whitehead, H. 1987. Updated status of the humpback whale, Megaptera novaeangliae, in Canada. Canadian Field-Naturalist 101: 284-294.

Whitehead, H. P. and J. E. Carscadden. 1985. Predicting inshore whale abundance – whales and capelin off the Newfoundland coast. Canadian Journal of Fisheries and Aquatic Sciences 42: 976-981.

Wiley D. N., R. A. Asmutis, T. D. Pitchford and D. P. Gannon.1995. Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. Fishery Bulletin, U.S. 93:196-205.

Williams, R. 2008. Modelling ship strike risk to fin, humpback and killer whales in British Columbia, Canada. Report to the International Whaling Commission. SC/60/BC8. 18pp. Available from www.iwcoffice.org

Williams, R. and P. O'Hara. 2010. Modelling ship strike risk to fin, humpback and killer whales in British Columbia, Canada. Journal of Cetacean Research and Management. Cetacean Res. Manage. 11:1– 8, 2010.

Williams, R. and L. Thomas. 2007. Distribution and abundance of marine mammals in the coastal waters of British Columbia, Canada. J. Cetacean Res. Manage. 9(1): 15-28.

Winn, H. E., T. J. Thompson, W. C. Cummings, J. Hain, J. Hundnall, H. Hays and W. W. Steiner. 1981. Songs of the humpback whale - population comparisons. Behav. Ecol. Sociobiol. 8: 41-46.

Personal Communications:

G. Ellis - Fisheries and Oceans Canada, Science, Nanaimo, B.C.

R. Carpenter – Heiltsuk Fisheries Program, Bella Bella, B.C.

J. Ford – Fisheries and Oceans Canada, Science, Nanaimo, B.C.

D. Freeman – Department of National Defence, Esquimalt, B.C.

J. Robbins – Provincetown Center for Coastal Studies, Provincetown, MA

J. Calambokidis – Cascadia Research Collective, Friday Harbor, WA

D. Mattila – National Oceanic and Atmospheric Administration, Maui, HI

APPENDIX A: DFO TECHNICAL TEAM

Tatiana Lee	Fisheries and Oceans Canada, Recovery Team Chair
John Ford	Fisheries and Oceans Canada
Graeme Ellis	Fisheries and Oceans Canada
Linda Nichol	Fisheries and Oceans Canada
Paul Cottrell	Fisheries and Oceans Canada
Lisa Spaven	Fisheries and Oceans Canada
Robin Abernethy	Fisheries and Oceans Canada
Rob Russell	Habitat Biologist under contract to Fisheries and Oceans
Gabrielle Kosmider	Fisheries and Oceans Canada

Linnea Flostrand	Fisheries and Oceans Canada
Peter Ross	Fisheries and Oceans Canada
Norm Sloan	Parks Canada Agency
Cliff Robinson	Parks Canada Agency
Scott Keehn	Fisheries and Oceans Canada
Carole Eros	Fisheries and Oceans Canada
Sheila J. Thornton	Fisheries and Oceans Canada

Technical Advisors:

John Calambokidis	Cascadia Research Collective, Friday Harbour, WA
Andrea Rambeau	University of British Columbia

APPENDIX B: GLOSSARY OF TERMS

Assessment template and definitions for terms used in the relative risk assessment for key threats to North Pacific Humpback Whales in British Columbia (Appendix C). Terms and template adapted from EC 2007 and modified to include threats to habitat.

THREAT ASSESSMENT	
Threat Category	Broad category indicating type of threat. A threat is considered any activity that detrimentally affects the survival or reproduction of an individual. This may include disturbances that impact an animal's ability to conduct its normal life processes
General Activity	General anthropogenic activity causing a specific stress to humpbacks. Has potential to affect population viability and impede recovery objectives
Specific Stress on Humpback Whales	Specific effect of the general activity on individual Humpback Whales
Potential Effect on Humpback Whales	List of potential impairments to demographic, physiological, and/or behavioural characteristics of an animal, based on the best available scientific information at present
Causal Certainty of Effect on Individuals	The likelihood of impact (resulting from the activity(s) listed) on survival or reproduction of an individual, based on the best available knowledge at present. Certainty is categorized as; *unlikely, plausible, expected, demonstrated, or unknown*
Causal Certainty of Effect on Population Viability	The likelihood of impact from the activity on population viability, based on the best available knowledge at present. Certainty is categorized as; *unlikely, plausible, expected, demonstrated, or unknown*
Causal Certainty of Effect on Habitat	The likelihood of impact from the activity on habitat, based on the best available knowledge at present. Certainty is categorized as; *unlikely, plausible, expected, demonstrated, or unknown*
Current Protections	List of current international, national, provincial and/or regional legislation, public programs and any other conservation measures that may protect the species, mitigate the threats and/or may assist in meeting recovery objectives
Extent of the Threat	Geographic extent of the activity(s). Indicate whether a localized or point source activity may have widespread effects on population. Categorized as; *negligible, localized, widespread or unknown*

RESIDUAL EFFECTS ASSESSMENT			
	Individuals in BC	**Population**	**Habitat**
Occurrence of the Activity	The history of the activity on 1) individuals; 2) populations; or 3) habitat. Categorized as; *historic, rare, current, imminent, anticipated, or unknown*		
Frequency of the Activity	How often an activity influences 1) an individual; or 2) the population; or 3) habitat. Categorized as; *one-time, recurrent, seasonal, continuous, or unknown*		
Severity of the Effect	Degree of impact the activity has on 1) Humpback Whale physiology, behaviour and individual survival or reproduction; or 2) population viability or 3) habitat quality and availability. Categorized as; *negligible, low, moderate, or high*		
Relative Risk	Taking into account all factors listed above, categorize relative risk of impact of an activity as *negligible, low, moderate, high, or unknown,* for impact on 1) individual survival and reproduction; or 2) population viability; or 3) habitat.		
Recommendation	Considering all factors listed above, evaluate whether further measures are necessary. Categorize *as; further study required, long-term planning recommended*, *action required* or *legal action required*		
Summary	Brief rationale regarding the threat, its rating and measures necessary for protection		

Terms for relative risk assessment of threats (Appendix C). Adapted from EC (2007).

TERMS	LEVEL OF EFFECT	DEFINITIONS
Causal Certainty of Effect (of Threat)	Plausible	Negative effect on individual survival or reproduction, population viability, or lhabitat is *possible* or plausible
	Expected	Effect is *correlated* with reduced individual survival or reproduction, reduced population viability or reduced quality of habitat
	Demonstrated	Effect is *causally linked* with reduced individual survival or reproduction, reduced population viability, reduced quality of habitat and failure to meet recovery objectives
	Unlikely	Given current information on the threat and population size, effect is considered unlikely (on its own) to negatively impact population viability or habitat
Extent of the Threat	Negligible	Minor proportion of range is impacted
	Localized	Stress relates to a specific site or narrow portion of the range
	Widespread	Stress relates to the entire distribution of the species, or all of B.C.
	Unknown	Available information is insufficient to gauge the degree to which the activity may affect species
Occurrence (of the Activity)	Historic	Activity is no longer practised
	Anticipated	Activity is anticipated to effect Humpback Whales or habitat *in 10 years*
	Imminent	Activity is anticipated to affect Humpback Whales or habitat *in 5 years*
	Current	Activity is currently practised and affects Humpback Whales or habitat
	Rare	Activity is expected to occur rarely or mitigations in place result in an effect rarely occurring even though activity is occurring
	Unknown	Available information is insufficient to gauge the degree to which the activity may affect species
Frequency (of the Stress)	One-time	Stress is expected to be acute, affecting only once
	Recurrent	Stress occurs infrequently and unpredictably, not on an annual or seasonal basis
	Regular	Stress occurs somewhat regularly, possibly unpredictably, not on an annual or seasonal basis
	Seasonal	Stress occurs only at certain times of the year, or species is migratory
	Continuous	Stress is on-going throughout the year
	Unknown	Available information is insufficient to gauge the frequency with which the stress may affect the species
Severity (of the Effect)	Negligible	No detectable effects
	Low	Effects of the stress are sub-lethal, potentially leading to short-term behavioural changes or transient degradation to habitat, unlikely to affect population viability
	Moderate	Effects of the stress result in chronic physiological and/or behavioural changes (e.g. potential for long-term displacement from habitat), or significant degradation of habitat; may have some effect on long-term population viability
	High	Effects of the stress are lethal, affects population viability
	Unknown	Available information is insufficient to gauge the degree to which the stress may affect individuals, population or habitat

Definitions for levels of relative risk to Humpback Whale survival, reproductive success or degradation of Humpback Whale critical habitat. Adapted from EC (2007).

Rating	Definition	General Description of Activity
Negligible	Activity is considered to have *negligible effect* at this time.	Activities typically do not affect individuals or habitat, or do not occur at this time
Low	There is minimal risk of negative effects at this time	Extent of activities may be localized and occurrence seasonal or infrequent. A low risk rating may indicate some unknown residual effects, or minimal effects to lifespan, reproductive output or habitat
Moderate	There is a moderate risk of negative effects on species recovery at this time	These activities may have chronic effects on individuals or habitat, occurrence of effects may range from rare to continuous, and/or effects may negatively impact lifespan or reproductive output
High	There is a substantial risk of negative effects on species recovery at this time	These activities may have widespread effects and currently occur on a continuous basis and/or lethal effects are likely
Unknown	Available information is insufficient to gauge the degree to which the activity may affect species recovery	Further study required to understand residual effects on individuals or habitat

APPENDIX C: Assessments of the Five Identified Threats to Humpback Whales in B.C.

THREAT ASSESSMENT		
Threat Category	Physical Disturbance	
General Activity	Marine vessel activity in the presence of Humpback Whales	
Specific Stress on Humpback Whales	Blunt force trauma and/or lacerations	
Potential Effect on Humpback Whales	Mortality, injury, stress, reduced survivorship (e.g. resulting from infection), habitat avoidance, habitat degradation	
Causal Certainty of Effect on Individuals	Mortality, injury: *Demonstrated* Stress, reduced survivorship: *Expected* Habitat avoidance: *Plausible*	
Causal Certainty of Effect on Population Viability	Unlikely	
Extent of the Threat	Widespread but concentrated in localized areas	
Current Protections	• SARA • *Fisheries Act,* Marine Mammal Regulations • *Be Whale Wise*: guidelines for paddlers, boaters and viewers	
RESIDUAL EFFECTS ASSESSMENT		
	Individuals in BC	**Population**
Occurrence of the Activity	Current	Current
Frequency of the Activity	Recurrent, Regular in localized areas	Recurrent, Regular in localized areas
Severity of the Effect	Low to High	Low
Relative Risk	Moderate, potentially increasing to High	Low, potentially increasing as shipping traffic increases
Recommendation	Further study required, particularly for impacts to Humpback Whales in southern B.C. Adaptive management as new information becomes available.	
Summary	Between 2001 and 2008, there have been 21 reports of vessels striking Humpback Whales within B.C. waters. Current risk is perceived to be low. Vessel strikes are known to cause injury and mortality to individual Humpback Whales. The population-level frequency of occurrence, proportion of incidents resulting in mortality and the cumulative impacts are less well understood. It is anticipated that the rate of occurrence of vessel strikes will increase as the population grows and as shipping traffic increases, and may result in a greater effect on the total population.	

THREAT ASSESSMENT	
Threat Category	Entanglement
General Activity	Aquaculture or fishing gear in Humpback Whale habitat
Specific Stress on Humpback Whales	Entanglement in net, line or other fishing and aquaculture gear
Potential Effect on Humpback Whales	Mortality, injury, stress, reduced survivorship (e.g. resulting from infection), habitat avoidance
Causal Certainty of Effect on Individuals	Mortality, injury: *Demonstrated* Stress, reduced survivorship: *Expected* Habitat avoidance: *Plausible*
Causal Certainty of Effect on Population Viability	Unlikely
Extent of the Threat	Widespread but concentrated in localized areas
Current Protections	• SARA • *Fisheries Act,* Marine Mammal Regulations • Fisheries management reporting and management measures to reduce by-catch and entanglements • B.C. Marine Mammal Response Network

RESIDUAL EFFECTS ASSESSMENT		
	Individuals in B.C.	**Population**
Occurrence of the Activity	Current	Current
Frequency of the Activity	Seasonal	Seasonal in B.C., Recurrent range-wide
Severity of the Effect	Low to High	Low
Relative Risk	Moderate	Low
Recommendation	Further Study Required. Adaptive management as new information becomes available.	
Summary	For B.C., there have been 40 reports of humpback whale entanglements (from 1987-2008). Humpback Whales are known to become entangled in a variety of fishing and aquaculture gear, leading to injury and occasional mortality. This threat is likely more seasonal in nature, coinciding with the timing of major fisheries and changes in Humpback Whale presence in this area (higher late spring through fall). The population level frequency of these occurrences, proportion resulting in mortality, and cumulative impacts to population viability is less well understood. It is anticipated that rate of occurrences will increase as the population grows and expands.	

THREAT ASSESSMENT	
Threat Category	Toxic Spill
General Activity	Marine transportation of petroleum and other potential toxins
Specific Stress on Humpback Whales	Acute or chronic pathological physiological effects from exposure via contact or ingestion of toxins, petroleum or residue; loss of habitat; prey reduction
Potential Effect on Humpback Whales	Mortality, reduced survivorship (e.g. resulting from compromised organs and infection), reduced reproductive success (e.g. resulting from compromised health of individuals)
Causal Certainty of Effect on Individuals	Mortality, injury: *Demonstrated in other cetaceans* Reduced survivorship or reproduction: *Expected*
Causal Certainty of Effect on Population Viability	Unlikely to Plausible
Causal Certainty of Effect on Habitat	Expected
Extent of the Threat	Widespread but concentrated in localized areas
Current Protections	• SARA • *Fisheries Act,* Marine Mammal Regulations • TEZ – Tanker Exclusion Zone (Voluntary) • Federal Moratorium on Oil and Gas Activities Offshore in BC

RESIDUAL EFFECTS ASSESSMENT			
	Individuals in BC	**Population**	**Habitat**
Occurrence of the Activity	Current and Imminent	Current and Imminent	Current and Imminent
Frequency of the Activity	Continuous and seasonal	Continuous and seasonal	Recurrent range-wide
Severity of the Effect	Low to High	Low to High	Low
Relative Risk	Moderate	Low	Moderate
Recommendation	Further Study Required. Adaptive management as new information becomes available		
Summary	The threat of a toxic spill is associated with a low risk of occurrence accompanied by a moderate to high risk of negative effects to individuals and to habitat. The population level frequency of these occurrences, proportion resulting in mortality, and cumulative impacts to population viability is less well understood. It is anticipated that the risk of occurrence will increase with increased marine traffic and specifically, increased transportation of petroleum in B.C. waters. The risk to habitat is variable and depends on the ability of the toxin to dissipate. It is anticipated that the threat to prey species would be greater in habitat areas with restricted access to open water, as the likelihood of spill dissipation would be reduced.		

THREAT ASSESSMENT	
Threat Category	Prey Reduction
General Activity	Over-exploitation of prey or disruption of prey habitat resulting in low abundance and/or availability of forage species, whether due to natural causes or human activities
Specific Stress on Humpback Whales	Reduced ability to meet energetic demands
Potential Effect on Humpback Whales	Mortality, stress, reduced growth rate and fat storage, reduced survivorship, reduced reproductive success and/or delayed maturation, disease, changes in normal seasonal distribution patterns and/or diet
Causal Certainty of Effect on Individuals	Mortality, stress, reduced growth rate and fat storage, reduced survivorship, reduced reproductive success and/or delayed maturation, disease: *Plausible* Changes in normal seasonal distribution patterns, changes in diet: *Plausible*
Causal Certainty of Effect on Population Viability	Plausible
Causal Certainty of Effect on Habitat	Expected
Extent of the Threat	Unknown
Current Protections	• *Species at Risk Act* (SARA) • *Fisheries Act* • DFO Pacific Region Integrated Fisheries Management Plans • DFO Policy on New Fisheries for Forage Species

RESIDUAL EFFECTS ASSESSMENT			
	Individuals in BC	**Population**	**Habitat**
Occurrence of the Activity	Unknown	Unknown	Unknown
Frequency of the Activity	Seasonal to Unknown	Unknown	Unknown
Severity of the Effect	Moderate	Low	Moderate to High
Relative Risk	Unknown – Risk of effects likely to increase as the population grows	Unknown – Risk of effects likely to increase as the population grows	Moderate
Recommendation	Further Study Required		
Summary	As the population continues to grow, food limitation will have a greater influence on the survival of individuals and potentially to population viability. At this time, the risk to humpbacks locally and range-wide is unknown. A main feature of habitat is prey availability; reduction in prey quality/quantity substantially threatens the quality of the habitat.		

THREAT ASSESSMENT	
Threat Category	Acoustic Disturbance
General Activity	Blasting, pile driving, sonar, seismic, ship noise, construction or any other anthropogenic loud underwater sounds
Specific Stress on Humpback Whales	Noise disruption leading to displacement from feeding habitat or migratory route
Potential Effect on Humpback Whales	Habitat avoidance, interrupting of feeding, changes in respiration and dive patterns, masking of communication, modified migration path, entanglement, strike, interference with prey detection and predator avoidance
Causal Certainty of Effect on Individuals	Habitat avoidance, interrupting of feeding, changes in respiration and dive patterns, masking of communication, modified migration path: *Demonstrated* Entanglement, prey detection, predator avoidance: *Plausible*
Causal Certainty of Effect on Population Viability	Unlikely to Plausible
Causal Certainty of Effect on Habitat	Expected
Extent of the Threat	Widespread but concentrated in localized areas
Current Protections	• *Fisheries Act*, Marine Mammal Regulations • Seismic surveys and development proposals reviewed by DFO on case to case basis, mitigation measures developed • Military sonar use protocols for mitigating effects to marine mammals • DFO Statement of Canadian Practice with respect to Mitigation of Seismic Sound in the Marine Environment

RESIDUAL EFFECTS ASSESSMENT			
	Individuals in BC	**Population**	**Habitat**
Occurrence of the Activity	Current or Imminent	Current or Imminent	Current or Imminent
Frequency of the Activity	Seasonal to Continuous	Seasonal to Continuous	Recurrent
Severity of the Effect	Unknown	Unknown	Unknown
Relative Risk	Unknown	Unknown	Low to Moderate
Recommendation	Further Study Required		
Summary	Anthropogenic sources of underwater sound have the potential to disrupt and displace Humpback Whales, potentially interfering with foraging in B.C. However, to what degree this threat is currently occurring, its impacts (both direct and cumulative), and long-term effects on individuals and population viability are poorly understood. This threat is expected to increase as the population grows and coastal development activities increase. Risk to habitat is elevated in areas with reduced sound dissipation – i.e. fjords and channels.		

APPENDIX D: Additional Anthropogenic Threats Considered

Chronic Persistent Bioaccumulating Toxins (Legacy and Emerging)

Known generically as Persistent Bioaccumulating Toxins (PBTs), or alternatively Persistent Organic Pollutants (POPs), these anthropogenic toxins are toxic, persistent, and tend to bioaccumulate within organisms and ecosystems. Since the 1970s and 80s, sources of many well-known legacy toxins (such as polychlorinated biphenyls (PCBs) and dichloro-diphenyl trichloroethanes (DDTs)) have been largely phased out or eliminated in industrialized countries. Consequently there has been a general decline in environmental concentrations (Alcock and Jones 1996, Muir *et al.* 1999) of these toxins. However they are likely to remain present in the environment for some time.

New emerging toxins of concern include polybrominated diphenyl ether flame retardants (PBDEs), perfluorooctanoic sulfate (PFOS), pesticides, and endocrine disruptors such as steroids, phthalates and synthetic estrogens (Ikonomou *et al.* 2002, Kannan *et al.* 2001, Porte *et al.* 2006). It can be reasonably expected that as the human population increases, so will the level of hormones and other contaminants discharged in waste and storm water. In the coming years, emerging contaminants such as PBDEs may be of increasing concern to marine mammal populations (Rayne *et al.* 2004), as demonstrated by the extremely high toxic loads in B.C.'s killer whale populations (Ross 2006)

However, data on bioaccumulation of toxic chemicals in B.C.'s other cetacean species may not adequately illustrate the relative risks to Humpback Whales due to differing diet compositions. Higher trophic-level prey such as salmon or seals, tend to present a greater risk to the predator for bioaccumulation of toxic contaminants (Ross 2006). Since humpbacks feed on relatively low trophic-level prey (krill and forage fish), they are likely at less risk from bioaccumulation of PBTs than higher trophic-level cetaceans (e.g. killer whales) (O'Shea and Brownell 1994).

Coastal species tend to have higher contaminant levels than oceanic populations, and Humpback Whales' consumption of herring and sardine do put them at a slightly higher trophic-level than the other baleen whales. Metcalfe *et al.* (2004) indicated that in general whales may be particularly vulnerable to contaminant exposure during early life stages. Although population level effects are likely minimal at this time, this source of vulnerability should be monitored, and research on PBT levels in blubber and contaminant levels in prey (from the central and north coasts of B.C.) will assist in clarifying the magnitude of this potential threat.

Biological Toxins

Biological toxins are naturally present in the world's ecosystems, however occurrence and densities of naturally-occurring biotoxins can be manipulated by anthropogenic influences such as sewage outflow. Impacts of biotoxins on cetaceans can be difficult to ascertain, but can range from chronic infection to acute mortality.

In 1987, fourteen north Atlantic Humpback Whales mortalities were attributed to exposure to a neurotoxic dinoflagellate present in their prey, Atlantic mackerel (*Scomber scombrus*) (Geraci *et* *al.* 1989). Geraci *et al.* (1989) proposed that certain diving adaptations in whales may make them especially vulnerable to systemic neurotoxins. When whales dive, blood is channelled to the heart and the brain, potentially directing neurotoxins to vital areas. Limited blood flow to the liver and kidneys may slow metabolism and elimination of toxins during such dives.

At present, biotoxins are not identified as a key threat to the North Pacific Humpback Whale population, due to its population size, and the potential wide range of naturally occuring impacts from chronic, low-level infection to acute effects.

Resumption of Whaling

Widespread commercial harvesting of Humpback Whales led to their global decline, and spearheaded several marine conservation efforts ranging from species-specific protections (i.e. IWC ban on commercial whaling of humpbacks) to general conservation of ocean ecosystems. The IWC and its member countries officially banned commercial hunting of Humpback Whales in the 1960s. Several First Nations, including the Nuu-chah-nulth and A'housaht, have indicated interest in including subsistence whaling rights for humpbacks and other whales in treaty negotiations. The Makah tribe (Neah Bay, WA) has also expressed interest in exercising hunting rights for whales in U.S. waters and this may extend to harvest of humpbacks as well. However, there is currently no subsistence or commercial harvest of Humpback Whales in the North Pacific and resumption of large-scale whaling in B.C. is considered extremely unlikely at this time.

As the North Pacific population grows over time, resumption of scientific, subsistence or commercial whaling may become a future consideration, whether for human consumption or to reduce potential predatory impacts on economically important commercial fisheries (DeMaster *et al.* 2001). Within the time span of this recovery strategy, resumption of either localized harvests of humpbacks in B.C. or widespread, large-scale whaling throughout the North Pacific is considered highly unlikely. Monitoring of the population will ensure that trends in distribution, abundance and reproductive rates are well understood in the event of future changes in national or international positions on subsistence or large-scale whaling.

APPENDIX E: BACKGROUND ON POPULATION TRENDS AND HARVESTS OF ZOOPLANKTON, HERRING AND SARDINE IN B.C. WATERS

Zooplankton

Multi-year average seasonal trends in zooplankton biomass and community composition for south Vancouver Island, north Vancouver Island shelf and offshore regions (including Hecate Strait and off the Scott Islands) are often very similar but variability between years and locations is also common (Mackas *et al*. 2004; Mackas *et al.* 2008). Off the south coast of Vancouver Island, peak zooplankton biomass is generally from April to June but in northern waters occurs in June and July. Hecate Strait tends to have a lower total biomass by 1.5 - 3 times compared to the continental margin off Vancouver Island (Mackas *et al*. 2008). The within-season, within-region variability in zooplankton abundance is typically a factor of 10-30 (i.e. 3 to 5-fold the amplitude of "average") due to spatial patchiness and inter-annual variability (Fulton *et al.* 1982; Mackas *et al.* 2007). Small to medium sized copepods (i.e. genera *Pseudocalanus, Calanus*, *Neocalanus, Acartia* and *Oithona*) tend to dominate the zooplankton community, especially in the spring, whereas peaks in euphausiid biomass (i.e. genera *Euphausia* and *Thysanoessa*) occur in late summer to early winter (LeBrasseur and Fulton 1967; Perry 1984; Mackas *et al.* 2004).

High euphausiid biomass is often found over steep sea floor slopes, which include the continental slope and margins of the deep troughs leading from the outer coast into Queen Charlotte Sound (Simard and Mackas 1989; Mackas *et al*. 1997; Lu *et al*. 2003). Variability in location and density of zooplankton aggregations appears to result from interactions between currents, bathymetry and zooplankton physical swimming abilities, the latter especially true for larger zooplankton (Simard and Mackas 1989; Mackas *et al.* 1997; Lu *et al*. 2003). In inlets, copepods, euphausiids, ctenophores and barnacle larvae are frequently the most abundant zooplankton (Mattson and Wing 1978; Mackas *et al.* 2007). In B.C., commercial harvesting of zooplankton has been permitted since 1983 but only for euphausiids (*Euphausia pacifica).* This fishery is managed by an annual quota (of 500 tonnes, since 1990) and has been restricted to areas within Knight Inlet, Jervis Inlet and the Strait of Georgia (For more information on the euphausiid fishery visit,

http://www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/euphausiid/default_e.htm

Pacific herring

Since the inception of stock assessment efforts in the 1930s, trends in Pacific herring abundance and spatial and temporal distributions of spawning and fishing patterns have shown considerable inter-annual variability within and between large scale regions (Schweigert *et al* 2009). However, from 2003 to 2008, declines in abundance from approximately 270,000 to approximately 70,000 tonnes coast-wide have been observed (Schweigert *et al*. 2009). These declines are associated with indicators of increased natural mortality, poor recruitment and reduced size at age.

Within the period from 1985 to 2008, annual B.C. commercial herring catches range from 11,000 to 42,000 tonnes, which corresponds to estimates of harvest rates ranging from 11-23% of total biomass. Most fishing occurs near spring spawning events (late February - April) in inshore sheltered waters near large spawning aggregations. There are IFMPs for roe herring, spawn on kelp, food and bait herring, and special use herring. Commercial fisheries are closed when stock abundance forecasts are below minimum biomass thresholds (by stock assessment region) and maximum commercial harvest rates target 20% of forecasted stock sizes. Similar harvest control rules for herring have been implemented in Washington and Alaska.

Pacific sardine

Considerable inter-annual variability in stock abundance and distribution has also been observed for Pacific sardine. Most sardine schools in B.C. waters are thought to be extended components of a meta-population linked to California waters, where fish migrate into B.C. in the summer to forage on plankton and migrate southbound for winter and spring spawning. Sardine biomass estimates reconstructed from scale deposits in marine sediments off southern California indicate that stock abundance undergoes large fluctuations roughly every 60-80 years (Ware and Thomson 1991, Baumgartner *et al.* 1992), and over the past 2,000 years, sardine biomass may have ranged from less than 50 thousand tonnes to a peak of about 16 million tonnes. Estimates of adult sardine abundance in California for the period of 1981 to 2007 range from below 200 000 tonnes (1981-1990) to over 1.6 million tonnes (2000), and more recent estimates range from 1.2 million down to 800 000 tonnes (2003-2007) (Hill *et al*. 2008).

From the 1920s to 1940s, harvest rates for sardine in B.C. waters were maintained at high levels for several years (i.e. often near 40% or more) and the stock drastically declined in the 1940s leading to a fishing moratorium and a designation of "Special Concern" in 1987 under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Sardines reappeared in B.C. waters in 1992 and some fishing was initiated in 1995 (23 tonnes). Based on updated information, in 2002 sardines were re-assessed by COSEWIC as Not at Risk. Annual abundance and migration rate estimates have been generated for sardines in B.C. based on summer trawl survey observations (Schweigert *et al.* 2009b) and U.S. stock assessment efforts (Hill *et al.* 2008). Although a maximum harvest rate of 15% has been applied to B.C. sardine stocks, until recently, annual harvests fluctuated considerably below harvest ceilings. Since the 1990s there have been considerable increases in abundance (exceeding 200,000 tonnes) and catches (to approximately 18,000 tonnes). In the last decade, there also appears to be some correlation in the distribution of sardines and humpbacks in B.C. waters.

APPENDIX F: RECORD OF COOPERATION AND CONSULTATION

North Pacific Humpback Whales are listed as a Threatened species on Schedule 1 of the *Species at Risk Act* (SARA). As an aquatic species, they are managed by both by Fisheries and Oceans Canada (DFO) and by the Minister of the Environment (as competent Minister for Parks Canada Agency under SARA)

DFO brought together a small internal working group of technical experts in science, and management to develop an initial draft of this recovery strategy. A 3-day Humpback Whale Recovery Planning Technical Workshop was hosted January 12-14, 2009 to provide a forum for sharing knowledge and expertise on Humpback Whales to support the drafting of this strategy. A group of scientific and technical experts including independent researchers, all coastal First Nations, environmental non-governmental organizations, and other governmental (federal and provincial) staff from both Canada and the United States were contacted to attend this workshop. Two invitation letters were sent to all coastal First Nations soliciting participation in development of the Recovery Strategy, and in the workshop. This workshop was invaluable in assisting the DFO working group in drafting the Recovery Strategy for North Pacific Humpback Whales in Canada. Given that the population considered in this document frequents international waters, including both Canadian and U.S. waters, bilateral government and non-government input and collaboration was sought. The draft strategy was sent to Parks Canada Agency, Environment Canada, Department of National Defence, Transport Canada, Natural Resources Canada, Canadian Coast Guard and the Province of British Columbia for review and comment.

This draft recovery strategy was posted to the DFO Pacific Region Consultation website for a public comment period from April 21 to May 24, 2010. These consultations were web-based, and included mail-outs to all coastal First Nations soliciting input and feedback on the draft recovery strategy. In addition, a message announcing the development of this document was sent to a marine mammal list serve (MARMAM) with broad local and international distribution to marine mammal researchers and interested parties. Notification of this consultation period was sent to a distribution list of whale-related contacts provided to DFO in recent years from environmental groups, non-governmental organizations, government agencies and the eco-tourism sector.

Comments were received from two First Nations, three non-governmental organizations, the Province of B.C and academia. Processes for coordination and consultation between the federal and British Columbian governments on management and protection of species at risk are outlined in the *Canada-B.C. Agreement on Species at Risk* (2005). The Parks Canada Agency provided input during the development of the recovery strategy through involvement on the Technical Team and as a competent agency under SARA.

Feedback from the public, scientific experts and government agencies has been carefully considered in the production of this recovery strategy. Peer review of the document was not considered necessary as applicable experts were in attendance at the Technical Workshop and were provided an opportunity to provide input through public consultation.

Technical Workshop Participants:

Brianna Witteveen	University of Alaska
C. Scott Baker	Oregon State University
John Calambokidis	Cascadia Research Collective
Ed Gregr	University of British Columbia
Andrea Rambeau	University of British Columbia
Jeep Rice	University of British Columbia
Brian Gisborne	Juan de Fuca Express
Jan Straley	University of British Columbia
Lynne Barre	NOAA Office of Protected Resources, Seattle
David Matilla	Hawaiian Islands Humpback Whale Sanctuary
Doug Sandilands	Cetus Research & Conservation Society
Nic Dedeluk	Cetus Research & Conservation Society
Lance Barrett-Lennard	Vancouver Aquarium Sciences Centre
Rob Williams	University of British Columbia
Erin Ashe	University of British Columbia
Kaja Brix	NOAA Office of Protected Resources, Alaska
Randy Carpenter	Heiltsuk Fisheries Program
Kyle Clifton	Gitga'at Fisheries Program
Karen Calla	Fisheries and Oceans Canada
Luciano Dalla Rosa	University of British Columbia
Fred Sharpe	Alaska Whale Foundation
Jake Schweigert	Fisheries and Oceans Canada
Melissa Boogaards	Fisheries and Oceans Canada
Tatiana Lee	Fisheries and Oceans Canada
John Ford	Fisheries and Oceans Canada
Graeme Ellis	Fisheries and Oceans Canada
Linda Nichol	Fisheries and Oceans Canada
Paul Cottrell	Fisheries and Oceans Canada
Lisa Spaven	Fisheries and Oceans Canada
Robin Abernethy	Fisheries and Oceans Canada
Rob Russell	Habitat Biologist under contract to Fisheries and Oceans
Gabrielle Kosmider	Fisheries and Oceans Canada
Linnea Flostrand	Fisheries and Oceans Canada
Scott Keehn	Fisheries and Oceans Canada