Canada

Living Marine Legacy of Gwaii Haanas. IV:

Marine Mammal Baseline to 2003 and Marine Mammal-related Management Issues throughout the Haida Gwaii Region

K.A. Heise, N.A. Sloan,
P.F. Olesiuk, P.M. Bartier,
and J.K.B. Ford

Report 38
December, 2003

Parks Canada
Technical Reports
in Ecosystem Science

Maintaining
Ecological Integrity
of our Parks

Parcs Canada
Rapports techniques
en matière de sciences
des écosystèmes

Maintenir
l'intégrité écologique
de nos parcs

Parks Canada Parcs Canada

Canada

Atlantic Region, Parks Canada is producing three report series in ecosystem science. They are intended to communicate new scientific information, document scientific data, summarize existing knowledge, or offer technical recommendations. The primary function and the intended audience of a report determine the series in which it will be published. Each report series contains scientific and technical information that contributes to existing knowledge but is not in a form suitable for the primary journal literature.

- ***Parks Canada-Technical Reports in Ecosystem Science*** promote a wide distribution of scientific and technical information from Parks Canada's ecosystem investigations. The subject matter, and the series reflect the broad interest and policies of Parks Canada in ecosystem science. This series includes such work as, ecosystem and resource inventories, studies, surveys of species or guilds, and innovative management concepts.
- ***Parks Canada - Ecosystem Science Review Reports*** provides a forum for literature reviews, bibliographies, and reviews of management options that are often prepared for or by Parks Canada. Resource Descriptions and Analyses or chapters thereof will be published in this series.
- ***Parks Canada - Ecosystem Monitoring and Data Reports*** provide a medium for filing and achieving data compilations where little or no analysis is included. Such compilations commonly are prepared in support of primary publications or Technical Reports in Ecosystem Science. Raw data not available in a national data base and considered worth archiving is published as a Parks Canada - Ecosystem Monitoring and Data Report.

Ecosystem Science Reports are printed in the official language chosen by the author to meet the language preference of the likely audience, with an abstract in the second official language.

Objectives

Our objectives for these report series are;

- To communicate the results of ecosystem science research to the scientific and management communities, and to the public interested in Parks Canada environmental and conservation activities;
- To provide credible, accurate, and professional publications through a peer review process,
- To encourage creativity, effectiveness, and teamwork in conducting research and in providing information through publications.

Peer Review

The editor appoints two referees to critically review each manuscript. Referees are found, if possible, from scientific staff within Parks Canada. Due to areas of expertise, available time, and to avoid the potential of 'inbreeding' external reviewers will often be sought. Referees review the manuscript and return it to the editor with their written comments. The editor then returns the paper to the author(s) with the referee's comments. The author(s) consider(s) the referees' comments and incorporates those that they accept, into the report. The author(s) return(s) the revised manuscript to the editor and/or provides a written rationale for any exclusions of the referees' comments considered unacceptable. The editor then sends the revised manuscript to the Chief Park Warden or for the case of Regional Office staff to the author(s) direct supervisor for approval to publish and printing. At the editor's discretion, the appointment of referees may be dispensed with, if the publication is minor in nature. In such instances, the editor and the author's direct supervisor would assume the roles of the referees. In the unlikely event that an author and editor are in disagreement over a manuscript, the matter will be refereed to a Senior Departmental Manager for adjudication.

Directives for Authors

These series are intended for the publication of work in ecosystem science that is conducted in the Atlantic Region. They are available for use by any Parks Canada or Department of Canadian Heritage staff or others working in collaboration with, or on a contract to, the Department of Canadian Heritage.

The author(s) submits one paper copy of the completed draft of their paper and a digital version on a diskette in WordPerfect Windows or DOS format to the regional editor along with three suggested referees. Suggested referees should not have been previously involved with the manuscript.

Detailed instructions to authors can be obtained from:

Neil Munro
Report Series Editor

Parks Canada
Historic Properties
Halifax, Nova Scotia
B3J 1S9

(902) 426-2797
(FAX) 426-2728

Parks Canada

Technical Reports in Ecosystem Science

Report 038

Living Marine Legacy of Gwaii Haanas. IV: Marine Mammal Baseline to 2003 and Marine Mammal-related Management Issues throughout the Haida Gwaii Region

by

K.A. Heise,[1,2] N.A. Sloan,[3] P.F. Olesiuk,[4] P.M. Bartier,[3] and J.K.B. Ford[4]

2003

[1]Department of Zoology, University of British Columbia, Vancouver, B.C.
[2]Vancouver Aquarium Marine Science Centre, Vancouver, B.C.
[3]Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte, B.C.
[4]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, B.C.

National Library of Canada cataloguing in publication data

Main entry under title :

Living marine legacy of Gwaii Haanas. IV.
Marine mammal baseline to 2003 and marine mammal-related management issues throughout the Haida Gwaii Region

(Parks Canada-Technical Reports in Ecosystem Science ; report 38)
Includes an abstract in French.
Includes bibliographical references.

ISSN 1200-3298: 38
ISBN 0-662-35840-6
Catalogue No. R61-2/19-38-2004E

1. Marine mammals – British Columbia – Queen Charlotte Islands.
2. Marine mammals – Gwaii Haanas National Park Reserve and Haida Heritage Site (B.C.)
3. Biotic communities -- British Columbia – Queen Charlotte Islands.
4. Biotic communities -- Gwaii Haanas National Park Reserve and Haida Heritage Site (B.C.)
5. Gwaii Haanas National Park Reserve and Haida Heritage Site (B.C.) – Management.

I. Heise, K.A. (Kathy Ann), 1959 - .
II. Parks Canada. Atlantic Region.
III. Title.
IV. Series: Technical reports in ecosystem science ; no. 38.

QL721.5B7L58 2004 333.95’95’097112 C2004-980000-0

Published by authority of the Minister of Canadian Heritage

Contents

List of Figures

List of Tables

Abstract

This is the fourth report in a series of baseline marine biological inventories for Haida Gwaii (Queen Charlotte Islands) region including Gwaii Haanas National Park Reserve and Haida Heritage Site. We present regional distribution and life history information for 26 species of marine mammals, including cetaceans, pinnipeds and the sea otter. We also review the history of research and conservation as well as traditional Haida knowledge of marine mammals. This background provides a context for discussion of marine mammal issues and how they will influence ecosystem-based management of the proposed Gwaii Haanas National Marine Conservation Area. The role of marine mammals in regional marine ecosystems is important, and they may be useful indicators of ecosystem well-being. The prospect of oil and gas development, bioaccumulation of toxins, interactions with commercial fisheries and tourism are conservation issues facing marine mammals.

Résumé

Ce rapport est le quatrième d'une série de documents de référence portant sur l'inventaire biologique des espèces marines de la région de Haïda Gwaii (îles de la Reine-Charlotte), y compris la réserve de parc national et le site du patrimoine haïda Gwaii Haanas. Nous y présentons des renseignements sur la distribution régionale et sur le cycle vital de 26 espèces de mammifères marins, notamment des cétacés, des pinnipèdes et la loutre de mer. Nous examinons également l'état des recherches et les mesures de conservation prises par le passé, de même que les connaissances traditionnelles des Haïdas au sujet des mammifères marins. Cet historique servira de base à la discussion des problèmes auxquels sont confrontés les mammifères marins et de leur incidence sur l'approche de gestion axée sur l'écosystème adoptée pour le projet d'aire marine nationale de conservation Gwaii Haanas. Les mammifères marins jouent un rôle important dans l'écosystème marin de la région; ils pourraient peut-être même servir d'indicateurs de l'état de l'écosystème. Les possibilités de travaux d'exploitation pétrolière et gazière, la bioaccumulation des toxines, les interactions avec les pêcheurs commerciaux et le tourisme sont tous des facteurs qui nuisent à la conservation des mammifères marins.

Acknowledgements

We particularly thank Dr. Lance Barrett-Lennard (Vancouver Aquarium Marine Science Centre) for reviewing the whole report, providing the preface, and facilitating access to the B.C. Cetacean Sightings Network database. We thank Doug Sandilands (B.C. Cetacean Sightings Network) for earlier maps of cetacean sightings. Linda Nichol (Fisheries and Oceans Canada [DFO], Pacific Biological Station, Nanaimo) kindly made available the whaling history database and reviewed an entire draft as well. We also thank Dr. Dolly Garza (University of Alaska and Alaska Sea Otter and Steller Sea Lion Commission, Sitka) for the 1996-1998 local knowledge survey data and to Doug Burn (U.S. Fish and Wildlife Service, Anchorage) for historical data on sea otter distribution in southeast Alaska. Victor Fradette and Ray Sjolund (DFO, Queen Charlotte City) provided insights on mammals and local fisheries management. Greg Martin and Charlotte Tarver (Laskeek Bay Conservation Society, Queen Charlotte City) generously shared the Society's annual marine mammal observations from 1990 to 2003. Keith Moore (Queen Charlotte City) shared information on local lobbying for sea otter translocations in the 1980s. Dr. Pippa Shepherd (Parks Canada, Vancouver) kindly reviewed the special conservation status section.

Rose Harbour whaling station workers posing in the mouth of a North Pacific right whale (date unknown; photograph courtesy of the British Columbia Archives, image E-01609, Victoria, B.C.).

Preface

Many who visit Haida Gwaii are struck by its beauty and wildness: it is not surprising that the Haida named the area 'place of wonder'. Yet, there is a darker side to this incredible place. For many years, marine mammals were heavily exploited in the waters surrounding the islands. By 1968, over 9,4000 whales were taken by commercial whalers in the region, and sea otters were virtually, if not completely, extirpated. Pinnipeds did not escape the attention of hunters either: elephant seals and fur seals were hunted to commercial extinction, and seals and sea lions were culled because they competed with humans for fish.

The opportunity for wonderment at the diversity and abundance of marine mammals at Haida Gwaii is returning: many of the mammal populations that were once depleted are beginning to show signs of recovery. Gray whale and harbour seal population levels are now at or close to historical levels. Humpback whales are seen with increasing frequency, blue whales are occasionally sighted in Hecate Strait near the South Moresby shore, and sperm whales can be found feeding in the deeper canyons of southern Hecate Strait and Queen Charlotte Sound. For other species, such as fin and right whales, the recovery may be more fragile. Indeed, no North Pacific right whales have been seen in the region since 1970.

Although the killing of marine mammals has not been allowed since 1970, marine mammal populations are still under pressure from a variety of sources. Commercial fishing has reduced some prey populations to well below their earlier abundance. There is currently a call to lift the moratorium on oil and gas exploration and development in the Queen Charlotte Basin, an activity that is not without significant risk. Contaminant levels in some species are so high that carcasses must be disposed of as toxic waste. These are just a few of the many important conservation issues facing marine mammals that are discussed herein.

A great deal of information describing the harvest, both commercial and aboriginal, of whales and pinnipeds is also presented herein, along with detailed maps showing the locations where whales were harvested. A detailed summary of the life history and population status of each species in the region is included, which establishes an important baseline for what is known about all of the mammals that travel the waters of Haida Gwaii. Importantly, the authors also make significant recommendations about management and future research that can be used to guide decision makers as they are forced to deal with controversial issues. The information presented in this report is intended for a wide reading audience, who I think will come away from it with a much greater appreciation and understanding of the marine mammals of Haida Gwaii, and of the history of this incredible place of wonder.

Dr. Lance Barrett-Lennard
Senior Marine Mammal Scientist
Vancouver Aquarium Marine Science Centre
Vancouver, B.C.

Adjunct Professor
Department of Zoology, U.B.C.
Vancouver, B.C.

Executive Summary

This is the fourth report in a series providing baseline marine biological inventories for the Haida Gwaii (Queen Charlotte Islands) archipelago region including the proposed Gwaii Haanas National Marine Conservation Area (NMCA) surrounding Gwaii Haanas National Park Reserve and Haida Heritage Site. Such assessments of biodiversity are central when addressing Parks Canada Agency's marine policy to protect representative samples of Canada's marine areas by maintaining ecosystem structure and function while enabling multiple sustainable uses such as fisheries and tourism.

This report includes distribution and basic life-history information on 26 species of marine mammals known to occur around Haida Gwaii. Information on seasonal occurrence (from a geographic information system [GIS] database) and other life history characteristics are included where available. We also include the following:

- a review of aboriginal (Haida) knowledge of marine mammals;
- an overview of regional marine mammal science and hunting history;
- a review of the conservation status of local marine mammals;
- a discussion of threats to marine mammals;
- an analysis of marine mammal issues relevant to future marine area management;
- recommendations for further work to address information gaps; and
- a detailed bibliography of source publications to enable further inquiry.

This volume is a technical reference defining marine mammal issues for forthcoming public consultations towards establishment of the Gwaii Haanas NMCA within the Haida Gwaii marine region. Our intent is to advise a wide readership including members of aboriginal and coastal communities, fishery and tourist sectors, non-governmental organisations, government agencies and researchers about regional marine mammals.

We have synthesised this information with a view to aiding discussion for long-term conservation management and identifying key knowledge gaps warranting attention. We discuss how marine mammal issues will influence ecosystem-based management of the proposed NMCA. The role of marine mammals is an important component of our understanding of regional marine ecosystems and they could be used as indicators of ecosystem well-being. For marine mammals, the prospect of oil and gas development, bioaccumulation of toxins, interactions with commercial fisheries and tourism are local conservation issues.

INTRODUCTION

Marine mammals (whales, dolphins, porpoises, seals, sea lions and sea otters) are key components of the marine fauna of the Haida Gwaii (Queen Charlotte Islands) region. Societal attitudes towards marine mammals have evolved remarkably over the last 40 years, from ruthless exploitation to affection and widespread respect. These animals are now enormously popular with the public and their presence is often considered symbolic of environmental health. Haida Gwaii populations of large whales supported commercial whaling for over 55 years, but now the commercial focus for marine mammals is sustainable ecotourism.

In this report, we briefly review the biology of the 26 species of marine mammals that have been recorded in the waters of Haida Gwaii. Where data exist, we describe the distribution and trends in abundance of each species. We also include the following:

- a review of published aboriginal (Haida) knowledge of marine mammals;
- a brief overview of regional marine mammal science and hunting history;
- a review of the species-at-risk status of local species;
- a discussion of threats to marine mammals, such as pollution;
- an analysis of marine mammal issues relevant to marine area management; and
- a detailed bibliography of the source materials to facilitate further inquiry.

This report is aimed at a broad readership and provides a synthesis of information on local marine mammals and connects this knowledge to marine area management issues. It is the fourth report in a series of baseline marine inventories of Haida Gwaii. Others in the series are on marine plants (Sloan and Bartier 2000), marine invertebrates (Sloan *et al.* 2001), and marine birds (Harfenist *et al.* 2002). The fifth report will be on shoreline biophysical inventory and others are planned for marine fishes and regional oceanography. This series will aid public consultation within the process to establish a National Marine Conservation Area (NMCA) extending up to the ordinary high water mark surrounding Gwaii Haanas National Park Reserve and Haida Heritage Site. The land national park reserve is cooperatively managed by Parks Canada Agency (PCA), mandated under the *Canada National Parks Act*, and the Council of the Haida Nation through the *Gwaii Haanas Agreement* of 1993.

Much information on marine mammals has been recorded in geographic information system (GIS) databases. In future, it will be possible to layer these inventories over other databases such as human use, water depth and other oceanographic features, etc. to address technical questions in aid of area management. Establishing a geo-referenced inventory is an important step towards linking species with habitat type and will augment our understanding of the role of marine mammals in Haida Gwaii ecosystems and the proposed Gwaii Haanas NMCA.

The marine mandate for PCA in the *Canada National Marine Conservation Areas Act* (passed June, 2002) [http://laws.justice.gc.ca/] is the protection and conservation of representative examples of marine regions, and includes maintaining ecosystem structure and function while permitting multiple sustainable uses, such as fisheries and tourism, within conservation areas. In order to accomplish this, an inventory of species diversity and life history is essential. The inventory presented here compliments PCA's mandate in the *Canada National Parks Act* (amended 2000) towards ecological integrity as parks strive to become "*centres of ecological understanding*" (Parks Canada Agency 2000). Interagency cooperation under Canada's Oceans Strategy led by

Fisheries and Oceans Canada [DFO] (DFO 2002a) means that Gwaii Haanas will belong to a proposed coordinated federal network of marine protected areas. Nearby areas include Bowie Seamount (180 km west of Haida Gwaii; Figure 1), proposed as a pilot MPA under the *Oceans Act* in 1998 (mandated to DFO) and a proposed Marine Wildlife Area around the Scott Islands (northern tip of Vancouver Island; Figure 1) by the Canadian Wildlife Service (Environment Canada) under the *Canada Wildlife Act* (CWS MPAs 1999). All this is happening at a time of great interest in marine conservation (NRC 2001), including a burgeoning popular science literature (Safina 2002; Ellis 2003).

In summary, this volume is aimed at a wide readership interested in regional marine mammal issues, particularly those associated with forthcoming public consultations towards declaration of Gwaii Haanas NMCA. Our report includes the following:

- information on cultural and scientific knowledge of regional marine mammals;
- a description of how government policy and legislation has influenced conservation;
- an integrated overview relevant to regional marine conservation;
- identification of noteworthy knowledge gaps; and
- recommendations for marine mammal science in support of future management.

STUDY AREA

The study area includes the Haida Gwaii archipelago and contiguous regional waters including Dixon Entrance, Hecate Strait, Queen Charlotte Sound and westward into the Northeast Pacific (Figure 1). It extends from the mainland coast west to 145°W and between 50.5°N and 55°N. Hereafter we call this area the Haida Gwaii region. The large area of the Haida Gwaii region reflects Parks Canada's policy of describing regional marine attributes, not just those within conservation area boundaries (Parks Canada 1994). The area covered herein extends from sheltered estuaries and nearshore kelp forests to the open ocean.

Thomson (1989) characterized this region's oceanography through transition processes linking open-ocean and coastal runoff into three domains as follows:

- Oceanic – along the west coast where offshore processes dominate;
- Eastern Coastal – including Hecate Strait and Queen Charlotte Sound where offshore and estuarine processes are both influential; and
- Northern Coastal – consisting of Dixon Entrance and adjoining channels in which runoff (*e.g.*, Nass and Skeena Rivers) creates estuarine flow patterns.

Regional nearshore oceanography is less well understood than the larger-scale offshore oceanographic processes.

There are several published reviews of the oceanography of the Haida Gwaii region (Thomson 1989; Robinson *et al.* 1999; Crawford 1997, 2000). The continental shelf (<200 m water depth) is ~30 km wide off Langara Island and narrows to ~5 km wide along much of the west coast of Gwaii Haanas (Figure 1). Seaward of the continental shelf is a steep continental slope descending to >2,500 m depth within 30 km offshore of Gwaii Haanas (Barrie and Conway 1996). The 200 m isobath demarcates the edge of the continental shelf before the descent down the slope into the deep-sea. Hecate Strait off the east coast of Haida Gwaii extends ~75 km to the northern British Columbia mainland and is generally <150 m depth (Thomson 1989; Fedje and Christensen 1999). Haida Gwaii's

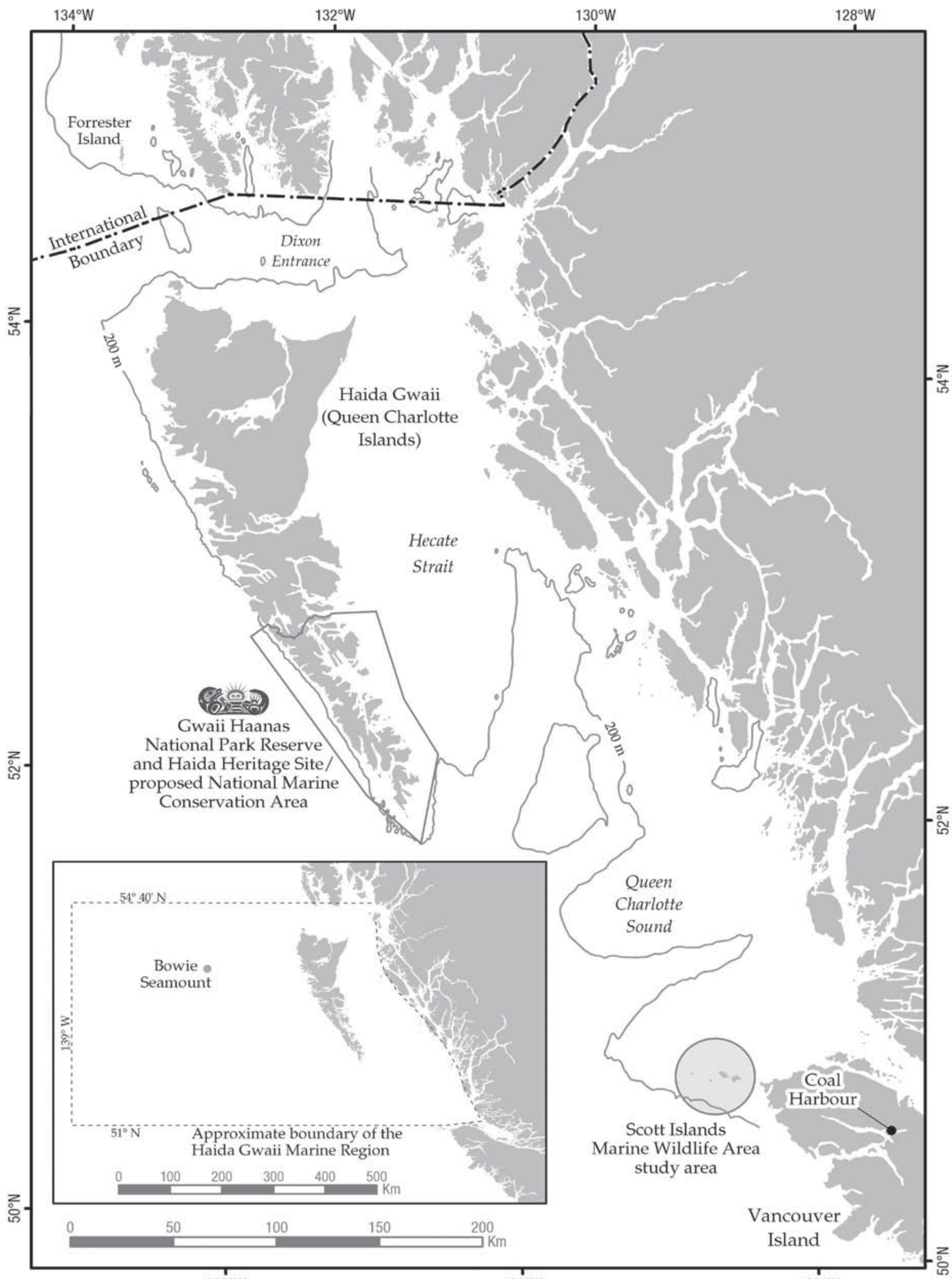

Figure 1. Map of the Haida Gwaii region including Gwaii Haanas National Park Reserve and Haida Heritage Site and the proposed Gwaii Haanas National Marine Conservation Area. The 200 m depth contour demarcates the edge of the continental shelf before steep decline of the continental slope in the deep ocean. Locations of Bowie Seamount (pilot Marine Protected Area) and Scott Islands (proposed Marine Wildlife Area) are also shown.

west coast is exposed to the full force of the Northeast Pacific's weather.

Gwaii Haanas comprises the southern end of Moresby Island and associated islands in southern Haida Gwaii (Figure 1). Gwaii Haanas includes ~1,470 km^2 of land, ~3,400 km^2 of proposed sea space and ~1,700 km of shoreline. Gwaii Haanas' coastal zone is a highly incised, mostly rocky (~75%) shoreline. Approximately 10% of the shoreline is course sediment (pebble, cobble, boulder), <10% is sandy and ~6% is level, estuarine wetlands. Analysis of the shoreline has led to preliminary biophysical classification (Harper *et al.* 1994) and this information is included in Gwaii Haanas' GIS databases. Gwaii Haanas represents Parks Canada's NMCA Natural Regions of "Queen Charlotte Islands Shelf" to the west, "Hecate Strait" to the east and borders the "Queen Charlotte Sound" region to the south (Mercier and Mondor 1995). Place names referred to in the text are shown in Figures 1 and 2.

Physical oceanography can provide insight into marine mammal distribution. For example, Gregr and Trites (2001) made predictions about the offshore habitat of six whale species off British Columbia using bathymetry (*e.g.*, the continental shelf edge), temperature, and salinity data superimposed on distribution (whaling record) data. For three of these species, the predictions were in agreement with the data. The interactions between marine mammals and physical oceanographic processes have being studied locally. Marine mammal distribution and abundance are also likely influenced by biological oceanographic features such as primary (phytoplankton) and secondary (zooplankton) productivity. These in turn are influenced by upwelling plumes, tides and currents. For this region, Robinson *et al.* (1999) provide an overview of current knowledge of biological oceanography.

MARINE MAMMAL SPECIES OF THE HAIDA GWAII REGION

The 26 marine mammal species recorded from the Haida Gwaii region include 20 species of whales, dolphins and porpoises, five species of seals and sea lions, and the sea otter (Table 1). Haida Gwaii is within the range of severall other species, but they have not yet been observed there. For example, the false killer whale (*Pseudorca crassidens*) ranges for Alaska to Chile, one of the largest ranges of any cetacean, and it has been reported off the west coast of Vancouver Island, but it has not been seen in Haida Gwaii (Stacey *et al.* 1994).

Carlton and Hodder (2003) introduced the term "maritime mammals" to describe terrestrial predators that eat intertidal prey and transfer their food energy to the land. The river otter (*Lutra canadensis*), although common along Haida Gwaii shores, falls into this category and is not considered a marine mammal. Other specific examples from Haida Gwaii include the black bear (*Ursus americanus carlottae*) and the introduced racoon (*Procyon lotor*). Burles *et al.* (2004) review knowledge of river otter and other terrestrial mammals of Haida Gwaii.

HISTORICAL OVERVIEW

ABORIGINAL USES OF MARINE MAMMALS

Along the British Columbia coast, by ~6,000 years BP (before present) there were well-established human populations using many marine foods including mammals (Hebda and Frederick 1990). By ~3,000 BP, the proliferation of shoreline middens (human food waste heaps) coast-wide indicated to Hebda and Frederick (1990) that there were widespread, increasingly sedentary settlements that used food preservation technologies.

Recent progress on the archaeology of Haida Gwaii has increased the antiquity of

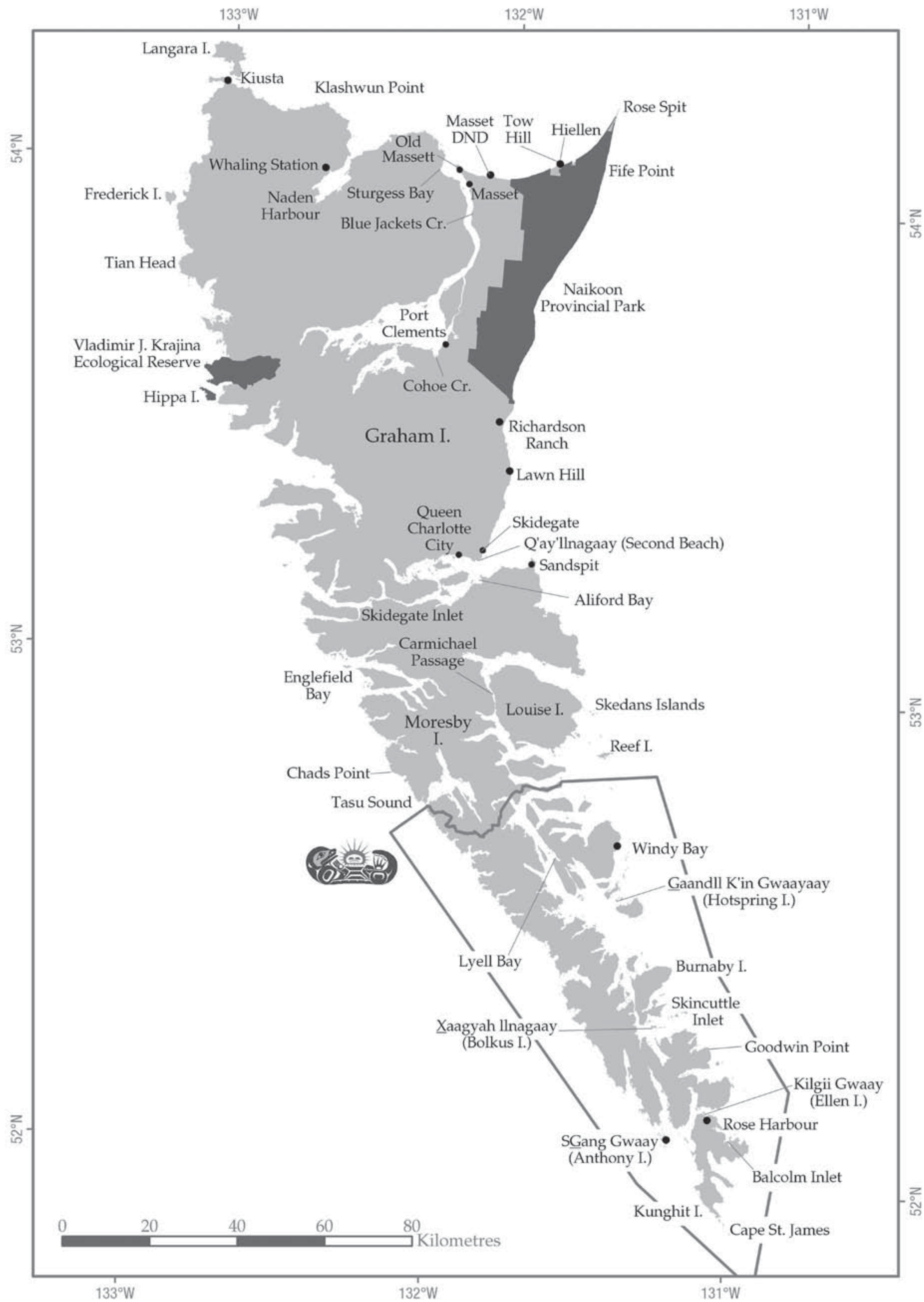

Figure 2. Map of the Haida Gwaii region showing towns and place names mentioned in the text. Spelling of Haida place names is current to September, 2003 (courtesy of Skidegate Haida Immersion Program [SHIP] of the Skidegate Haida Language Authority).

British Columbia coastal human history as people have occupied this region for at least 10,000 years (Ackerman 1996; Josenhans *et al.* 1997; Fedje *et al.* 2001a). Haida Gwaii is important to theories about coastal human migration from the northeastern Asian land link (Beringia) to Pacific North America between 14,000 to 10,000 BP (Mandryk *et al.* 2001; Fedje 2002). In the Gwaii Haanas area alone, there are 604 coastal archaeological sites recorded on Gwaii Haanas' GIS database (Fedje *et al.* 2001b) of which 369 are middens (I. Sumpter, Parks Canada, *personal communication*). Further, current shorelines represent only a part of the history of coastal occupation of Haida Gwaii due to sea-level fluctuations (Fedje and Christensen 1999).

The most extensive published archaeological survey with marine mammal information is by Acheson (1998). He reported from 18 (17 randomly selected) of 114 archaeological sites of midden and

Table 1. Marine mammal species recorded from the Haida Gwaii region.

		Species Name	
Order	**Suborder or Family**	**Common**	**Scientific**
Cetacea	Odontoceti	Sperm whale	*Physeter macrocephalus*
		Killer whale	*Orcinus orca*
		Baird's beaked whale	*Berardius bairdii*
		Cuvier's beaked whale	*Ziphius cavirostris*
		Stejneger's beaked whale	*Mesoplodon stejnegeri*
		Short-finned pilot whale	*Globicephala macrorhynchus*
		Risso's dolphin	*Grampus griseus*
		Pacific white-sided dolphin	*Lagenorhynchus obliquidens*
		Northern right-whale dolphin	*Lissodelphis borealis*
		Common dolphin	*Delphinus delphis*
		Striped dolphin	*Stenella coeruleoalba*
		Dall's porpoise	*Phocoenoides dalli*
		Harbour porpoise	*Phocoena phocoena*
	Mysticeti	Blue whale	*Balaenoptera musculus*
		Fin whale	*Balaenoptera physalus*
		Sei whale	*Balaenoptera borealis*
		Humpback whale	*Megaptera novaeangliae*
		Gray whale	*Eschrichtius robustus*
		Minke whale	*Balaenoptera acutorostrata*
		North Pacific right whale	*Eubalaena japonica*[1]
Pinnipedia	Otariidae	Steller sea lion	*Eumetopias jubatus*
		California sea lion	*Zalophus californianus*
		Northern fur seal	*Callorhinus ursinus*
	Phocidae	Northern elephant seal	*Mirounga angustirostris*
		Harbour seal	*Phoca vitulina*
Fissipedia	Mustelidae	Sea otter	*Enhydra lutris*

1 there is confusion on the name of this species: Fisheries and Oceans Canada (O and Ford 2003) and the Encyclopedia of Marine Mammals (Perrin et al. 2002) state that the North Pacific species is *E. japonica* with the North Atlantic species being *E. glacialis*; other publications such as Guide to Marine Mammals of Alaska (Wynne 1997), Marine Mammals of the Pacific Northwest (Harbour Publishing 2001) and recent science literature (e.g., Read and Wade 2000) identify the species as *E. glacialis* from North Pacific waters

dwelling (house pit) soil strata (dating ~1,600 BP) in southern Gwaii Haanas. The sites are shown in Figure 3 with notes on those with noteworthy proportions marine mammal remains. At the Flamingo Inlet site, 100% of the mammal remains were harbour seal. At the site nearby Moore Head, 100% of the mammal remains were sea otter and at one of the Cape Freeman sites, 70% of the mammal remains were whale bones. Listed in Table 2 are the proportions of all mammal remains represented by marine mammals at all of Acheson's sites; with sea otter, harbour seal and whale representing the most often recorded marine mammal remains. Acheson (1998) did speculate on the overall importance of cetaceans in the diet of the Kunghit Haida, but he was unable to determine whether the Haida actively hunted cetaceans or just scavenged stranded animals.

Notes on marine mammal remains from excavations at other archaeological sites in Haida Gwaii are provided in Table 3 and

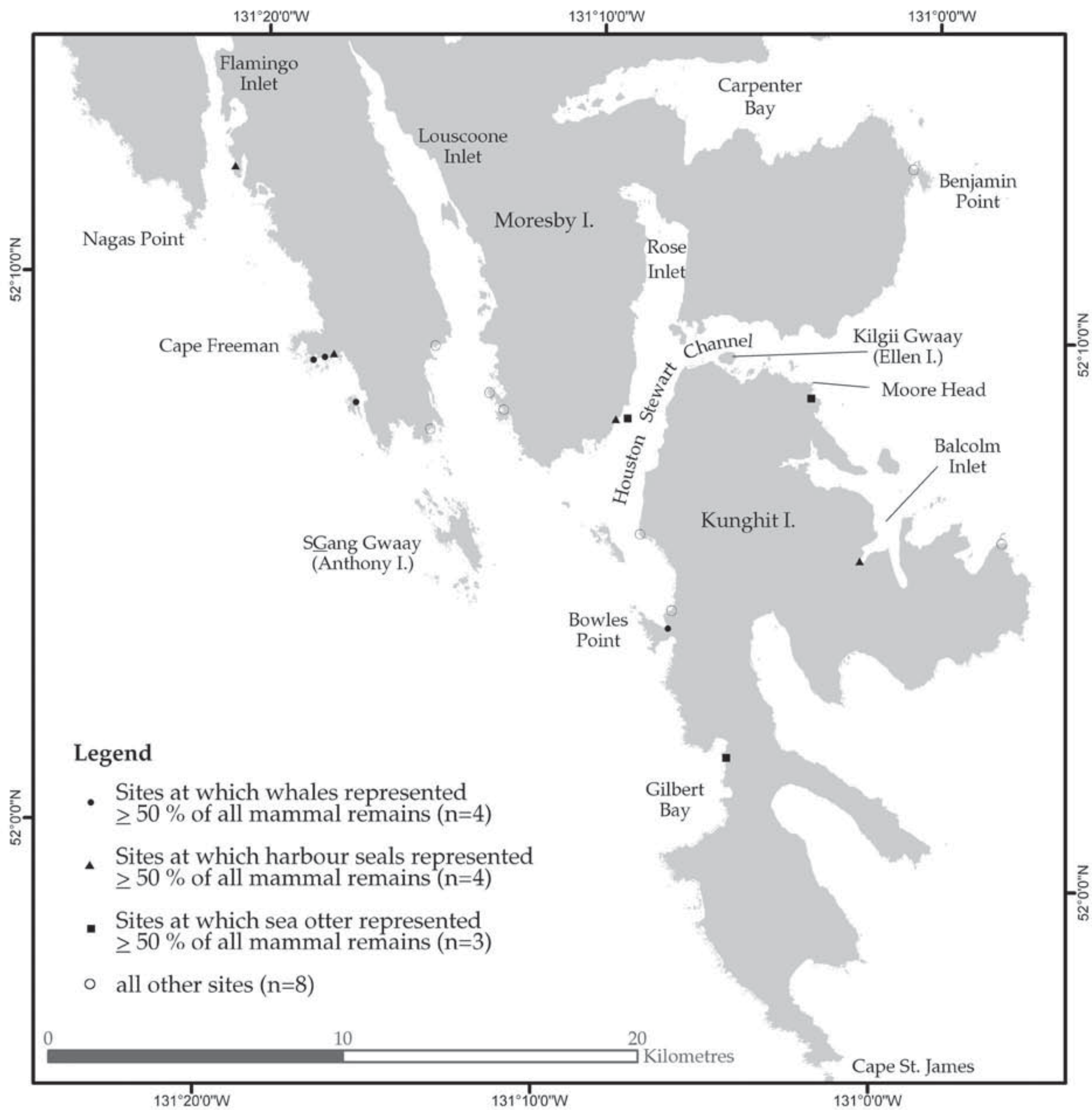

Figure 3. Locations of 18 Kunghit Island-area Haida archaeological excavation sites in southern Gwaii Haanas (data from Acheson 1998).

site locations are shown according to the types of remains in Figure 4. Locations of the named archaeological sites are shown in Figure 2. The northwest and west coasts of Haida Gwaii remain to be sampled. Although the ecological conditions differed greatly between sites (*e.g.*, sheltered estuarine – Cohoe Creek; highly exposed sandy beach – Tow Hill; moderately exposed boulder shore-Kilgii Gwaay), harbour seal and sea otter were hunted at most sites. Cetacean bones occurred at many sites with large whale bones dominating cetacean remains at the southern sites. Mitchell's (1988) conclusion that relatively few Haida Gwaii middens contained whale bones is not supported by more recent evidence. The importance of Kilgii Gwaay (Ellen Island), as one of the oldest (~9,400 BP) shell middens in Pacific North America (Fedje *et al.* 2001a), is enormous. That site revealed an ancient, highly "maritime-capable" culture (Fedje *et al.* 2001a), likely with efficient water-craft, that had sufficiently well-developed marine hunting skills to take marine mammals.

Listed in Table 4 are the northern and southern Haida words for marine mammals. Haida dialects from the northern and southern areas of Haida Gwaii differ appreciably (Enrico 1989). The southern Haida words have recently been revised by the Skidegate Haida Immersion Program (SHIP) of the Skidegate Haida Language Authority. All Southern (Skidegate) Haida words have been under review by SHIP to clarify spelling and pronunciation (Barb Wilson, Gwaii Haanas, *personal communication*).

The Haida used many products from marine mammals: teeth, meat, blubber (eaten or rendered into oil), whole pelts, hide (strips for line and perhaps armor), whiskers (for ceremonial items such as frontlets), stomach/intestines (for storing oil) and bone (Dawson 1880; Blackman 1979, 1990; Acheson 1998). Meat was preserved (smoked or dried) or cooked fresh and oil was eaten, although not at feasts (Blackman 1979). Although meat of small cetaceans, pinnipeds and likely whales was eaten, it is unclear whether sea otter was eaten (Blackman 1979).

The effects of past Haida hunting on regional pinniped populations are unknown. Bigg (1988a) speculated that, coast-wide, aboriginal hunting of Steller sea lions kept sea lion numbers reduced during the 1800s. Newcombe and Newcombe (1914) and Wailes and Newcombe (1929) suggested that sea lion numbers increased coast-wide in the late 1800s and early 1900s as the level of aboriginal hunting declined.

Table 2. The percentage of the number of identifiable remains of all mammal species represented by marine species or groups (and river otter) excavated from 18 Kunghit Island-area Haida sites in southern Gwaii Haanas (extrapolated from data in Acheson 1998).

Species or Group According to Acheson	Number of Sites with Mammal Remains	Percent of all Mammal Remains at all Sites	
		Mean	Range
whale	10	19.0	0.0-70.6
porpoise	4	0.5	0.0-5.7
Northern sea lion[1]	10	2.3	0.0-9.3
Northern fur seal	10	4.4	0.0-29.8
Harbour seal	14	25.6	0.0-100
Sea otter	15	30.4	0.0-100
River otter	11	5.1	0.0-16.7

1 likely Steller sea lion

One of the intriguing possibilities is whaling by the peoples of Haida Gwaii. Dawson's (1880, p. 111 B) following statement about the Haida has been influential: "*I cannot learn that the former* (whales) *were ever systematically pursued as they were by the Makah Indians of Cape Flattery and Ahts* (Nuu-chah-nulth) *of the west coast of Vancouver Island. When, however, by chance one of these comes ashore it is a great*

Figure 4. Locations of archaeological excavation sites in Haida Gwaii illustrating according to whether small cetacean, large cetacean, pinniped or sea otter remains were recovered.

prize to the owner of the particular strip of beach on which it may be stranded. " Domning (1972) speculated that ancient practises of nearshore hunting for Steller's sea cow (*Hydrodamalis gigas*) throughout the North Pacific facilitated the development of indigenous peoples' whaling after the sea cows were locally extirpated. This species became extinct shortly after it was described by western science (Domning

Table 3. Notes on marine mammal remains from archaeological excavations on Haida Gwaii, excluding Acheson (1998).

Site				
Approximate Age (years BP[1])	**Name[2]**	**Archaeology Code**	**Marine Mammal Remains**	**Reference**
Unknown	Hiellen	GaTw-7[3]	Sea otter	Christensen (2000)
Unknown	X̲aagyah llnagaay (Bolkus I. village)	714T[4]	Marine mammal	Fedje & Sumpter (2001)
Unknown	Lyell Bay	785T[4]	Pacific white-sided dolphin, porpoise, sea otter, harbour seal, Otariid	Orchard (2003)
Unknown		972T[4]	Sea mammal	Zacharias & Wanagun (1993)
170 to 1,590	SG̲ang Gwaay (Anthony I.)	FaTt-1[3] 660T[4]	Harbour seal, sea otter, whale, northern fur seal, northern sea lion, porpoise	Wigen (1982), Acheson (1984)
163 to 193	Richardson Ranch	FjTx-1[3]	Sea otter, sea lion, "delphinid", whale, small sea mammal (otter or seal)	Fladmark (1973)
1,100 to 1,880	G̲andll K'in Gwaagaay (Hotspring I.)	922T[4]	Mammal remains dominated by marine species; sea otter, harbour seal and river otter present in equivalent amounts - no cetacean remains (Fur seal, northern Sea lion)	Fedje & Sumpter (1999), Sumpter (1999), Wigen (1999 a)
1,150 to 1,180	Q'ay'llngaay (Second Beach)	FhTx-19[3]	Sea otter, harbour seal, Pacific white-sided dolphin (mammals were 7% of all vertebrate remains)	Wigen (1999 b)
1,310	Massett DND	GhUa-11[3]	Sea otter	Dady & Christensen (2000)
5,000	Tow Hill	GaTw-5[3]	Seal and "some larger sea mammal(?)"	Severs (1974 a)
5,000 to 6,000	Cohoe Creek	FjUb-10[3]	Harbour seal, "porpoise?"	Ham (1990)
5,560	Blue Jackets Creek	FlUa-4[3]	Sea otter and seal	Severs (1974 b)
8,150 to 9,010		1127T[4]	Whale skull	Fedje & Sumpter (1996)
8,550 to 9,270		1128T[4]	Sea otter	Fedje & Sumpter (1996)
9,400	Kilgii Gwaay (Ellen I.)	1325T[4]	Mammal bones 13% of all faunal remains; among all mammal remains, harbour seal (34%), sea otter (9%) and sea lion (3%)	Fedje *et al*. (2001 a)

1 BP = before present
2 Locations of sites are illustrated in Figure 2
3 Borden Number (an archaeological code convention for site identification)
4 Parks Canada designation, rather than a Borden Number

1972). In O'Leary's (1984) review, she listed 8 of 44 groups between the Aleutian Islands and Washington State as whalers. The Haida, Tlingit (southeast Alaska) and Tsimshian (northern mainland British Columbia coast) were lumped together as being peoples who "*utilized only stranded whales*" although she did concede that Haida "*may have occasionally hunted whales*." Acheson (1998) reviewed the historic, ethnographic and archaeological evidence for whaling and found evidence that the Haida utlized whales, but could not determine whether animals were hunted or scavanged. Acheson and Wigen (2002) compared two Kunghit Haida archaeological sites with Nuu-chah-nulth sites (Hesquiat, west coast of Vancouver Island; Ozette, Washington State [Makah tribe]), plus historical documentation, and concluded "*cautiously*" that the Haida did actively hunt whales, although not as actively as the Nuu-chah-nulth. For example, Huelsbrek (1988) suggested that besides subsisting on large whales, the Makah traded whale commodities with other indigenous groups. In post-contact times, the Haida likely did trade in whale products as Hudson Bay Company records from Fort Simpson (north of Prince Rupert) from the 1830s to the 1860s listed trade in oil and bone (Acheson and Wigen 2002). Reasons for the lack of whaling ritual and ceremony (such as among the Nuu-chah-nulth [Jonaitis 1999]) in the recorded ethnography of the Haida are unknown (Acheson and Wigen 2002). A lack of archaeological information (O'Leary 1984) and generally poor documentation of pre-contact subsistence practises (Acheson and Wigen 2002) continue to foster uncertainty about Haida whaling.

Table 5 lists notes on marine mammal hunting seasons by the Haida. There apparently was a blend of seasonal and year-round hunting according to species. Little is reported on Haida marine mammal hunting methods. Murdock (1934, p. 229) describes a sea otter canoe as being a "*special double-ended*" designed "*to pass readily through a bed of kelp*." Large canoes with 10 paddlers were reportedly used for whaling and small craft were used for seal and sea otter hunting in more nearshore areas from one Haida elder (Blackman

Table 4. Haida words for marine mammals.

Species or group	**Southern Haida**		**Northern Haida**
	Jones (1999)[1]	**SHIP**[2] **(2002)**	**(Blackman 1979)**
stranded whale		kungaawagan	
Humpback whale	kun	sgap	kun
Gray whale		kun	
Killer whale	sgaana	sgaana	sqən[3]
Dall's porpoise	sk̲ul	k̲'aang	sqwhul
Short-finned pilot whale			skugwit[4]
Harbour porpoise		sk̲uul	au sqwhul
Northern (Steller) sea lion	k̲'aay	k̲aay	q'ai
Northern fur seal	k̲'uuwan	k̲'uu7an	k'waan
Harbour seal	x̲uud	x̲ud	xot
Sea otter	k̲uu	k̲uu	qo

1 southern Haida words obtained from audio tapes of an elder (Solomon Wilson) and the spellings reviewed by the Skidegate Haida Immersion Program (SHIP)
2 revised SHIP spellings as of October 16, 2002
3 in the absence of a standard orthography for Masset dialect, Blackman used a modified version of the international phonetic alphabet in her spellings
4 called "Scammon's blackfish" by Blackman and the assigned species is a best approximation (Graeme Ellis, DFO, *personal communication*)

1979). This elder suggested that whalers hunted humpback whales, but from the size and behaviour of the whales he describes, it may have been minke whales or young grey whales that were taken. Whales and small cetaceans were harpooned, but spearing apparently was replaced over time by shooting for pinnipeds and particularly sea otter (Dawson 1880; Niblack 1890). Spearing for seals was likely preferred as they sink when killed, while shooting sea otters was relatively more common as they float when killed. Niblack (1890) described how in the north coast region, sea otters were often circled by groups of hunters in canoes and then struck by spear or arrow. It seems likely that sea otters were hunted year-round, although there are no reports of this. Although pelt conditions are prime in the colder months in Alaskan waters (M. King, Chugach Region–Alaska Sea Otter and Sea Lion Commission, *personal communication*), it is not known if this was a consideration in Haida Gwaii.

Sea otters played a central role in early European/American-Haida relations. Trade in sea otter pelts is the main context of the immediate post-contact era during which a pulse of material wealth including iron and other metal goods, cloth, beads, firearms, molasses, biscuit and rum entered rapidly into Haida culture. Pelts fetched high prices in the Chinese port of Canton. One of the great trading chiefs was Cuneah of Kiusta village who became enormously wealthy (Robinson 1996). Trade began with first contact in July of 1774, when the Spanish vessel *Santiago* (commanded by Juan Pérez) encountered the Haida off western Langara Island. Translations of logs revealed that the Spanish exchanged cloth, knives, abalone shell (*Haliotis* spp. from the Spanish-occupied California area [Sloan 2003]) for sea otter and other pelts (Beals 1989, p. 111). Large-scale fur trading began with the British, but soon shifted to the Americans. However, the trade ended by the 1840s after sea otter populations collapsed from over-hunting (Gibson 1992), and trade shifted to other lower-value commodities. Sea otters remained "*extremely sparse*" around Haida Gwaii in the late 19th century (Dawson 1880, p. 154 B), as they were throughout the north coast (Niblack 1890), and populations have not yet recovered around Haida Gwaii (Watson *et al.* 1997).


VANCOUVER AQUARIUM
MARINE SCIENCE CENTRE
Environment Canada Environnement Canada Fisheries and Oceans Canada Science Pêches et Océans Canada Sciences

Whale, Dolphin, and Porpoise Sighting Form

Date ____ Local Time (24hr) ____
General Location ____ Latitude/Longitude (please use decimal minutes) ____
Sea State ____ Wind Speed ____
Species Name* ____
*If uncertain of species identity, please note body shape and size, presence or absence of dorsal fin, body colouration, and any other distinguishing features. Use back of form for sketches or further details.

ID Confidence ☐ Certain ☐ Probable ☐ Possible ☐ Uncertain
Body Length Estimate: ☐ <3m (<10 ft.) ☐ 3-8m (10-25 ft.) ☐ 8-16m (25-50 ft.) ☐ 16-26m (50-80 ft.) ☐ >26m (>80 ft.)
Sighting distance ____
No. in group ____ +/- ____

Fishing Interactions
(circle these or add your own in comments section)
Contact with gear / Contact with vessel
Feeding from gear / Feeding on discards
Entangled in gear / Following vessel while fishing

Photos / Video: ☐ photographs ☐ video
Sighting Platform: (height off water) ____

Comments (describe in your own words all features seen, behaviours observed and anything else of note)

Observer ____ Vessel ____
Address ____ Phone ____
email ____

Please return to:
B.C. Cetacean Sightings Program
Cetacean Research Lab
Vancouver Aquarium Marine Science Centre
PO Box 3232, Vancouver, BC, V6B 3X8
or fax: 604-659-3515

Any questions or concerns can be emailed to: Sightings@vanaqua.org
www.wildwhales.org

Figure 5. An example of the reporting form from a cetacean sighting log book issued by the British Columbia Cetacean Sightings Network.

In summary, although the extent to which midden deposits represent historical diets is speculative, marine mammals have been part of indigenous peoples' diets in the Haida Gwaii region for ~10,000 years. Historical records show that marine mammals were hunted for food, clothing and trade in the 18th and 19th century. Now, however, marine mammals are much less hunted by the Haida than before the early 20th century.

Aboriginal Whaling in Other Regions

There is much interest in aboriginal (subsistence) whaling (IWC 1998; Reeves 2002). Discussion of how to manage aboriginal whaling depends on whether one's priorities are whale-centred or people-centred (Reeves 2002). Around arctic North America, Inuit peoples take bowhead whale (*Balaena mysticetus*) in the far west (although bowheads are listed as *Endangered* in the United States), and small cetaceans such as beluga (*Delphinapterus leucas*) and narwal (*Monodon monoceros*) are also hunted (McCartney 1995; Perrin *et al.* 2002; Reeves 2002). The bowhead hunt is permitted under an allowance to Alaskan natives in the *Marine Mammal Protection Act* (*MMPA*). In Washington State, hunting for gray whales was recently resumed by the Makah (Nuu-chah-nulth people). This has been a highly contentious issue, with non-governmental organizations (NGOs) in court against the Makah and the National Marine Fisheries Service (the agency that sanctioned the hunt based on treaty obligations dating from the 1800s). The sanctioning occurred after gray whales were removed from the US federal Endangered and Threatened Species List in 1994 and no longer protected under the Endangered Species Act (Gerber *et al.* 1999). The International Whaling Commission (IWC) also sanctioned the hunt. One whale was taken in 1999 amid great controversy. The Nuu-chah-nulth people of Vancouver Island also proclaimed their intention to resume hunting gray and humpback whales, although this was most contentious after the first kill by the Makah (Reeves 2002). In 2001, National Marine Fisheries Service expanded the whaling permit issued to the Makah, which had previously restricted the hunt to migrating whales. The Makah were now allowed to include the small year-round resident population of gray whales in Juan de Fuca Strait. However, in December 2002, a United States Federal Court of Appeals overturned the lower (trial) court decision enabling the hunt, ruling that the hunt violated the *MMPA* by not having a sufficient environmental impact analysis. The Makah may appeal this decision to the United States Supreme Court, citing the greater priority of treaty obligations over *MMPA* regulations.

HISTORY OF REGIONAL MARINE MAMMAL SCIENCE

"*Historically, there has been little interest in the study of marine mammals for purely scientific or even management purposes*." (Nichol *et al.* 1993)

The benchmark account of Northeast Pacific marine mammals and whaling history is Scammon (1874). His book describes many of the species occurring in Haida Gwaii waters and likely Scammon spent some time in this region. Overall, however, reports from European explorers and traders in the 1700s and 1800s yielded little knowledge of marine mammals around Haida Gwaii. This is ironic as trade involving sea otter pelts was the prime context for this region's early post-contact history (Gibson 1992).

Most of the scientific knowledge of large whales of the Haida Gwaii region comes from commercial whalers' data (Hagelund 1987a; Webb 1988; Nichol and Heise 1992; Nichol *et al.* 2002). Between 1910 and 1967, whales were hunted around Haida Gwaii. This whaling stimulated regional collection of large whale distribution data through documention of locations where whales were killed (Townsend 1935; Nichol and

Heise 1992; Gregr 2002; Nichol *et al.* 2002). Catch records (location, sex, body length) of whales landed in Haida Gwaii are only known from 1924 to 1928 and, therefore, records are not consistent throughout the commercial whaling era. Nonetheless, these data have been the basis for migration, population structure, habitat use and diet studies of large whales off British Columbia (Gregr *et al.* 2000; Gregr and Trites 2001; Finn *et al.* 2002).

The first major coast-wide overview of marine mammals in British Columbia was by Pike and MacAskie (1969). They relied, for example, on reports by Osgood (1901) and McTaggart-Cowan and Guiguet (1956) who described some species coast-wide, including Haida Gwaii. They also extensively used Coal Harbour whaling data and Pike's research based on those data. Pike and MacAskie (1969) listed sightings and strandings of all species from published and unpublished sources up to 1967, and included notes on seasonal occurrence, sizes, locations of museum specimens and other basic natural history information. Few scientific data were collected before the 1940s and it was not until the 1950s that focused marine mammal studies were initiated, such as the Skeena River estuary harbour seal study (Fisher 1952). Relatively little research on marine mammals was undertaken coast-wide until the 1970s when DFO and NGOs, such as the Vancouver Aquarium initiated research on pinnipeds and killer whales. In a review of marine mammal data collected in the Haida Gwaii and northern mainland coast region (excluding the west coast of Haida Gwaii and offshore) from 1862 to 1991, Nichol *et al.* (1993) noted that the only species that had been the subject of focused research were the killer whale, Steller sea lion, northern fur seal, harbour seal and sea otter.

In the early 1980s, the prospect of lifting the 1972 federal moratorium on oil and gas exploration and development in areas including Hecate Strait and Queen Charlotte Sound fostered the first regional compilations of marine mammal information. These Initial Environmental Evaluations were funded by Chevron and Petro Canada (Anonymous 1982, 1983) and drew largely upon information in Pike and MacAskie (1969). They were prepared for public consultations that led a federal-provincial panel to recommend that exploration proceed (WCOEEAP 1986), although the moratorium was not subsequently lifted. As well, the panel issued a request for additional information, including seasonal marine mammal vulnerability maps (haulouts, rookeries, feeding areas, migration corridors) in the proposed exploration areas and an assessment of seismic disturbance potential (Anonymous 1985). Data in this report would enable updating vulnerability maps. Gregr (in press) has recently reviewed the role of marine mammals in the Hecate Strait area in response to the prospect of offshore oil and gas.

There is currently a high level of both public and scientific interest in marine mammals in British Columbia. There are active marine mammal research programs at the Vancouver Aquarium Marine Science Centre (VAMSC), the North Pacific Universities Marine Mammal Research Consortium [http://www.marinemammal.org.] of the Fisheries Centre at the University of British Columbia in Vancouver, and the Pacific Biological Station (DFO) in Nanaimo. Faculty and students at the University of Victoria, Simon Fraser University and the University of British Columbia also undertake research on marine mammals. As well, there are regional NGOs that conduct focused research and monitoring, such as OrcaLab on Hansen Island, Johnstone Strait and the Laskeek Bay Conservation Society in Queen Charlotte City.

Within the Haida Gwaii region, Gwaii Haanas has commissioned several studies of cetaceans, facilitated through Dr. J.K.B. Ford, then of the Vancouver Aquarium (now with DFO), as background for the proposed NMCA. These include a review of the historic whaling data (Nichol and Heise 1992), two killer whale overviews (Ford *et al.* 1992, Heise *et al.* 1993) and two general cetacean overviews (Ford *et al.* 1994; Heise and Ford 2002). Gwaii Haanas has also cooperated with DFO on regional Steller sea lion and harbour seal assessments (*e.g.*, Olesiuk *et al.* 1993).

MARINE MAMMAL CONSERVATION AND EXPLOITATION

Marine mammals are relatively long-lived and have low reproductive rates. In some species, individuals may take years to reach sexual maturity, and may reproduce only once every few years thereafter. As a result, marine mammal populations may have comparatively low productivity rates, rendering them vulnerable to aggressive exploitation and slow to recover from population declines. This is discussed in greater detail in the Small Remnant Populations text of the Conservation Issues section.

Early Conservation History in the North Pacific

The first era of Canadian marine mammal conservation in the North Pacific, from the early 20th century to the 1970s, was a pragmatic response to overhunting. Formal conservation measures began in 1911 with the signing of the *North Pacific Fur Seal Treaty* by the United Kingdom (for Canada), the United States, Russia and Japan. This agreement prohibited pelagic sealing of northern fur seals, and protected sea otters in waters up to three nautical miles offshore. By 1911, <2,000 sea otters remained in British Columbia, including the waters off Haida Gwaii (Jameson *et al.* 1982; Watson *et al.* 1997). Despite the treaty, sea otters were commercially extinct (too rare to profitably hunt) in British Columbia by 1930. The treaty expired in 1941 and was replaced by the *Interim Convention on Conservation of North Pacific Fur Seals* in 1957. This convention expired in 1984 and fur seals are now only taken for aboriginal subsistence (Olesiuk and Bigg 1988).

While conservation measures were being implemented to protect sea otters and fur seals, in 1913, federal fisheries managers introduced a system of culls, bounties and commercial harvests for meat, blubber, and hides of both harbour seals and sea lions in British Columbia (Olesiuk and Bigg 1988). Under these culls, harbour seal and Steller sea lion numbers were significantly reduced coast-wide as described later in the Pinniped section of this report. These programs ended by 1969 and in 1970 it became illegal to kill any marine mammal without a permit issued under the *Fisheries Act*.

In 1905, whaling increased in intensity off the British Columbia coast with the introduction of steam powered chaser boats, modernized harpoons and steam-powered winches (Webb 1988). In recognition of dwindling whale stocks, the first *International Whaling Convention* (1931) was signed by 26 nations in an attempt to protect right whales, gray whales and immature whales, and females with calves of all species. This agreement was not ratified by Canada until 1935 and proved ineffective because neither Japan nor Russia signed the agreement, and both countries continued to hunt whales. In 1937, the *International Agreement for the Regulation of Whaling* was signed by fewer countries than the 1931 agreement, but it introduced more stringent controls such as controlling factory ship operations, establishing hunting areas and improving data collection (Webb 1988). Japan and Russia did not sign this agreement either. Statistics suggest that mostly immature whales were being killed (Webb 1988). This led to worldwide whaling bans on gray and right whales, but most stocks continued to decline, with high proportions of juvenile whales being taken.

The International Whaling Commission

The *International Convention for the Regulation of Whaling* was signed in 1946 establishing the world's first global resource management body, the IWC (Perrin *et al.* 2002). The IWC's mission was to regulate the whaling industry and conserve stocks. However, continuing stock depletion led to an international moratorium on whaling in 1982 that remains in place. Small cetaceans, such as porpoises and dolphins, are not covered by IWC agreements, and Canada is not one of the 40 member nations of the IWC. The IWC sanctions subsistence whaling, and has issued scientific permits to Japan and Iceland. Norway, a member, continues to whale commercially despite the moratorium. Another 20 nations have cetacean hunts, but are not IWC members.

In the North Pacific, there have been problems with whaling, despite IWC agreements. The Soviets, for example, significantly underreported their catch after 1945. They reported 2,710 humpbacks killed, but the true total was >48,000. The difference between the reported and actual total catches of all whales was >100,000 (Yablokov 1994). As well, problems with commercial whaling under the pretext of "scientific" research still occur. For example, the meat of minke whales taken under Japanese scientific permit is sold for human consumption. The South Koreans also allow the sale of whale meat if the animals are caught as bycatch in commercial fisheries. Recent molecular analyses by Baker *et al.* (1996, 2000) showed that meat for sale in Japanese markets was from minke, sei, fin, Bryde's, blue, humpback, sperm, killer and beaked whales, and at least six species of dolphin. In Korea, the meat of minke, Bryde's, beaked and killer whale as well as dolphin has been detected in food shops. Baker *et al.* (2000) and Dalebout *et al.* (2002) found genetic evidence that a protected stock of minke whales from the Sea of Japan was being hunted and could result in the collapse of this population. The IWC remains at the center of "intense controversy" around the politics, economics and ethics of international whaling (Friedheim 2001). Current opposition to scientific whaling is strong and in May 2002 a group of 21 distinguished scientists wrote an open letter to the Japanese government criticizing Japan's "scientific" whaling program (Holt 2003; Orians *et al.* 2003).

Commercial Exploitation in the North Pacific

In the North Pacific, marine mammals were commercially exploited for over 200 years before effective conservation measures were implemented. As a result, many species of whales and pinnipeds were hunted to commercial extinction, that is, reduced to densities no longer economic to hunt. Some species such as gray whales and California sea lions have fully recovered throughout their geographic ranges, while others, such as the right whale and sea otter, have not.

Commercial exploitation began in the mid 1700s, when Russians began hunting both sea otters and northern fur seals for their pelts (Riley 1967; Gibson 1992). Northern fur sealing was a particularly large commercial venture. This trade was the main impetus for exploration in the North Pacific and for the purchase of Alaska from Russia by the United States in 1867. Exploitation of fur seals began at rookeries discovered on the Commander Islands (western Bering Sea) during the Bering expedition in the mid 1700s and spread eastward to the enormous rookeries (2.5 to 3 million seals) at the Pribilof Islands (central Bering Sea) after their discovery later in the 1700s (Riley 1967; Gentry 2002b). During the period of Russian ownership and exploitation (by the Russian American Company until 1867), ~2.5 million pelts were taken. Populations were severely reduced by the 1830s (Lander 1980 in York 1987), leading to a 5-year moratorium on killing and a subsequent ban on taking females and the imposition of limits on the numbers of males taken. This is one of the earliest wildlife management actions on record (Gentry 2002b). The population had largely recovered to pre-exploitation levels by 1867. Under United States ownership during 1870-89 and 1890-1909, 20-year leases were awarded, with ~1,854,000 and ~342,000 pelts taken during the first and second lease periods respectively.

Pelagic sealing for northern fur seal begans in 1868 off the west coast of Vancouver Island, and over the next 20 years extended along the entire west coast of North America with Victoria as a major landing port (Murie 1981). Between 1889 and 1909, the peak period of pelagic sealing, ~600,000 were taken at sea, most of which were females. Populations declined dramatically, and by 1910, only 125,000 to 300,000 remained in the Pribilof Islands. In 1911, the *North Pacific Fur Seal Treaty* was signed, which prohibited pelagic sealing except by aboriginal people using simple methods, in return for which Canada received 15% of pelts taken on rookeries. The herd rebuilt to ~1.8 million and began showing signs of overcrowding (Lander and Kajimura 1976). Between 1956 and 1963, 270,000 females were taken. Unfortunately, this take did not have the expected result, and the herd declined. However, it began to rebuild and by 1974 it had reached ~1.25 million. For reasons unknown, and unrelated to hunting, the Pribilof population began to decline, to ~900,000 by the early 1980s. It has increased in size since then, but began declining in 2000 (Angliss and Lodge 2002). A new population of northern fur seals has colonized San Miguel Island off central California in the 1950s or 1960s, and has grown to >4,000; still tiny compared to the Alaskan herd.

An intensive commercial hunt for California sea lions (for oil and hides) greatly reduced their population off southern California and Mexico by the 1920s. The population has rebounded since protection in the 1970s (Heath 2002). An elephant seal hunt (also for oil rendered from blubber) in the same areas reduced the population to ~100 animals on one breeding island by 1890, from which the population has also largely recovered (Stewart *et al.* 1994; Hindell 2002).

Between 1840 and 1850 there was extensive whaling for North Pacific right whales in the 'Kodiak Grounds'- the area between Vancouver Island and the Aleutian Islands, and from the coast west to 150° W (Scammon 1874). During this brief period, this species was hunted to commercial extinction. Gray whales were hunted in the calving lagoons of Mexico and this species was commercially extinct by 1900 (Rice 1986).

Intensive whaling occurred in the Haida Gwaii region from 1910 until 1967 (Nichol and Heise 1992). Whaling stations were located at Rose Harbour (active 1910 to 1943) and Naden Harbour (active 1911 to 1941). There are numerous historical accounts of these whaling stations (Simpson 1971; Hagelund 1987a, b; Dalzell 1988; Webb 1988; Morton 1992; Nichol and Heise 1992). Whalers also travelled to the area from a whaling station in Coal Harbour, Vancouver Island (active 1948 to 1967) (Figure 1). Table 6 lists the whale species landed at Haida Gwaii whaling stations. Over 9,400 whales from this region were killed (Nichol and Heise 1992). Catches were dominated by sperm, fin and humpback whales, and their numbers give a sense of relative abundance of large whale species in the region. After 1946, the IWC compelled whalers to keep records on the catch location, sex, maturity, stomach contents and other biological data for each whale captured (Webb 1988) and some of these data are provided in Nichol and Heise (1992).

Whaling may have had far reaching consequences on marine mammal species other than those targeted. Springer *et al.* (2003) speculate that past whaling in the North Pacific may be linked to dramatic declines of sea otters, Steller sea lions and harbour seals around the Aleutian Islands

Table 6. Whale species landed at the two Haida Gwaii whaling stations during their years of activity (data from Nichol and Heise 1992).

	Numbers of Whales According to Species							
Station (years)	Sperm	Baird's Beaked	Blue	Fin	Sei	Humpback	North Pacific Right	Totals
Naden Harbour (1911 to 1941)	734	0	302	1,350	76	574	5	3,041
Rose Harbour (1910 to 1943)	2,086	6	338	1,597	431	608	3	5,069
Totals	2,820	6	640	2,947	507	1,182	8	8,110[1]

1 >1,200 whales taken from the Haida Gwaii region were landed at Coal Harbour

of western Alaska. This is because as large whale numbers declined, killer whales switched to smaller mammal prey (*e.g.*, sea otters - Estes *et al.* 1998; Doroff *et al.* 2003). However, in British Columbia, for example, sea lion and harbour seal numbers are increasing despite past whaling.

CURRENT CONSERVATION STATUS IN THE NORTHEAST PACIFIC

Marine mammals have the highest proportion of species with "listed" conservation status of any marine animal group around Haida Gwaii. Table 7 provides the conservation status in British Columbia, Canada, United States and internationally for the 26 marine mammal species occurring around Haida Gwaii, and the definitions of all listing criteria. The status of many species varies across jurisdictions. International listed status is relevant to Canada, which is a signatory nation to agreements such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Marine mammal protection through international governance such as Law of the Sea is reviewed by Kimball (2003)

Since 1970, all marine mammals in Canada have been federally protected by DFO under Marine Mammal Regulations appended to the *Fisheries Act*. In response to the explosive growth in the whale-watching industry, draft amendments to these regulations underwent a public consultation process in the Pacific region in 2003 [http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/marinemammals/]. Since 1977, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has had the federal mandate of assessing and designating species at risk (COSEWIC 2000). Canada's *Species at Risk* [*SAR*] *Act* (passed in 2002) involves three federal departments (Environment Canada, DFO, Heritage Canada [for PCA]) with responsibility for its implementation. The *SAR Act* compels protection and recovery of all federally (COSEWIC) listed species including protection of their critical habitats in federally-controlled areas (*e.g.*, NMCAs) and in cooperation with the provinces on provincially controlled areas. Further, a species' listed status requires the drafting of a National Recovery Strategy which following public consultation results in a formal Action Plan to guide recovery efforts. In June 2004, the *SAR Act* prohibitions will come into force, protecting individuals, their "residences" (*e.g.*, sea lion rookeries) and critical habitats (*e.g.*, key foraging areas). As well, PCA marine policy supports species recovery, including by active restoration, where research verifies its efficacy (Parks Canada 1994).

The highest federal status (*Endangered*) is currently applied to blue whales, sei whales, North Pacific right whales and the southern resident killer whale population. *Threatened* status is applied to sea otter, humpback whale and the northern resident and transient killer whale populations. These species have, or will have, National Recovery Strategies and Action Plans under the *SAR Act*. For example, the sea otter (Nichol *et al.* 2003) and North Pacific right whale (O and Ford 2003) recovery strategies are in final form after public consultation and the development of Action Plans are underway.

Unfortunately, for most species, there are few data on earlier population sizes. Indeed, recent genetic analyses by Roman and Palumbi (2003) suggest that in the North Atlantic we may be underestimating the past population size of some large whale species, and that the carrying capacity of the ocean may be much larger than previously thought. For example, they suggest historical population sizes of ~240,000 humpback, ~360,000 fin and ~265,000 minke whales, which are 6 to 20 times higher than present-day estimates for humpback and fin whales, and double the number of minke whales in the North Atlantic. These genetically based population estimates remain highly controversial though, and may not reflect populations at the ontset of commercial whaling. However, appreciating the possibility of much larger baleen whale populations may be important, for example, when setting targets for species recovery.

Federally, most other regional marine mammal species or populations are considered *Not at Risk*, although three are of *Special Concern* and one is *Data Deficient*. Factors important to consider when assessing status include the population size and trends within the species' historical range, environmental contaminant levels, prey availability and vulnerability to harm from human activities.

British Columbia listed status is currently assigned to 22 of the 26 species (Table 7). The Conservation Data Centre in Victoria is responsible for regional (British Columbia) species rankings [wlapwww.gov.bc.ca/wld/] within a cooperative, continent-wide system of ~80 regions. The provincial status of species can vary from federal status, for example, Steller sea lions are *red*-listed provincially and listed as *Special Concern* federally.

Seven of the species in Table 7 are listed in the United States under the *Endangered Species Act* [*ESA*] of 1973. In United States' waters, a 1994 amendment of the *Marine Mammal Protection Act* [*MMPA*] of 1972 compels assessment of all separate populations (stocks) of marine mammal species while the *ESA* is used to formulate the List of Endangered or Threatened Wildlife (Read and Wade 2000).

Regional marine mammals also have international status designations (Table 7). These include CITES and IUCN (The World Conservation Union) listings on 12 and 10 species respectively. CITES designations are applied to prevent international trade in endangered species. The IUCN's "Red List" of species embodies the baseline global status for all threatened species.

The ranges of many Northeast Pacific marine mammals straddle Canada-United States territories in which they have different conservation listings (Table 7). For example, Steller sea lions are listed as *Special Concern* federally by COSEWIC, listed as *Endangered* in United States waters west of 144º W longitude and listed as *Threatened* in southeastern Alaska waters (east of 144° W), yet, the population is considered indistinguishable between southeast Alaska and British Columbia (Calkins *et al.* 1999). Steller sea lions branded on the southeast Alaska's largest rookery at Forrester Island can occur at the Cape St. James rookery (Figure 2). As well, sea otters are listed as *Threatened* in Canada, unlisted in adjacent southeast Alaska waters and listed as *Threatened* in Washington. Perhaps the most dramatic situation is that of the *southern resident* population of killer

Table 7. Marine mammal species of the Haida Gwaii region with notes on their "listed" conservation status in British Columbia, Canada, United States and word-wide.

Species	Notes on Listed Status				
	British Columbia[1]	Canada[2] (year of designation)	United States[3] (year of designation)	CITES[4]	IUCN[5]
Sperm whale	*Blue*	*Not at risk* (1996)	*Endangered* (1970) through its entire geographic range	I	VU
Killer whale	*Red* (all resident & transient populations) *Blue* (offshore population)	Southern resident population *Endangered*; northern resident & transient populations *Threatened*; offshore population *Special Concern* (all 2001)	Not listed	Not listed	Not listed
Short-finned pilot whale	*Yellow*	*Not at risk*(1993)	Not listed	Not listed	Not listed
Baird's beaked whale	Not listed	*Not at risk*(1992)	Not listed	I[6]	Not listed
Cuvier's beaked whale	Not listed	*Not at risk*(1990)	Not listed	I[6]	Not listed
Stejneger's beaked whale	Not listed	*Not at risk*(1989)	Not listed	I[6]	Not listed
Risso's dolphin	*Yellow*	*Not at risk*(1990)	Not listed	Not listed	Not listed
Pacific white-sided dolphin	*Yellow*	*Not at risk*(1990)	Not listed	Not listed	Not listed
Northern right-whale dolphin	*Yellow*	*Not at risk*(1990)	Not listed	Not listed	Not listed
Common dolphin	Not listed	*Not at risk*(1991)	Not listed	Not listed	Not listed
Striped dolphin	*Yellow*	*Not at risk*(1993)	Not listed	Not listed	Not listed
Dall's porpoise	*Yellow*	*Not at risk*(1989)	Not listed	Not listed	Not listed
Harbour porpoise	*Blue*	*Data Deficient* (1991), up-listed to *Special Concern* (2003)	Not listed	Not listed	VU
Blue whale	*Blue*	*Endangered* (2002)	*Endangered* (1970) through its entire geographic range	I	EN/VU
Fin whale	*Blue*	*Special Concern* (1987)	*Endangered* (1970) through its entire geographic range	I	EN
Sei whale	*Blue*	*Endangered* (2003)	*Endangered* (1970) through its entire geographic range	I	EN
Humpback whale	*Blue*	*Threatened* (1985), status upheld (2003)	*Endangered* (1970) through its entire geographic range	I	VU
Gray whale	*Blue*	*Not at risk* (1989)[7]	Not listed, delisted from *Endangered* (1994)	I	EN
Minke whale	Not listed	Not listed[7]	Not listed	I	Not listed
North Pacific right whale	*Red*	*Endangered* (1990), status upheld (2003)	Not listed; northwest Atlantic stock *Endangered* (1970)	I	EN
Steller sea lion	*Red*	*Not at risk* (1987), up-listed to *Special Concern* (2003)	*Threatened*(1990) through its entire geographic range; up-listed to *Endangered*(1997) for the area west of 144° W	Not listed	EN
California sea lion	*Yellow*	*Not at risk* (1987)	Not listed	Not listed	Not listed
Northern fur seal	*Blue*	*Not at risk* (1996)	Not listed	Not listed	VU
Northern elephant seal	*Yellow*	*Not at risk* (1986)	Not listed	Not listed	Not listed
Harbour seal	*Yellow*	*Not at risk* (1999)[7]	Not listed	Not listed	Not listed
Sea otter[8]	*Red*[9]	*Endangered* (1978)[10], status upheld (1986); down-listed to *Threatened* (1996), status upheld (2000)	Southern (California area) population (*Enhydra lutris nereis*) *Threatened* (1977); in 1987, an *Experimental Population*[11] was designated south of Point Conception, CA	I	Not listed

1 provincial listing by the Conservation Data Centre, B.C. Ministry of Sustainable Resource Management [http://srmwww.gov.bc.ca/cdc/] *Red*-listing = extirpated, endangered or threatened; *Blue*-listing = vulnerable/at risk; *Yellow*-listing = not at risk (listings current to January, 2002)

2 the Canadian national listing is by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), this committee [http://www.cosewic.gc.ca] is an arms-length technical group of provincial/territory, federal agency, Aboriginal and scientific representatives that determines species' nation-wide status and forwards listing recommendations to the political decision-maker, the Canadian Endangered Species Conservation Council (listings current to May 2003); COSEWIC listings are defined as: *Endangered* = facing imminent extirpation or extinction / *Threatened* = likely to become endangered if limiting factors are not reversed / *Special Concern* = has characteristics that make it particularly sensitive to human activities or natural events / *Data Deficient* = there are insufficient data to support a status designation / *Not at Risk* = species examined and concluded as not being at risk; the legal listing in Canada is mandated to the Minister of Environment through the *Species at Risk Act* (passed in 2002)

3 federal listing [http://endangered.fws.gov/] using the *Endangered Species Act* (Read and Wade 2000), by the Division of Endangered Species, U.S. Fish and Wildlife Service, Department of Interior (listings current to January, 2003)

4 Appendix status in CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora -[http://www.cites/org/]); this international agreement between governments came into force in 1975 to ensure that trade in species does not threaten their survival; Appendix I is the highest listing for species "threatened with extinction" and international trade in these species or their products is prohibited, unless explicitly permitted because of exceptional circumstances (*e.g.*, scientific research)

5 "Red List" category of the IUCN (The World Conservation Union-[http://www.iucn.org/]), the world's largest environmental NGO (founded in 1948); the IUCN's Species Survival Commission issues the IUCN Red List [http://www.redlist.org] which is the base global inventory of conservation status for all species; of the nine Red List categories, those relevant here are EN=Endangered and VU=Vulnerable as well as a combined EN/VU which means that different stocks are threatened at different levels of severity within their total geographic range; note also that a species having one category does not mean that it is necessarily under uniform threat throughout its total range and the category could apply to only one stock of the species

6 applies to all beaked whale species; for the Haida Gwaii region: these are Baird's, Cuvier's and Stejneger's beaked whales

7 under review, report due 2004

8 sea otters and northern fur seals have been internationally protected in the North Pacific region under the Northern Fur Seal Treaty, signed in 1911, by the U.K. (for Canada), U.S.A., Japan and Russia

9 was initially listed in 1980 under the *British Columbia Wildlife Act* as *Endangered*

10 federally protected firstly under the *Fisheries Act*, now all listed species are protected under the *Species at Risk Act*

11 an *Experimental Population* was established at San Nicolas Island, outermost of the Channel Islands south of Point Conception, CA (34°26.9′ N), with 139 translocated sea otters between 1987 and 1990 by the U.S. Fish and Wildlife Service with an undertaking to relocate any sea otters from the *management zone* along the mainland south of Point Conception to protect fisheries; to date, there are few (<20) sea otters around San Nicolas Island (as many emigrate back to mainland areas) and there are problems with keeping them out of the *management zone* which concerns the fishing industry

whales listed as *Endangered* in Canadian (southern British Columbia) waters. For United States (Washington State) waters, the National Marine Fisheries Service decided against listing this straddling population in 2002, eliciting court action by NGOs seeking to overturn the federal agency decision. In 1997, the Canada-U.S. Framework for Cooperation in the Protection and Recovery of Wild Species at Risk [http://www.speciesatrisk.gc.ca/] was created to prevent the extinction of populations that are shared by Canada and the United States. However, no marine mammal species are currently listed under this agreement.

There were few marine mammal conservation efforts around Haida Gwaii until the 1980s, with hunting and sanctioned culling being cited as examples of short-term economic thinking (Foster 1989). Despite protection for species, however, some problems remain. For example, after >25 years of active protection and ~10 years of research, North Pacific right whales are still not recovering (Read and Wade 2000; O and Ford 2003). Nonetheless, there are now strong legislated mandates for protecting and restoring marine mammal populations in the Northeastern Pacific. These will be influential for regional marine mammal conservation and restoration well into the future.

SEA OTTER CASE STUDY

Sea otters provide an interesting case study of science and policy involvement in recovery activities for a federally listed species. A National Recovery Strategy for sea otters was completed after public consultation (Nichol *et al.* 2003) with an Action Plan due to proceed through public consultation in 2004. The ultimate goal of recovery is to have the species delisted by COSEWIC. Parks Canada's policy is to support the Recovery Strategy's main objectives of specifying a minimum viable sea otter population size and identifying adequate geographic distribution to ensure survival from a disaster.

The spectrum of regional opinions on sea otters range from vermin (QCI Observer 2003 [January 23]) to a species warranting active reintroduction (Moore 1988). The potential threat of a catastrophic oil spill remains a key reason for the species' *Threatened* status in British Columbia. For Haida Gwaii, therefore, the prospect of Hecate Strait-Queen Charlotte Sound oil and gas exploration and development is a key sea otter issue. Similarly, the threat of oil spills to sea otters in southern California prompted United States recovery team scientists to recommend retaining listed status (Brody *et al.* 1996; Ralls *et al.* 1996).

The sea otter's voracious appetite means that its recovery will decrease populations of invertebrate prey species (Watson 2000), including the northern abalone (*Haliotis kamtschatkana*) which itself is federally listed as *Threatened*. Northern abalone has a National Recovery Strategy (DFO 2002b) and an Action Plan. It is known that sea otter predation reduces abalone populations to low numbers of cryptic, crevice-dwellers (Sloan and Breen 1988). There is the prospect, therefore, of success with one listed species (sea otters) hampering recovery efforts for another listed species (northern abalone) and difficult decisions towards desired recovery outcomes may have to be made (Sloan 2004). This is further complicated by the expectation of some that recovery will achieve densities observed in previous decades, when sea otters were absent. Little northern abalone recovery has occurred despite the complete coast-wide closure to harvest in 1990 (still in force) (Campbell 2000). This has been a hardship for the Haida for whom northern abalone was an important subsistence fishery (Richardson and Green 1989; Jones and Guujaaw 2000). As well, sea otter recovery could affect current commercial and subsistence shellfisheries around Haida Gwaii, such as for red sea urchin

(*Strongylocentrotus franciscanus*), intertidal clams and Dungeness crab (*Cancer magister*). The prospect of sea otter recovery, therefore, involves complex socioeconomic and scientific issues (Sloan 2004).

Given that the proposed Gwaii Haanas NMCA waters would be under federal jurisdiction, the *SAR Act* regulations would apply and sea otter populations would be fully protected within the proposed NMCA. Further, Parks Canada (Parks Canada 1994) policy includes potential marine ecosystem restoration through sea otter reintroduction. In the policy's Ecosystem Management section, restoration of extirpated species is supported in principle provided that "….*research has shown that reintroduction is likely to succeed and that its probable effects are acceptable within the conservation area and the surrounding region*." This PCA policy was drafted before the *SAR Act* and the latter now provides the key legal protection for federally listed species.

Natural reestablishment of sea otters is distinctly possible. Sea otters do occur in the Haida Gwaii region and there are rapidly expanding populations on the central mainland coast directly across Hecate Strait, on the northern tip of Vancouver Island and in Southeast Alaska. Expansion throughout Haida Gwaii would likely be rapid if a breeding group was established.

Alternatively, sea otters could be translocated to Haida Gwaii by humans. This would likely be accompanied by rapid population expansion to the whole archipelago. Translocation of sea otter populations has been common along the Northeast Pacific coast (Bodkin *et al.* 1999). In British Columbia, 89 Alaskan (Aleutian and Prince William Sound stocks) sea otters were translocated to the northwestern coast of Vancouver Island (Checleset Bay) by DFO in cooperation with the province from 1969 to 1972 (McAskie 1987; Watson *et al.* 1997).

There is a history of interest in translocation of sea otters to Haida Gwaii. The now defunct Islands Protection Society (Masset) once promoted the idea of translocating Alaskan stock to Hippa Island in the V.J. Krajina Ecological Reserve (Anonymous 1976). Moore (1988) recounted that the British Columbia Wildlife Branch included the translocation concept in their 1980-1984 Regional Wildlife Management Plan, but no funding was provided. The concept was not in their 1985-1990 Plan, but the Branch apparently was amenable to private funding for a reintroduction (Moore 1988). In the Council of Haida Nation's (CHN) 1987 House of Assembly, a Resolution (R.02.87) supporting reintroduction was passed. In 1987, the CHN, a private donor, and the British Columbia Ministry of Environment applied for a translocation permit to the Wildlife Branch. As well, the province formally proposed the reintroduction idea to DFO using Alaskan stock (preferred sites: SGang Gwaay [Anthony Island] and Hippa Island - alternate sites: Englefield Bay and Skincuttle Inlet). A public meeting was held in Masset in January 1988, and both opposition and support was expressed (Moore 1988), but the fisheries-based opposition prevailed. As well, Alaska was by then unwilling to issue a permit as the local proposal was deemed too weak on "scientific purpose" (Moore 1988).

The sea otter National Recovery Strategy (Nichol *et al.* 2003), to which Parks Canada adheres, does not currently recommend translocation. The strategy does recommend assessing the feasibility of translocation to achieve the "adequate distribution" objective. In the case of either natural or human-influenced return of sea otters, educating the public of possible ecosystem and fishery outcomes is important.

METHODS

To review the distribution and life history of marine mammals in Haida Gwaii, we consulted the following sources:

- cetacean sighting records (of the *British Columbia Cetacean Sightings Network*);
- the historical whaling database (Nichol *et al*. 2002);
- North Pacific Fur Seal Commission data held by DFO;
- unpublished pinniped data held by P.F. Olesiuk, DFO;
- peer-reviewed scientific literature (*e.g.* journal articles, books);
- secondary ("grey") literature including government documents;
- unpublished consultants' reports;
- unpublished archaeological reports commissioned by PCA and others;
- Laskeek Bay Conservation Society mammal sightings records;
- Gwaii Haanas' sea otter occurrence database; and
- websites of government agencies and non-government organisations involved in marine mammal study and/or conservation.

Since 1989, the VAMSC has collected cetacean sighting records for all of British Columbia. Within Haida Gwaii, the Aquarium also distributed logbooks to Haida Gwaii Watchmen, tour-boat operators, government vessels and the Laskeek Bay Conservation Society. These logbooks contain standardized sighting record forms that are returned to the Aquarium. The Marine Mammal Research Group of Victoria has in the past collected sightings from mariners using a toll free phone number to solicit information. Gaston and Jones (1991) summarized six years of systematically collected sighting data from western Hecate Strait. The VAMSC and DFO have collated all sighting data (including that of Gaston and Jones 1991) into the *British Columbia Cetacean Sightings Network*. This network was established in 2000 by DFO and the VAMSC to solicit and consolidate sighting records province-wide [www.wildwhales.org]. Sighting logbooks are also distributed to mariners who do not have web access. A copy of the form is shown in Figure 5.

The reviews of Webb (1988), Nichol and Heise (1992) and Nichol *et al.* (2002) are the prime historical sources on regional commercial whaling. The historical whaling database is now complete coast-wide (Nichol *et al.* 2002). Records from Nichol and Heise (1992) also provided locations of sightings for rare species such as the northern right whale and Baird's and Cuvier's beaked whales. Another source of data used in this report comes from the collection of animals. Much of what we know about fur seals, harbour seals and sea lions comes from scientific kills, and as mentioned earlier, the Japanese continue to capture whales for scientific purposes. Since the end of commercial whaling in the 1960s, however, scientists usually rely on less destructive methods such as photo-identification, stranded-animal necropsies, and tissue sampling with biopsy darts. For species such as the beaked whales, sightings are rare and virtually all information comes from stranded animals. A stranded whale of any species provides a relatively rare opportunity to gain new knowledge.

Cetaceans are now often studied using photo-identification of individuals (Hammond *et al.* 1990), including blue (Sears *et al.* 1990), fin (Agler *et al.* 1990) and minke whales (Dorsey *et al.* 1990). In British Columbia, photo-identification is used to study gray, blue humpback and killer whales. Photographs are generally taken using high-speed black and white film, and more recently with digital cameras. Efforts are being made to identify gray whales that over-summer following spring migration (Calambokidis *et al.* 1994; Deecke 1997; Calambokidis *et al.* 2002). An example of a gray whale identification photograph is shown in Figure 6. The photograph is taken of the whales' left side, just before deep diving, so that the prominent series of

A project of:
VANCOUVER AQUARIUM
MARINE SCIENCE CENTRE

Environment Canada | Environnement Canada | Fisheries and Oceans Canada Science | Pêches et Océans Canada Sciences

Whale, Dolphin, and Porpoise Sighting Form

Date ____________________ **Local Time** (24hr) ____________________

General Location ____________________ **Latitude/Longitude** (please use decimal minutes) ____________________

Sea State ____________________ **Wind Speed** ____________________

Species Name* ____________________

*If uncertain of species identity, please note body shape and size, presence or absence of dorsal fin, body colouration, and any other distinguishing features. Use back of form for sketches or further details.

ID Confidence ☐ Certain ☐ Probable ☐ Possible ☐ Uncertain

Body Length Estimate:
☐ <3m (<10 ft.)
☐ 3-8m (10-25 ft.)
☐ 8-16m (25-50 ft.)
☐ 16-26m (50-80 ft.)
☐ >26m (>80 ft.)

Sighting distance ____________

No. in group ________ +/- ________

Fishing Interactions
(circle these or add your own in comments section)
Contact with gear | Contact with vessel
Feeding from gear | Feeding on discards
Entangled in gear | Following vessel while fishing

Photos / Video: ☐ photographs ☐ video

Sighting Platform: (height off water) ____________________

Comments (describe in your own words all features seen, behaviours observed and anything else of note)

Observer ____________________ **Vessel** ____________________

Address ____________________ **Phone** ____________________

email ____________________

Please return to:

B.C. Cetacean Sightings Program
Cetacean Research Lab
Vancouver Aquarium Marine Science Centre
PO Box 3232, Vancouver, BC, V6B 3X8
or fax: 604-659-3515

Any questions or concerns can be emailed to: Sightings@vanaqua.org
www.wildwhales.org

Figure 5. An example of the reporting form from a cetacean sighting log book issued by the British Columbia Cetacean Sightings Network.

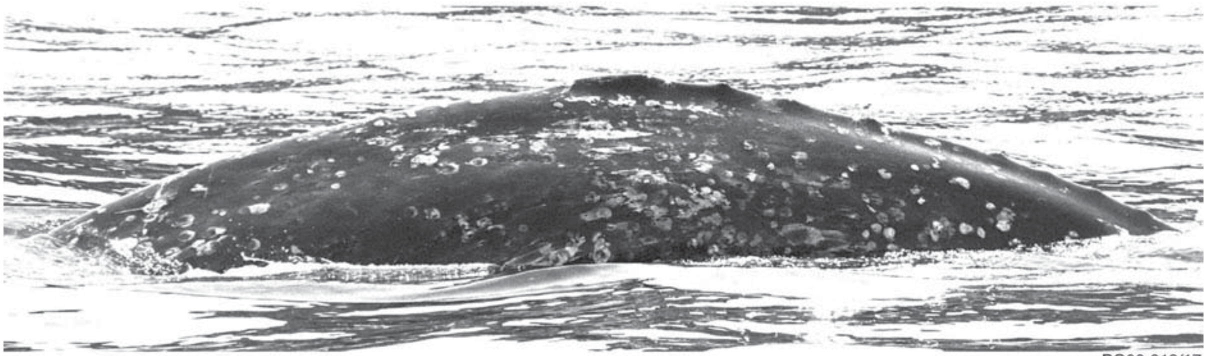

Figure 6. An example of a gray whale identification photograph of the left side (photo courtesy of B. Gisborne).

knuckles along the dorsal ridge is visible. The method for photographing killer whales is described in Bigg *et al.* (1987) and Figure 7 is an example of an identification photograph showing the preferred left side of the dorsal fin with the saddle patch at its base. Identification photographs of humpback whales require the underside of the tail (Figure 8).

At Langara Island a commercial sport-fishing lodge has been sponsoring cetacean research since 1990. Usually twice each year, in July and September DFO researchers photo-identify the area's humpback and killer whales. So far, >1,000 individual humpbacks have been identified in northern British Columbia, often while feeding on krill (euphausiids) and Pacific

Figure 7. An example of a killer whale identification photograph of the left side (photo by K. Heise).

Figure 8. An example of a humpback whale identification photograph of the underside of its tail fluke (photo by K. Heise).

herring (*Clupea pallasii*) (J.Ford, DFO, unpublished data). Humpback tail fluke photographs have revealed that some migrate to Hawaii in winter. Details on this research are reported in the individual species reports on humpback and killer whales.

Whenever possible, original documents were used. However, if original sources were unavailable, we used information from secondary sources such as review papers and cite them accordingly. Quantitative data on the locations of marine mammals around Haida Gwaii used in this report have been compiled by the VAMSC, DFO and Gwaii Haanas. We illustrate all records of sightings and historic whaling kills between 50.5° N and 55° N, and from the mainland coast west to 145°W. However, not all the whales landed at the stations are represented by kill locations in the whaling database.

The three main databases used to map the locations of marine mammals around Haida Gwaii are the *British Columbia Cetacean Sightings Network* database (from DFO and VAMSC), the historical whaling database (Nichol *et al.* 2002; from L. Nichol, DFO) and sundry pinniped data (from P. Olesiuk, DFO). Once incorporated into Gwaii Haanas' GIS, these databases share most of the following properties:

- database records are referenced, where possible (*e.g.*, a literature citation);
- records are spatial and temporal;
- databases are geo-referenced in a standard format (spatial coordinate system);
- each database has information on the location quality; and
- each database contains some level of metadata, which is information that describes databases using conventional standards such as text describing methods and codes used to construct databases.

There are four caveats influencing how our maps should be interpreted. Firstly, each data point needs to be interpreted cautiously. Cetaceans and pinnipeds live in three dimensions, and most species travel widely and spend much of their at-sea time underwater. As a result, points on a map capture fleeting moments in the lives of these animals, and while these maps may be informative, they cannot capture the full range of habitat that each species utilizes. The kill data are terminal observations of individuals while the sightings data could include multiple observations of the same animal over time. Areas described may be of seasonal importance, but will certainly have variable and indeterminate boundaries. Nonetheless, these databases reflect the current state of regional marine mammal knowledge and remain works-in-progress as new information is forthcoming. Secondly, the reliability of sighting reports is not uniform. The *British Columbia Cetacean Sighting Network* has a data field that estimates the reliability of reports by unknown observers, but incorporating these into the maps was beyond the scope of this report. Thirdly, some of the sighting records in the database are actually strandings of dead or dying animals, which may not reflect a species true distribution. For beaked whales, the majority of records are of strandings. Finally, very little of the information was gathered as a result of systematic surveys, so coverage is weighted toward locations and seasons frequented by observers. The known distribution of a species is likely, therefore, to be more indicative of the distribution of observers than of the animals themselves.

CETACEANS

Here we summarize knowledge on the life history and occurrence of cetacean species in the Haida Gwaii region. Cetaceans fall into two categories; those with teeth and those with baleen. The species accounts presented here are organized accordingly. More details on life histories of each species are provided in the Encyclopedia of Marine Mammals (Perrin *et al.* 2002).

Cetaceans occur in a variety of habitats from open-ocean to coastal inlet. Some, such as the humpback whale, range widely in both nearshore and offshore waters, whereas others, such as the harbour porpoise, are largely restricted to nearshore areas. The number of observers is low along much of the relatively isolated coast of Haida Gwaii, and it is possible that some species, such as the blue, fin, sei and beaked whales, are more abundant than the data reflect. Accurate population estimates do not exist for most species in British Columbia, but we include population estimates for Washington, Oregon and Alaska where available to give the reader a sense of species abundance in nearby areas.

Table 8. Numbers of cetacean sightings according to species from two reviews of the Haida Gwaii region.

Species	Ford *et al.* (1994)	Heise & Ford (2002)
Sperm whale	7	49
Killer whale	483	586
Baird's beaked whale	1	7
Cuvier's beaked whale	7	12
Stejneger's beaked whale	0	2
Short-finned pilot whale	0	4
Risso's dolphin	4	4
Pacific white-sided dolphin	99	296
Northern right-whale dolphin	0	3
Common dolphin	0	1
Striped dolphin	0	1
Dall's porpoise	92	234
Harbour porpoise	84	102
Blue whale	1	3
Fin whale	10	34
Sei whale	0	6
Humpback whale	253	683
Gray whale	90	142
Minke whale	86	108
North Pacific right whale	0	0
All species	1167	2277
Toothed whales	727	1301
Baleen whales	440	976

These values have a coefficient of variation (CV) associated with them. These are a measure of the data reliability on a scale of 0 to 1; the lower the value, the more reliable the data. For example, the United States National Marine Fisheries Service sets a goal of CV = 0.2 as an indication of fairly reliable data. Listed in Table 8 are the numbers of cetacean sightings and strandings around Haida Gwaii (1994 and 2002) that demonstrate the growth of regional sightings data.

TOOTHED WHALES (ODONTOCETI)

Besides having teeth, odontocetes are also distinguished by having a single blowhole. Of the 13 species of toothed whales recorded from around Haida Gwaii, killer whales, Pacific white-sided dolphins and Dall's porpoises are the most commonly sighted.

Sperm whale (*Physeter macrocephalus*)

Sperm whales are the largest of the toothed whales and are distinctive with enormous heads that comprise over a third of their body length (Reeves and Whitehead 1997). Their exhalations (blows) are unique in that they angle forward and to the left. They have a small hump rather than a distinct dorsal fin. Males attain a length of 18 m and females ~12 m (Leatherwood and Reeves 1983).

Sperm whales are acoustically active, and have a highly developed system of echolocation and communication that involves the use of low frequency clicks in either regular patterns, or in unique sequences called "codas" (Watkins and Schevill 1977). These clicks can be detected using the same hydrophones used for detecting the vocalizations of killer whales and dolphins. Codas appear to be produced during social behaviour (Whitehead and Weilgart 1991) and may have a variety of forms.

Much of what is known about the complex social structure of sperm whales comes from research in the South Pacific and the Caribbean. The basic element of sperm whale social organization is a long-term association of about 10 to 12 females and their young, termed "units" (Christal *et al.* 1998). These units are generally but not strictly matrilineal, as individuals sometimes move between units (Whitehead and Weilgart 2000). A unit typically forms temporary "groups" with one or more other units for a few days or more. Variation in the proportional use of different coda types by different groups led to the suggestion that sperm whales may have group-specific dialects (Weilgart and Whitehead 1997). In the South Pacific and Caribbean social groups of sperm whales can be divided into one of six acoustic "clans" (Rendell and Whitehead 2003). A clan can contain many thousands of animals, and range over thousands of kilometers. Units form groups preferentially with other units from the same clan.

Male sperm whales disperse from their natal groups at ~6 years of age but this can happen at any time between the ages of 4 and 21 (Whitehead 2002). In British Columbia, whalers obseved that large males tend to travel alone or in small groups that are separate from female and juveniles (Pike and MacAskie 1969), which is consistent with the social behaviour of sperm whales described by Whitehead (2002) from the South Pacific and Caribbean. Groups of 50 to 150 animals were reported in the waters of British Columbia (Pike and MacAskie 1969). Based on Rendell and Whitehead (2003) these large associations may have been members of the same acoustic clan. Pike and MacAskie (1969) suggested that the breeding season is in February and March, when groups of females are accompanied by bulls. At other times of the year, schools of females and juveniles tend to remain offshore, whereas males tend to travel nearshore (Pike and MacAskie 1969; Gregr *et al.* 2000). Genetic evidence has shown that mating is generally outside of the natal group (Lyrholm *et al.* 1999). Gregr *et al.* (2000) examined the locations of sperm whale catches in British Columbia from 1908 to 1967 and suggested that calving may take place in offshore British Columbia waters. If true, this is in contrast to the southern hemisphere, where they migrate to lower (tropical) latitudes to breed, and travel to higher (polar) latitudes after breeding (Best 1979).

The population status of sperm whales in the North Pacific is poorly known. Unpublished reports presented at IWC meetings in 1998 estimate ~100,000 whales in the northwestern Pacific and 39,000 in the northeastern Pacific (Ferrero *et al.* 2000). There are no data on population trends (Reeves and Whitehead 1997; Ferrero *et al.* 2000). Off the coast of California, Oregon and Washington, Forney *et al.* (2000) estimated ~900 (CV = 0.99), but this was revised to ~1,407 (CV = 0.39) by Caretta *et al.* (2002). The latter estimate took into account the proportion of whales diving (and therefore not counted) during the survey. There is no abundance estimate for British Columbia.

Sperm whales were once very abundant in the waters off Haida Gwaii. Shown in Figure 9 are the locations of kills from the whaling database (Nichol *et al.* 2002). Most whales were taken within 100 km of shore. Between 1933 and 1943, sperm whales comprised 79% of the catch from Naden and Rose Harbour whaling stations (Pike and MacAskie 1969). In total, >5,000 sperm whales were taken by whalers in British Columbia between 1905 and 1967 (Pike and MacAskie 1969). Most sightings of sperm whales were of small groups of <5, and, not surprisingly, most sperm whales taken were males (Pike 1965).

Only one stomach of a sperm whale from Haida Gwaii waters has been examined and it contained squid (*Moroteuthis robusta* and *Gonatus* sp.), ragfish (*Icosteus aenigmaticus*) and lamprey (*Lampetra* sp.) (Robbins *et al.* 1937). This was similar to the stomach contents of many of the 697 sperm whales landed at Coal Harbour. Flinn *et al.* (2002) found that in April and May, both male and female sperm whales consume fish and squid. Later in the season males were found to have a higher frequency of fish in their stomachs than did females, likely reflecting the fact that they were in nearshore waters where squid are less abundant.

The sightings of sperm whales reported from this region are shown in Figure 10. The majority are from the west coast and waters further offshore, although there are 12 sightings from Queen Charlotte Sound. Of eight recent strandings reported in British Columbia (Reeves and Whitehead 1997), four were from Haida Gwaii.

Killer whale (*Orcinus orca*)

Killer whales are one of the most readily identified cetaceans on the coast of British Columbia. Males reach maximum lengths of 9 m and females 7.7 m, but the characteristic that distinguishes killer whales from most other cetaceans is their striking black and white pigmentation (Ford 2002). Killer whales are unusual among cetaceans in that adult males have much larger dorsal fins than females. Killer whales are individually recognizable, based on the unique pattern of markings at the base of their dorsal fin (saddle patch) and the shape of their dorsal fin (Ford 2002). Photo-identification studies over the past 25 years have documented >700 individuals (Ford and Ellis 1999; Ford *et al.* 2000).

Since the early 1970s, researchers have studied the distribution, abundance, social organization, population dynamics and other aspects of killer whale ecology (Bigg *et al.* 1990; Ford and Ellis 1999; Ford *et al.* 2000; Ford 2002). Biopsy samples are being collected for genetic analyses by the VAMSC and for toxicological analyses by DFO (Ross *et al.* 2000). DFO is also

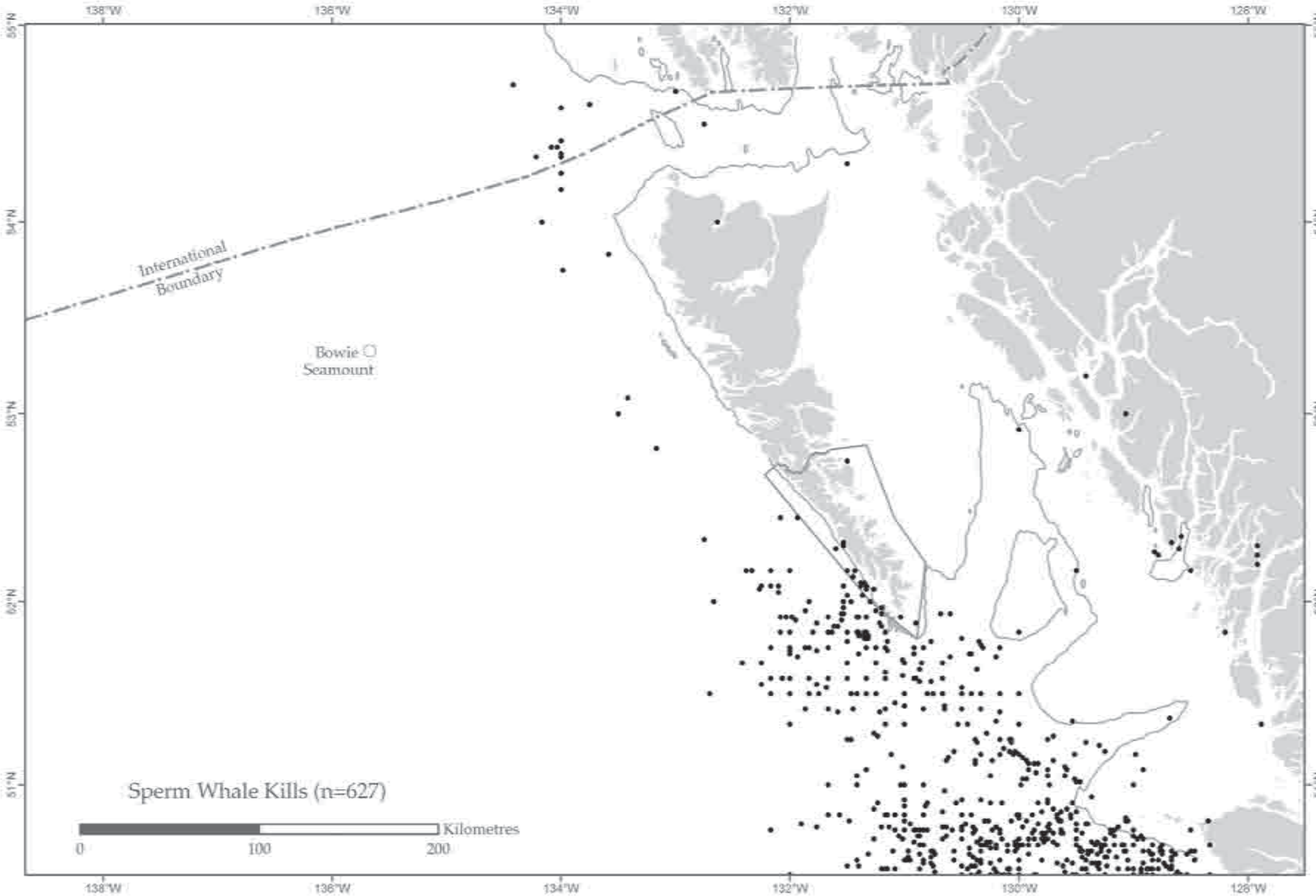

Figure 9. Locations of sperm whale kills recorded in the northern British Columbia area (north of 50.5° N) from the whaling history database compiled by Nichol *et al.* (2002) (data courtesy of L. Nichol, DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

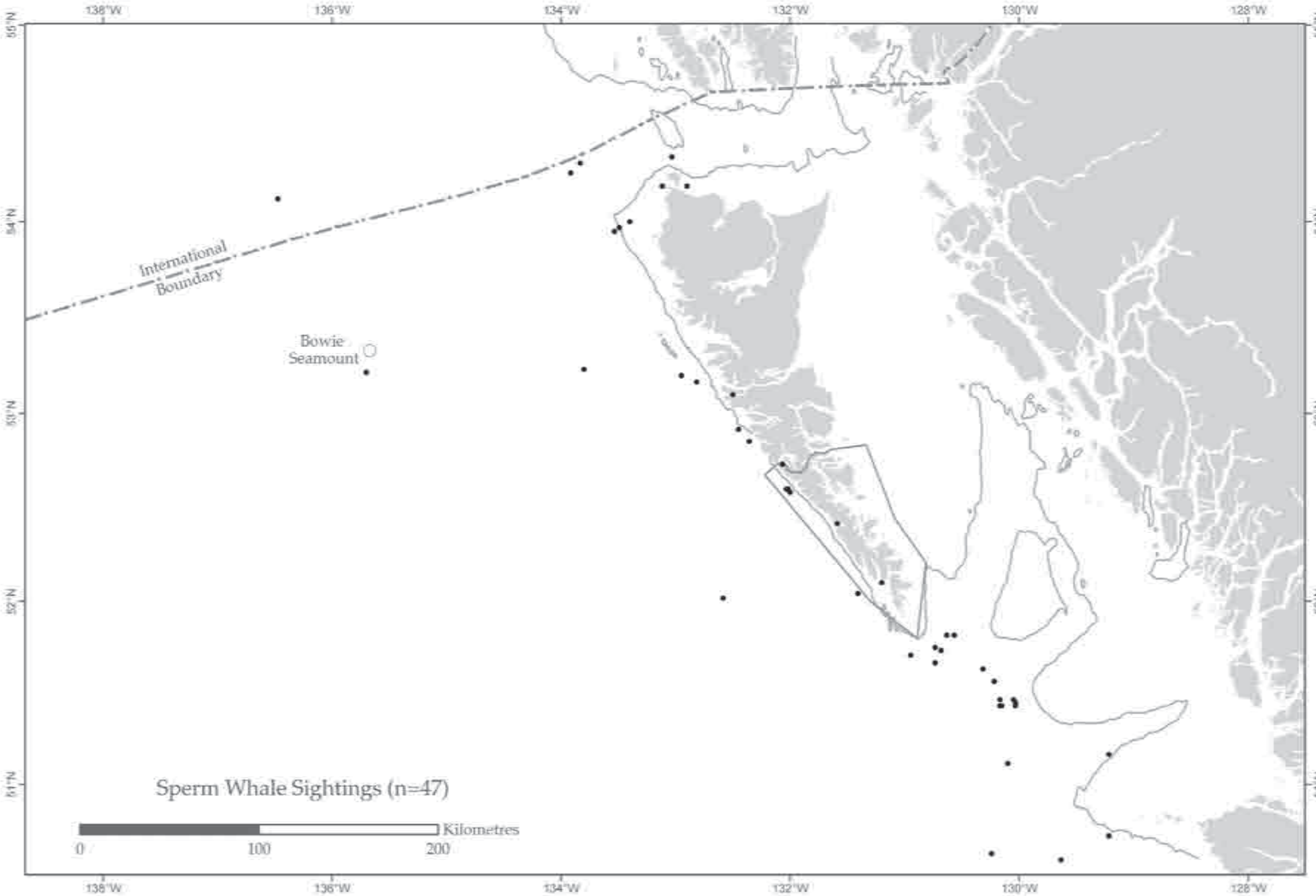

Figure 10. Locations of sperm whale sightings to 2002 in the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

overseeing ongoing acoustic studies of killer whales. Many additional collaborators also participate in this work.

Research has revealed three distinct populations; *residents*, *transients*, and *offshores*. Each population differs in many respects, yet all are known to overlap geographically, and members of each population have been seen around Haida Gwaii (Ford *et al.* 1994).

Resident killer whales feed primarily on salmon (*Onchorhynchus* spp.) in the summer (Ford *et al.* 1998), and often spend long periods in coastal areas. They are, therefore, the easiest to study of the killer whale populations. In British Columbia coastal waters, r*esidents* are divided into two sub-populations; *southern residents* and *northern residents* that number a total of ~300 whales (Ford *et al.* 2000).

Resident killer whales societies are complex. The fundamental social unit for residents is the "matriline" (a group structured around the maternal female), which is stable over time (Ford *et al.* 2000). *Resident* killer whales appear to be unique among mammals in that dispersal is very rare; males and females remain in their natal matrilines for life. Since killer whales are long lived, a matriline may contain 3-4 generations. The only exception to this is two whales that left or were separated from their matrilines sometime during the winter of 2001-02 [www.vanaqua.org]. One whale has since rejoined her pod, but not her matriline (her mother died) and the other remains isolated as of December 2003. R*esident* matrilines often travel in "pods" (groups of one to three related matrilines). Pods are not as stable as matrilines, but in general matrilines travel with matrilines from their own pod more than with other matrilines.

Resident killer whales are acoustically active and vocalizations are easily recorded using hydrophones. Each *resident* pod has a unique repertoire of discrete calls, a dialect, which can readily be distinguished from the dialect of all other pods (Ford 1989, 1991). Pods that share calls are considered members of the same acoustic "clan". In British Columbia, there are four acoustic clans of killer whales (Ford *et al.* 2000). The purpose of calls is uncertain, but they may help individuals to remain in contact with other members of their matriline (Ford 1991) and facilitate various social interactions between matrilines (Barrett-Lennard 2000).

Members of the second population of killer whales are known as *transients*. The *transient* population is divided into at least three subpopulations, only one of which is known to travel in the coastal waters of British Columbia; the *west coast transients*. In 1998, this subpopulation numbered ~219 whales (Ford and Ellis 1999). *Transients* live in groups of 1 to 6 individuals, but they are seen far less predictably than *residents*. Membership of these groups is more fluid than those of *resident* pods, and dispersal occasionally occurs (Ford and Ellis 1999).

Unlike *residents*, *transients* are usually acoustically quiet. This strategy allows them to detect their prey through passive listening and to avoid alerting them (Barrett-Lennard *et al.* 1996). *Transients* eat marine mammals, including harbour seals, Dall's and harbour porpoises, and California and Steller sea lions (Ford *et al.* 1998). Kills of mammalian prey are usually not obvious to surface observers, although small oil slicks, blood clots and blubber fragments are sometimes seen. On other occasions, kills may occur with much surface activity, as in the case when adult sea lions are attacked (Ford *et al.* 1998; Heise *et al.* 2003). Immediately following a kill, *transients* often vocalize for up to 30 minutes before falling silent again.

As *residents* and *transients* have overlapping ranges, they occasionally may be observed in proximity. However, they do not intermingle and they may even avoid each other. There has been one documented case of a large group of *residents* attacking a small group of *transients* (Ford and Ellis 1999). Researchers used stomach content analyses of stranded animals to confirm the dietary segregation between *residents* and *transients* indicated by behavioural observations (Ford *et al.* 1998; Heise *et al.* 2003).

The third population of killer whales in British Columbia waters is the *offshores*, which number ~200 (Ford *et al.* 2000). This population was first identified in the late 1980s, and frequents outer continental shelf areas. *Offshores* travel in groups of ~25 or more and they are acoustically active. Ford *et al.* (2000) suggested that they are primarily fish eaters; supported by stomach contents of two beached *offshores* in Alaska (Heise *et al.* 2003). It cannot be ruled out that they also eat mammals and more diet data are needed.

Although there are relatively few sources of anthropogenic (human-caused) mortality for killer whales, recent toxologicial (PCB) analyses suggest that they are among the most contaminated cetaceans in the world (Ross *et al.* 2000). They entangle in fishing gear, but relatively rarely. In the Bering Sea groundfish trawl fishery, one whale was reported killed over a 10-year period (Angliss and Lodge 2002). Killer whales have been reported occasionally interacting with commercial longline gear in Queen Charlotte Sound (G.Ellis, DFO, *personal communication*). Occasionally whales are struck by boats in British Columbia. There has been at least one fatality (Ford *et al.* 2000) and a juvenile survived a strike in the summer of 2003 (J. Ford, DFO, unpublished observation). The only commercial capture of killer whales in British Columbia was a live-capture fishery off southern Vancouver Island from 1962 to 1977 that took 68 animals from British Columbia and Washington State waters (Olesiuk *et al.* 1990c). Genetic evidence has shown that the Japanese have taken killer whales as part of their scientific whaling program, but the number is unknown (Baker *et al.* 1996).

The sighting records of killer whales around Haida Gwaii are shown in Figure 11. For most sightings, it was not possible to determine which population type individuals represented. For those with confirmed identities, all four population types are represented. When photographic, genetic or acoustic data have been collected, killer whales can be identified to the population level. Based on this information, 82% of the sightings of known animals around Haida Gwaii were *transients*. In January 1941, there was a mass stranding of 7 females and 4 males within a 75 m length of shore in Sturgess Bay, across Masset Sound from Old Massett (Cameron 1941). This was likely a *transient* pod as the largest male (~7 m long) contained the remnants of 13 small cetaceans and 14 pinnipeds.

Baird's beaked whale (*Berardius bairdii*)

Baird's beaked whales have relatively long, tube-like beaks, often visible when they surface, and prominent bulbous foreheads. They are the largest species of beaked whale, reaching ~13 m in length (Leatherwood and Reeves 1983). They have four teeth, two of which are visible near the tip of the mouth in males, and a small dorsal fin more than two-thirds of the way along their body. They are gregarious and are often seen in groups of 2 to 20 (Leatherwood and Reeves 1983). Baird's beaked whales occur throughout the North Pacific, but are usually seen offshore in waters >1,000 m deep. There are no population estimates for this species for the northeastern Pacific (Ferrero *et al.* 2000).

Pike and MacAskie (1969) reported on the stomach contents of 13 individuals examined at Coal Harbour between 1950 and 1958. Three were empty and seven contained fish bones (primarily small rockfish), seven contained squid, and two had skate egg-cases. In a survey of stomach

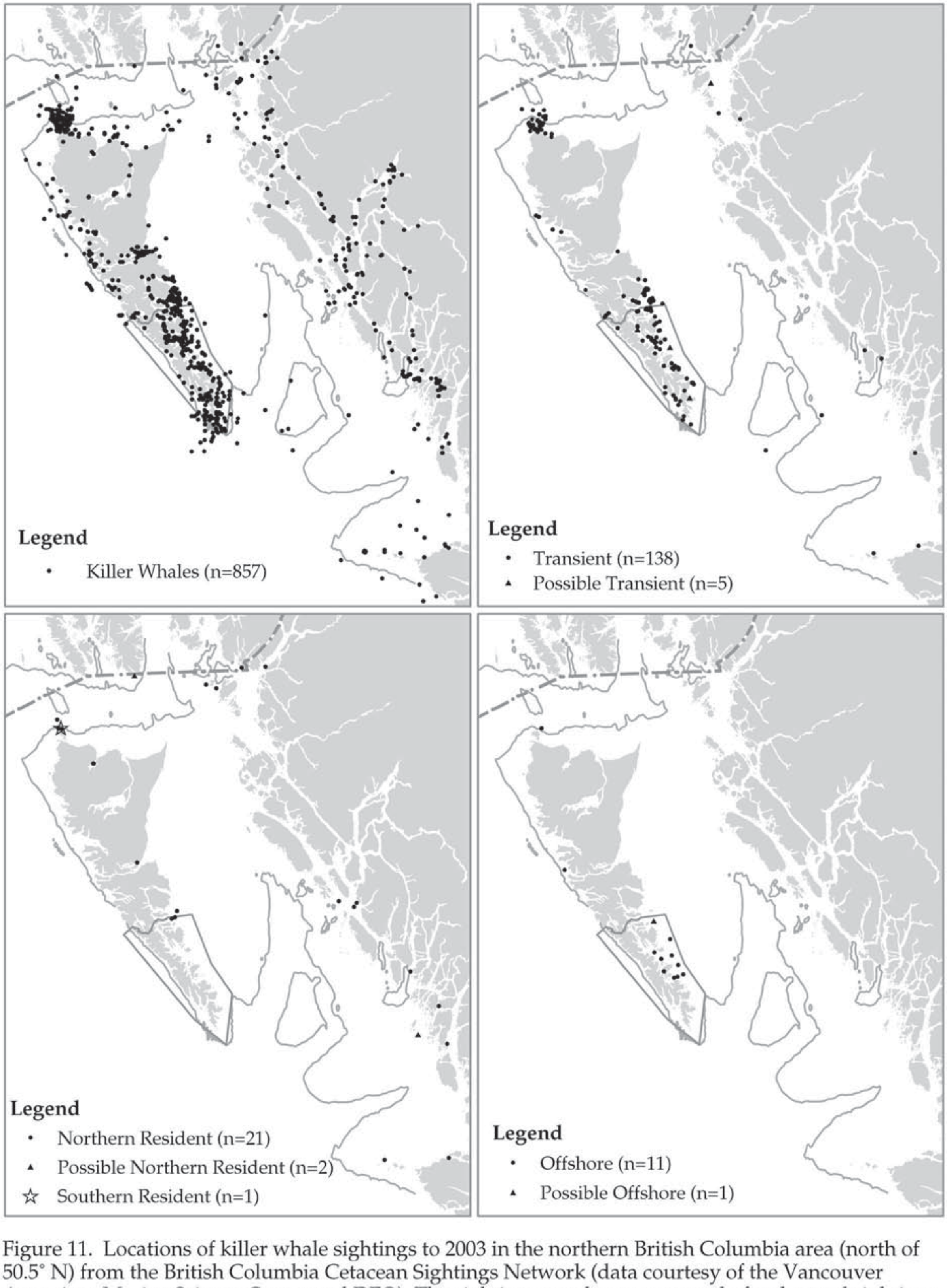

Figure 11. Locations of killer whale sightings to 2003 in the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The sightings are shown separately for the total sightings, the *transients*, the *residents* (including a *southern resident* off Langara island) and the *offshores*. The 200 m isobath demarcating the edge of the continental shelf is shown.

contents of 107 beaked whales caught in the Pacific waters of Japan, Walker *et al.* (2002) found that whales fed primarily on benthopelagic (deep-water) fish (82%) and squid (18%), suggesting that the whales dove to depths of 800 to 1,200 m to feed. In the southern Sea of Okhotsk, Walker *et al.* (2002) and Ohizumi *et al.* (2003) found that whales fed primarily on squid.

Six Baird's beaked whales were landed in Haida Gwaii by whalers (Table 6) and two others from the region were landed in Coal Harbour (Nichol and Heise 1992). Two were caught well off the west coast, and the remainder were taken in Queen Charlotte Sound between 1953 and 1958. Reeves and Mitchell (1993) provide locations for six of these whales. Figure 12 illustrates the sightings records of the three beaked whale species from Haida Gwaii waters. Since the 1960s, the one report from around Haida Gwaii was a stranding at Fife Point in March 1992 (Guenther *et al.* 1993; Willis and Baird 1998). The other sighting was in Queen Charlotte Sound. Baird's beaked whales are difficult to approach, and there are no recent sightings of living animals in Haida Gwaii. Because they are a pelagic species, they may be more common off the west coast. Three other strandings reported in British Columbia were from the west coast of Vancouver Island (Willis and Baird 1998).

Cuvier's beaked whale (*Ziphius cavirostris*)

Cuvier's beaked whales reach a maximum length of 7.5 m (Leatherwood and Reeves 1983). They are also known as goose-beaked whales as their lower jaw curves up to their upper jaw. They have two teeth near the tip of their jaw, although these may not erupt in females. Their colouration is variable from dark brown, to grey, to fawn with their bellies tending to be lighter than their backs. Their back and sides are usually covered in scars, caused by intraspecific fighting. They have a cosmopolitan distribution, but are better known from stranding records than from sightings (Leatherwood and Reeves 1983). In a review of diet data from 38 Cuvier's beaked whales from around the world, Macleod *et al.* (2003) found that they fed primarily on cephalopods (87%), but also ate crustaceans and fish.

There are no population estimates for the North Pacific (Houston 1991, Caretta *et al.* 2002), although there are more strandings of Cuvier's than any other beaked whale (Leatherwood and Reeves 1983). There have been 18 strandings along British Columbia, of which nine were from Haida Gwaii (Pike and MacAskie 1969; Ford *et al.*1994; Willis and Baird 1998) (Figure 12). These include two males, one near Tow Hill in the winter of 1959-1960 and a second near Sandspit in 1961. A female Cuvier's stranded in Balcolm Inlet in August 1988, and a second female stranded near Langara Island in July 1991. This animal had numerous squid beaks (*Gonatus* spp.) in its stomach. In 1994, a male stranded at Tian Head. A single Cuvier's beaked whale was incidentally caught in the flying squid (*Ommastrephies bartrami*) fishery in offshore waters in 1986 (Willis and Baird 1998). Reliable sightings of Cuvier's beaked whale were made in June and September 1988, off Windy Bay and Reef Island respectively (Ford *et al.* 1994). Willis and Baird (1998) also report a sighting off Skedans Islands in June 1989.

Stejneger's beaked whale (*Mesoplodon stejnegeri*)

All that is known about Stejneger's beaked whale is based on stranding records. They reach at least 5.3 m in length (Leatherwood and Reeves 1983). They have two large teeth located well behind the tip of the beak and that protrude well above the gum. These are generally only erupted in males, and the bodies of males are also covered in scars. They are thought to be endemic to the sub-arctic and cold temperate waters of the North Pacific, although they have been recovered from as far south as Monterey, CA (Leatherwood *et al.* 1982). There are no population estimates for the species (Caretta *et al.* 2002).

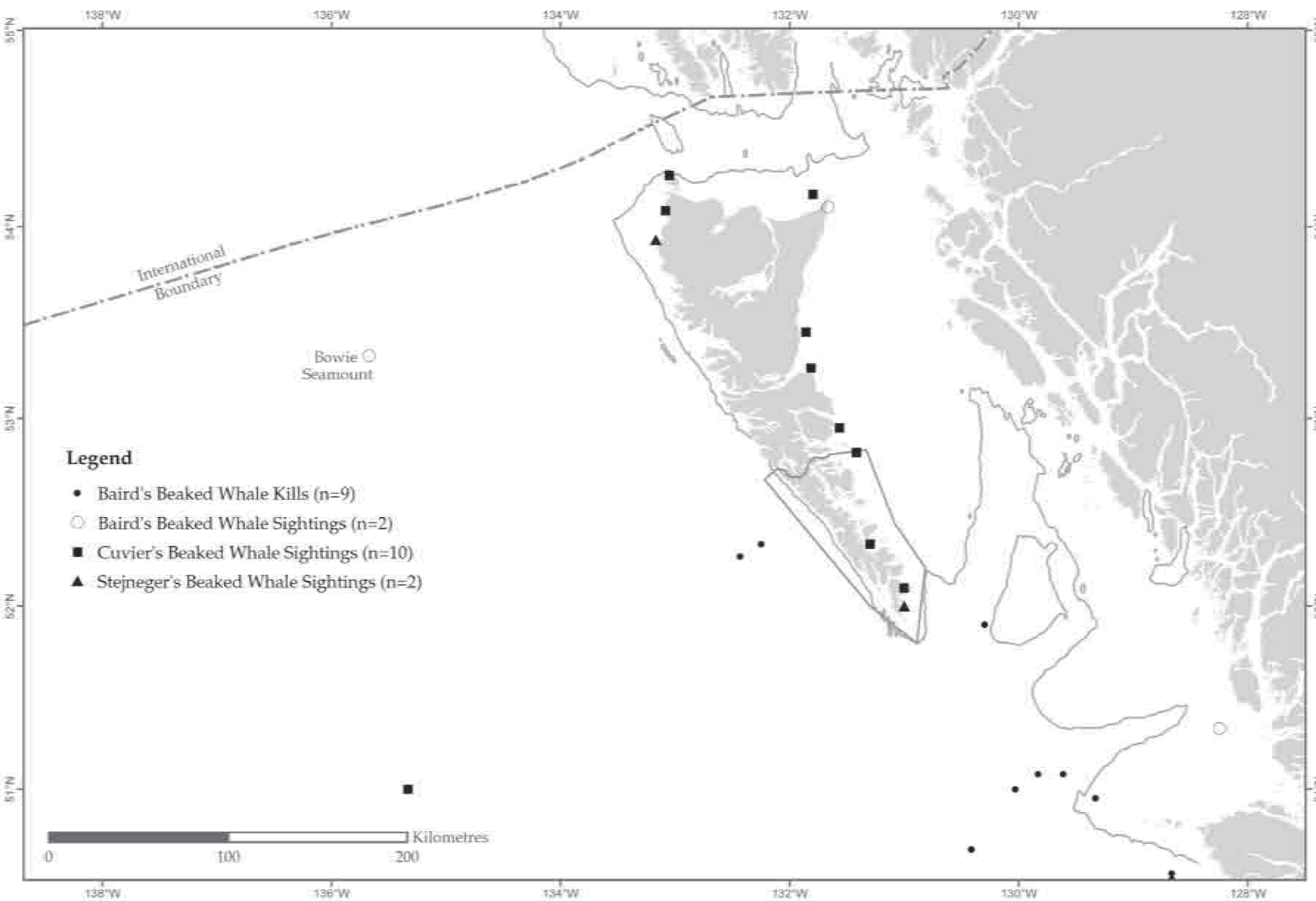

Figure 12. Locations of Baird's beaked whale kills and sightings/strandings of Baird's, Cuvier's and Stejneger's beaked whales in the northern British Columbia area (north of 50.5° N) from the whaling history database compiled by Nichol *et al.* (2002) (data courtesy of L. Nichol, DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

Willis and Baird (1998) report five strandings in British Columbia coastal waters, of which two were from Haida Gwaii (Figure 12). In April 1971 a male was found on Frederick Island and in July 1973 a female was found on the east side of Moresby Island.

Short-finned pilot whale (*Globicephala macorhynchus*)

Short-finned pilot whales resemble the long-finned pilot ("pothead") whales of the Atlantic. The Pacific species is black to dark brown with uniquely shaped bulbous foreheads. Their dorsal fins are distinctive, being set relatively far forward, and are falcate (sickle-shaped) and rounded rather than pointed at the tip. They reach maximum lengths of 6.1 m for males and 5.5 m for females (Perrin and Reilly 1984). In the northwestern Pacific, pilot whales have been hunted for food for many years. Between 1985 and 1989, Japan took 2,326 (Bernard and Reilly 1999). In the northeastern Pacific, they are incidentally caught in coastal fisheries gear.

In the northeastern Pacific, short-finned pilot whales range into the Gulf of Alaska (Baird and Stacey 1993). They are most common from Point Conception, CA south to Peru, although they are found in all tropical and temperate waters (Leatherwood and Reeves 1983). They can show marked seasonality in their distribution, perhaps matching the abundance of prey such as spawning squid (Bernard and Reilly 1999). As well, their abundance may change interannually. For example, they were commonly seen in the California Bight on surveys during the 1970s and early 1980s, but have been rare thereafter. Forney *et al.* (1995) speculated that the northward shift in pilot whale distribution was due to an increase in water temperature associated with the El Niño event of 1982-1983. Forney *et al.* (2000) suggested that pilot whales are gradually returning to the area with ~700 animals along California, Oregon and Washington. Stacey and Baird (1993) suggested that they are at the northern limits of their range off British Columbia.

Osgood (1901) and Wailes and Newcombe (1929) stated that pilot whales occur regularly off the British Columbia coast, but these sightings were discounted by Pike and MacAskie (1969). The latter authors felt that the sightings were more likely to be killer whales, since Osgood (1901) did not mention killer whales or Dall's porpoises in his species accounts, and Wailes and Newcombe saw "*very large groups*" of pilot whales in Hecate Strait. Without photographs or collected specimens it is impossible to determine which interpretation is correct.

There have been no reported sightings around Haida Gwaii since 1988. Given that pilot whales do show large changes in distribution over time, the possibility that they may be seen again around Haida Gwaii is likely. Pike and MacAskie (1969) listed 18 sightings, mostly offshore, off British Columbia between 1957 and 1960. Between 1970 and 1985 there were two reported sightings in British Columbia, both around Vancouver Island (Baird and Stacey 1993). However, between 1985 and 1989 there were 12 sightings, four of which occurred around Haida Gwaii (Figure 13).

Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)

Pacific white-sided dolphins are among the most acrobatic dolphins, and their wide variety of aerial behaviours is a distinguishing feature. They frequently ride both the bow and stern waves of boats. They are found in groups ranging from a few to >1,000 (Stacey and Baird 1991), although in British Columbia the average group size is ~100 (Heise 1997a). They reach maximum lengths of 2.5 m and weights of 198 kg but the averages are ~1.7 m and ~82.5 kg (Heise 1997b). The young are about 0.9 to 1.0 m at birth. They are distinctly marked, with a white belly outlined by a

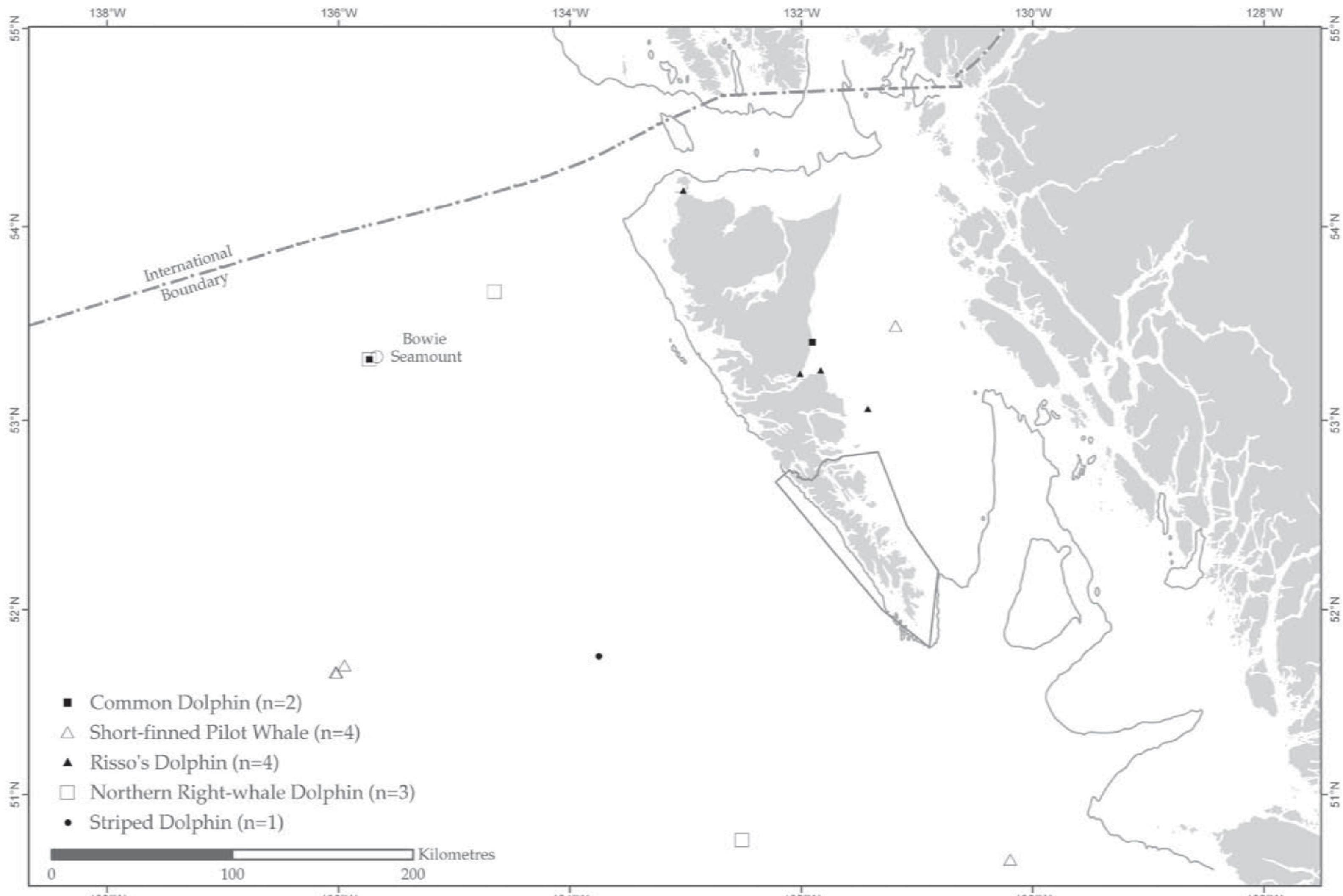

Figure 13. Locations of northern right whale dolphin, Risso's dolphin, common dolphin, striped dolphin and short-finned pilot whale sightings to 2002 in the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

black stripe and they are dark grey above with grey "suspenders" on their sides. They range from 20°N to 61°N in the Eastern Pacific, and in the west along the coast of Japan to the Kurile and Commander Islands (Leatherwood *et al.* 1982). There appear to be several different stocks in the North Pacific (Lux *et al.* 1997). No genetic differences have been found in dolphins occupying inshore and offshore waters. Off the coast of North America there are northern and southern stocks that mix around southern California (Lux *et al.* 1997).

Human-caused sources of mortality of Pacific white-sided dolphins are not well understood, although thousands died during the high-seas driftnet fishery. Other sources of mortality include accidental entanglement in inshore net fisheries (Stacey *et al.* 1997). The only report of contaminant levels in the species was by Minh *et al.* (2000), who found relatively high levels of PCBs and dioxin equivalents in a single individual analyzed from the central North Pacific. Other sources of mortality include predation by killer whales, although the agility, speed and large group size of Pacific white-sided dolphins makes them difficult prey (Ford *et al.* 1998; K. Heise, UBC, unpublished data).

Little is known about the population status of Pacific white-sided dolphins; population estimates range from 206,000 to 4,216,000, with a mean of 931,000 (CV = 0.90) across the North Pacific (Buckland *et al.* 1993). There is no information on population trends, but population estimates for California, Washington and Oregon are 25,825 (CV = 0.49) (Carretta *et al.* 2002) and for Alaska are 26,880 (CV = 0.90) (Angliss and Lodge 2002). Their distribution has changed significantly since the mid-1980s, and sightings have become much more frequent in inshore waters in British Columbia (Heise 1996, Morton 2000). There are several possible explanations for this. It may be that the population is expanding, although demographic data from Heise (1997 b) suggest that the population is not growing. Alternatively, the movements may be a result of the expansion of the high seas flying squid driftnet fishery in the early 1980s (internationally banned in 1992), and that animals moved inshore to escape the fishery. This fishery resulted in a high by-catch of ~49,000 to 89,000 killed between 1978 and 1990 (Tanaka 1993). However, the dolphins have remained inshore since this fishery ended (Heise 1996). A third, and most likely, explanation is that they have changed their distribution in response to changes in the distribution of their prey. Archaeological records show that there have been periods of Pacific white-sided dolphin abundance in the past (Mitchell 1988; Matson and Mclay 1996). Midden records also show a shift in diet of aboriginal people from mammals to salmon within the last 2,000 years (Mitchell 1988). If fish populations change significantly, it is possible that the dolphins move in response to these changes (Heise 1996).

Recent studies indicate that in the coastal waters of British Columbia, these dolphins feed on Pacific herring, salmon, cod (Family Gadidae), shrimp (Order Decapoda) and capelin (*Mallotus villosus*), and that they feed throughout the day (Heise 1997a). In the Broughton Arhcipelago, Morton found that they feed on herring, capelin and sardine (*Sardinops sagax*). In other areas of their range, dolphins feed most often at night on benthic or deep-water prey such as mesopelagic fish, Pacific hake (*Merluccius productus*) and squid that rise to the surface at night (Stroud *et al.* 1981; Walker *et al.* 1986; Walker and Jones 1993).

The sighting records of Pacific white-sided dolphins around Haida Gwaii are shown in Figure 14. They have been reported in all months of the year, and in numbers ranging from one to >500. Ford *et al.* (1994) reported that most groups were of ~50 or less, and the additional sightings presented here are similar. They are found in both nearshore and offshore areas. A notable feature of groups around Haida Gwaii is that they are accompanied by calves (K. Heise, UBC,

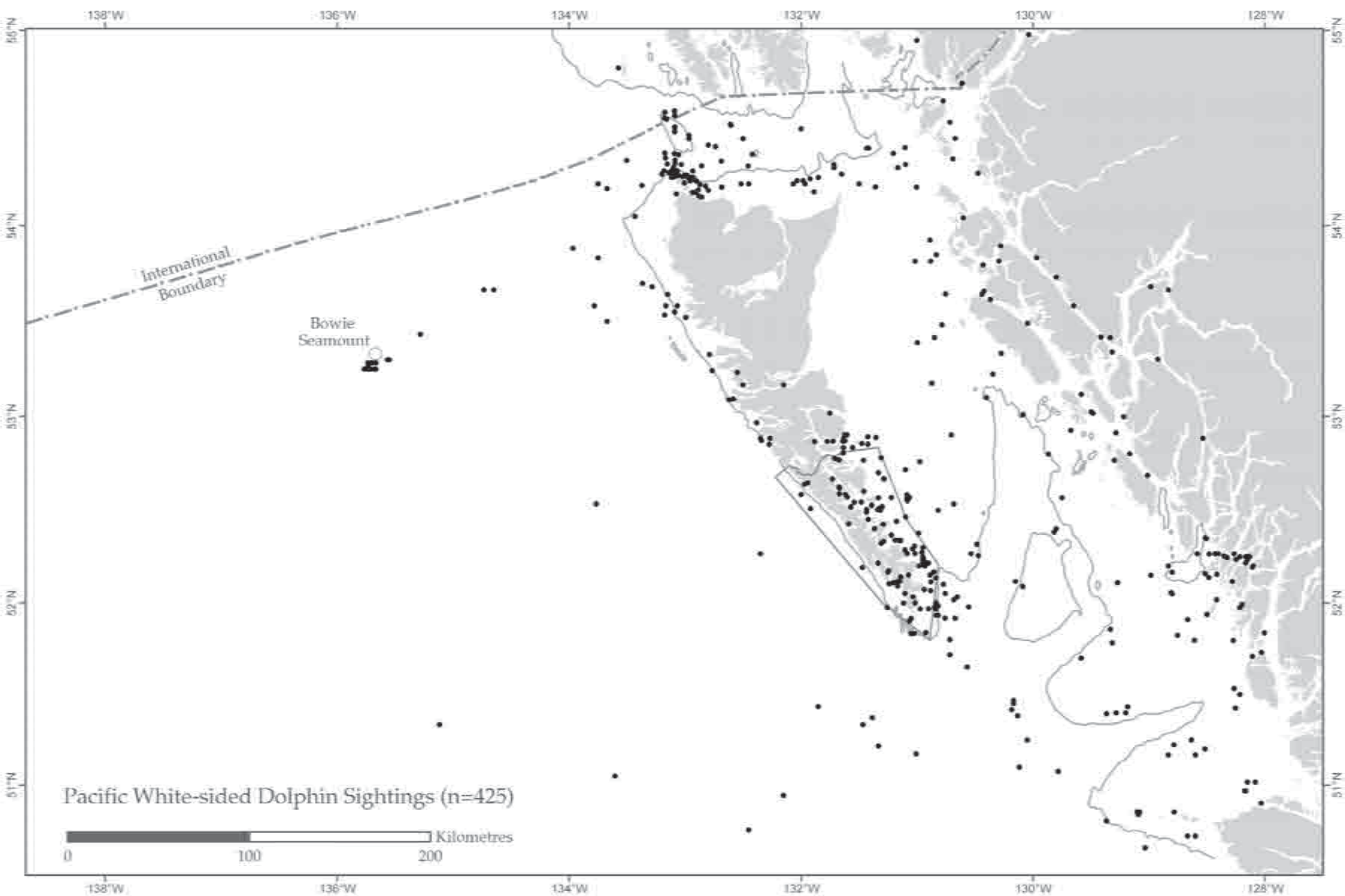

Figure 14. Locations of Pacific white-sided dolphin sightings from the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

unpublished observation). In other areas of the British Columbia coast such as Johnstone Strait, calves are rarely seen, even though dolphins can be relatively common.

Northern right whale dolphin (*Lissodelphis borealis*)

Northern right whale dolphins are the only small cetaceans found around Haida Gwaii that lack dorsal fins. Males and females reach lengths of 3.1 and 2.3 m respectively (Leatherwood and Reeves 1983). They are highly gregarious, and are usually found well offshore in groups of several hundreds. They are often seen with other species such as Pacific white-sided dolphins, and seem to prefer deep-water areas between 30° and 50° N, although they have been sighted as far north as the Gulf of Alaska and near the southern Aleutian Islands (Kajimura and Loughlin 1988; Baird and Stacey 1991b).

Population estimates in the North Pacific vary. Based on bycatch data from the squid driftnet fishery, Hiramatsu (1993) estimated ~400,000 in the Northwest Pacific. Using line transect sampling, Miyashita (1993) estimated ~144,000 in the Northwest Pacific and ~163,000 in the Northeast Pacific. This is appreciably higher than Buckland *et al.*'s (1993) estimate of ~68,000 (CV = 0.709) for the whole North Pacific. Carretta *et al.* (2002) estimated ~13,705 (CV = 0.38) dolphins off the coasts of California, Oregon and Washington.

The expansion of the high seas squid driftnet fishery in the early 1980s resulted in a high bycatch of northern right whale dolphins. According to Buckland *et al.* (1993), the species is highly vulnerable to entanglement, and ~10,000 were killed annually until 1992. They were the most frequently killed small cetacean in the fishery, and the population may have declined ~50% before the fishery ended (Hobbs and Jones 1993).

Although this dolphin may be abundant in the North Pacific, it has not often been seen around Haida Gwaii (Figure 13). Baird and Stacey (1991b) report three sightings well offshore in latitudes between 50.25°N and 50.45°N, just below the southern limit of the Haida Gwaii region. There are only three reported sightings in the study area and all are located well offshore. One was in Queen Charlotte Sound in 1983, the other two were in 1991 and 1992, relatively close to the Bowie Seamount. Group size ranged from 3 to 20 animals.

Risso's dolphin (*Grampus griseus*)

Risso's dolphin occurs mostly in warm temperate and tropical areas of all oceans (Leatherwood and Reeves 1983), usually in waters >200 m deep (Leatherwood *et al.* 1980). Adults are light grey with a tall dorsal fin and their bodies are covered with scratch marks. They are relatively large dolphins, up to 4 m in length (Mitchell 1975), and travel in groups ranging in size from 25 to several hundred animals (Leatherwood and Reeves 1983). Leatherwood *et al.* (1980) suggest that there may be long-term fluctuations in the range of these dolphins, possibly due to environmental changes. Green *et al.* (1992) suggest that animals found off California during colder months shift north into Oregon and Washington as water temperatures increase, based on aerial and shipboard survey data. Off California, Oregon and Washington, Carretta *et al.* (2002) estimated ~16,483 (CV = 0.28). It is possible that their numbers are increasing, but there is no definitive statement on trends in population size.

There are only a few records of Risso's dolphins around Haida Gwaii (Figure 13). These include a group of 14 animals seen near Langara Island in 1978 (Reimchen 1980). The other three records are strandings (Baird and Stacey 1991a).

Common dolphin (*Delphinus delphis*)

Common dolphins can reach up to 2.5 m (Leatherwood *et al.* 1982). The beak is well defined and the dorsal fin prominent. The belly is white, and the dorsal area is black. This black pigmentation extends to the belly in the area below the dorsal fin, producing an hourglass pattern. Forward of the dorsal fin, the sides range from greyish green to yellow or tan. Aft of the dorsal fin, the sides are generally grey. Common dolphins are highly gregarious, and often are seen in groups of >1,000.

Common dolphins occur in all oceans in warm-temperate to subtropical waters, and are generally found offshore (Leatherwood and Reeves 1983). Cmmon dolphins were divided into two species, short-beaked (*D. delphis*) and long-beaked (*D. capensis*) (Rosel *et al.* 1994). It is likely that any common dolphins seen in the waters of British Columbia waters are short-beaked, because they tend to have a more northern distribution than long-beaked common dolphins (Forney *et al.* 2000). They are the most abundant cetacean off California, and are widely distributed between the coast and 550 km offshore (Forney *et al.* 2000). However, even these are rare in waters north of California, and only four strandings have been reported in Washington and Oregon since 1942 (Forney *et al.* 2000). One animal was reported stranded in Victoria in April 1953 (Guiget 1954). A pair of common dolphins was seen in Vancouver harbour in September 2002 (L. Barrett-Lennard, VAMSC, *personal communication*) There are two reported sightings of a common dolphin around Haida Gwaii; a sighting of 20 animals off the west coast in 1991 and a sighting of four off Lawn Hill (Figure 13).

Striped dolphin (*Stenella coeruleoalba*)

Striped dolphins resemble common dolphins in appearance, but are slightly smaller and do not have the hourglass pigmentation pattern (Leatherwood *et al.* 1982). As with common dolphins, striped dolphins also have a worldwide distribution in warm temperate and tropical waters, but appear to be much less abundant in the Northeast Pacific. They have been reported off California, but there have been no sightings of live animals reported off Washington or Oregon (Forney *et al.* 2000).

Pike and MacAskie (1969) report one sighting, in March 1958, of 5 to10 animals in Haida Gwaii waters (Figure 13). Baird *et al.* (1993) list the locations of 10 strandings or as bycatch, all of which occurred well south of Haida Gwaii.

Dall's porpoise (*Phocoenoides dalli*)

Dall's porpoise reach a maximum length of 2.4 m and weigh ~200 kg (Houck and Jefferson 1999). Their body shape is stocky and, as is typical of porpoises, they have no beak. In the coastal waters of British Columbia, their bodies are black with a white patch that extends from the ventral area beneath their dorsal fin aft to the anus. Their dorsal fins are small and triangular, and they often have light grey or white markings. Dall's porpoise tend to be relatively short-lived. Ferrero and Walker (1999) report that males and females reached maximum ages of 14 and 15 years, respectively. The peak mode of calving occurs in early July, and Dall's porpoises appear to reproduce annually after age four (Ferrero and Walker 1999). Leatherwood *et al.* (1982) consider Dall's porpoises to be one of the most widely distributed small cetaceans in the North Pacific, ranging from 32°N to the Bering Sea, and west to the coastal waters of Japan. Throughout their range there are at least three and up to nine different stocks, but only one stock inhabits the coastal waters of North America (Amano *et al.* 2000; Escorza-Trevino and Dizon 2000).

There are no data on the diet of Dall's porpoise around Haida Gwaii. The species typically eats small fish and squid (Stroud *et* *al.* 1981; Walker 1996; Houck and Jefferson 1999). Although in some areas they feed nocturnally (Stroud *et al.* 1981), they also feed throughout the day (Amano *et al.* 1998), perhaps reflecting activity of their prey.

Dall's porpoises are prey of *transient* killer whales (Ford *et al.* 1998; Saulitis *et al.* 2000), and can be entangled in fishing gear (Walker and Jones 1993; Stacey *et al.* 1997; Ferrero and Walker 1999). In the western portion of their range, they are hunted for human consumption. Since 1981, 9,000 to 40,000 have been harpooned annually around Japan (Houck and Jefferson 1999). Dall's porpoises may be vulnerable to pollution. Males in the western Pacific carry extremely high contaminant loads of PCB's (Minh *et al.* 2000). In harbour seals, these levels would be sufficient to cause immunosuppression (Ross *et al.* 1995). Jarman *et al.* (1996) found that Dall's porpoises from British Columbia also contained high levels of organochlorines (dioxins and furans), although they analyzed tissue from stranded animals, which may have shown elevated levels due to metabolic changes as the animals neared death.

Dall's porpoises are often seen bow-riding in front of vessels and/or swimming rapidly, throwing a 'rooster-tail' of spray when they surface. These behaviours distinguish them from harbour porpoise, which usually avoid boats. Their tendency to be attracted to boats biases line transect counts of Dall's porpoises upwards. Turnock and Quinn (1991) suggest that a correction factor of 0.2 accounts for this attraction.

The status of Dall's porpoises in British Columbia is unknown and there are no population trend data (Jefferson 1990; Ferrero *et al.* 2000). In the western portion of their range, populations may be declining (Turnock and Buckland 1995). Buckland *et al.* (1993) estimated their total population size in the North Pacific at ~1,186,000 (CV = 0.09). This is lower than estimates by Jones *et al.* (1987 - in Houck and Jefferson 1999) of 1.4 to 2.8 million, but takes boat attraction into account. In the waters off California, Oregon and Washington, Forney *et al.* (2000) estimate ~117,545 (CV = 0.45), and in Alaska, Angliss and Lodge (2002) estimate ~83,400 (CV = 0.097). Both of these estimates are also corrected for vessel attraction. Carretta *et al.* (2002) suggest that Dall's porpoises show north-south movement between California, Oregon and Washington depending on oceanographic conditions.

The sightings of Dall's porpoises in northern British Columbia are shown in Figure 15. Animals are recorded from a wide range of habitats such as Bowie Seamount to sheltered mainland inlets. Ford *et al.* (1994) reported that the mean group size of two was most common in the waters of Haida Gwaii. They are typically seen in groups of 2 to 20, although Leatherwood *et al.* (1982) reports foraging groups in Alaska of several hundreds. Around Haida Gwaii they are reported in all months of the year, and in both offshore and nearshore locations. Pike and MacAskie (1969) also reported them in all seasons and at distances >2,400 km offshore.

Harbour porpoise (*Phocoena phocoena*)

Harbour porpoises are found in coastal waters in both the North Pacific and North Atlantic. In the northeast Pacific, they are common between Point Conception, CA and the Gulf of Alaska (Leatherwood and Reeves 1983). They are often seen alone or in small groups, and they are the most commonly reported stranded cetaceans along the British Columbia coast (Baird and Guenther 1995). This may reflect their nearshore habits. The maximum recorded length is ~2 m and weight is ~90 kg; typical lengths are 1.5 to 1.6 m and weights are 45

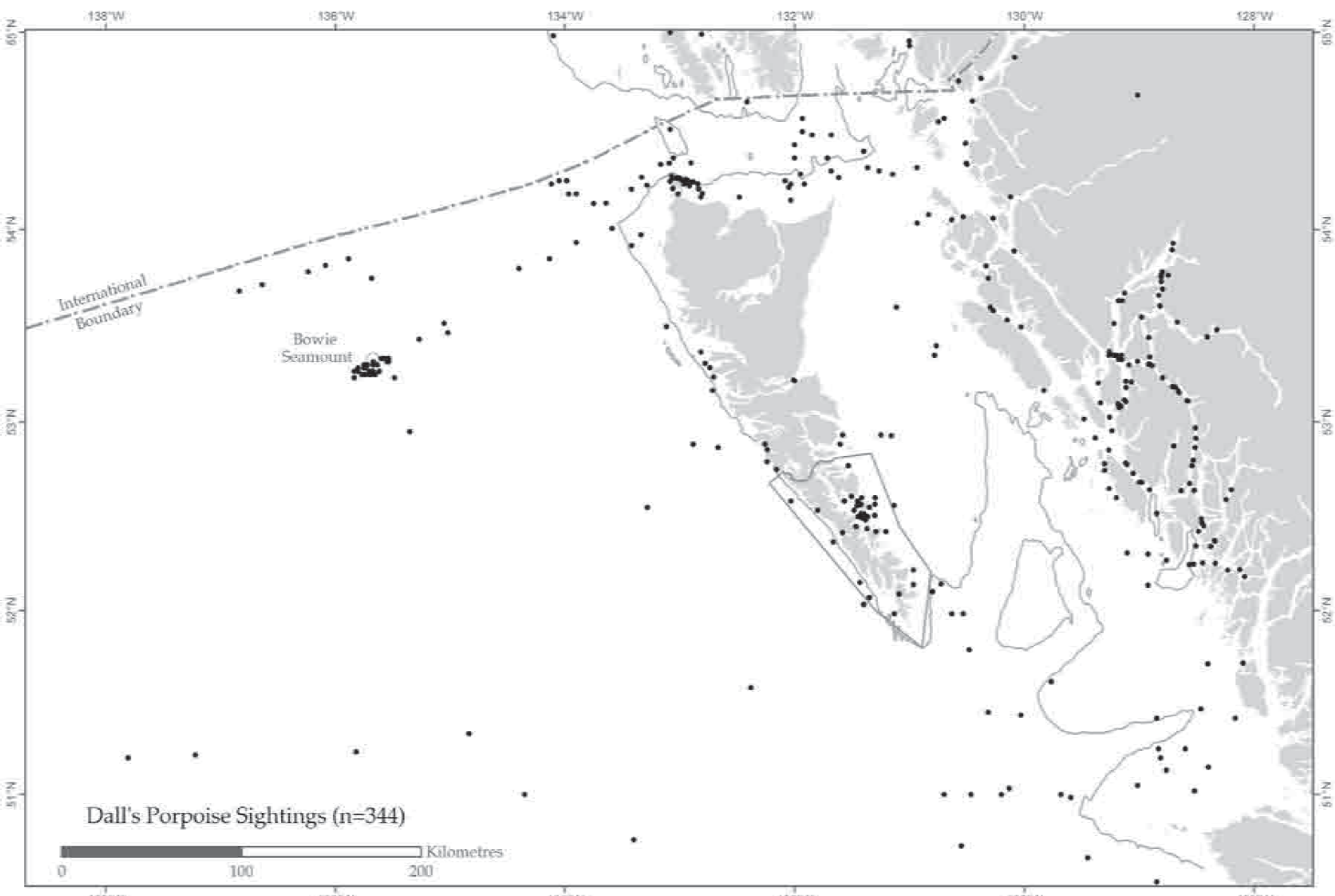

Figure 15. Locations of Dall's porpoise sightings to 2003 in the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

to 60 kg (Leatherwood and Reeves 1983). They are dark brown or grey above, and light on the belly.

Although harbour porpoises are relatively common, they are difficult animals to study in the wild because they do not approach or follow moving boats, and it is difficult to identify individuals from natural markings. They have complex patterns of social behaviour, with frequent sexual and agonistic interactions (Read 1999). There may be some segregation by age and sex of animals, but the mechanisms for this are not understood. Harbour porpoises feed on small schooling fish typically <40 cm long. They tend to forage independently, seldom using cooperative strategies for concentrating prey (Read 1999).

In the Atlantic, harbour porpoises may undergo extensive movements (Read 1999) but in the Pacific, based on regional differences in pollutant residues from animals recovered along the coast, they appear fairly restricted in their movements (Calambokidis and Barlow 1991). This is further supported by genetic evidence, which suggests that the eastern North Pacific harbour porpoise population is finely structured, and that numerous small subunits exist within (Chivers *et al.* 2002). This could have important consequences in management plans for the species.

Harbour porpoises are vulnerable to coastal fisheries throughout their range, including British Columbia (Gaskin 1984; Guenther *et al.* 1993; Baird and Guenther 1995; Stacey *et al.* 1997). They are also negatively affected by acoustic harassment devices used on fish farms to deter seals (Johnston 2002; Olesiuk *et al.* 2002). Harbour porpoises also carry high levels of contaminants in their tissues (Read 1999; Ikonomou *et al.* 2002), although the effects of these high levels are uncertain (Read 1999). Harbour porpoises are also an important prey of *transient* killer whales (Ford *et al.* 1998; Saulitis *et al.* 2000). They were consumed by aboriginal peoples, and bones in southern Haida middens could be harbour porpoise (Acheson 1998).

There is no information on the abundance of harbour porpoises in British Columbia, or on population trends (Forney *et al.* 2000). The only evidence of declining harbour porpoise populations is in southern Puget Sound, where they are rarely observed. This is a dramatic change from the early 1940s when they were abundant (Scheffer and Slipp 1948; Forney *et al.* 2000). In Alaska, Angliss and Lodge (2002) estimate a population of ~10,508 animals (CV = 0.274). In Oregon and Washington there are ~39,586 (CV = 0. 384).

The sightings of harbour porpoises, reported year-round in the Haida Gwaii region, are shown in Figure 16. More than 50% of sightings are of single animals, although a group of eight was reported in September 1989 at 52° 17'N, 131° 03' W, by the Marine Mammal Research Group in Victoria.

BALEEN WHALES (MYSTICETI)

Seven species of baleen whales have been recorded from the Haida Gwaii region, ranging in size from the largest (blue) to one of the smallest (minke). The females of all baleen whale species are slightly larger than males of the same species. Baleen whales differ from odontocetes in that they lack teeth and instead have a structure for filter-feeding comprising baleen plates. These plates extend down from the upper jaw and enable sieving of small fish and plankton. Baleen whales also have a double blowhole rather than a single one, as found in the toothed whales.

Large baleen whales, such as blue, fin and sei, communicate using low frequency sound, typically in the range of 20 to 3,000 Hz (Evans 1987). These sounds can travel large distances, particularly in oceanic "deep sound channels." These channels are typically 600 to 1,200 m deep in low

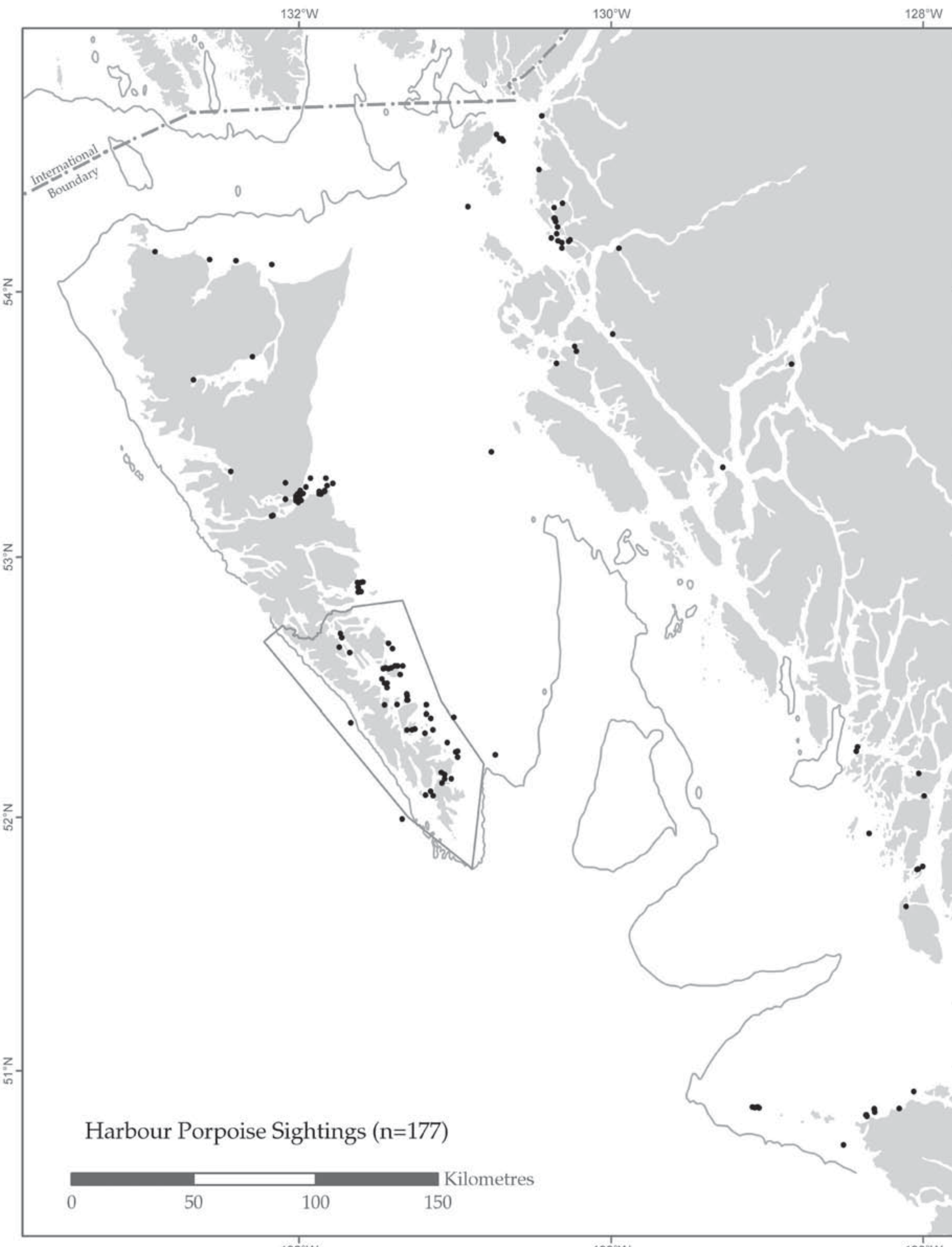

Figure 16. Locations of harbour porpoise sightings to 2003 in the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

latitudes, and approach the surface at polar latitudes. The channels prevent sound energy from dispersing vertically, allowing it to spread horizontally. Sounds from some species can travel 100s to 1,000s of km (Tyack and Clark 2000).

Some North Pacific baleen whale species, such as the humpback and gray, undertake migrations from warmer, low-latitude breeding areas in winter to high-latitude (temperate to arctic) feeding grounds in summer. Various hypotheses have been invoked to explain this migration pattern. For example, calves born in warm, relatively calm waters have more energy for growth and development; whales leave productive temperate areas to reduce the risk of predation by killer whales, which are uncommon in the tropics; migratory behaviour evolved when feeding and calving areas were close together, and migration has become extended as a result of continental drift (Cockeron and Connor 1999; Connor and Cockeron 2001; Clapham 2001).

Gray whales migrate northward each spring, passing near Haida Gwaii. In some years, individuals stop to feed in sheltered shallow areas such as Skidegate Inlet before resuming their migration. In contrast, many of the humpback whales that visit Haida Gwaii each year travel no further, and feed in or near the area from the spring to the fall.

Blue whale (*Balaenoptera musculus*)

Blue whales are the largest animals that have ever lived; individuals can exceed 30 m in length and 170 tons in weight (Bannister 2002). In the North Pacific, the largest reported was 27.7 m, taken off Haida Gwaii (Nichol and Heise 1992). Blue whales are distinguished from other baleen whales because of their enormity and light bluish-grey mottling. Their blows are slender and tall (to ~9 m high) and are very different from the bushier blows of humpback and gray whales. They have small dorsal fins that are < 33 cm, located well aft and not visible until they begin to dive. They often raise their tail flukes when they dive. Blue whales are usually seen alone or in pairs. Whales are individually identifiable due to unique pigmentation patterns (Calambokidis *et al.* 1990; Sears *et al.* 1990). Over 1,200 have been identified off California, Washington and Oregon (Calambokidis *et al.* 2000a).

Whalers from Rose and Naden Harbours landed 640 blue whales between 1910 and 1943 (Table 6). The catch peaked in 1911 when 205 were taken, and declined markedly thereafter (Gregr *et al.* 2000). Another 82 were taken around Haida Gwaii between 1948 and 1965 and landed at Coal Harbour. Individuals of both sexes and all sizes were taken, including very young and recently weaned calves (Nichol and Heise 1992). Whalers generally encountered them in the open Pacific, and only rarely within 10 km of the west coast or in Hecate Strait. In total, 9,500 were reported taken from the North Pacific (Ohsumi and Wada 1974). There are now no known immediate threats to the recovery of blue whale numbers, although they are occasionally vulnerable to ship strikes and they may also be affected by increasing levels of anthropogenic noise (Clapham *et al.* 1999, Caretta *et al.* 2002).

Although blue whales may be recovering from the effects of commercial whaling, sightings are not common. Figure 17 shows the locations of kills and sightings for blue whales. Based on both mark-recapture and line transect methods, the best estimate of blue whale abundance off the coast of California, Oregon and Washington is 1,940 (CV = 0.15). Pike and MacAskie (1969) suggest that in British Columbia, blue whales are usually found well offshore, which is supported by acoustic data collected from fixed hydophones moored well offshore off the coast of Washington (Stafford *et al.* 1999). These acoustic data also indicate that blue whales may summer off the coast of Vancouver Island. Blue whales are rarely seen further north and

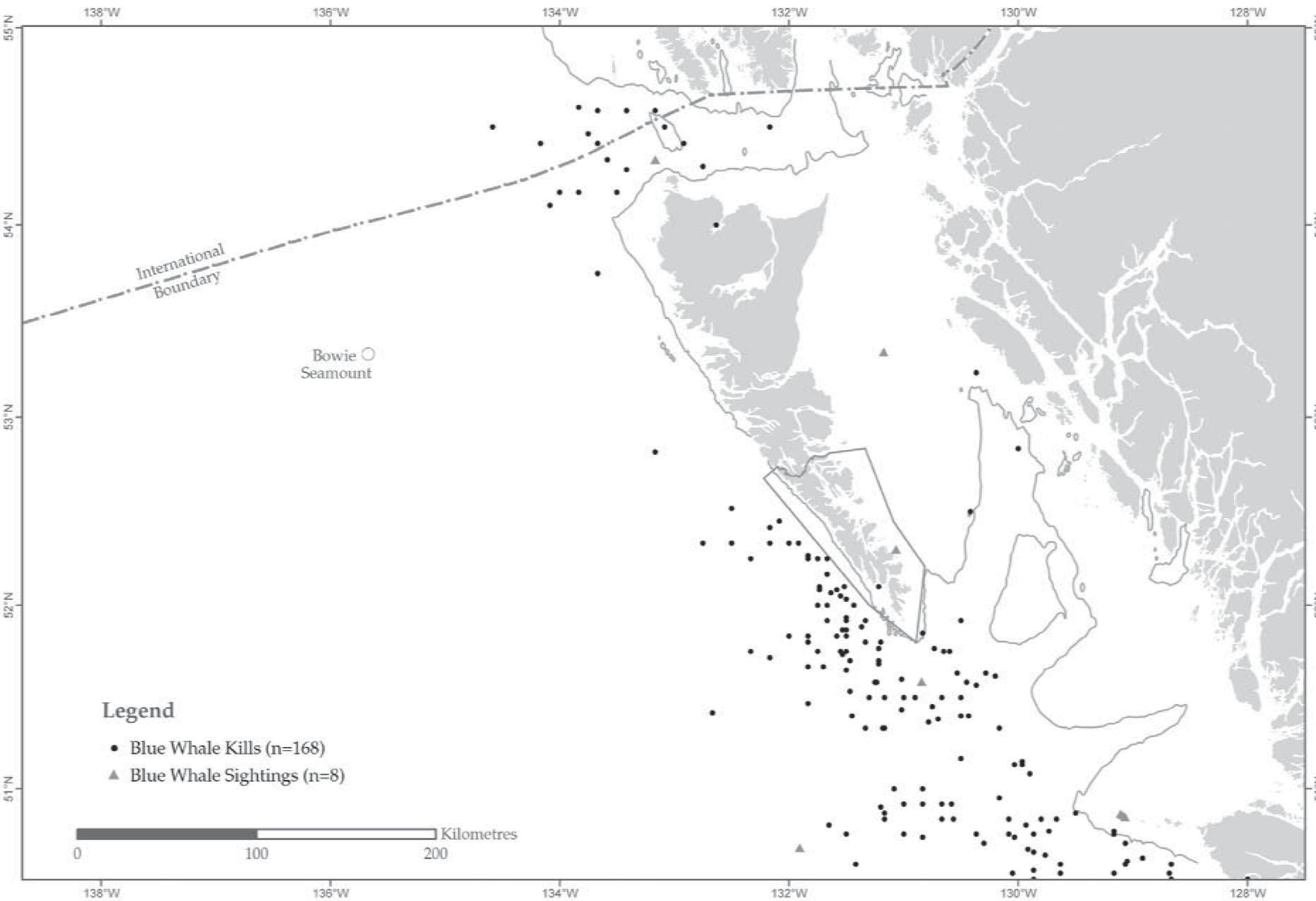

Figure 17. Locations of blue whale kills recorded in the northern British Columbia area (north of 50.5° N) from the whaling history database compiled by Nichol *et al.* (2002) (data courtesy of L. Nichol, DFO). Also shown are the locations of blue whale sightings to 2002 in the same area from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

have not been seen in any recent surveys in Alaska (Carretta *et al.* 2002). A group of three was seen in Hecate Strait in May 1989, light-keepers at Langara Island reported a possible sighting 10 km offshore in August 1992, there was a sighting off Skincuttle Inlet in June 1997, and another off Cape St. James in May 2002.

Fin whale (*Balaenoptera physalus*)

Fin whales are the second largest species of whale. In the North Pacific, females reach lengths of 24 m (Leatherwood *et al.* 1982) and males are slightly smaller. Their blows are large and powerful, rising >6 m. As with blue and sei whales, they are long, slender and fast (up to 37 km per hr). Their dorsal fins are located about two thirds of the way along the back. Their pigmentation is asymmetrical with dark grey to brownish-black on their backs and sides, and light bellies. They typically have a light chevron visible on their back just behind their head, and their lower lips and jaws are white on the right side and grey on the left. Unlike blue whales, they rarely show their tail flukes when diving. As with other species of baleen whales, fin whales calve and breed in lower latitudes during winter, and migrate to feeding areas in northern latitudes in summer (Leatherwood *et al.* 1982).

Before commercial whaling, fin whales in the North Pacific numbered ~42,000 to 45,000. By the early 1970s, their numbers had declined to ~14,620 to 18,630 (Ohsumi and Wada 1974). There are no current estimates for the North Pacific. A 3,700 km boat survey south of the Aleutian Islands in August 1994 found only four groups (Forney and Brownell 1996), and a survey in the central Bering Sea provided an abundance estimate of 4,951 (CV = 0.29) for that area (Angliss and Lodge 2002). Carretta *et al.* (2002) estimated 1,851 (CV = 0.19), based on ship survey data. They also suggested that fin whale numbers may be increasing but that the trend is not statistically significant. Factors that may be slowing the recovery of fin whales include the possible effects of unauthorized takes (Yablokov 1994; Baker *et al.* 2000) and their relatively high vulnerability to ship strikes (Laist *et al.* 2001).

Whalers found that fin whales were more abundant off Haida Gwaii than blue whales (Nichol and Heise 1992). Locations of fin whale kills are shown in Figure 18. Although fin whales were caught throughout the whaling season, catches were highest in July and August. They were found off the west coasts of Kunghit and Moresby Islands up to 100 km offshore, between Cape St. James and Vancouver Island (Nichol and Heise 1992), in Hecate Strait and in Dixon Entrance. During the Coal Harbour whaling period (1948 to 1967), fin whales were also taken in mainland inlets and channels. Pike and MacAskie (1969) suggested that there may have been a summer resident population of immature fin whales feeding off the coast because 50% of the fin whales taken by Coal Harbour whalers were immature (Pike 1956). Fin whales taken off the southern end of Haida Gwaii and off the west coast of Vancouver Island by whalers fed mostly on krill (euphausiids), although they also ate copepods and fish (Nichol and Heise 1992; Flinn *et al.* 2002).

The majority of whales seen around Haida Gwaii until the late 1960s were in groups of 1 to 3 whales, yet groups of 10 to 15 whales were seen on 12 occasions and groups of 20 or more were seen twice (Nichol and Heise 1992). Fin whale sightings are shown in Figure 19, the majority of which were in Hecate Strait and Dixon Entrance.

Sei whale (*Balaenoptera borealis*)

Sei whales closely resemble fin whales but are smaller, up to 16 m in length, and are more symmetrical in their pigmentation (Leatherwood *et al.* 1982). Their lower lip is grey on both sides. Ohsumi and Wada (1974) estimated that there were more sei whales than fin whales in the North Pacific

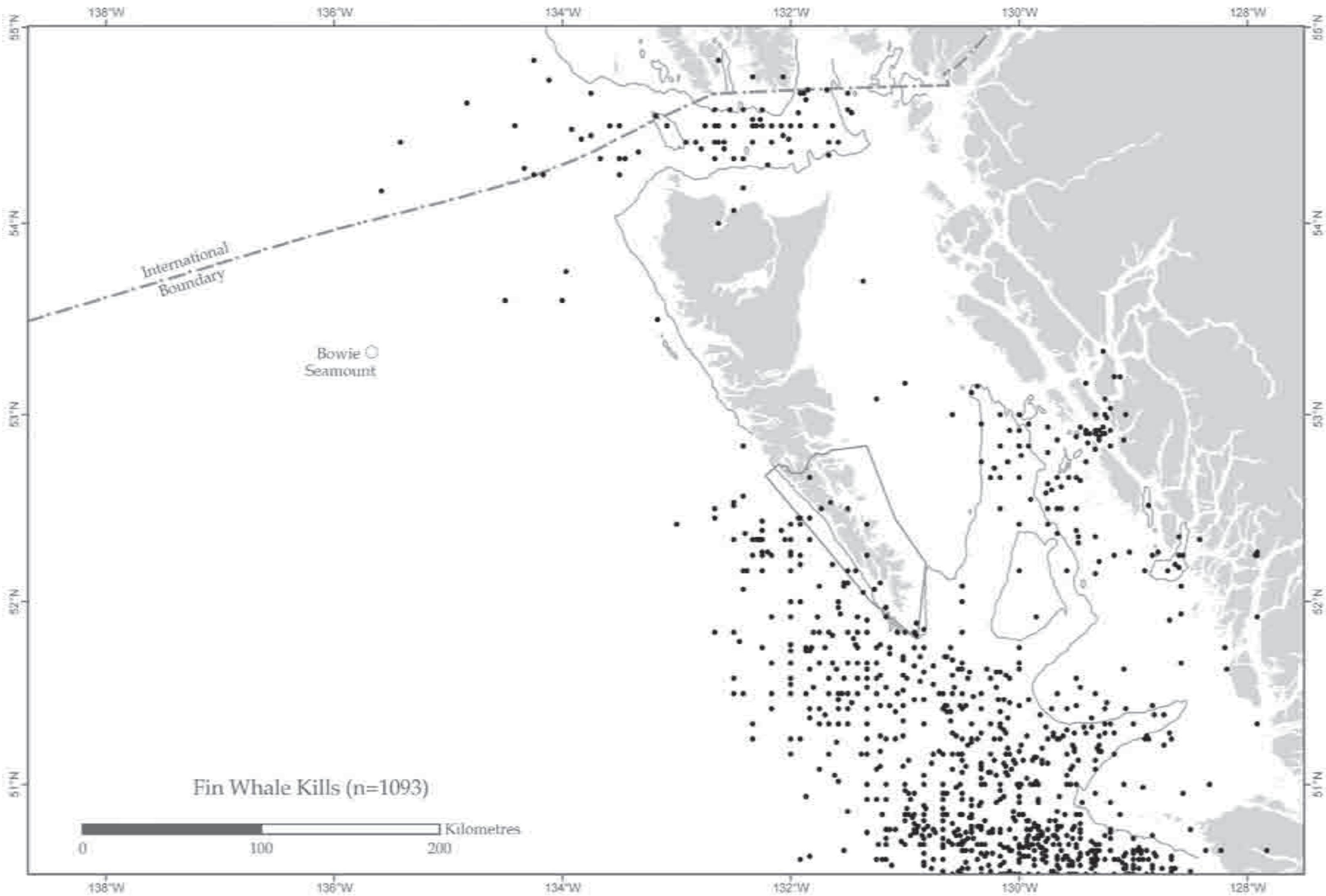

Figure 18. Locations of fin whale kills recorded in the northern British Columbia area (north of 50.5° N) from the whaling history database compiled by Nichol *et al.* (2002) (data courtesy of L. Nichol, DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

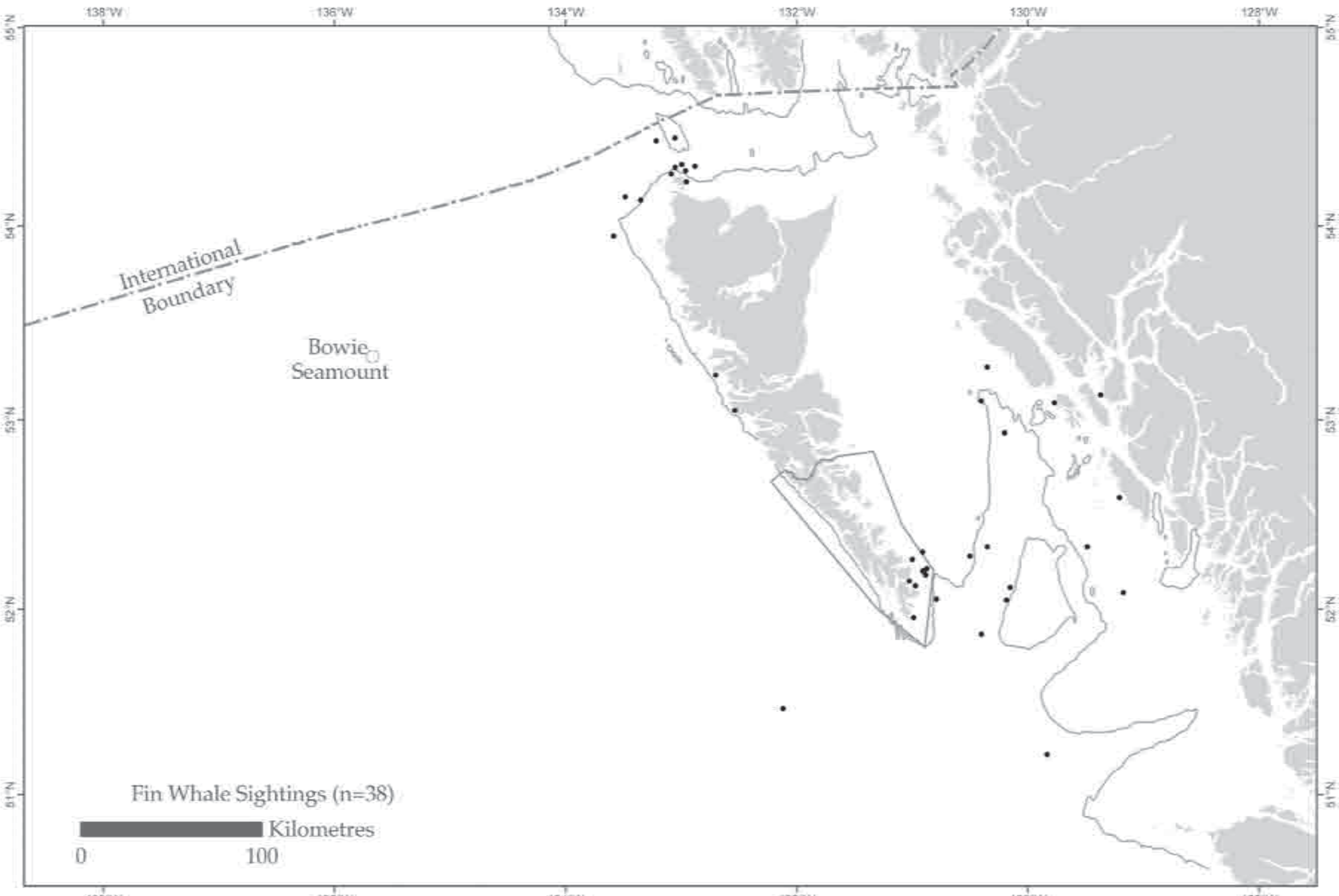

Figure 19. Locations of fin whale sightings to 2002 in the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

prior to commercial whaling (58,000 to 62,000 sei whales compared to 42,000 to 45,000 fin whales). They are now rarely seen and there are no population estimates or trend data from the North Pacific (Carretta *et al.* 2002). As with fin whales, sei whales may not be recovering from the cessation of whaling due to illegal hunting by Russia in the past (Yablokov 1994) and by Japan more recently (Baker *et al.* 2000). R.C. Haldane (in Horwood 2002) described the sei whale as the "*most graceful of all the whales*" and "*it is also far the best to eat, the flesh tasting something between pork and veal and quite tender*" which may be why it is still hunted. There is also growing concern that sei whale populations may be negatively affected by increasing levels of human-caused noise, as they communicate using low frequency sound. Little is known about sei whales because they generally remain offshore (Forney *et al.* 2000).

Off the southern tip of Haida Gwaii and off the west coast of Vancouver Island, sei whales feed primarily on copepods, but they also eat euphausiids, Pacific saury (*Coloabis saira* - a small schooling fish that eats copepods [Hart 1973]) and other small fish (Nichol and Heise 1992; Flinn *et al.* 2002). As their baleen is relatively fine, they can sieve smaller prey than most other baleen whales (Rice 1977).

The locations of sei whale kills are shown in Figure 20. Sei whales were less frequently encountered by whalers in Hecate Strait and Queen Charlotte Sound than fin whales. Between 1963 and 1967, there were 1,446 sightings of sei whales, 88% of which were of individuals or of groups of <5 (Nichol and Heise 1992). Leatherwood *et al.* (1982) reported that they are generally not seen north of the Aleutian Islands. Gregr *et al.* (2000) suggested that 55°N is their northern limit. COSEWIC (2003) suggests that there are few if any mature animals remaining in the waters of British Columbia. There are six recent sightings around Haida Gwaii of which two were in Hecate Strait and two in Dixon Entrance (Figure 20). Two of the sightings were of single animals, and the rest were of groups of two.

Humpback whale (*Megaptera novaeangliae*)

The humpback whale is one of the most recognizable baleen whales. Females and males reach lengths of 16 and 15 m respectively (Leatherwood and Reeves 1983). Distinguishing features of these darkly pigmented whales include large pectoral flippers that can attain a third of their body length. Their heads have small fleshy knobs, and they have large tails that they often raise out of the water when deep diving. Their dorsal fins are variable in size and shape, ranging from small triangles to tall and sharply falcate. They are readily identified individually based on scars and pigmentation patterns on the underside of their tail flukes (Katona *et al.* 1979; Darling and Jurasz 1983; Perry *et al.* 1990). An example of a tail fluke identification photograph is shown in Figure 8.

Humpback whales make long migrations between high-latitude summer feeding areas and low-latitude winter breeding grounds (Rice 1978; Darling and Jurascz 1983; Baker *et al.* 1986, 1990). Based on collaborative photo-identification studies by 16 independent research groups, Calambokidis *et al.* (2001) have shown that there are at least three relatively but not completely separate populations that breed in different areas (Calambokidis *et al.* 2001). These are: a breeding winter/spring population in coastal Central America and Mexico that migrates to the coast of California and southern British Columbia in summer and fall to feed (Calambokidis *et al.* 1997 2001), a winter/spring population in Hawaii that migrates to northern British Columbia - Southeast Alaska and Prince William Sound - Kodiak Island to feed (Baker *et al.* 1990; Perry *et al.* 1990; Calambokidis *et al.* 1997, 2001) and a winter/ spring population in Japan that migrates to Gulf of Alaska waters west of the Kodiak archipelago to feed (Nishiwaki

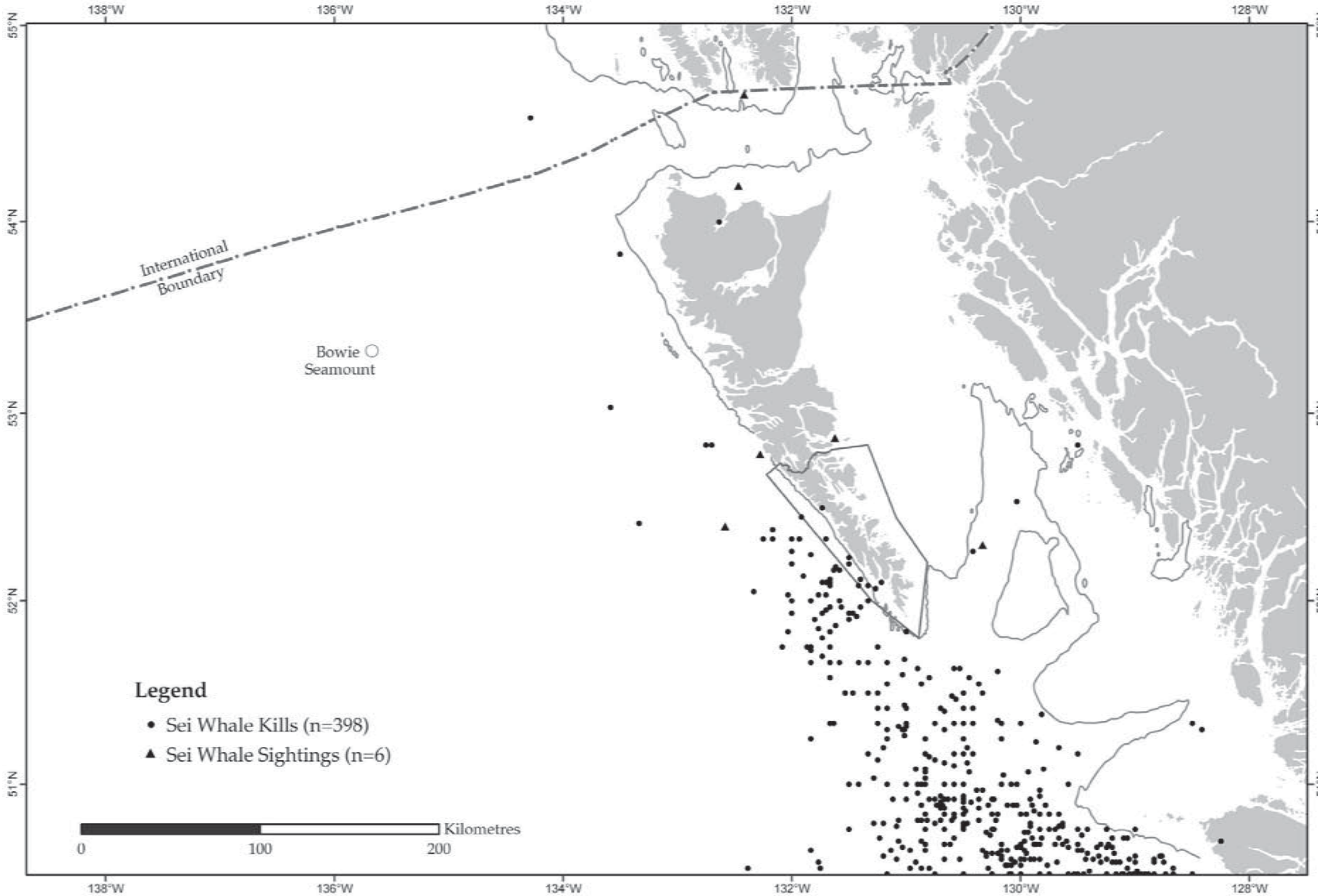

Figure 20. Locations of sei whale kills recorded in the northern British Columbia area (north of 50.5° N) from the whaling history database compiled by Nichol *et al.* (2002) (data courtesy of L. Nichol, DFO). Also shown are locations of the sei whale sightings to 2002 in the same area from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

1966; Calambokidis *et al.* 2001). Some whales may move between Japan and British Columbia (Darling *et al.* 1996; Calambokidis *et al.* 1997), as well as between Japan and the Kodiak Archipelago (Calambokidis *et al.* 1997). The fastest known migration of a humpback was a male that travelled from Alaska to Hawaii in 39 days (Gabrielle *et al.* 1996).

There is a continuous distribution of feeding humpback whales from British Columbia to Russia (Ferrero *et al.* 2000). There may be fidelity to feeding areas based on the return of calves to feeding areas introduced to them by their mothers (Baker *et al.* 1986; Calambokidis *et al.* 1997; Waite *et al.* 1999). There are also repeated interannual sightings of the same whales on the same feeding grounds, although there is a small amount of movement between feeding areas (Calambokidis *et al.* 1997). Some females from each population may also overwinter in feeding areas, possibly due to the high energetic cost of migration (Craig and Herman 1997). Researchers have noted that there is a 1:1 male: female sex ratio on the feeding grounds, yet on the breeding grounds males outnumber females 8:1.

Males are known to “sing” while they are on the breeding grounds. Their songs consist of “phrases” that are repeated to form a “theme”. A song is a collection of themes sung in a specific order, and may last anywhere from a few to >30 minutes (Payne and McVay 1971). Songs vary by geographic area, and change over time, but all whales within a breeding population sing the same song. There are many hypotheses put forward as to why humpbacks sing, including to attract mates (Tyack 1981) or to mediate interactions among males (Darling 1983). While travelling to their summer feeding areas, humpback whales continue to sing (Norris *et al.* 1999). On the feeding grounds, humpback whales are comparatively quiet. Humpback vocalizations can occasionally be heard if a hydrophone is lowered near a group.

The North Pacific population of humpback whales may have contained 15,000 to 20,000 individuals before commercial whaling (Rice 1978). By the time humpbacks became protected internationally in 1966, their numbers had been reduced to ~1,000. Rice (1978) estimated that >28,000 were taken from the North Pacific in the 20th century. This is likely an underestimate because the Soviets significantly under-reported their catches (Yablokov 1994).

Based on photo-identification studies and at-sea surveys, the population of humpback whales in the North Pacific ranges between 4,500 and 8,000 (Calambokidis *et al.* 1997; Ferrero *et al.* 2000). Photo-identification studies of humpback whales are continuing off of Tofino (J. Darling, West Coast Whale Research, *personal communication*), and off Langara Island (DFO), as well as in other areas. The DFO is compiling a photographic database that can be used to facilitate comparisons of tail fluke photographs with those taken in other areas such as southeast Alaska and Hawaii. This work will lead to an improved understanding of the migration of humpback whales, as well as estimating their population in the eastern North Pacific. Biopsy samples are also being collected for future genetic and contaminant analysis.

Around Haida Gwaii, 1,182 humpbacks were taken between 1910 and 1943 (Table 6) and 117 were landed at Coal Harbour between 1948 and 1967 (Nichol and Heise 1992). The kill locations from the whaling database are shown in Figure 21. They were encountered up to 100 km off the west coasts of Kunghit and Moresby Islands, as well as between Cape St. James and the north tip of Vancouver Island (Nichol and Heise 1992). They were also taken in Dixon Entrance and at least 80 km west of Graham Island. Stomach content analyses from

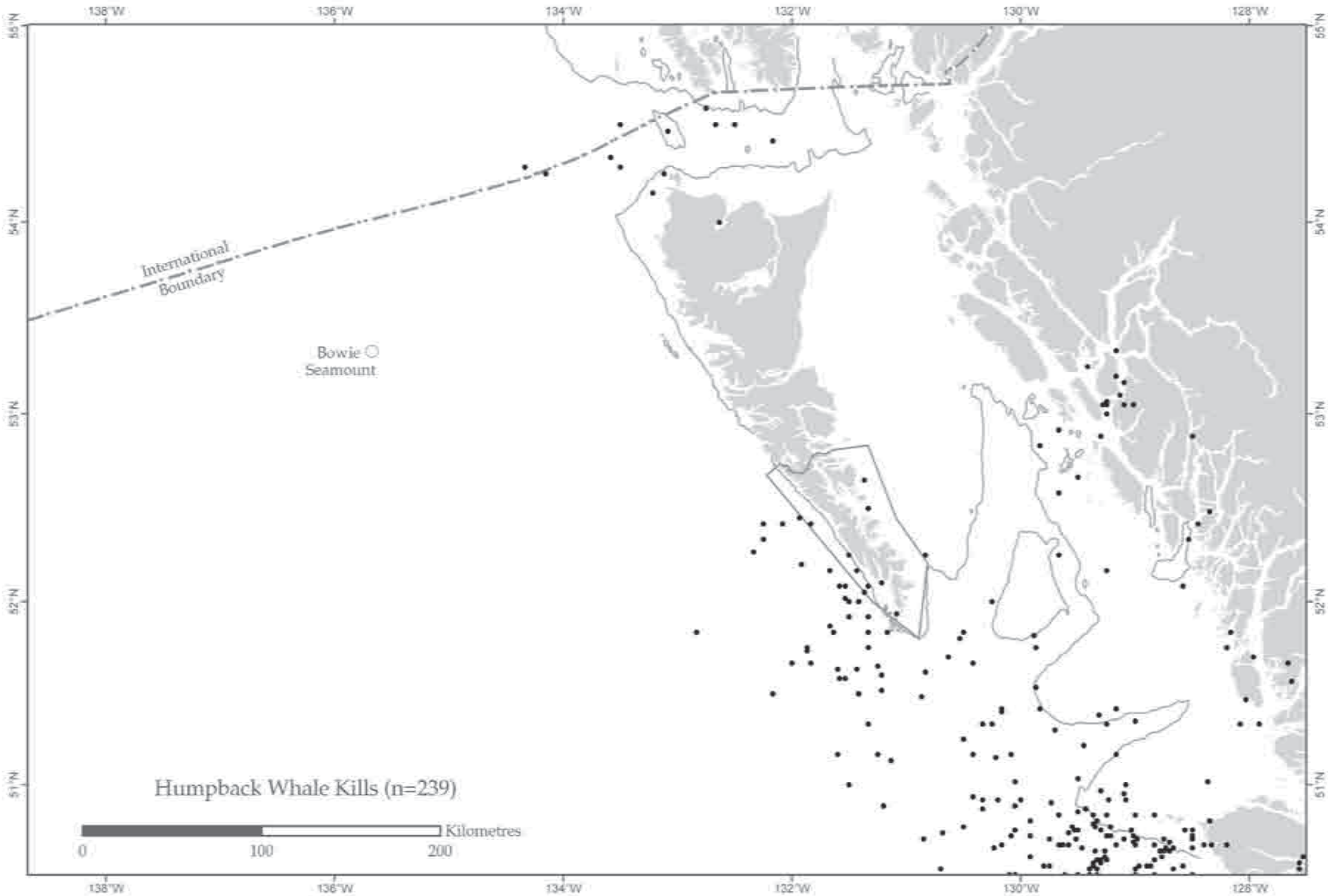

Figure 21. Locations of humpback whale kills recorded in the northern British Columbia area (north of 50.5° N) from the whaling history database compiled by Nichol *et al.* (2002) (data courtesy of L. Nichol, DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

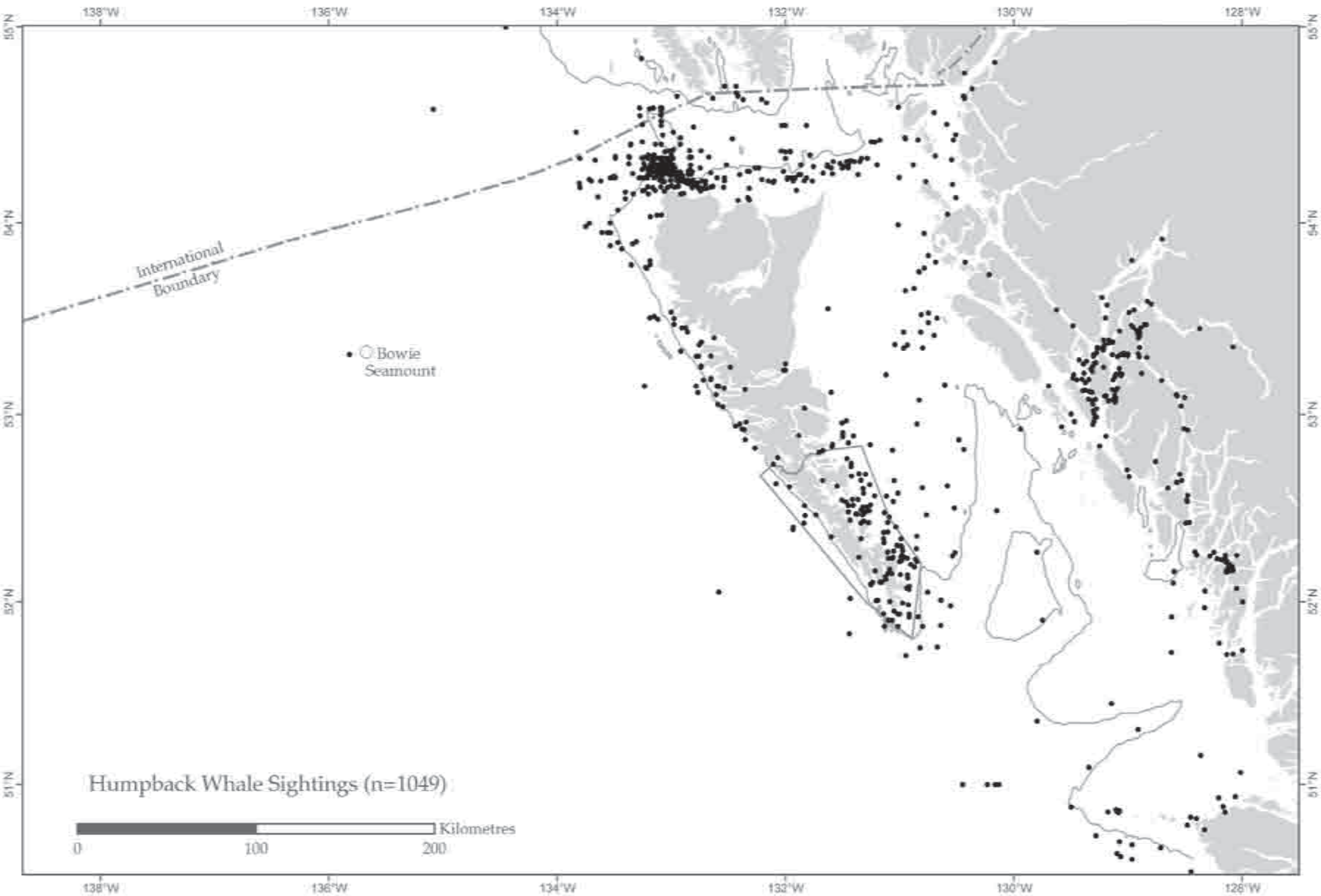

Figure 22. Locations of humpback whale sightings to 2003 in the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). There is one sighting in the database from 1931. The 200 m isobath demarcating the edge of the continental shelf is shown.

captured humpbacks off Haida Gwaii revealed that they ate mostly euphausiids, but also copepods, Pacific herring and other small fish (Nichol and Heise 1992). This is consistent with data recorded by the Japanese during pelagic whaling in the North Pacific (Nemoto 1959). Around Langara Island, humpbacks observed during recent field surveys were seen expelling red feces, suggesting that they were feeding on euphausiids (Ford *et al.* 1994).

Humpback whales are the most frequently reported baleen whales in the waters of Haida Gwaii (Figure 22). In recent years, large groups have been sighted off the east coast of Moresby Island, such as ~75 whales seen ~3 km northeast of Burnaby Island in early October 2002. This group was feeding on a krill aggregation underlain by Pacific herring (T. Tomascik, PCA, *personal communication*). Between 1992 and 2002, >1,000 different humpback whales were individually identified in northern British Columbia (J. Ford, DFO, unpublished data). The majority were photographed around Langara Island. Off of California, Washington and Oregon, >1,000 whales have been individually identified (Calambokidis *et al.* 2000a).

Gray whale (*Eschrichtius robustus*)

Gray whales are unique in appearance among baleen whales. Instead of a dorsal fin they have a series of bumps or "knuckles" along the dorsal midline and their bodies are often distinctly festooned with barnacles. Their maximum length is ~14.1 m (Leatherwood and Reeves 1983). Gray whales are a success story in marine conservation. After years of whaling in their calving lagoons, they were nearly extinct by 1900. They received international protection in 1938 and the Northeast Pacific population has recovered to ~26,635 (CV = 0.100) in 1998 (Angliss and Lodge 2002). However, a second population of gray whales, known as the Northwest Pacific or "*Korean*" stock, is one of the world's most critically endangered large whale populations with perhaps 100 to 250 animals remaining (Clapham *et al.* 1999; [http://www.iwcoffice.org/]). North Atlantic gray whales were hunted to extinction by the early 18th century (Jones and Swartz 2002).

Gray whales migrate from calving and breeding lagoons in Baja California, Mexico each spring to summer feeding grounds in Alaska (15,000 to 20,000 km round trip), a journey that takes about two months. This is the longest migration of any large whale (Calambokidis *et al.* 2000b; Jones and Swartz 2002). Gray whales can be seen alone or in small groups of up to 16 (Leatherwood *et al.* 1982). During northward migration, they tend to travel and feed close to shore, enabling them to be counted. Systematic counts have been taking place off Granite Canyon in central California since 1967 (Angliss and Lodge 2002).

Off British Columbia, the northward migration is from February to May; peaking in the first two weeks of April (Pike and MacAskie 1969). As whales are travelling north, a portion of the population tends to stop and feed, such as in Skidegate Inlet, where they are often seen in early spring (Figure23). Likely, most of the population probably travels along the west coast of Haida Gwaii. When whales return south in December, most whales travel without stopping (Pike and MacAskie 1969). Some whales over-summer in coastal waters to feed, and are referred to as *residents*. Eight collaborating organizations are currently studying *resident* grey whales throughout their range, and have found, through photo-identification studies, that the average tenure of *resident* whales in these feeding areas is 56 days (Calambokidis *et al.* 2002).

Information on gray whale diets comes mostly from studies in their northern feeding grounds. These whales are mostly benthic suction feeders that sieve small prey out of sediments or off of vegetation, creating visible feeding plumes, although they can also feed in the water column and at the surface (Darling *et al.* 1998). Over 80 species of prey have been identified (Jones and Swartz 2002). Although there is little information on the diet of gray whales in Haida Gwaii, off Vancouver Island they are known to prey on Pacific herring eggs and larvae, crab larvae, mysids, amphipods and ghost shrimps (Darling *et al.* 1998; Dunham and Duffus 2002).

Although the gray whale population is not considered at risk, they remain vulnerable to collisions with boats, likely because of their nearshore migration (Laist *et al.* 2001) and to entanglement in fishing gear (Angliss and Lodge 2002). As well, they are vulnerable to changes in their food supply. Moore *et al.* (2003) suggest that a significant decline in amphipod productivity in the northern Bering Sea from 1983 to 2000 may have contributed to the deaths of 100s of whales that stranded in 1999 and 2000. Gray whales are also vulnerable to noise, both above and below the water (Moore and Clark 2002).

Gray whales have been hunted by aboriginal peoples (possibly including the Haida) in the North Pacific for millennia. From 1996 to 2000, an average of 97 were killed annually by Russian aboriginals of the Chukotka Peninsula area (Angliss and Lodge 2002). The Makah (Nuu-chah-nulth) people of Washington State resumed their traditional hunt as described earlier, taking one gray whale in 1999, but their legal right to do so was overturned in December 2002. It is likely that this issue will remain controversial for some time to come.

The sightings of gray whales around Haida Gwaii are shown in Figure 23. Most sightings were divided equally between Langara Island, Cape St. James and Skidegate Inlet. Whales were usually seen in groups of 1 to 5. Groups of 10 to 15 have also been seen, particularly around Cape St. James, including several reports of >30. Sightings were most frequent from April to June and from December to January; whales have been sighted in all months except February. Whales seen in summer could be seasonal residents that remained to feed, although this requires verification through photo-identification. Whales are not observed with equal frequency each year. For example, there were > 30 sightings in 1995 and none in 1998. Reasons for this interannual variation are unknown, but may be due to prey availability (Ford *et al.* 1994). Darling *et al.* (1998) found that off Vancouver Island, gray whales used some feeding areas annually, whereas other areas were used at irregular intervals exceeding 10 years.

Minke whale (*Balaenoptera acutorostrata*)

Minke whales are the smallest baleen whales found around Haida Gwaii. In the northern hemisphere, they reach lengths of 9.2 m. In the southern hemisphere, females and males reach 10.7 and 9.8 m in length respectively (Leatherwood and Reeves 1983). They are darkly pigmented above and lighter below. Some animals also have a light chevron just behind their head, and on their sides just forward of their dorsal fin and/or above and behind their pectoral flippers. In the northern hemisphere, they also have a conspicuous blaze of white across their pectoral flippers. They have a distinct falcate dorsal fin that is tall relative to other baleen whales, and is placed about two thirds of the way along the back. Their blow is generally small and inconspicuous.

Of all of the baleen whales, minke whales are known to segregate by age and sex class the most (Leatherwood and Reeves 1983). In summer and early fall, whales show small-scale spatial segregation (Dorsey *et al.* 1990). Individually recognizable whales have been resident in the same areas over several years. Since feeding is the most common activity of baleen whales in summer, this segregation may allow whales to feed most efficiently in areas where their prey occurs in patches. Hoelzel *et al.* (1989) found that

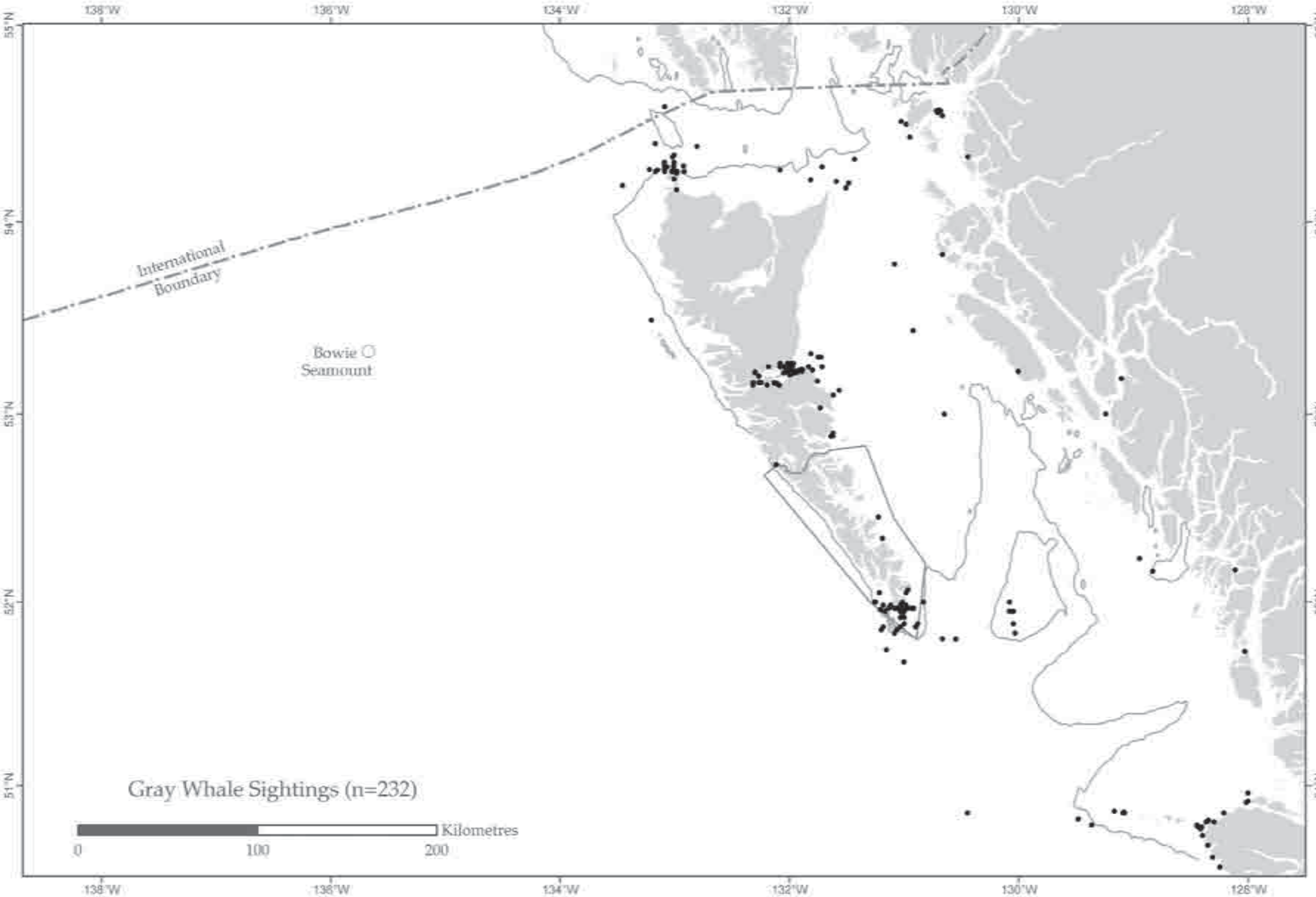

Figure 23. Locations of gray whale sightings to 2003 in the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

23 whales in the San Juan Islands showed specialized feeding strategies. Some whales would seek out foraging flocks of gulls and alcids and surface in their midst to capture small schooling fish. Other whales used lunge feeding to capture their prey (Pacific herring and Pacific sand lance [*Ammodytes hexapterus*]).

There are no population estimates for minke whales in the North Pacific (Carretta *et al.* 2002). Between California, Washington and Oregon, there are ~631 (CV = 0.45), and in the central Bering Sea ~936 (CV = 0.35) (Angliss and Lodge 2002). There are no population estimates for the coast of British Columbia.

Much of what is known about minke whales comes from 'scientific' whaling by the Japanese. The meat from these whales generally ends up on the commercial markets. Japan has taken ~100 annually in the northwest Pacific since 1994 (Baker *et al.* 2000). There are at least two stocks in the North Pacific; an *offshor*e Pacific stock and a *protected* stock in the Sea of Japan - East China Sea (Donovan 1991). Both have been hunted by the Japanese (Baker *et al.* 2000) and Dalebout *et al.* (2002) suggest that at least 98 different individuals from this protected stock were taken by Japan and Korea between December 1997 and October 1999.

The sighting records of minke whales around Haida Gwaii are shown in Figure 24. Most (84%) were of single animals. Sometimes two have been seen together and a group of four was recorded once. There are only two records of minke whales being taken from the waters of Haida Gwaii; both in 1923 (Pike and MacAskie 1969). This contrasts with the Antarctic where thousands continue to be taken in Japanese 'scientific' whaling (IWC 1997).

North Pacific right whale (*Eubalaena japonica*)

North Pacific right whales were considered the "right" whales to hunt in early whaling because they were large (to 19 m in length), floated when dead, and could easily be taken by whalers in small vessels. An alternative explanation for their name is that they are 'true' whales, as reflected in their genus name *Eubalaena* (Kenney 2002). The largest whales weighed up to 72 t. Whales of similar lengths but of different species might only weigh 22 to 54 t (Scharff 1986). Right whales swim slowly and lack any distinctive dorsal fin or ridges.

Before whaling, there may have been ~11,000 North Pacific right whales in the North Pacific (Angliss and Lodge 2002). By the mid-1800s, they were hunted to commercial extinction, although the Russians continued to hunt them in the Northwest Pacific and Sea of Okhotsk into the 1960s (Yablokov 1994). Their population has not recovered, and they remain the most threatened of all baleen whale species (Clapham *et al.* 1999). DFO recently issued a draft recovery plan for the species (O and Ford 2003). So rare are these whales that a single sighting is sufficient to warrant publication (Clapham *et al.* 1999). Wada (1973) estimated there were ~100 to 200 whales left in the whole North Pacific. There are no current population estimates, but their numbers are extremely low. A few recent sightings provide some hope. In April 1996, a right whale was seen off of Maui (D. Salden, Pacific Whale Foundation, *personal communication*; Ferrero *et al.* 2000). Several sightings of small groups of right whales have also been recorded since the mid 1990s in Alaska (Goddard and Rugh 1998; Ferrero *et al.* 2000). In total, 14 individuals have been identified, and two animals have been photographed in more than one year. However, this very high 'mark-recapture' suggests a very small population size (Angliss and Lodge 2002).

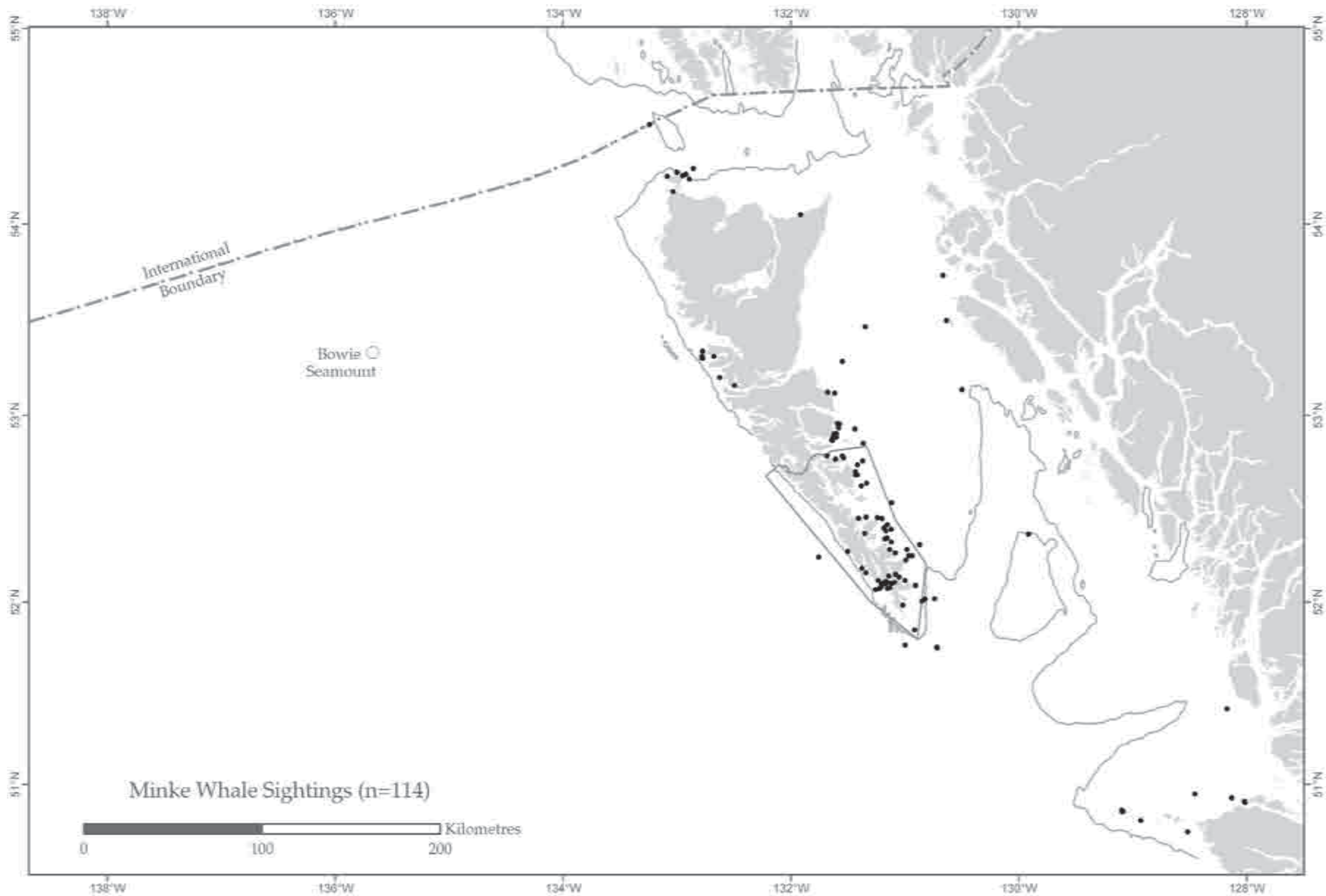

Figure 24. Locations of minke whale sightings to 2002 in the northern British Columbia area (north of 50.5° N) from the British Columbia Cetacean Sightings Network (data courtesy of the Vancouver Aquarium Marine Science Centre and DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

Given the rarity of northern right whale sightings in the North Pacific, it is not surprising that there have been no recent reports from around Haida Gwaii. The last report of a right whale sighting in British Columbia was in 1970 off the west coast of Haida Gwaii (Wada 1973). Between 1910 and 1934, eight whales were taken (Table 6), and three (all taken in 1924) were recorded in the whaling database (Figure 25). A male (17 m) and small female (14 m) were taken in the western portion of Dixon Entrance, while a female was caught off the northwest tip of Graham Island. A second male (13 m) was caught off the southern tip of Haida Gwaii (Nichol and Heise 1992). Although no stomach content data are available from whales taken locally, right whales feed selectively on copepods (Leatherwood and Reeves 1983).

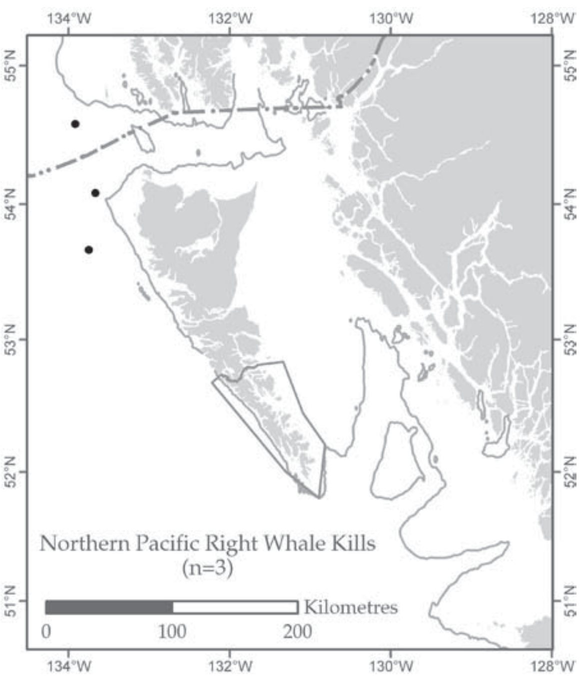

Figure 25. Locations of the North Pacific right whale kills recorded in the northern British Columbia area (north of 50.5° N) from the whaling history database compiled by Nichol *et al.* (2002) (data courtesy of L. Nichol, DFO). The 200 m isobath demarcating the edge of the continental shelf is shown.

PINNIPEDS

Pinnipeds straddle the marine and terrestrial realms. Although they spend the majority of their time traveling and foraging at sea, they come ashore (haulout) to rest, mate, give birth and moult. Pinnipeds include three distinct families: eared seals (Otariidae), true seals (Phocidae), and walruses (Obendinidae). Taxonomists now group pinnipeds along with dogs, bears, otters, racoons and weasels in the Order Carnivora. Five species, from the first two families, are recorded from around Haida Gwaii.

EARED SEALS (OTARIIDAE)

Sea lions and fur seals are differentiated from true seals by the presence of an external ear flap. More importantly, they can prop themselves up on their large, bare-skinned fore-flippers and rotate their hind-flippers forward under themselves, thus allowing them to climb on rocky shores. In water, the fore-flippers are used for both propulsion and steering.

Steller Sea Lion (*Eumetopias jubatus*)

Steller (or northern) sea lions are the largest of the world's eared seals. The species exhibits marked sexual dimorphism with the adult males (bulls) being much larger than adult females (cows) (Olesiuk and Bigg 1988; Calkins *et al.* 1998; Winship *et al.* 2001; Loughlin 2002). Adult females grow for 6 to 8 years (average life span of ~30 years) and attain a length of up to 2.9 meters and can weigh ~350 kg. Adult males continue growing throughout much of their lives (average life span of ~15 years), attaining a length of 3.25 m and typically weighing 400 to 800 kg, although bulls can weigh >1,100 kg just prior to breeding (Olesiuk and Bigg 1987; Loughlin 2002). The tan or golden brown fur of both sexes is short, coarse and slightly darker on the undersides; especially the chest. The fur of pups (animals younger than 6 months; Bigg 1985) appears silver-black, although it is actually dark brown.

Adult vocalizations in air consist of deep-throated bellows and roars. Territorial males wheeze as part of their threat displays (Orr and Poulter 1967; Gentry 1970), and produce a loud guttural sound both in the air and underwater (Schusterman *et al.* 1970). Pups bleat similar to sheep.

Steller sea lions are perhaps the most researched marine mammal in the North Pacific with >270 studies for which they were the primary focus published between 1751 and 2000 (Hunter and Trites 2001). Their life history and occurrence in British Columbia waters was fully reviewed by Bigg (1985, 1988a). This species occurs from the Channel Islands of southern California northward along the coast to Alaska and eastward across the Aleutians, Bering Sea and Kuril Islands, and southward to the Sea of Japan and central Japan (Loughlin 2002). Within this range, they breed on ~60 rookeries and rest at >300 haulouts. They are non-migratory, but may disperse considerable distances from rookeries (Rowley 1929; Fisher 1981; Raum-Suryan *et al.* 2002). Animals haul out on a regular basis throughout the year. Steller sea lions are generally observed within 60 km of land and in water depths <400 m, but may venture 100s of km offshore well off the continental shelf (Kenyon and Rice 1961; Merrick and Loughlin 1997). Animals occasionally venture into freshwater (Jameson and Kenyon 1977; Roffe and Mate 1984; Beach *et al.* 1985). Worldwide, two populations of Steller sea lions are recognized based on genetic differentiation of mitochondrial DNA (reflecting maternal lineage): an eastern population (California to Southeast Alaska) and a western population (Gulf of Alaska, Bering Sea, Aleutian Islands, Russia, Japan) (Bickham *et al.* 1996). Division of these two populations – which occurs at Cape Suckling, Alaska (at 144°W) - is further supported by other analyses including population trends, distribution, movements, and morphology (Loughlin 1997, 2002).

Steller sea lions aggregate at three distinct types of land sites: (1) breeding rookeries (most active May to August) where they give birth, nurse pups, and mate; (2) year-round haulouts that are usually occupied continuously in fairly consistent numbers throughout the year; and (3) winter haulouts that are used less regularly and primarily during the non-breeding season. As well, in some areas, such as British Columbia (Bigg 1985), animals have specific winter rafting sites where suitable haulout sites are not available. Rookeries generally have peripheral haulout sites occupied mainly by non-breeding males and juveniles. In most cases, animals continue to use rookeries as haulout sites throughout the year, albeit in much reduced numbers.

In the spring, Steller sea lions aggregate to breed on isolated rookeries (Loughlin 2002). In the Northeast Pacific, bulls arrive first, beginning in early-May to compete for breeding territories that are established by early June. Territories range in size from 150 to >500 m^2 and are usually delineated with natural features such as cracks, faults and ridges in the rock, but may be more fluid and defined by groups of females or tide level on featureless terrain such as sediment beaches (Gentry 1970; Gisiner 1985; Smith 1988). Once established, territories are maintained primarily by ritualized threat displays (Gentry 1970). Only the largest males, aged 10+, acquire and defend territories, which they may hold for several years in succession (maximum 7 years). The ratio of cows to territorial bulls on rookeries is usually 10-15:1 (Pike and Maxwell 1958; Merrick 1987). Breeding bulls will maintain their territory for ~40 days (range 20 to 68 days), generally without feeding and often without drinking (Gentry 1970), although some males may take short foraging trips or take a drink of seawater (Gentry 1981a). The advantages of larger body size in acquiring and defending territories, and in providing energy and possibly water reserves during tenure, probably accounts for the sexual dimorphism (Fisher 1958; Repenning 1975).

Pregnant cows arrive at rookeries (usually of their birth) 2 to 3 weeks after the bulls and give birth to a single pup (twinning is rare) of up to 23 kg weight within a few days of arrival (Loughlin 2002). Cows stay ashore with their pups for ~1 week during which they bond using both vocal and olfactory cues (Gentry 1970; Sandegren 1970, 1976). Females subsequently make regular 1-day feeding trips followed by 1-day rests on shore (Higgins 1984; Merrick 1987; Hood and Ono 1997; Milette and Trites 2003). Copulations usually occur prior to the first feeding trip with the male holding the territory or one of the adjacent territories to where the cow is raising its pup (Gentry 1970; Sandegren 1970, 1976; Edie 1977; Gisiner 1985).

Steller sea lion pups are precocious; they have open eyes and can crawl at birth. They begin to enter tide pools and intertidal areas at ~2 weeks of age, and swim in the open ocean by ~4 weeks of age, when mothers begin moving them from the rookeries to nearby year-round and winter haulouts (Sandegren 1970; Bigg 1984). By the end of August, few animals remain on the rookeries. Weaning occurs usually within ~12 months with parental bonds broken by spring (Calkins and Pitcher 1982; Porter 1997). Occasionally, cows on rookeries nurse both new pups and yearlings (and even older juveniles) indicating that period of dependency can extend beyond a year.

During the breeding season, year-round haulouts are occupied by immature animals, non-pregnant adults, and females nursing pups from previous summers that do not return to the rookeries. Some bulls also use summer haulouts and establish territories, and occasionally breed with mature females (A. Trites, UBC, *personal communication*). Outside of the summer breeding season, animals use year-round haulouts as well as winter-haulouts that may be considerable distances from their rookeries and located in protected waters. Cows with dependent young may stay at a single haulout or may move their pups to any number of haulouts. Average length of feeding trips by lactating cows in winter is ~2 days, followed by a day on shore (Porter 1997; Trites and Porter 2002). Females without pups may spend extended time at sea between visits to shore. Haulouts are not restricted to any single age or sex class during the non-breeding season. Foraging is more localized during the breeding season. In contrast, seasonal movements of animals during the non-breeding season (September-May) are much wider and are likely related to distribution of schooling fish prey. Foraging trips of satellite tracked adult females in Alaska have averaged ~17 km during summer, compared to 153 km during winter (Merrick and Loughlin 1997). Off the coast of California, Steller sea lions were concentrated within 1 to13 km (average 7.0 km) of rookeries during summer and were seen less frequently compared to autumn when they were up to 7 to 59 km offshore (average 28.2 km) (Bonnell *et al.* 1983). Foraging ranges of immature non-breeding animals are intermediate to the summer and winter ranges of adults (Merrick and Loughlin 1997).

Females mature at ~3 to 6 years of age. They ovulate and mate 1 to 2 weeks after giving birth, but embryonic development is suspended for ~3 months following fertilization until implantation occurs in September or October (delayed implantation), resulting in a gestation period of ~8 to 9 months (Vania and Klinkhart 1967; Calkins and Pitcher 1982). The majority of cows conceive each year, but the rate of reproductive failure appears to be high. Pitcher *et al.* (1998) reported that 97% of females sampled in the Gulf of Alaska were pregnant during early gestation, but that pregnancy rates declined to 67% and 55% during late gestation in the 1970s and 1980s respectively. Pregnancy rates have not been estimated for animals in British Columbia (Bigg 1985). Males may begin producing sperm by 3 to 7 years of age (Calkins and Pitcher 1982), but only those holding territories mate.

Mortality of pups < 1 month old is high and is influenced by factors such as storms (Pike and Maxwell 1958; Orr and Poulter 1967). For example, Edie (1977) observed that 30% of pups belonging to known cows disappeared during a storm, and he estimated that overall pup mortality at ~50%. The principle cause of death for pups is drowning; not because they are not able to swim, but because they are unable to get back on shore (Orr and Poulter 1967; Edie 1977). Being bitten, tossed or trampled by older animals also kills pups, as does being abandoned or separated from their mothers (Orr and Poulter 1967; Gentry 1970; Sandegren 1970, 1976). Rookeries are thus especially sensitive to disturbance during the breeding season.

Juvenile mortality is difficult to estimate due to potential sampling biases, but appears to be high for both sexes. Calkins and Pitcher (1982) estimated that ~48% of females and 26% of males survived to 3 years of age. Mortality rates are significantly lower for adults (~10-15% per year for females, and ~13-25% for males). The higher mortality rates for males results in a progressively skewed sex ratio favouring females. The oldest animals aged from the wild were ~18 years for bulls and 30 years for cows (Calkins and Pitcher 1982). However, longevity (defined at the 99^{th} percentile of known aged individuals) is ~14 years for bulls and 22 years for cows (Trites and Pauly 1998). It should be noted that the only life tables available were derived from specimens collected in the Gulf of Alaska just prior to major population declines, and life history and population parameters (such as life expectancy and generation time) may vary with status of populations. In marine mammals, density dependence is expressed primarily in factors affecting reproductive rates (especially of younger animals) such as age at first reproduction, fecundity rates, and juvenile survival (Eberhardt 1985; Fowler 1987).

The value of food to Steller sea lions varies with the species and quality of prey. Mature females require ~15 to 20 kg and mature males ~30 to 35 kg of prey daily (Winship *et al.* 2002). Animals eating relatively low-fat fishes such as gadids (hake, pollock, cod) require significantly more prey than those eating fattier fishes such as herring (Trites and Donnelly 2003; Winship and Trites 2003). Steller sea lions forage mainly at night (Spalding 1964). They can dive to 310 m (Andrews 1999) and for >8 minutes (Swain and Calkins 1997), with most dives being to 15 to 50 m depth and lasting for 1.5 to 2.5 min (Merrick and Loughlin 1997; Swain and Calkins 1997; Loughlin *et al.* 1998; Andrews 1999; Swain 1999). Diving capabilities are developed early; pups <1 month old dive to ~10 m, increasing to ~100 m by 5 months of age, and to >200 m by 10 months of age (Merrick and Loughlin 1997; Rehberg *et al.* 2001).

Over 50 species of fish and invertebrates are eaten by Steller sea lions (Wilke and Kenyon 1952; Pike 1958; Spalding 1964; Sinclair and Zeppelin 2002). Their diets vary according to which prey are locally and seasonally most abundant or accessible. Preferred prey are small- to medium-sized schooling fishes, which in British Columbia include herring, hake, sandlance, salmon, dogfish, eulachon and sardines (Pike 1958; Spalding 1964; Olesiuk and Bigg 1988, Trites and Olesiuk, unpublished data). Bottom fish, such as rockfish, flounder and skate, can also be important prey (Trites and Olesiuk, unpublished data). In addition to fish, squid and octopus are sometimes eaten, but their importance was probably exaggerated in earlier studies because cephalopod beaks may accumulate in stomachs over time (Bigg and Fawcett 1985). Crabs, mussels, clams, and other invertebrates are occasionally recovered in stomachs and scats (feces), but these may represent secondary prey eaten by the prey of sea lions. Animals occasionally prey on gulls (O'Daniel and Schneeweis 1992) and other pinnipeds, including fur seal pups (Gentry and Johnson 1981) and harbour seals (Pitcher and Fay 1982, E. Mathews, University of Alaska, Juneau, *personal communication*).

Marked population declines and subsequent listed status in United States territorial waters of western Alaska (listed as *endangered* west of Cape Suckling [144^o W] including Aleutian archipelago and the Bering Sea), has fostered much research on factors affecting their decline (Wooster 1993; Trites *et al.* 1999; DeMaster and Atkinson 2002; Springer *et al.* 2003; Trites and Donnelly 2003). In contrast, the population breeding from Southeast Alaska through British Columbia to Oregon has been increasing steadily from the late 1970s to current times (Bigg 1988a; Calkins *et al.* 1999). Nonetheless, this population is listed as *threatened* in United States waters east of 144^{o}W and became listed as *special concern* in Canadian waters in November 2003.

Theories on the western Alaskan population declines vary and this is an active area of current research. Although it is agreed that the availability of food ultimately limits Steller sea lion populations (Wooster 1993), it remains unclear the extent to which decreased food levels have been caused by changing ocean conditions and/or commercial fishing on feed stocks used by sea lions (DeMaster and Atkinson 2002). Indeed, fishing effects likely confound analyses when trying to differentiate between indirect human versus ocean-state influences on populations including marine mammals (Benson and Trites 2002). Springer *et al.* (2003) have suggested a controversial top-down hypothesis in which post-war commercial whaling decreased great whale stocks in the North Pacific to the extent that killer whales switched predatory focus from whales to sea otters and pinnipeds (such as Steller sea lions), thus driving down their numbers.

Before they became protected in 1970, Steller sea lions in British Columbia were subject to federally managed culls for fisheries (mostly salmonid) predator control programs that greatly reduced populations, including those in Haida Gwaii (Bigg 1984, 1985, 1988a; Olesiuk 2003). Between 1913 and 1968, ~49,000 sea lions were culled and 5,700 taken in commercial hunts province-wide (Bigg 1988a). These kills reduced the breeding population in British Columbia to ~30% of peak levels observed in the early 20th century; reduced to ~4,000 from ~11,000 to 12,000 (Pike and MacAskie 1969; Bigg 1985).

The most intensive culling occurred at Virgin and Pearl Rocks (the Sea Otter Islands group, Figure 26), purportedly to protect the Rivers Inlet salmon run. Federal fishery officers culled these rookeries annually (1923 to 1939) in mid-June and shot every breeding animal possible before landing and clubbing pups too young to escape. Approximately 20,000 (including 7,000 pups) were killed. Once these rookeries were destroyed, culls were executed on the Scott Islands group (Figure 26), where ~7,500 (including 2,800 pups) were killed during 1936 to 1939. There was an attempt to hunt animals for hides commercially, but this proved uneconomical. Culls also occurred at the rookery on Danger Rocks (Figure 26) and at year-round haulouts on rocks off the north mainland coast (Bigg 1988a). Large-scale culls were suspended during World War II, although the Canadian military may have killed animals during bombing practices, although there are no data on the magnitude of such kills (Bigg 1985).

With protection in hand, the systematic aerial surveys for Steller sea lions began in 1971. Surveys are best flown during the last few days of June or first few days of July, by which time most pups have been born, but not old enough to disperse. This enables estimates of total pup production, and total abundance estimated by applying multipliers derived from life tables based on the expected ratio of pups to "non-pups"

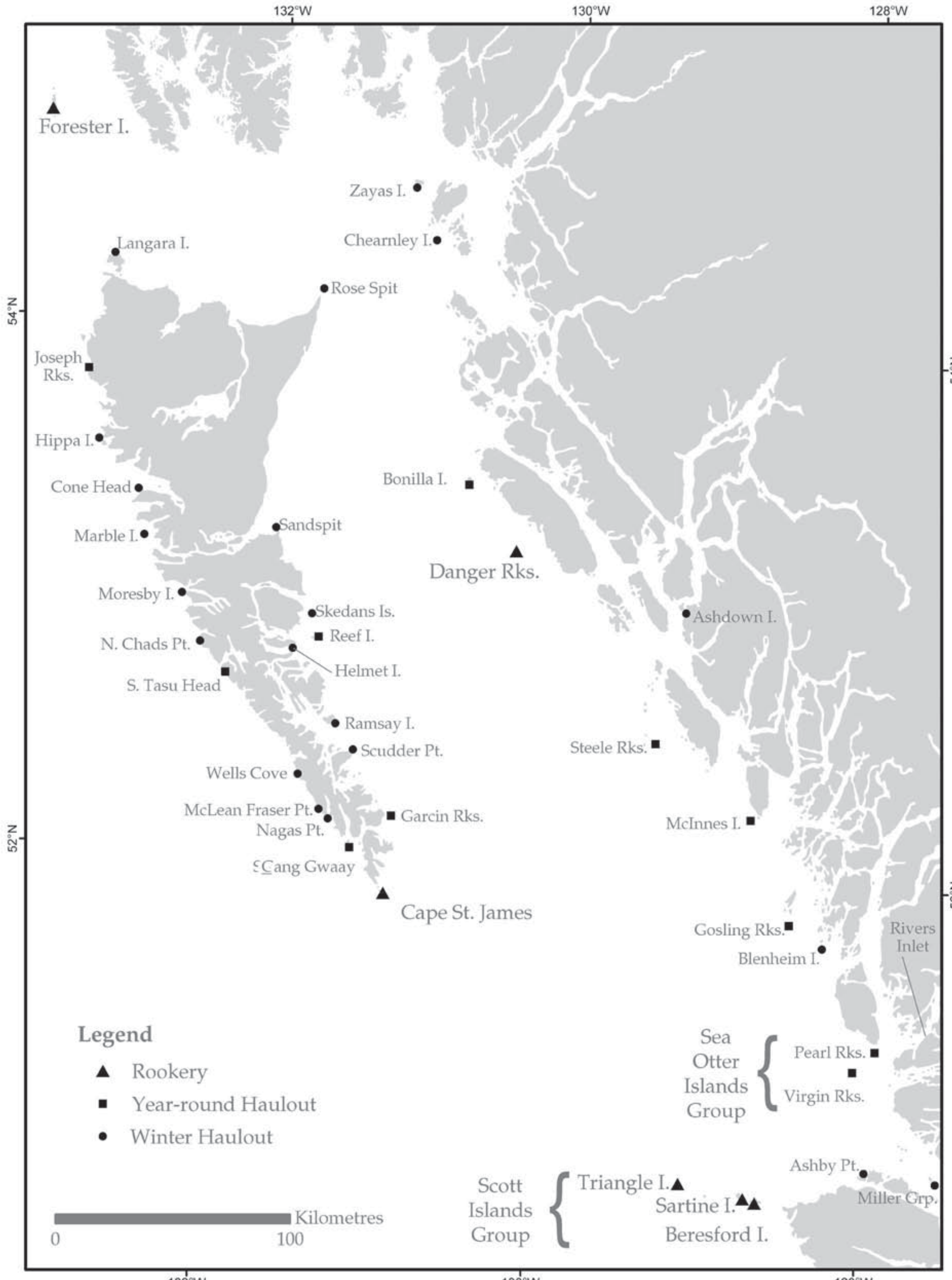

Figure 26 Map of Steller sea lion rookeries and haulouts in northern British Columbia including the Haida Gwaii region (updated from Bigg 1985, Olesiuk et al. 1993).

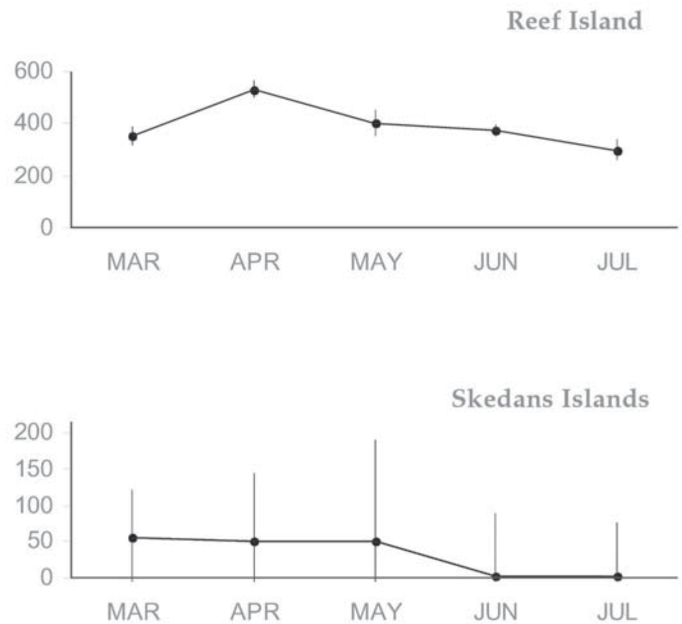

Figure 27. Average monthly (March to July) counts of Steller sea lions at Reef Island (year-round haulout) and Skedans Islands (winter haulout) recorded by Laskeek Bay Conservation Society, 1990 to 2002 (data courtesy G. Martin and C. Tarver, Laskeek Bay Conservation Society, Queen Charlotte City, B.C.). The error bar at the top of columns is one coefficient of variation.

[animals older than six months; Bigg 1985] (Calkins and Pitcher 1982; Trites and Larkin 1996; Olesiuk 2003).

Locations of the three types of Steller sea lion aggregation sites in northern British Columbia are shown in Figure 26. In the Haida Gwaii region, there is one breeding rookery on the Kerouard Islands just south of Cape St. James, 5 confirmed year-round haulouts and 15 winter haulouts. There are no winter rafting areas reported from Haida Gwaii. Among the year-round haulouts, several have been used since the 1930s to 1950s, with a few new ones established in the last 20 years as populations recovered. Year-round haulouts have consistent numbers through seasons, including significant numbers during the June to July breeding season. In contrast, winter haulouts are used primarily during the non-breeding season and sporadically by small numbers in June and July. Counts made by the Laskeek Bay Conservation Society at Reef Island (year-round haulout) and Skedans Islands (winter haulout) show this general pattern (Figure 27).

Counts have been recorded from the Cape St. James rookery since 1913 (Table 9). The two winter counts yielded much lower numbers. Summer numbers had declined from the first assessment to ~1,000 by 1916, which Bigg (1985) speculated was due to harassment by staff and servicing vessels for the nearby lighthouse completed in 1914. The population had recovered to ~2,500 (+1,500 pups) by 1956. After that, a series of annual culls (1959 to 1966) reduced the count sharply by 1961. After the 1970s, numbers have steadily increased.

Haida Gwaii largely escaped the carnage during the early (pre mid-1950s) culling era with ~393 killed (63% from the rookery at Cape St. James and 37% from various haulouts; figures updated from Bigg 1988a). Coast-wide from 1956 to 1968 culling claimed ~12,367 sea lions from rookeries and haulouts, not including those commercially hunted for mink food that proved to be an uneconomic venture (Bigg 1988a). From 1959 to 1966, culls at Cape St. James totalled ~3,530 (including 278 pups) (Bigg 1988a updated). Besides the kills at Cape St. James, another 820 were killed at various haulouts around Haida Gwaii (*e.g.*, Langara Island and Joseph Rocks) by 1968.

The population trend in Haida Gwaii mirrors that of British Columbia as a whole. Listed in Table 10 are all the census results from sites around Haida Gwaii (1971 to 2002). The correction factor for pup counts when using various photographic techniques is given in Olesiuk *et al.* 2003). Total number of non-pups around Haida Gwaii increased at a mean rate of 2.9% annually (compared to 3.2% coast-wide) since 1971. Numbers were quite stable up to 1982, but subsequently increased more rapidly at an annual rate of 3.8%. Pup production at Cape St. James increased from an average of 319 in the 1970s to 660 in 2002.

Table 9. Summer counts of non-pup (>6 months old) and pup Steller sea lions recorded from the Cape St. James rookery, 1913 to 2002 (data from Bigg 1988 a, Olesiuk et al. 1993 and P. Olesiuk, DFO). The years of aggressive culling were 1959 to 1966 with a peak of 1,438 sea lions in 1960. There are two winter counts (of non-pups): 258 in 1971 and 310 in 1976.

Year	Non-pups (pups)
1913	2,500
1916	1,000
1938	2,800
1956	2,500 (1,500)
1961	797 (644)
1971	631 (350[1])
1973	549 (282[1])
1977	782 (315[1])
1982	698 (420[1])
1987	1,021 (381[1])
1992	867 (503[1])
1994	797 (346[1])
1998	763 (503[1])
2002	982 (660[1])

1 adjusted pup counts using a correction factor invoked by multiplying the raw pup count by1.04 to account for the difference between pups not visible using oblique photography versus more pups visible using verticle over-head photography of the rookery.

The total count at Cape St. James in 2002 was roughly 66% of the estimated number present at the relatively undisturbed rookery in 1913. Although pup counts are relatively complete, ~20 to 25% of non-pups are at sea feeding and likely missed during surveys (Olesiuk 2003). In summary, ~4,500 (including 660 pups) were around Haida Gwaii in 2002. This yields a non-pup: pup ratio of ~5.8:1 compared to the 3.5:1 expected from life tables. The former ratio suggests that Haida Gwaii waters support not only the breeding population at Cape St. James, but a surplus of foraging non-breeding animals associated with other rookeries, most likely Forrester Island, Southeast Alaska.

In assessing the status of Steller sea lions in Haida Gwaii, the potential influence of the large rookery at Forrester Island (~75 km north of Langara Island; Figure 26) cannot be ignored. This rookery was inactive or very small in the early 1900s when culling was initiated in British Columbia. Animals probably began to breed on Forrester Island in the 1930s and by the early 1980s, pup production at Forrester Island had stabilized at ~2,800 annually, and this rookery now represents the largest breeding aggregation of Steller sea lions in the species' eastern range (Olesiuk 2003; Pitcher *et al.* 2003). The recent leveling-off of pup production suggests that this rookery may have reached its capacity, perhaps explaining the recent increase in numbers around Haida Gwaii.

To summarise, with recent declines in Steller sea lions in western Alaska, the waters of the greater Haida Gwaii region now represent the epicenter of the species' eastern distribution. Haida Gwaii supports the Cape St. James rookery. The largest rookery is at Forrester Island and the second largest rookery is at the Scott Islands group ~170 km south of Haida Gwaii. Combined, these three rookeries support >60% of the eastern stock, and 35% of the overall North American population.

Research on Steller sea lions around Haida Gwaii has recently intensified with annual Canada-United States cooperative research visits in June to July each year since 2000. The key research objectives have been to record individuals from the 800 pups branded by United States agency staff on Forrester Island in 1994 and 1995. Each year, branded animals have been seen at Cape St. James rookery (Figure 28). Branded animals have also been seen elsewhere, for example, in spring 2003 two were sighted at the Reef Island year-round haulout by Laskeek Bay Conservation Society (C. Tarver, *personal communication*). This is not surprising as the Southeast Alaska to Oregon Steller sea lion population is considered to be contiguous (Calkins *et al.* 1999).

A second initiative at Cape St. James since 2000 has been the collection of scats (feces) to examine local diets of Steller sea lions during the breeding season (Trites and Olesiuk, unpublished data). Preliminary scat analyses indicate the key summer prey are small schooling fish, primarily Pacific herring and Pacific sand lance (present in 77% of scat samples); rockfish (49%); gadids (hake, Pollock, cod) (23%); flatfish, mainly arrowtooth flounder [*Atheresthes stomias*] and various soles (23%); salmon (10%); cephalopods (6%); and variety of other prey such as skates, small sharks, ratfishes, pricklebacks, wolf eel, myctophids, and lampreys (22%). Further, proportions of prey species vary according to location. In summer 2000, prey species remains varied significantly between Cape St. James (dominated by rockfish) and the year-round haulout at Reef Island (dominated by sandlance) (Trites 2002). Winter diets form Haida Gwaii have not been examined, but Pacific herring is the main winter prey elsewhere in British Columbia (Spalding 1964; Olesiuk and Bigg 1988).

Table 10. Counts of non-pup (>6 months old) and pup Steller sea lions according to site around Haida Gwaii, 1971 to 2002 (data from Olesiuk *et al.* 1993 and P.F. Olesiuk, DFO). The pup counts (at Cape St. James only) have been adjusted using a correction factor invoked by multiplying the raw pup count by 1.04 to account for the difference between pups not visible using oblique photography versus more pups visible using over-head photography of the rookery.

Site Name[1]	Site Type[2]	28 June to 30 June 1971	29 June to 03 July 1973	27 June to 30 June 1977	28 June to 01 July 1982	29 June to 03 July 1987	28 June to 03 July 1992	28 June to 01 July 1994	29 June to 04 July 1988	02 July to 06 July 2002
Cape St. James	R	631	549	782	698	1,021	867	797	763	982
		350[3]	282	315	420	381	503	346	503	660
Reef Island	Y	207	105	88	36	482	489	538	216	370
Joseph Rocks	Y	408	NS[4]	399	366	309	327	397	601	696
South Tasu Head	Y	76	NS	278	117	263	80	196	285	151
SGang Gwaay	Y	NS[5]	NS	NS	NS	44	279	617	359	313
Garcin Rocks	Y	NS[5]	NS	NS	NS	NS	NS	NS	NS	329
Langara Island	Y/W[6]	6	NS	0	3	3	NS	0	217	3
Skedans Islands	W	0	NS	0	45	0	0	0	0	0
Moresby Islets	W	NS	NS	NS	NS	0	3	115	65	2
Cone Head	W	NS	NS	NS	NS	0	70	21	1	131
	Non-pups	1,328	1,237	1,547	1,265	2,122	2,115	2,681	2,507	2,977
	Pups[3]	350	282	315	420	381	503	346	503	660
	Total	1,678	1,520	1,862	1,685	2,504	2,618	3,027	3,010	3,637

1 these sites are illustrated in Figure 26
2 R = rookery / Y = year-round haulout / W = winter haulout (not all occupied in summer)
3 these rows are the adjusted pup counts
4 NS = not surveyed
5 NS = not surveyed because these sites were not confirmed as used until 1987 (SGang Gwaay) and 2002 (Garcin Rocks)
6 Langara Island may be a transition site from designated winter haulout to a year-round haulout

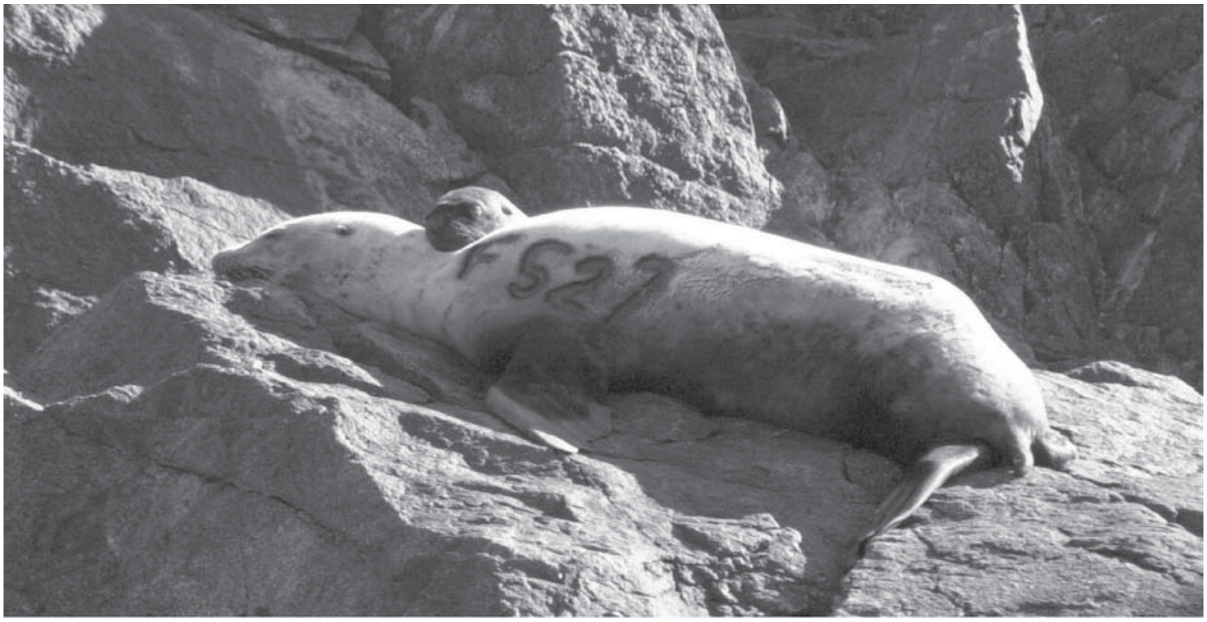

Figure 28. Female Steller sea lion branded at Forrester Island rookery, Southeast Alaska in 1994 and photographed, with its pup, at the Cape St. James rookery in the summer of 2000 (photo by P. Olesiuk, DFO).

California Sea Lion (*Zalophus californianus*)

The California sea lion is a seasonal migrant in British Columbia waters. Females grow for 6 to 8 years and attain lengths of up to 1.7 m and can weigh 110 kg (Heath 2002). They mature at 4 to 5 years of age, and ~80% of mature females become pregnant each year. Adult males are considerably larger and grow throughout much of their lives, attaining a length of 2.5 m and weighing up to 400 kg (Heath 2002), although bulls can weigh ~500 kg just prior to breeding (S. Jeffries, Washington Department Fish and Wildlife, *personal communication*). At ~5 years of age, males mature and develop a distinct sagittal crest and steep forehead peaked with patch of light fur. At the same time, males also begin marked seasonal fattening cycles that peak just prior to breeding (Schusterman and Gentry 1971). The fur of both sexes is short and coarse, and varies in colour from a light chocolate brown when dry to black when wet (more golden in southern latitudes off Mexico). Newborns have very dark brown fur. California sea lions have a distinctive honking bark (Poulter 1965; Peterson and Bartholomew 1967), compared to the deep-throated bellows and roars of the Steller sea lion.

California sea lions breed on beaches of offshore islands from the Farallon Islands, central California, to the southern tip of Baja California and throughout the Gulf of California. Their breeding biology is similar to that of Steller sea lions (Mate and DeMaster 1986; Heath 2002). Bulls come ashore first to establish territories in late May with the numbers of territorial males peaking in early July (Peterson and Bartholomew 1967; Odell 1972). Bulls aged 9+ years acquire and hold territories for ~12 to 41 days during which they fast (Heath 2002). Pregnant cows arrive on rookeries between mid-May and late June, and give birth to a single pup (weighing 6 to 9 kg) within a few days of arrival. Mating occurs within 30 days after pups are born. Cows forage regularly during lactation and pups are usually weaned within ~12 months (Heath 2002).

Following the breeding season, cows with pups usually remain nearby their rookery year-round, or move south (Heath 2002). Most bulls have vacated the rookeries by early August, and travel north. Along the Oregon coast, Mate (1975) noted two distinct seasonal peaks in abundance. Animals began to appear in mid-August and numbers peaked in mid-October in a northward-moving wave. A second and smaller peak occurred in spring, presumably representing the southward migration. California sea lions eat a variety of fish species that differ according to season, location and year. Dives are usually <100 m in depth and last 2 to 10 minutes (Heath 2002).

Commercial hunting for California sea lion oil (rendered from blubber) and hides started in the 1800s off California and Mexico. During the early 20th century, animals were also hunted for dog food, and hundreds were captured for display in zoos and oceanariums. These takes severely depleted populations to ~1,500 by the 1920s and resulted in commercial extinction. Protection since the 1970s has facilitated population rebuilding to ~185,000 to 188,000 (Gentry 2002a; Heath 2002). The population continues to grow, although events such as El Niño (warm ocean water events) can decrease numbers by starvation due to declines in feed stocks. Concurrent with this recovery, the population's range is expanding northward. For example, Steller sea lions used to be the most common species in the Channel Islands, southern California in the 1930s, but they no longer breed there (their southernmost rookery is now ~600 km to the north at Ano Nuevo, central California). Conversely, since the 1930s the California sea lion population of the Channel Islands have increased from 100s to >70,000 (Mate and DeMaster 1986).

The occurrence and life history of California sea lions in British Columbia waters is reviewed by Bigg (1985, 1988b). The local population is a seasonal extension of bulls and sub-adult males from the main breeding population of the coasts of California and Mexico. Animals begin to appear off southern Vancouver Island in late August, numbers remain fairly stable from October to April, and most depart in May, with only a few summer-time stragglers (Bigg 1985; Olesiuk, in preparation b). To date, one female that had been rehabilitated in captivity and released (P. Olesiuk, DFO, unpublished data) has been reported from British Columbia waters. However, it is often difficult to distinguish females from younger sub-adult males. On the wintering grounds, California and Steller sea lions share the same haulout sites and feed on similar prey, which off southern Vancouver Island is mainly herring, hake, dogfish, salmon, squid, pollock and eulachon (Olesiuk and Bigg 1988).

Numbers of California sea lions wintering in British Columbia have increased in recent years. Prior to the 1960s, the species was rare. Newcombe and Newcombe (1914) and Newcombe *et al.* (1918) saw none during their investigations, but cited accounts of them in Barkley Sound, Vancouver Island in the late 1800s and early 1900s, and Wailes and Newcombe (1929) later recounted proof of the species' existence in British Columbia. Guiguet (1953) described a skull collected just north of Barkley Sound in the 1800s. Guiguet (1971) reported small numbers seen by fishermen in Barkley Sound during winter in the mid-1950s, with an increase in the 1960s. By the late 1960s, a small colony had formed at Race Rocks, the southernmost islets on the west coast of Canada off Vancouver Island (Hancock 1970), and up to 300 were reported in Barkley Sound in the winter of 1970-71 (Hatler 1972). Numbers wintering off southern Vancouver Island increased dramatically during the 1970s and early 1980s; peaking at ~4,500 by 1984 (Bigg 1985). Numbers wintering off southern Vancouver Island have since stabilized at 2,000 to 3,000. During the mid-1990s, the species extended its range further north to the tip of Vancouver Island. Systematic surveys have not been conducted, but California sea lions became a problem for fish farmers as far north as Kyuquot Inlet, Vancouver Island during the mid-1990s (Jamieson and Olesiuk 2001), and anecdotal reports of numbers feeding on Pacific sardine (*Sardinops sagax*) off the northeast side of Vancouver Island (P. Olesiuk, DFO, unpublished data).

There have also been a number of sightings of California sea lions in Haida Gwaii (Figure 29) and in Alaska since the mid-1990s (Maniscalco *et al.*, under review). These sightings include mostly single individuals, although groups of 7 and of ~10 animals are recorded. Sightings are most common in April to May with two in June and one in early July. This presumably reflects an increase sighting effort in the spring through summer, and not the actual seasonal distribution around Haida Gwaii. No systematic winter surveys have been conducted since the mid-1970s, and field

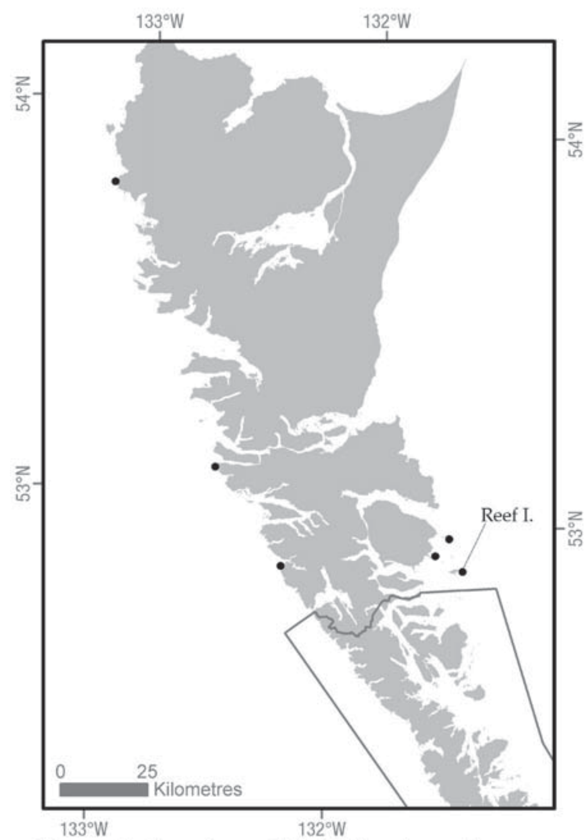

Figure 29. Locations of 12 California sea lion sightings around Haida Gwaii, 7 of which appear as a single dot at Reef I. (data courtesy of Laskeek Bay Conservation Society and P. Olesiuk, DFO).

activities are minimal during October to April when peak abundance would be expected, so it is not known how many California sea lions actually winter in Haida Gwaii.

Northern Fur Seal (*Callorhinus ursinus*)

The northern fur seal is most pelagic of the North Pacific pinnipeds, coming ashore only briefly each year to breed. It is different from other species in having a shorter, down-turned snout, longer ear flaps, and longer rear flippers (Gentry 2002b). This species exhibits marked sexual dimorphism (Bigg 1979; Trites 1990). Females grow mostly during the first 5 to 10 years of life, reaching up to 1.35 m in length and weighing up to 50 kg in spring when they are in prime condition and often pregnant. Males, in contrast, continue growing throughout life, with those in prime breeding condition up to 2 m long and weighing up to 280 kg (Gentry 2002b). A distinctive feature is their thick, waterproof underfur protected by longer, courser and less numerous guard hairs (Gentry 2002b). The fur appears black when wet, but when dry females appear silver-grey on top and reddish-brown underneath, while males vary from grey to redish-brown to almost black, usually with darker undersides (Gentry 1981b).

Northern fur seals occur throughout the subarctic and temperate waters of the North Pacific (Gentry 2002b). In the Western Pacific, they breed on the Commander Islands in the Western Bering Sea, Robben Island in the Sea of Okhotsk, and the Kurile Islands north of Japan. In the Eastern Pacific, most breed on rookeries in the Pribilof Islands, central Bering Sea (~97% of eastern pup production), with much smaller rookeries on Bogoslof Island in the eastern Aleutian Islands (~2% of eastern pup production) and San Miguel Island, central California (~0.5% of eastern pup production) (Angliss and Lodge 2002; Carretta *et al.* 2002). During the non-breeding season, fur seals make large migrations and are widely distributed over the continental shelf as far south as Tokyo, Japan and the California-Mexico border.

Northern fur seal migrations have been described from late 19th century sealing records (Townsend 1899; Murie 1981), and from research conducted by the North Pacific Fur Seal Commission from 1958 to 1974 (Bigg 1990; Trites and Bigg 1996). During May to July, most animals in the Northeast Pacific occur in the Bering Sea, although a few females may remain south of the Aleutian Islands. Adult males leave the rookery in August, and do not return to the haul out again until the following May. Their movements are not well known, but most appear to winter just south of the Aleutian Islands and eastward into the Gulf of Alaska, with some remaining in the Bering Sea. Cows and juveniles of both sexes leave the rookery and begin to migrate south in October and November. They fan out across the North Pacific, traveling to coastal feeding areas between Southeast Alaska and southern California; arriving in December and January respectively. In winter, highest densities are found off southern California (Point Areana to Point Conception), and off the "Vancouver Island sealing grounds" (central Vancouver Island to Columbia River). Most animals occur on the continental shelf, 20 to 150 km offshore. The return migration appears to be slower, with seals in California beginning the migration in March, and moving along the coast of Oregon, Washington, British Columbia, and to the western Gulf of Alaska by April to June, west through the passes in the Aleutian Islands in June, and arriving on the Pribilof Islands in July. Some travel along the coast, but many take a more direct offshore route between California and the Gulf of Alaska, or between Washington - British Columbia and the eastern Aleutian Islands. Most pups and juveniles do not travel as far south, and winter mainly off Southeast Alaska, British Columbia and Washington, sometimes closer to shore and occasionally up inlets. These younger animals may not make the trip back to Pribilof Islands, instead spending the summer offshore (Townsend 1899; Manzer *et al.* 1969; Bigg 1990).

As the sexual disparity in size would imply, polygamy is well established in northern fur seals (Peterson 1968; Bigg 1986; Gentry 2002b). The older bulls that will hold territories begin to arrive at rookeries in early May and compete for desirable breeding locations. Dominant bulls exercise authority not only over breeding territories, but they also try to exert control over breeding cows, giving rise to the misnomer that bull fur seals maintain "harems". In practice, cows are attracted to one another and gather in clusters near the centre of breeding territories, apparently to avoid aggressive interactions between bulls that occur near the periphery. Bulls have little control over the arrival and departure of cows. The oldest pregnant cows begin arriving on the rookery in mid-June and give birth within a day of their arrival, and are followed by younger pregnant and non-pregnant cows. Pupping peaks during the first two weeks of July and is complete before the end of July. Cows mate 3 to 6 days after giving birth, and the day after copulation begin making 4- to 5-day feeding trips that extend 100s of km from the rookery, interspersed with 2-day nursing periods on shore (Gentry and Holt 1986; Gentry 1981b). The foraging trips get progressively longer, reaching 8 to 9 days by October when pups are weaned and their mothers begin dispersing from the rookeries.

Both males and females mature at 3 to 7 years of age. Pregnancy rates are greatest for females aged 8 to16 years, and decline to near zero by 23 years of age. Males begin producing sperm at ~5 years of age and continue until the onset of senescence at ~15 years of age (Gentry 1981b). Generally only the older, dominant bulls will mate, and often with numerous cows. Some bulls have been observed copulating >70 times in a season. Although pelagic for most of the year, there is considerable knowledge about distribution and biology at sea based on pelagic fur seal research conducted by the North Pacific Fur Seal Commission. During 1958 to 1974, >18,000 seals were shot and collected at sea and examined for sex, size and weight, age, reproductive condition, and diet (Trites and Bigg 1996). The long history of commercial hunting of northern fur seal is reviewed previously in the exploitation section of this report.

Up to 500,000 northern fur seals may pass through British Columbia offshore waters annually (A. Trites, UBC, *personal communication*). In an early report on their occurrence off Haida Gwaii, Fraser (1938) mentioned their migration (likely northward) well off the west coast in May and June. Haida Gwaii offshore waters represent, therefore, important habitat for fur seals (Figure 30). Some travel along the west coast of Haida Gwaii on their northward migration, while others take a more direct route across the open ocean. The northward migration along Haida Gwaii peaks in May (1.5 seals sighted per hour; 81% of collected animals) and June (0.5 seals sighted per hour; 12% of collected animals), with only a few yearlings present in February to April (0.3 seal sighted per hour; 8% of collected animals). The wave of migrants in May to June is mainly mature females (50% of specimens, of which 83% are pregnant), and immature animals aged 1 to 3 (50% of specimens, of which 58% are female) (Table 11). Animals are widely distributed from 4 to 450 km offshore. Their diet is mostly squids and salmonids. Weighted volumetrically and ignoring trace occurrences, the diet off the west coast of Haida Gwaii is ~64% squid and ~23% salmon, ~9% pollock and various fishes (P. Olesiuk, DFO, unpublished data) which is typical of the offshore diet in other parts of British Columbia at that time of year (Perez and Bigg 1986). The northward migration off of Haida Gwaii coincides with a short period of rapid weight gain prior to arriving on the Pribilof Islands (Trites and Bigg 1996). This fattening is likely important for cows that will be nurturing pups in the next few months. On southward migration, animals seem to head more directly to preferred wintering areas, and fewer occur off Haida Gwaii.

In addition to the northward migrants, the east side of Haida Gwaii supports an unusually high density of wintering animals (Figure 30). Abundance in Hecate Strait is fairly stable from January to April (mean 0.7 [range 0.4 to 1.1] seals sighted per hour), but declines abruptly during May to June coinciding with the migration back to the Pribilof Islands. The Hecate Strait group was dominated by either yearlings (28% of total) or adult females (67% of total; 77% of which are pregnant) (Table 11). In contrast to the offshore areas, the diet in inshore waters is mostly fish: ~55% herring, ~19% gadids, ~5% sablefish and ~6% other fish (P. Olesiuk, DFO, unpublished data). Squid comprise ~9% of overall diet. Unlike the west coast where animals are widely distributed, fur seals in Hecate Strait aggregate in certain areas, perhaps linking to prey concentrations, especially winter holding areas for herring.

Northern fur seals were also hunted pelagically off Haida Gwaii. Sealing vessels typically made two trips per year: a "spring" voyage out of Victoria in January, hunting off California in February, off Vancouver Island in March, and in the eastern Gulf of Alaska in April. Vessels were usually back in Victoria by May when the peak of the migration passed Haida Gwaii.

Table 11. Age and gender composition (percentage) of northern fur seals migrating offshore of the west coast of Haida Gwaii and in Hecate Strait from research done under the North Pacific Fur Seal Commission, 1958 to 1974 (data from P. Olesiuk, DFO).

Age and gender	Offshore west coast	Hecate Strait
Yearlings	3	28
Juveniler	39	6
Adult males	0	0
Adult females	58	66

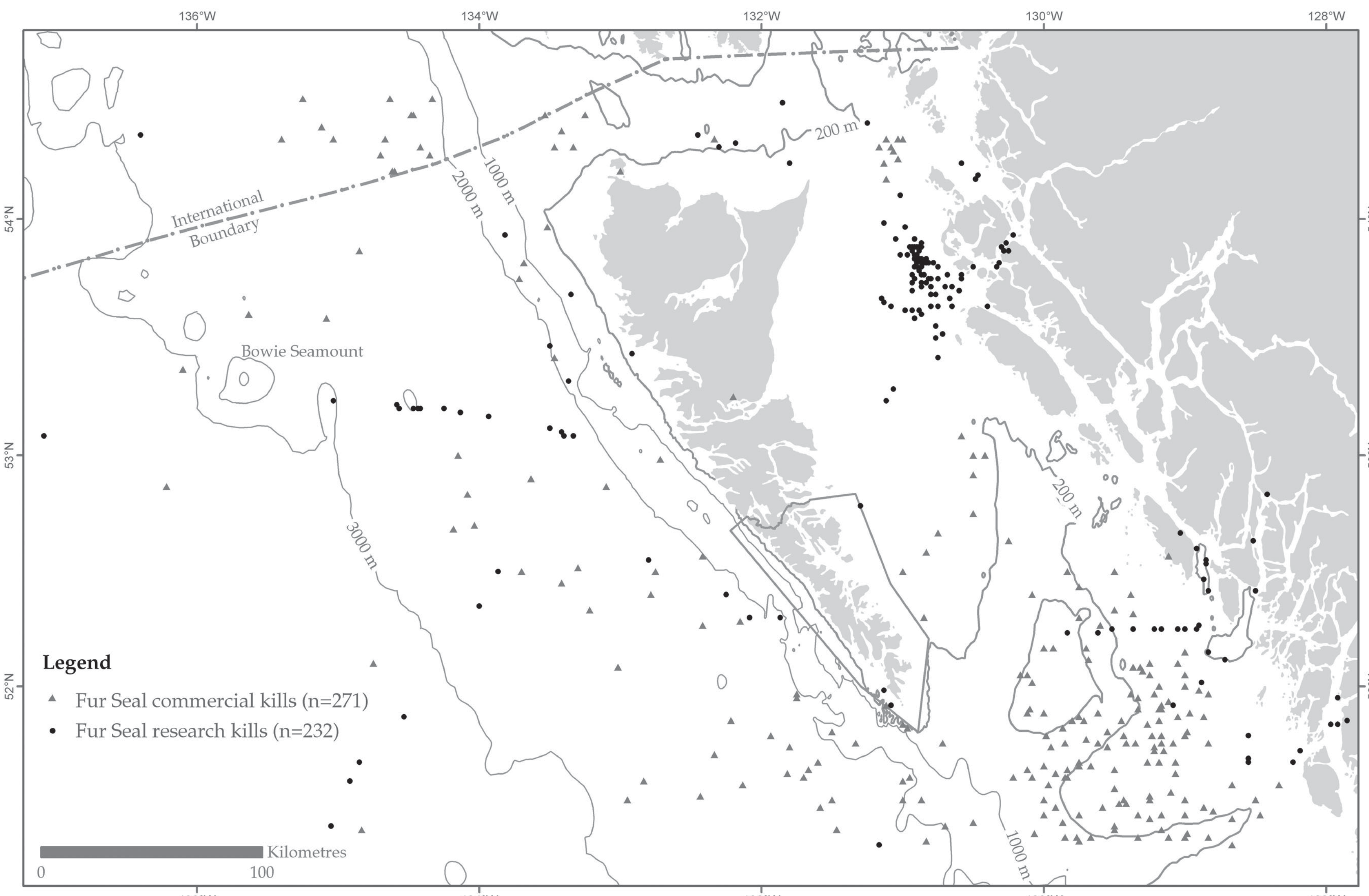

Figure 30. Locations of pelagic research collections (1958 to 1974) and hunting locations from pelagic sealing records (1897 to 1909) of northern fur seals around Haida Gwaii from research done under the North Pacific Fur Seal Commission (data from P. Olesiuk, DFO).

Approximately 83% of kills off Haida Gwaii were made during the last half of April just prior to returning to port, which coincides with the time seals are departing winter feeding areas and making their northward migration past Haida Gwaii (P. Olesiuk, DFO, unpublished data). This hunt accounted for ~37% of all seals taken in Canadian waters, and ~1.4% of those taken pelagically in the total Northeast Pacific. The number collected off Haida Gwaii also represents ~31% of those taken in Canadian waters and ~1.5% of the number taken throughout the Northeast Pacific. Since both the sealers and researchers hunted seals widely, these figures reveal the importance of Haida Gwaii waters; overall they represents ~1.5% of the foraging habitat of this population of >1 million animals, which would make the northern fur seal one of the more ecologically important pinnipeds in the region.

TRUE SEALS (PHOCIDAE)

True seals have no external ears, small fur-covered fore flippers, and cannot rotate their hind flippers forward. The are, therefore, awkward on land and must haul themselves along by rhythmically undulating their bodies using a caterpillar-like motion while making synchronized dragging strokes of the fore-flippers. The true seals are, therefore, typically found on low-lying rocks and sandbars close to the water. In water, the hind flippers provide propulsion, while the fore-flippers are used for steering.

Northern Elephant Seal (*Mirounga augustirostris*)

The northern elephant seal is the largest pinniped in the North Pacific and, world-wide, second in size only to the southern elephant seal (*M. leonina*). Females typically grow for 6 to 10 years and attain a length of ~2.6 m and mass of up to ~550 kg. Elephant seals exhibit the most extreme sexual dimorphism of any mammal with males of the southern species becoming 8 to 10 times larger than females (Hindell 2002). Bulls' bulk likely evolved to provide strength and energy (from fat reserves) for maintaining rookery territories while fasting during their breeding colony tenure (LeBoeuf 1994; Haley *et al.* 1994). Males of the northern species grow for 8 to10 years and average ~3.8 m long (maximum 5 m) and weight ~1,800 kg (maximum ~2,300 kg) (Deutsch *et al.* 1994; Hindell 2002). In addition to their enormity, bulls have an enlarged proboscis and thick, scarred chest and neck hide from fighting (LeBoeuf and Laws 1994). The short fur of adults varies from grey to brown, except during the moult when it becomes silver-grey. Pups have a woolly black natal fur that is moulted within 4 to 6 weeks and replaced by silver-grey fur (Laws 1956).

Northern elephant seals inhabit the Northeast Pacific from central California to the Gulf of Alaska. Similar to many pinnipeds, northern elephant seals congregate at traditional rookeries to breed (Stewart *et al.* 1994). Rookeries are on offshore islands or remote continental shores that are gradually sloping sediment beaches or spits, but rarely on rocky beaches. There are ~15 rookeries from Natividad, Baja California, Mexico to Point Reyes off central California (LeBoeuf and Laws 1994).

Breeding begins in early December (LeBoeuf and Laws 1994) when the oldest bulls arrive first on rookeries, with all breeding bulls present by late December. Bulls fight for a position on breeding beaches and for a ranking within their hierarchy. Cows begin arriving in late December and form tight aggregations to which only the dominant bulls become associated. Within a week of their arrival, cows give birth to a single pup weighing ~30 to 40 kg, which is nursed for ~30 days during which it may triple in weight (Hindell 2002). Once weaned, the pups accumulate on the fringes of rookeries, away from the adults. Also at this time, cows come into oestrus and mate with one or more of the dominant bulls. Cows then disperse to feed and replenish fat reserves used during the month-long fast while nursing. Bulls also begin to disperse from rookeries in late February, but some linger on land to rest until the end of March. Weaned pups spend their first 2 to 3 months perfecting swimming skills and then begin to disperse in March (Reiter *et al.* 1978).

After breeding, northern elephant seals disperse to forage and then return to breeding beaches to moult for 3 to 5 weeks while fasting (LeBoeuf and Laws 1994). This species is one of the few that undergoes a "catastrophic" moult in which both the underlying epidermis and fur are sloughed. As the last females to wean their pups begin to leave, the females that bread early start to arrive to moult in mid-March. Over the next month as females continue to arrive, they are joined by juveniles, and most have moulted by early May. The bulls return to moult later, in July or August.

Both female and male northern elephant seals mature between 3 to 6 years of age (Reiter *et al.* 1978; LeBoeuf and Laws 1994). Most females give birth to a single pup annually, although they may skip the year after first birth (Huber 1987; Huber *et al.* 1991). Only the large dominant bulls breed, starting at age 5 to 8, but peaking at age ~12. This species is relatively short-lived; free-ranging males live ~14 years and females ~20 years (Clinton and LeBoeuf 1993). LeBoeuf *et al.* (2000) speculated that the differences in size and longevity reflected by differences in foraging strategies, with males compromising security for prey quality, and females compromising prey quality for security.

When not ashore to breed or moult, elephant seals remain at sea (Hindell 2002). Females spend ~9 to 10 months at sea annually; two months between weaning their pups and returning to moult, and another 8 months following the moult. Bulls spend more time at rookeries with ~8 months spent at sea annually. Advances in archival tags and satellite telemetry reveal that animals make extended excursions and suggest that males and females may segregate the pelagic habitat (LeBoeuf *et al.* 2000; Bowen *et al.* 2002). Males tend to migrate directly and rapidly (~90 km per day) north or northwest from rookeries and haulouts to relatively small focal foraging areas associated with the continental shelf break (edge between continental shelf and slope), and occasionally in inshore waters between Oregon and the western Aleutian Islands (500 to 4,800 km from rookeries). They dive almost continuously while en route to foraging areas, and seem to return to the same foraging areas on both spring and fall trips, and in consecutive years. Larger males tend to travel furthest and have least time in focal foraging areas. Diving patterns suggest feeding on benthic prey, at depths of 200 to 600 m, with dives lasting 20 minutes followed by 2 to 4 minute surface intervals. Diving bouts can last several days with males spending ~88% of their time submerged (Hindell 2002). Males make these trips twice a year, as they return both to breed and moult, but trips appear to be identical.

In contrast, females range across a much wider area of the Northeast Pacific from 38° to 60°N and from the coast to 173°E, and appear to feed on vertically migrating, pelagic prey in the water column. Movements are more variable than for males and females fan out in all directions. Females disperse widely rather than spending extended periods in localized foraging areas. Dives are ~200 to 400 m depth and, unlike males, females forage more in the water column. Dives tend to be shallower at night, suggesting the females are feeding on vertically-migrating prey. Maximum dive depths often exceed 1,000 m (deepest recorded ~1,567 m). As was the case with males, the spring and fall excursions seem to be the same, even though the latter tend to be about 2.5 times as long for the females.

Due to their wide pelagic foraging, it is difficult to assess northern elephant seal diets. Most information comes from stomachs of dead animals, and those lavaged (washed-out) from animals returning to rookeries (Condit and LeBoeuf 1984; Antonelis *et al.* 1987, 1994; DeLong and Stewart 1991), and these data only reflect prey consumed in last few days of transit. These studies show that animals feed on epi- and meso-pelgagic (upper- and mid-water) bioluminescent squids, fish such as hake and rockfish, crustaceans, elasmobranches (small sharks and skates), cyclostomes (lamprey and hagfish), and tunicates. Combined with studies on foraging movements and diving behaviour, diet studies suggest that females focus mainly on epi- and meso-pelagic squids and fish. Males take the same prey while transiting to focal foraging areas, but then change their focus to benthic elasmobranches and cyclostomes. Because their diets consist mainly of non-commercial species, there have not been major conflicts with fisheries as with other Pinnipeds.

The northern elephant seal was commercially hunted in the 19th century for their blubber (for rendering into oil), and barely escaped extinction (Hindell 2002). Records are poor, but by 1850 animals were scarce and by the 1870s the species was thought to be extinct. However, by 1890 perhaps just 100 were still breeding at Isla de Guadalupe, Mexico (designated as a reserve in 1922). The species began to recover and animals reoccupied old breeding beaches such as Islas San Benito, Mexico and the Channel Islands, southern California. The population increased very rapidly with most of the growth at California rookeries. Numbers had reached ~127,000 by 1991 (Stewart *et al.* 1994). Updated figures are not available for Mexico where populations appear to be stable, but numbers are still growing in California (Carretta *et al.* 2002; Hindell 2002).

Given this population recovery, sightings of northern elephant seals in British Columbia waters could become more common. No systematic records have been published since those of Pike and MacAskie (1969), who termed them "occasional visitors." Some animals, mostly yearlings, come ashore to moult and are often mistaken for sick harbour seals. Small colonies are perhaps becoming established in Washington and British Columbia, for example, at Race Rocks off Victoria, 13 were recorded in February 2003. A stranding at Port Louis, west coast of Vancouver Island in July 1988 of an animal tagged as a newly weaned pup on San Miguel Island in February 1987 indicates that even young animals make extensive excursions.

On the north coast, Pike and MacAskie (1969) reported most sightings from the Hecate Strait area and the channels between islands of the mainland coast. Most sightings from around Haida Gwaii are made along the east side of Moresby Island between April to August (Figure 31). This undoubtedly represents sighting effort, by the Laskeek Bay Conservation Society for example, rather than actual distribution. Most sightings are of lone individuals, but 6 juveniles and an adult were seen on June 28, 1992 at the mouth of Juan Perez Sound between Tuft and Skincuttle Islands (L. Barrett-Lennard, VAMSC, unpublished observation). Given lack of continental shelf off west coast of Haida Gwaii, this region is not likely an important male feeding area, although several tagged males have had feeding areas off the west coast of Vancouver Island north to Southeast Alaska. However, the limited shelf waters off the west coast of Haida Gwaii may render them more important for open water-feeding females than bottom-feeding males.

Harbour Seal (*Phoca vitulina*)

The harbour seal is a nearshore species with the broadest distribution (throughout the world's northern oceans) and occupying the greatest array of habitats (temperate to arctic) of any pinniped (Burns 2002). They occupy marine coasts and estuaries, as well as navigable rivers and lakes in some areas including British Columbia (Bigg 1969a; Hammill 2002). Five subspecies are recognized worldwide but only one (*P. vitulina richardsi*) occurs in the North Pacific (Bigg 1981; Burns *et al.* 1984; Burg *et al.* 1999; Burns 2002).

The North Pacific harbour seal is a small species described as large-headed, short-bodied and short-limbed (Allen 1880). Females typically grow for 5 to 7 years and attain a length of 1.4 m and mass of 65 kg, whereas males continue to grow for 8 to 10 years and attain a length of 1.5 m and mass of 85 kg (Bigg 1969a; Olesiuk 1993). Their short, coarse fur is highly variable in colour from almost white to almost black, but is usually mottled with rings, blotches and spots. The two most common fur patterns consist of light sides and belly with dark spots or blotches and grey back with light and dark blotches and light rings (light phase) and black or nearly black background with light spots or rings and black blotches or spots (dark phase) (Bishop 1967; Stutz 1967; Shaughnessey and Fay 1977; Kelly 1981). Coloration is usually bright white, silver and black following the annual moult, but over the year the fur fades to a dull grey, tan or brown (Shaughnessey and Fay 1977). Yearlings often have a distinctive muddy appearance (Thompson and Rothery 1987). Full-term pups usually have adult-type fur, although premature pups are often born with the white lanugo (fetal fur shed shortly after birth) coat (Bishop 1967; Shaughnessy and Fay 1977; Oftedal *et al.* 1991; Cottrell *et al.* 2002).

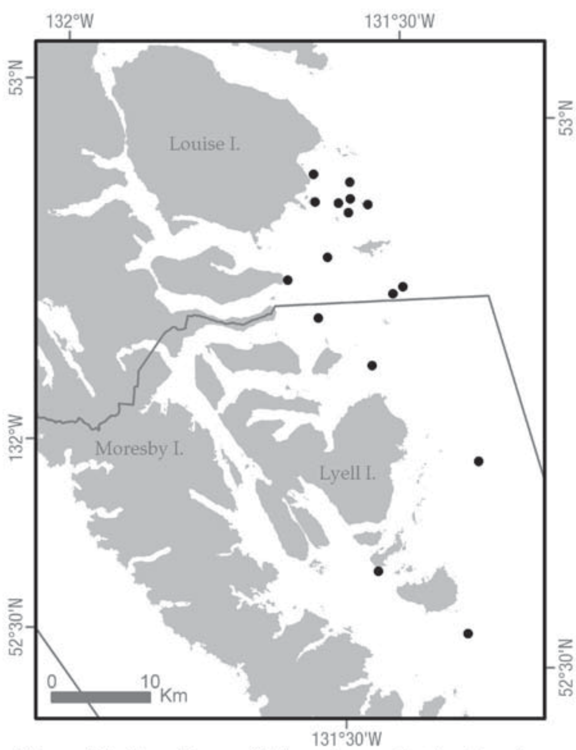

Figure 31. Locations of 17 northern elephant seal sightings and strandings around Haida Gwaii (data courtesy of Laskeek Bay Conservation Society and D. Burles, Gwaii Haanas). The distribution reflects sighting effort rather than the actual distribution of northern elephant seals.

In the North Pacific, harbour seals are distributed mostly nearshore along the coast from Baja California, Mexico northward through the Aleutian Islands and Bristol Bay, westward to the Kamchatka Peninsula and south to northern Japan (Burns 2002). Within this total range, southern British Columbia has the densest population (Olesiuk 1999). The life history, abundance and distribution of harbour seals have been studied in British Columbia for >50 years (Fisher 1952; Bigg 1969a,b, 1973, 1981; Olesiuk 1993, 1999; Olesiuk *et al.* 1990a,b).

Unlike many pinnipeds that congregate on rookeries to breed, pupping and mating in harbour seals is dispersed at haulout sites throughout their range. The pupping season lasts 1.5 to 2 months and varies with latitude (Bigg 1969b, Temte *et al.* 1991). In southern British Columbia, pups are born from mid-July to late-August, but in the north (Skeena River estuary) pups are born from early-May to early-July with a peak in mid-June (Fisher 1952; Bigg 1969a; Olesiuk *et al.* 1990a).

Females give birth to a single pup weighing ~8 to 14 kg (Bigg 1969a; Cottrell *et al.* 2002). Newborns are precocious; their eyes are open and they can swim and crawl

(Knudtson 1974, 1977). Most births occur on land, but occasionally occur in water (Scheffer and Slipp 1944; Bishop 1967). Pups suckle fat-rich milk (42% fat by volume; Jeffries and Newby 1986) over a 3 to 6 week nursing period during which they more than double in mass (Bishop 1967; Bigg 1969a; Cottrell *et al.* 2002). Nursing mothers continue to forage, but tend to haul out more often, increase the amount of time spent ashore, and dive less frequently and less deeply (Olesiuk 1999). Females typically ovulate within two weeks of weaning their pups. Males are in breeding condition for up to 9 months of the year and usually initiate matings, but receptivity of the female appears to determine mating success (Allen 1985). The species may be slightly polygamous, with dominance among males perhaps established by aquatic displays that include water slapping, bubble blowing, rolling and fighting (Sullivan 1981; Allen 1985). Conception usually takes place in the water, with animals nuzzling and biting (it being impossible to distinguish the sexes in most cases), leading to significant scarring and bleeding, while the pair cavorts and rolls at the surface (Allen 1985). Shortly after mating, seals undergo an annual moult of all their fur within 3 to 4 months.

Both females and males mature between 3 to 5 years of age, and females maintain a high rate of fecundity (>90%) throughout life (Bigg 1969a; Olesiuk 1993). In British Columbia, annual mortality is ~27% during the first year of life, ~10% for juveniles of both sexes, ~5% for adult females and ~15% for adult males (Olesiuk 1993). Maximum longevity of free-ranging harbour seals is ~20 years for males and ~29 years for females (Bigg 1969a); averages are ~8.2 years for males and ~10.4 years for females (Olesiuk 1993).

Harbour seals are non-migratory. Radio- and satellite-tagging have shown that seals exhibit a high degree of site fidelity, with the majority of tagged animals repetitively hauling out at the capture site or sites within 10 to 25 km of the capture site (Pitcher and Calkins 1979; Pitcher and McAllister 1981; Brown and Mate 1983; Jeffries 1986; Allen *et al.* 1987; Harvey 1987; Yochem *et al.* 1987; Cottrell 1995; Olesiuk *et al.* 1995a; Swain *et al.* 1996; Frost *et al.* 1997; Swain and Small 1997). However, longer-range excursions of 100s of km are commonly documented, although animals often returned to the capture site. Brown and Mate (1983) recovered a flipper tag from one animal 550 km from the original tagging site. Some of these movements may be temporary shifts associated with feeding. Harbour seals prefer to give birth in large estuaries (Brown and Mate 1983; Jeffries 1986; Olesiuk *et al.* 1990a,b), and congregate at river mouths and in small estuaries increases in autumn when salmon or eulachon (*Thaleichthys pacificus*) are spawning (Fisher 1952; Jeffries 1986; Olesiuk *et al.* 1990a). In the only long-term study of movements, seals branded as pups dispersed 100s of km from where they were born, but in all cases females returned to birth site to reproduce (Harkonen and Harding 2001).

Harbour seals haul out on an almost daily basis year-round (83 to 92% of days off California [Allen *et al.* 1987; Hanan 1996]; 85% of days in the Strait of Georgia [Olesiuk 1999]). Animals are gregarious on land, assembling in groups of a few to 1,000 animals, which may be an adaptation for predator avoidance by distributing the cost of vigilance among the group (da Silva and Terhune 1988). Daily activity patterns likely are dictated mainly by tidal and diurnal cycles, with animals hauling out mainly at low tide or during mid-day. Animals are less inclined to haulout during heavy rains (Olesiuk 1999) and high winds (Watts 1991), and on hot windless days the duration of haulouts may be limited by animals overheating (Watts 1991, 1992). Seals can spent ~20% of their time hauled out, ~35% resting in shallow water, usually near haulouts, and ~30% foraging (Olesiuk 1999).

The extent of daily harbour seal foraging movements probably varies geographically. In the inside waters of the Strait of Georgia which supports an especially high density of seals, foraging trips generally lasted several hours and seals rarely ventured >10 km from haulout sites (Olesiuk 1999, unpublished data). Suryan and Harvey (1998) found a similar pattern among the San Juan Islands, Washington State. Daily movements have not been examined along the outer coast of British Columbia.

The offshore distribution of harbour seals is poorly defined. They are generally considered a nearshore species occurring within ~20 km of land (Spalding 1964). Seals living along exposed coastlines can make offshore foraging trips of ~100 km and lasting several days (Stewart and Yochem 1989; Thompson *et al.*, unpublished MS). Seals were occasionally observed on La Peruse Bank ~70 km off the west coast of Vancouver Island during aerial porpoise surveys (Laake *et al.* 1998). In Alaska, harbour seals routinely occur on the productive Portlock and Albatross banks ~100 km off Kodiak Island (Fiscus *et al.* 1976; Hoover-Miller 1994).

Harbour seals forage during the day and at night, and foraging behaviour appears influenced by the type of prey available (Eguchi and Harvey 1995; Oxman 1995; Suryan and Harvey 1998). Dives last ~3 to 10 minutes, but they can stay submerged at least 24 minutes. Animals exhibit pronounced diurnal changes in diving patterns; during the day dives tend to be longer and deeper and more uniform in both duration and depth, whereas at night dives tend to be shorter and shallower and highly variable in both duration and depth (P. Olesiuk, DFO, unpublished observations). Most dives are <100 m, with the deepest dive recorded to 504 m (Swain *et al.* 1996).

Harbour seals are opportunistic predators and their diet varies according to which prey are locally and seasonally most abundant or accessible. Food requirements vary with sex, age and quality of prey, but average ~1.9 kg per day (Olesiuk *et al.* 1990b; Olesiuk 1993). Newly weaned pups feed primarily on bottom-dwelling crustaceans for several months, with pandalid shrimp being particularly important (Bigg 1973). Older seals prey mainly on fish, cepalopods, and to lesser extent on other invertebrates. In British Columbia, they are known to prey on >40 different prey species (Fisher 1952; Spalding 1964; Olesiuk *et al.* 1990b).

Harbour seal populations in British Columbia have been increasing since protection in 1970. Their population status is monitored by aerial surveys conducted near the end of the pupping season with small planes (Olesiuk 1999). Surveys are flown within two hours of low tide when peak numbers of animals generally haul out. Nevertheless, corrections must be applied to account for uncounted animals in the water. Studies in British Columbia indicate that 54 to 67% of animals are hauled out under survey conditions, so counts must be multiplied by factor of 1.5 to 1.9 to estimate actual abundance. Coast-wide in British Columbia, abundance increased rapidly during the 1970s and 1980s at rate of ~12% per annum, which represents the biological maximum for the species (Olesiuk *et al.* 1990a; Olesiuk 1999). However, the growth rate began to slow in the mid 1990s, and stabilized to ~108,000 coast-wide in the late 1990s (Olesiuk 1999).

Commercial harbour seal hunting in British Columbia extends back over a century and this hunt had a major impact on populations, including those in Haida Gwaii. During 1879 to 1914, harbour seals were hunted for pelts, during which ~164,000 were landed. Few details are available for this era, but a market for "hair" (= harbour) seal pelts likely was incidental to the pelagic harvest of northern fur seals that operated out of Victoria. There are no records of where harbour seals were taken. The market for "hair" seals apparently collapsed shortly after the *North Pacific Fur Seal Treaty* of 1911 prohibited the pelagic hunting of northern fur seals.

From 1913 to 1962, a federally sponsored bounty program was intermittently in effect to purportedly protect salmon fisheries. Bounty payments of $1 to $5 per snout were offered in 1913-18, 1927-34, 1936-40, and 1941-64, during which periods DFO made payments on ~116,000 snouts. The bounty program ended in 1964, by which time a market had emerged for pelts. From 1962 to 1968, this commercial hunt yielded 16,600 pelts (bounties were also paid on 7,600 of these) for the European market. There were no restrictions on the number, sex, size, season or location of animals to be hunted, and effects on populations were not monitored. The pelt market collapsed in 1966 due to a change in public attitude toward seal fur, mainly as a result of boycotts and protests associated with the Atlantic Canada harp seal hunt. In 1967 and 1968 the numbers of pelts processed in British Columbia had fallen to 100s annually. However, the reported number of bounties paid and pelts processed represents only a fraction of those actually killed because carcasses often sink before recovery. Estimates of hunting loss rates range from 25% to 50% (average 37.5%) (Fisher 1952; Boulva and McLaren 1979; Heide-Jørgensen and Härkönen 1988; M. Bigg, DFO, *personal communication*). Assuming a recovery rate in British Columbia of ~62.5%, the total number of harbour seals killed during 1879 to 1968 approaches half a million.

Historical reconstruction indicates that the bounty and commercial kills were sufficient to have severely decreased harbour seal populations (Olesiuk, in preparation a). There were ~60,000 to 120,000 harbour seals on the British Columbia coast in the late 1880s (Figure 32). Large hunts during the 1890s and early 1900s likely reduced abundance by ~80% by the end of the first era of hunting in 1914. Populations recovered somewhat with the end of commercial hunting and suspension of the bounty program in the early 1920s, and were subsequently maintained at about half historic levels when the bounty payments

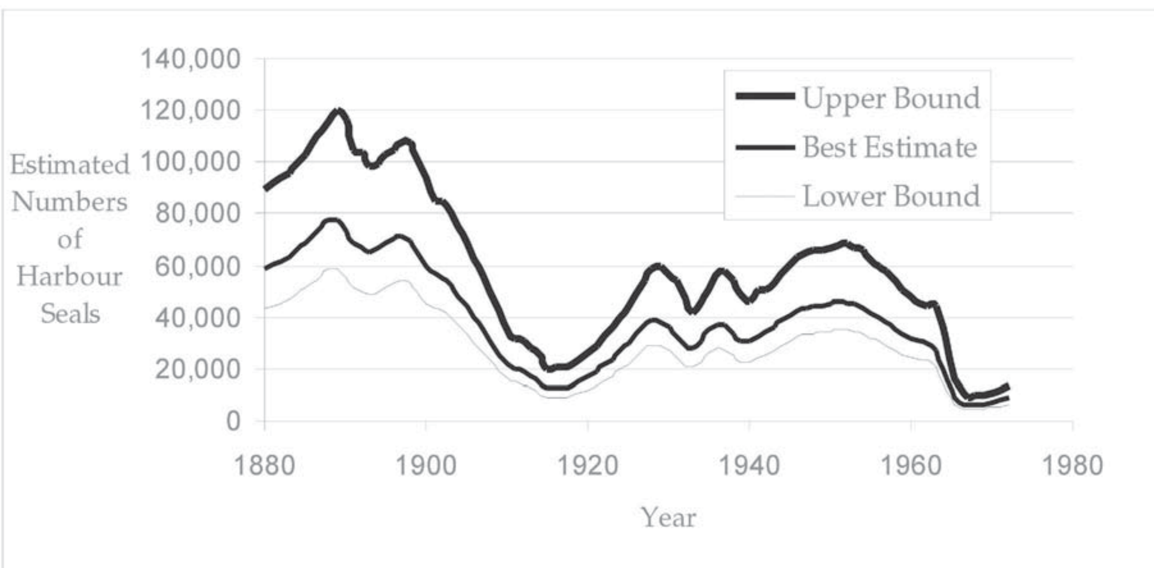

Figure 32. Historic reconstruction of harbour seal populations in British Columbia (1880s to 1790s) based on the numbers of seals killed relative to the number that could have been sustained. The commercial hunts of the late 1800s and early 1900s and during the mid-1960s severely reduced populations (data from Olesiuk, in preparation a).

were re-initiated in the late 1920s to the 1940s. In 1945, bounty payments were doubled from $2.50 to $5.00. This increase attracted serious bounty hunters, most notably Don and Dan McNaughton of Pender Harbour who sealed from 1955 to 1960 around Haida Gwaii (Dalzell 1993, p. 35). The McNaughtons developed sophisticated hunting and carcass recovery procedures, and would work specific areas intensively for 4 to 5 years, getting to know the local habits and haulout sites during the 1st year. Kills generally peaked in the 2nd year, with local populations being noticeably reduced in their subsequent years of hunting. Bounty payments peaked in the mid-1950s, with the McNaughtons accounting for ~25% of all kills coast-wide. The increased bounty kills reduced populations to ~40% of historic levels. Hunting pressure intensified during the second phase of commercial hunting starting in the early 1960s, with value increasing from $5.00 for bounty to a peak of $25 (including bounty) per pelt. The population, already reduced by bounty kills, was depleted to <10% of historic levels.

Harbour seals in Haida Gwaii were more heavily hunted than in other areas. Although the archipelago currently supports just under 10% of the total British Columbia population, it accounted for ~15.4% of the bounty claims during 1928 to 1947, and 29.5% of the claims during 1957 to 1959 (Table 12). The latter increase was probably attributable to the McNaughtons, with their take peaking at 1,084 in 1957 and declining to 171 by 1960. The proportion dropped to 21.7% during the hunt for pelts during the 1960s.

Aerial surveys in Haida Gwaii are best done early July to early August toward the end of the local pupping season. Local aerial surveys were flown in 1986, 1992 and 1994; covering ~74% of the coastline (Olesiuk 1999) as shown in Figure 33. Only the northwest coast from Chads Point on the west coast of Moresby Island to Klashwun Point on the north side of Graham Island has not been surveyed. The distribution of seals probably reflects the availability of suitable habitat for both hauling out and foraging. Ninety-one haulout sites have been documented, representing one for every 78 km of shoreline (Figure 33). The number utilizing each site ranges from 2 to 381 animals (average is 49.2). The largest site is Rose Spit, which is adjacent to the longest stretch of coast unsuitable for haulouts, suggesting that seals may gather there from farther afield. The estimated abundance of seals according to the areas shown in Figure 33 is given in Table 13. The lowest density (~0.9 per km of shoreline) occurs along the southwest coast of Moresby Island - this highly exposed coastline provides few protected areas for haulouts, and there is little in the way of continental shelf for foraging. Most of the larger sites along this coast are in protected inlets, such as Tasu Sound. In contrast, the highest density (3.0 seals per km of shoreline) and largest number of haulouts (one for every 21 km of shoreline) are found in protected waters along the east side of Moresby Island, with its many tidal reefs and islets for hauling out, and expansive areas of relatively shallow water for foraging. The absence of seal haulouts along the east coast of Graham Island, which is mainly sand and gravel beach, is due to the lack of suitable haulout sites.

Table 12. Numbers of harbour seal kills in British Columbia with the proportions represented from Haida Gwaii for the years for which data are available (data from P. Olesiuk, DFO).

Reason for kill	Period		Total British Columbia	Haida Gwaii (% of total)
Bounty	1928-1934		26,245	4,558 (17.4)
Bounty	1942-1947		15,173	1,827 (12.0)
Bounty	1957-1959		11,225	3,307 (29.5)
Pelt	1963-1968		14,401	3,129 (21.7)
		Total	67,044	12,821 (19.1)

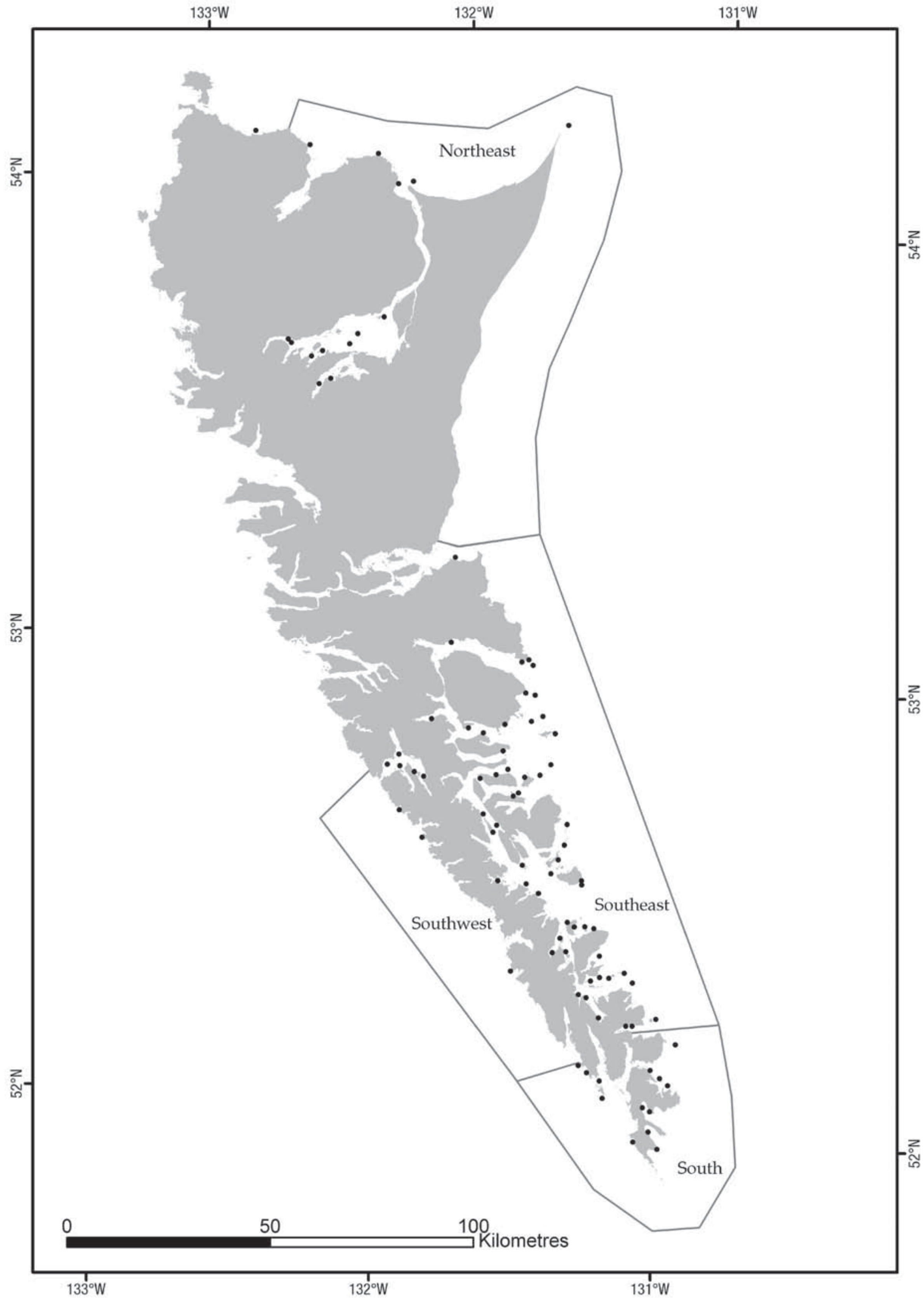

Figure 33. The four areas of Haida Gwaii within which harbour seal counts from aerial surveys (1986 to 1994) have been recorded. Also shown are the locations of the 91 haulout sites recorded from aerial surveys (data from P. Olesiuk, DFO)

Table 13. Estimated abundance and density of harbour seals in Haida Gwaii (data from Olesiuk 1999). Abundance was adjusted to 1996 - 1998 levels, assuming population trends were the same as in other areas of British Columbia. Abundance could be appreciably higher if the region's harbour seal population was depleted to a greater extent than others, and perhaps taking longer to recover.

Area of Haida Gwaii[1]	Number of seals	Shoreline length (km)	Seal density (seals per km)
Northeast	2,779	949	2.9
Southeast	3,427	1,145	3.0
South	542	255	2.1
Southwest	320	358	0.9
Total Surveyed	7,068	2,707	2.6
Not Surveyed	2,462[2]	943	2.6[2]

1 these areas are shown in Figure 33
2 the overall average density was applied to estimate abundance in unsurveyed areas

Around Haida Gwaii, abundance of harbour seals in the area surveyed in 1986 and again in 1992 increased at a rate of 9.2%, and the area surveyed in 1986 and again in 1994 increased at a rate of 16.0%, representing a mean rate of increase of 12.6% (Olesiuk *et al.* 1993; Olesiuk 1999). As no surveys have been conducted since the mid-1990s, it is unknown whether populations in Haida Gwaii have also stabilized or are taking longer to recover from hunting. Assuming trends in Haida Gwaii were the same as other areas in British Columbia, and that densities of harbour seals in the areas that have been surveyed are representative of the entire archipelago, the most recent population estimate is ~9,500 (Table 13).

Data on the chronology of harbour seal pupping in Haida Gwaii come only from the McNaughton's logbooks showing near-term fetuses were most prevalent in animals taken at the end of May, became less prevalent during June, and were absent by the end of June (Table 14). This suggests that timing of pupping in Haida Gwaii is similar to that of the Skeena River (Fisher 1952; Olesiuk 1999).

Although movements have not been examined around Haida Gwaii, some preliminary genetic analyses have been done (Burg *et al.* 1999). On a broad scale, Haida Gwaii seals are part of a genetically similar northern British Columbia - Alaska population and separate from the southern British Columbia population. The degree to which the Haida Gwaii harbour seal sub-population is separated within the northern population is unknown. However, Alaskan studies have shown that significant genetic differences – implying limited gene flow on an evolutionary time-scale - can occur on the scale of 100s of km (O'Corry-Crowe *et al.* 2003).

With the exception of analyses of scats collected throughout Masset Inlet (Table 15), there are few data on harbour seals diets from Haida Gwaii. In April, seals ate mostly Pacific herring (33.3%) and similar proportions of sandlance, flatfishes (mainly starry flounder), perches, and sculpins, with smaller fractions of other species. In the seven samples collected in June, Pacific herring dominated (76.2%) and flatfishes were also important. Spalding (1964) reported the contents of 44 harbour seal stomachs collected "predominantly" from the Haida Gwaii during mid-September to

Table 14. Proportions of 838 harbour seals with near-term fetuses listed according to period within May to July from hunting around Haida Gwaii (1955 to 1960 logbook data of Don and Dan McNaughton on file with DFO, Pacific Biological Station).

Time period	Number killed	Percent with near-term fetuses
14 May – 20 May	29	13.8
21 May – 27 May	40	15.0
28 May – 03 June	77	28.6
04 June – 10 June	63	12.7
11 June – 17 June	63	3.2
18 June – 24 June	140	1.4
25 June – 01 July	208	0.0
02 July – 08 July	218	0.0

mid-December. The diet was ~30.4% salmon (mainly pink and chum), 17.4% squid, 15.8% octopus, 10.8% herring, 8.7% flatfish, and lesser amounts of pollock, eulachon, other smelt, rockfish, greenling, sablefish, cabezon and clamshells. The importance of cephalopods was probably exaggerated in the stomachs because their beaks can remain much longer than other prey remains (Bigg and Fawcett 1985). These scat and stomach collections are too limited to make generalizations about seal diets diet in Haida Gwaii other than that they appear to be generalist predators.

Table 15. Diet of harbour seals in Masset Inlet based on 34 scat samples collected in April and 7 scat samples collected in June, 1983 (data from P. Olesiuk, DFO). Relative importance has been calculated using split-sample frequency of occurrence (Olesiuk *et al*. 1990 b).

	Percent occurrence according to month	
Prey type	April	June
Pacific herring	33.3	76.2
Sculpin	11.0	4.8
Perch	11.6	0.0
Salmon	1.1	0.0
Rockfish	1.1	4.8
Flatfish	11.6	14.3
Skate	3.2	0.0
Stickleback	2.7	0.0
Sand lance	12.4	0.0
Smelt	0.5	0.0
Cod	6.7	0.0
Eelpout	0.8	0.0
Squid	0.8	0.0
Shrimp	3.2	0.0

SEA OTTER (*Enhydra Lutris*)

Images of the sea otter and its red sea urchin (*Strongylocentrotus franciscanus*) prey are the Haida family crest (acquired through potlatch) of Gwaii Haanas National Park Reserve and Haida Heritage Site (Figure 34). These symbols were chosen for Gwaii Haanas by Haida elders as they resonate in local history, reminding us of the vulnerability of marine species and ecosystems. Red sea urchins are superabundant around Haida Gwaii, and likely prevent the full extent of kelp forests

Figure 34. The Haida family crest of Gwaii Haanas National Park Reserve and Haida Heritage Site depicting the sea otter (**k̲uu**) and its red sea urchin prey (**guuding.aay**) by Haida artist G̲iitsx̲aa.

from developing because their predator, the sea otter, was extirpated due to the fur trade (Sloan *et al*. 2001).

Sea otters are the largest member of the weasel family and are highly marine-adapted (Kenyon 1969; Estes and Bodkin 2002). They spend their days feeding, grooming and resting at sea, their nights sleeping entangled at the water surface in the kelp canopy and relatively little time is spent ashore. They eat mostly benthic invertebrates from sedimentary to rocky substrates, but also consume small fishes and even sea birds (Estes and Bodkin 2002). Dives can exceed four minutes in duration and extend down to a maximum of ~100 m (Estes and Bodkin 2002). Males can weigh up to ~45 kg and reach ~1.5 m in length and females can weigh ~33 kg and reach ~1.4 m in length (Kenyon 1969).

Sea otters are social and often form male-only or female/pup-only groups or "rafts" (Kenyon 1969). Groups of >100 otters are known from Alaska (Kenyon 1969). Daily movements of females are usually limited between feeding sites and more sheltered resting sites within a home range of ~5 to 10 km^2. Males range more widely, making trips exceeding 150 km between rafts and temporary breeding areas (Kenyon 1969). Females are mature at age four and have one pup every one to two years. Mating usually occurs in fall with most births in spring to early summer. Males mature at age 6, but do not usually breed until older. Maternal care and training of pups is intensive over 6 to 8 months with no male assistance (Kenyon 1969).

Sea otters have the densest fur of any mammal and they rely on trapped air groomed into their fur for insulation rather than a blubber layer (Kenyon 1969). For this reason, they are vulnerable to hypothermia if their fur is contaminated by oil (Loughlin 1994). To enable their metabolism to generate body heat, they eat ~25 to 30% of their body weight daily (Kenyon 1969). Populations can expand at rates exceeding 18% annually when reoccupying food-rich areas within their historical range (Watson *et al.* 1997; Woodby *et al.* 2000; Estes and Bodkin 2002).

Sea otters were overexploited in the Haida Gwaii region for their pelts, but likely remnant numbers were present after the mid 1800s, as described in the Aboriginal Use section. Kenyon (1969) stated that the last sea otter recorded from Haida Gwaii was before 1920 and McAskie (1987) reported that the last one recorded in British Columbia (before the reintroduction) was in 1929 off Vancouver Island. Also, there are sightings in Haida Gwaii including an animal trapped near Carmichael Passage, Louise Island in the early 20th century (Jones and Ryan 2002). Patch (1922, p. 103) reported that in the 1920s one was seen near Langara Island, and that during one day in the 1890s, 27 sea otters were taken by Haidas hunting from 19 boats in the northern Graham Island area. Finally, a skull fragment with attached teeth was collected from a Masset area beach in 1937 (Royal British Columbia Museum, Catalogue No. 2362; Lesley Kennes, *personal communication*).

Sea otters are found in areas surrounding the Haida Gwaii region. They occur to the north in Southeast Alaska, to the southeast in the central mainland coast (Milbanke Sound to the Goose Islands group) and to the south along the north and west coasts of Vancouver Island (Figure 35). The north and south distributions originate from translocations completed in the 1960s and 1970s (Watson *et al.* 1997; Bodkin *et al.* 1999). The British Columbia translocation site and the two from far Southeast Alaska, at which sea otters from the Aleutian Islands and Prince William Sound were introduced, are shown in Figure 35. The origin of the central coast population is unknown, but this will be revealed as genetic analyses are currently underway (L. Nichol, DFO, *personal communication*).

Over the last 30 years, there have been eight confirmed sightings in Gwaii Haanas' GIS database (Figure 35). One sighting is of a pair (1980) and all others are of single individuals; all sightings were likely of free-ranging males. Sightings from 1972 and 1976 were published (Edie 1973; Taylor and Gough 1977), the 2001 sighting may be published (K. Raum-Suryan, Alaska Department of Fish and Game, *personal communication*) and five were validated via interview with the observers (a DFO Fishery Officer, three wilderness guides and a coastal logger-fisher – all persons with many years coastal wildlife experience). Two sightings have attendant photographs (1994, 2001). The potential for mistaken identity with the river otter or harbour seal was explicitly overruled. Sea otter have, therefore, been present in regional waters in low numbers for decades. There is as yet no indication of a breeding population around Haida Gwaii.

KEYSTONES AND CASCADES

"The concept's (of keystone species) *potential significance to conservation biologists is that it designates species that exert influences on the associated assemblage, often including numerous indirect effects, out of proportion to the keystone's abundance or biomass."* (Paine 1995).

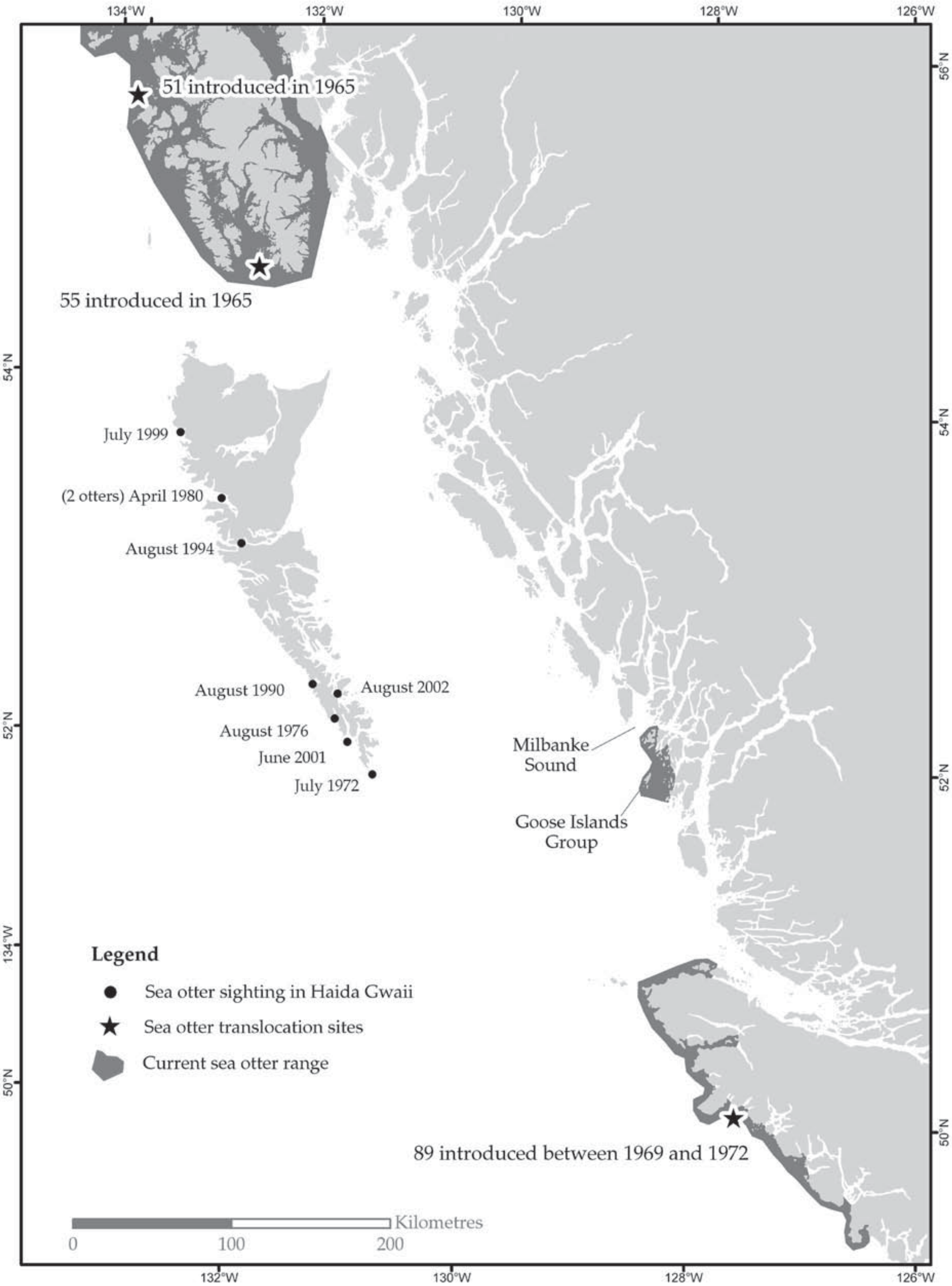

Figure 35. Distribution of sea otters surrounding the Haida Gwaii region as of 2002 (data courtesy of L. Nichol, DFO and D. Burn, U.S. Fish and Wildlife Service, Anchorage, AK). Also shown are the locations of the eight confirmed sea otter sightings around Haida Gwaii (1972 to 2002) in Gwaii Haanas' geographic information system. The locations of sea otter translocation sites (of Aleutian stock) are shown. As well, within Southeast Alaska, but northward of this map, there are another 5 sites at which a total of 306 sea otters were translocated in the 1960s and 1970s.

The sea otter is a keystone species whose influence on nearshore rocky and soft-bottom ecosystems is greatly out of proportion to the species' numbers and biomass in Alaska and British Columbia waters (Breen *et al.* 1982; Kvitek *et al.* 1992; Watson 1993; Estes and Duggins 1995; Estes and Bodkin 2002). In southern California waters, the extent of their keystone status has been questioned as deforestation by sea urchins is uncommon in the absence of sea otters (Foster 1990). Nonetheless, in northern waters, removal of sea otters has caused cascading effects on kelp forest ecosystem structure and function (Estes *et al.* 1989). For example, rebounding kelp populations released from intense sea urchin grazing pressure creates more kelp-associated adult and nursery habitat for fish (*e.g.*, rockfishes [*Sebastes* spp.]) and invertebrates, more detritus from degrading kelp biomass into nearshore food webs and more drift algal wrack on beaches. This bounty is called a "trophic cascade" (Sala *et al.* 1998).

The extirpation of sea otters from the Haida Gwaii region has, therefore, likely affected kelp forests and associated prey species. Watson and Smith (1996) and Watson (2000) speculated that the absence of sea otters in British Columbia allowed some invertebrate stocks, such as red sea urchin, to accumulate to unnaturally high levels. Further, there likely was a widespread decrease in kelp biomass after the release of red sea urchins from predation pressure. Examples are the sea urchin "barrens" that occur as a light-coloured band of encrusting coralline algae on rocks denuded of fleshy algae seaward of the linear fringe of kelp forests along rocky shores. Approximately 50% of the rocky coastline of Gwaii Haanas has kelp forest, and half of that also has urchin barrens (Harper *et al.* 1994; Sloan and Bartier 2000). Factors determining red sea urchin abundance in Haida Gwaii are complex. For example, in the absence of sea otters off northern Graham Island, densities of red sea urchins and kelp vary widely (Jamieson and Campbell 1995). Jamieson and Campbell suggested that depth and shelter from wave action are also important factors in the distribution of these species. Therefore, the return of sea otter may have a significant effect on the expansion of Haida Gwaii kelp forest in some areas, but not in others.

Estes *et al.* (1998) found that adding an apex predator (killer whales) to a kelp forest ecosystem under top-down control from sea otters in the Aleutian Islands had predictable effects of decreased kelp biomass due to intense grazing by red sea urchin populations. They suggested that commercial fishing and climate change may have decreased offshore fish resources that, in turn, decreased populations of pinnipeds. This then caused killer whales to switch from feeding on pinnipeds to feeding on nearshore sea otters, which resulted in ecosystem changes in keeping with the sea otters' keystone role. This suggests ecosystem linkages by which offshore events can induce appreciable nearshore changes. The annual rate of population decline of Aleutian sea otters exceeded 17% in the 1990s and now the overall population level is presently at ~10% of the area's potential carrying capacity (Doroff *et al.* 2003). Recently, Springer *et al.* (2003) speculated that effects of whaling have induced killer whales to switch to smaller mammal prey (pinnipeds and sea otters) because of the scarcity of their large whale prey around the Aleutian Islands. Such prey switching has not been recorded from British Columbia.

Another marine mammal species historically associated with kelp forest ecosystems in the North Pacific was Steller's sea cow (*Hydrodamalis gigas*). This large (~10 m long), non-diving kelp grazer lived in herds throughout the North Pacific ~20,000 years ago (Domning 1972). The species' last refuge was the Commander Islands in the northwest Pacific where it became extinct by 1768. Estes *et al.* (1989) suggested that aboriginal hunters extirpated Steller's sea cow from most of its range before the 1700s. Anderson (1995) theorized that sea cows may have been "*precariously balanced on sea otter carnivory*" by evolving as specialized surface-feeders of abundant kelp maintained by sea otter predation on sea urchins. Pitcher (1998) speculated on a keystone role of Steller's sea cow in nearshore habitats over the last few millennia. Perhaps the kelp forests of Haida Gwaii developed through the influences of two mammal species, sea otter and Steller's sea cow. The recovery of sea otters may therefore yield a somewhat different kelp forest ecosystem than existed when (and if) sea cows were present in the area.

CONSERVATION ISSUES WITH REGIONAL MARINE MAMMALS

Conservation issues involving marine mammals are complex and range from immediate concerns such as ship strikes and incidental catch (bycatch) in fisheries, to longer-term threats such as the effects of tourism and climate change. Most of these issues are human-caused, although some are naturally occurring, such as mortalities from toxic phytoplankton blooms (Scholin 2000). Conservation issues in other areas could affect local populations, as some species occur over large geographic areas. For example, whale hunting around Japan (Dalebout *et al.* 2002) could threaten the population recovery of some large whale species that travel through the waters of Haida Gwaii. As many marine mammals feed at relatively high levels in food webs (Bowen 1997; Pauly *et al.* 1998), they can be useful as indicators of emerging environmental issues such as reductions in food supply (Springer *et al.* 2003), or through bioaccumulation of toxins (Ross 2000; Ross *et al.* 2000).

The issue of habitat degradation for marine mammals in the Haida Gwaii region, with its low human population and relatively undeveloped coast, does not compare with that of the southern Strait of Georgia where dense human populations, high vessel activity, pollution and coastal developments are likely having negative effects on some populations, such as *southern resident* killer whales. Long-term decline in habitat quality can be caused by factors such as overfishing, acoustic pollution or climate change. Degradation can also occur in the near-term, such as acute habitat damage from an oil spill. Quantifying how degradation could affect each species, however, is beyond the level of knowledge for most species we discuss.

A challenge faced when describing threats is that despite the popularity of marine mammals, there are some species, such as most small cetaceans, about which relatively little is known for the Haida Gwaii region. For example, in nearshore Haida Gwaii waters there is an estimate for killer whale numbers but none for harbour porpoises or Pacific white-sided dolphins. Our imperfect knowledge is a key consideration when contemplating regional conservation and recognition of this uncertainty through the precautionary approach will be important. Below we discuss the current state of these and potential future issues for marine mammals in the Haida Gwaii region and Gwaii Haanas area in particular.

AREA CONSERVATION AND ZONING

The challenge of marine area conservation is facilitating a range of coexisting sustainable uses, such as fisheries and tourism, with preservation of ecosystems and species. The *Canada NMCA Act* explicitly states that the tool of zoning (including no-take and commercial use areas) be used to enable both preservation and sustainable use occur within a NMCA. The only legislated prohibition for NMCAs is the extraction of non-renewable resources (petroleum/minerals/aggregates). Inherent in planning for Gwaii Haanas NMCA, therefore, is the challenge of zoning that will rely on sound science for ecosystem delineation, species' uses of ecosystems, and human use patterns. Further, zoning would be contingent upon public consultation enabling appropriate stakeholder input based on local knowledge, economy and culture. The issue of zoning is easier to envision nearshore for species with relatively small areas of activity, such as harbour seal and sea otter. Some potential benefits of area zoning for marine mammals include:

- reducing interactions with commercial fisheries;
- creating acoustically quieter areas;
- conserving prey populations; and
- protecting habitats for feeding, resting and social interactions.

What of species that live offshore and/or have large geographic ranges? Is zoning the appropriate tool for protecting such marine mammals? The spatial scale of Gwaii Haanas for some species of pinnipeds and large whales is a fraction of their total ranges within which they travel. Gwaii Haanas could, therefore, provide only short-term protection for some of these species. Further, some species are difficult to observe as they spend much of their time offshore. Offshore values can be high for cetaceans (Faucher and Weilgart 1992), for example, the canyon of the Nova Scotia continental shelf (Sable Gully) is essential habitat for bottlenose whales (*Hyperoodon ampullatus*) (Hooker *et al.* 1999), and in 2004 the Gully will become a DFO marine protected area under the *Oceans Act*. In summary, the application of zoning will vary greatly in time and space according to the life history parameters of each species and knowledge on these parameters is currently deficient for most species.

THE PRECAUTIONARY APPROACH

The precautionary approach is critical to the future of Canadian marine conservation. The approach is an underlying principle of Canada's Oceans Strategy for all federal departments (DFO 2002a) and both the *NMCA* and *Oceans Acts* are explicitly committed to the approach. The Canadian Wildlife Service (EC) also invokes this approach in their marine protected areas policy (CWS MPAs Working Group 1999). As well, the scientific review panel's report for the task force on regional offshore oil and gas supported the approach (Anonymous 2002 - Appendix 20). Finally, applying the precautionary approach has been stressed in pinniped (Johnston *et al.* 2000) and cetacean (Ralls and Taylor 2000) conservation management, and underpins the whale-watching criteria in DFO's Marine Mammal Regulations (Lien 2001).

The precautionary approach embodies conservative (risk-averse) action in the absence of certainty - not waiting for full scientific proof prior to decision-making. Garcia (1996) described the approach as a set of agreed, cost-effective measures and actions including future courses of action, which ensures prudent foresight and reduces or avoids risk to the resources, the environment, and the people, to the extent possible taking explicitly into account existing uncertainties (i.e., lack of full scientific certainty) and the potential consequences of being wrong. Hilborn *et al.* (2001) expanded the approach by examining how its current use serves future generations. Other components of the precautionary approach are:

- that proponents for change from conservative, risk-averse action should assume the burden of proof that their proposed actions are not damaging (Dayton 1998) and assume costs of executing research to support any such change; and
- applying the approach to the protection of both humans and other organism populations through managing risks of resource management decisions to coastal communities (Hilborn *et al.* 2001).

MARINE MONITORING

As with the precautionary approach, the prospect of monitoring is discussed in each volume of this series. Monitoring is fundamental to Parks Canada's mandate, defined in the *Canada National Parks Act* (amended 2000), for ecological integrity in terrestrial national parks (Woodley 1993; Parks Canada Agency 2000) and for facilitating sustainable use without compromising ecosystem structure and function in NMCAs.

In a major review of marine area conservation science (NRC 2001), the following three tasks were considered central to monitoring:

- assessing management effectiveness;
- measuring long-term trends in ecosystem properties; and
- evaluating economic impacts, community attitudes, involvement and compliance.

To these we add:

- maintaining scientific accuracy and repeatability.

Monitoring should be treated as part of adaptive management; a structured process of "learning-by-doing" that treats management as an experiment in which hypotheses are formulated and findings are used to test these hypotheses. Canada's Oceans Policy (DFO 2002a) explicitly identifies adaptive management as a tool in coastal management. Included in an adaptive management regime are target variables, pre-set values and decision points (management options) established in advance depending on whether explicit performance criteria are met. Monitoring facilitates the feedback necessary to instruct managers and to guide adjustments as the experiment unfolds. Thus, monitoring should be experimental and begin with a conceptual model of the ecosystem and focus on the population dynamics of selected species relative to key ecosystem components and physio-chemical environmental variables (Davis 1993).

Parks Canada's marine policy (Parks Canada 1994; Mercier and Mondor 1995) discuss the following goals for monitoring programs:

- ensuring long-term viability of marine ecosystems;
- understanding natural spatial and temporal variability in structure (*e.g.*, biodiversity) and function (*e.g.*, production);
- examining how human effects such as fishing interact within the background of natural variability; and
- relating present-day ecosystem conditions to past ecosystem conditions.

The science of marine monitoring has expanded rapidly (Schmitt and Osenberg 1996) along with governments' commitments to it. In Canada, monitoring marine environmental quality is undertaken by EC and DFO. Under the Oceans Act, monitoring marine environmental quality is one of DFO's three components of their Ocean Management Strategy (DFO 2002a). Both EC and DFO have collaborated to develop categories of marine indicators; parameters tracked over time to reveal trends in processes of interest such as ecosystem health (Smiley *et al.* 1998; Vandermeulen 1998). As well, DFO has a national initiative to facilitate use of indicators towards marine environmental quality (DFO 2000). These developments highlight the advances in marine monitoring relevant to interagency cooperation. Parks Canada has not been part of the interagency marine monitoring cooperation, but this will change in the near future, driven, in part, by the prospect of oil and gas development.

Monitoring is also done to quantify ecosystem restoration or rehabilitation within a conservation area. Monitoring may help identify, locate and estimate the spatial scale of threats to marine ecosystems. Climate change, some species introductions, and external (non-point source) pollution cannot be managed solely on a local level, although they are worthy of monitoring. However, habitat destruction, species introductions and overfishing may be locally manageable within a conservation area. Those threats for which the spatial scales match those of conservation areas should be a prime management focus. However, Parks Canada marine policy is clear that in order to support our regional representation mandate, and in keeping with the openness and dynamism of marine environments, we must be concerned "*well beyond*" marine conservation area boundaries (Parks Canada 1994). An example would be monitoring the presence of migratory gray whales that temporarily occupy Haida Gwaii waters.

Monitoring will be a foundation of Gwaii Haanas' management in which the NMCA should function as a long-term reference site for Pacific Canada. Marine mammal monitoring has occurred in the United States' system, for example, there is specific pinniped monitoring protocol for the Channel Islands National Park, southern California (DeMaster *et al.* 1988). An overall monitoring program would best be achieved through interagency (PCA, CWS, DFO) efforts, including funding, and through public consultation, and all resulting data would be a shared regional asset. For example, if oil and gas exploration and development proceeds, this would increase the importance of Gwaii Haanas as a regional marine reference site. Monitoring costs should be integrated into long-term operational funding rather than under short-term project funding. Enough is known about regional marine mammals and ecosystems to envision where and when monitoring should occur, as discussed below in the recommendations.

REDUCTION IN FOOD SUPPLY

Marine mammals compete with humans for prey, although the extent to which this affects populations is uncertain, and the effects may be sublethal. Trites *et al.* (1997) estimate that marine mammals in the Pacific consume about three times the human take of fish. More than 60 % of their food is deep-sea squid and mesopelagic fish, which are not normally targeted by commercial fisheries. However, there is direct competition for the remaining 40% of prey, which is cause for concern for dolphin, porpoise and pinniped populations. Reductions in food supply, perhaps caused by overfishing, have been implicated in the dramatic population decline of Steller sea lions in western Alaska (Fritz *et al.* 1993; Trites and Larkin 1996; Rosen and Trites 2000). Baleen whales, which feed on plankton lower in the food web, are probably less likely to be affected by commercial fisheries (Clapham *et al.* 1999).

Certain fishing methods such as bottom trawling can result in more immediate habitat declines for marine mammals. There is great concern over the effects of bottom trawling on the seabed (Watling and Norse 1998; NRC 2001; Cryer *et al.* 2002; Field *et al.* 2002). According to Cryer *et al.* (2002), the effects can be widespread: "*We infer that trawling probably changes benthic community structure and reduces biodiversity over broad spatial scales on the continental slope as well as in coastal systems.*" Exactly how these effects manifest themselves in marine mammal populations remains an important but unanswered question. It is possible that, in particular, fishing near pinniped haul-outs and rookeries harms pinniped populations because they are restricted by how far away they can travel to forage. As a result of this, in western Alaska where Steller sea lion numbers have dramatically declined, there has been no trawling permitted within 20 nautical miles of the sea lion rookeries since 1991. The trawl exclusion zones appear to be effective in protecting some non-migratory prey species (NMFS 2003).

DeMaster *et al.* (2001) have made predictions about marine mammal populations and their prey in the next century, based on fishing patterns over the past 50 years, the current status of populations, and life history information. They predict that commercial fisheries will deplete localized food resources for marine mammals without necessarily overfishing the target species of fish. As a result, the number of extant populations of marine mammals will be reduced, with the greatest impact seen on coastal populations. They go so far as to predict that unless existing forms of fisheries management change, predator control programs for marine mammals will become common, and that protein from marine mammals will become a more important component of the human diet than it currently is. The declaration of marine conservation areas is an important first step in changing how we exploit resources, but only time will refute or support DeMaster *et al.*'s predictions.

CLIMATE CHANGE

Climate change takes place at different time scales, from relatively frequent El Niño events to decadal and longer oscillations (Bertram *et al.* 2001; Benson and Trites 2002). A "regime shift" from cold to warm water in 1976-77 resulted in significant changes in zooplankton and fish production off British Columbia (Benson and Trites 2002). In the longer term, general climate warming is changing plankton production (Roemmich and McGowan 1995), an important food supply for some of the baleen whales, and certainly for many of the fish species that are prey for other species of cetaceans and pinnipeds. Drawing on the changes that occurred in the transitions between previous glacial and interglacial periods, Fields *et al.* (1993) infer that, in general, there will be a reduction in primary productivity along the west coast as a consequence of global warming, due to a reduction in wind-driven upwelling. Changes in the circulation patterns will affect the distribution and survival of pelagic larvae of many marine species.

How these changes will affect marine mammal populations is uncertain. It is possible that highly mobile species such as baleen whales may better adapt to changes in prey distribution than harbour porpoises or sea otters that forage in more confined nearshore areas. There are a few examples demonstrating the vulnerability of marine mammals to climate change. Changes in climate and the resulting changes in food supply may explain the disappearance of pilot whales from the coast of California and El Niños were cited as the cause of population declines of California sea lions in 1983, 1992-93 and 1998 (Caretta *et al.* 2002). In the Arctic, where the extent of the sea ice is declining (Johannessen *et al.* 1999; Vinnikov *et al.* 1999), and the sea ice is breaking up earlier, polar bears (*Ursus maritimus*) are showing reduced survival and condition (Stirling *et al.* 1999). In Haida Gwaii, the Steller sea lion colony at Cape St. James may be vulnerable to climate change if there are dramatic declines in local productivity, because animals forage near rookeries during the breeding season.

POLLUTION

Two forms of pollution may affect marine mammals; ingestion of floating materials (*e.g.*, plastics or oil) by skim-feeders such as right and sei whales, and contamination. Likely the latter is of greater concern because of the high contaminant loads carried by various species (Jarman *et al.* 1996; Reijinders *et al.* 1999; Minh *et al.* 2000; Ross *et al.* 2000; Endo *et al.* 2003). Hazardous chemicals enter the sea through runoff, from the atmosphere and by dumping. Some contaminants, such as heavy metals, have significant toxic effects, but do not readily bioaccumulate and transfer slowly through marine food webs. Others, such as organochlorines (polychlorinated biphenyls [PCBs] and pesticides such as DDT) are highly toxic, persistent, and fat-soluble chemicals. The manufacture of PCBs has been banned, for most applications, in North America since the late 1970s. Canada aspires to a total phase-out of PCBs by 2008, but they are still produced in many developing nations. Marine mammal predators positioned high in food webs bioaccumulate organochlorines, in their blubber, from prey species that have themselves bioaccumulated contaminants through their prey. In Japan, for example, all samples of odontocete meat for human consumption tested for contamination (nine species, 137 animals) exceeded the permitted level of mercury, whereas among the mysticetes tested (six species, 62 samples), only one sample exceeded the permitted level (Endo *et al.* 2003). Likely this is because the mysticetes feed lower in the food web.

In the North Pacific, research has focused on the bioaccumulation of organochlorines and the results are of concern (Jarman *et al.* 1996; Minh *et al.* 2000; Ross *et al.* 2000). Although all cetaceans bioaccumulate these toxins, the trend is different for males and females (Aguilar *et al.* 1999). Males show a gradual increase in contaminant levels as they age. Females show the same pattern until they reach sexual maturity. However, when they become pregnant, mothers pass these fat-soluble chemicals to their fetuses, and this transfer rate increases via their milk during nursing. As successive offspring are born, the contaminant levels of their mothers are further reduced. First-born offspring thus carry the highest contaminant load of all. Females that remain barren have similar contaminant levels to those of males of the same species.

High contaminant PCB levels have been reported from *northern* and *southern resident* and *transient* populations of killer whales (Ross *et al.* 2000). These are among the most heavily contaminated cetaceans in the world. Their toxin levels surpass those of St. Lawrence River area beluga whales whose blubber caused reproductive system impairment in laboratory mice (Ruby *et al.* 2003). The mammal-eating *transients* yielded higher contamination levels than the fish-eating *residents*, perhaps reflecting the former's higher trophic level in food webs as mammal predators. Ross *et al.* (2000) concluded that the PCB levels represented a "*significant toxicological risk*" to the populations studied. Other species such as Pacific white-sided dolphin and Dall's and harbour porpoise also have extremely high levels (Jarman *et al.* 1996; Minh *et al.* 2000). Similar levels in harbour seals were sufficient to cause immunosuppression (Ross *et al.* 1995). How contaminant loads such as PCBs affect cetaceans in their daily lives or at the population level over the long-term is unknown.

ACOUSTIC INTERFERENCE

Sound is very important to many marine mammals. They use it to detect prey and predators, to communicate, and to acquire acoustical cues about their environment. Richardson *et al.* (1995) and OSB (2003) review how noises from human activities affect marine mammals. Many of these noises are <5 kHz, and have source levels of 130 to 230 dB re 1 μPa (Richardson *et al.* 1995). These sounds are associated with shipping, seismic exploration, military surveillance and acoustic oceanography.

To understand the effects of sound on marine mammals it is necessary to explain how sound is measured underwater. Sound pressure is measured in micropascals (μPa). The standard reference pressure is 1 μPa in water (and 20 μPa in air). Decibels (dB) are used to describe the ratio between the sound pressure level of the source to the sound pressure level of 1 μPa at 1 m from the source (dB re 1 μPa at 1m). This is often abbreviated to dB. The United States National Marine Fisheries Service has established a limit of 180 dB that can be produced underwater in the vicinity of marine mammals. The United States Geological Survey has a standard that noise must be attenuated to 180 dB within 40 m of the source, creating safety zones of 50 m for pinnipeds and toothed whales and 100 m for baleen whales (USGS 1999). For comparison, in air, gunshots produce 130 to 140 dB and the human eardrum ruptures at 160 to 185dB (using the reference of 20 μPa at 1 m).

Both baleen and toothed whales produce and perceive sound. Baleen whales generally produce low frequency sounds. For example, fin whales produce sounds in the 20 Hz range at 140 dB at 100 m, which are capable of traveling large distances (Richardson *et al.* 1995). Minke whales produce sounds in the 100 to 200 Hz range. Among the toothed whales, sperm whales produce a broad spectrum of sounds from 200 Hz to >30 kHz and killer whales produce sounds from 500 Hz to 25 kHz (Marrett 1992; Richardson *et al.* 1995). In comparison, the human hearing range is between 20 Hz to 20 kHz.

Background noise may significantly affect marine mammals by masking their ability to hear relevant sounds in the presence of other sounds, including communication signals between members of the same species, as well as the sounds produced by potential prey. Quantifying behavioural changes of marine mammals in response to noise are challenging because the responses are highly variable and depend on a variety of internal and external factors, as well as whether the sounds are constant or are perceived suddenly (OSB 2003). Internal factors that influence responses include the hearing sensitivity and activity patterns of the individual, past exposure (which may lead to sensitization or habituation), individual noise tolerance, and demographic factors such as age, sex and presence of offspring. External factors include non-acoustic characteristics of the source (moving or stationary), environmental conditions that may influence transmission, habitat characteristics, and location, such as proximity to shore. Interference may be manifested as a change in behaviour such as surfacing patterns, a change in vocalizations and/or by directly leaving the area, although these effects are not always measurable. If whales actually leave an area, it is hard to prove that the sounds were the cause, and if mortalities occur, carcasses are rarely discovered and necropsied.

The results of controlled experiments with low frequency sounds on fin, blue and male sperm whales did not show any measurable behavioural effect (Croll *et al.* 2001; Madsen *et al.* 2002). However, there are some examples of noise causing measurable changes in cetacean behaviour (Kraus *et al.* 1997). In Newfoundland, there were significantly increased entrapment rates of humpback whales in fishing nets near a site of underwater explosions (under 1000 Hz, 153dB re 1 Pa) (Todd *et al.* 1996). The whales showed little behavioural reaction to the explosions, but Todd *et al.* (1996) speculated that the high entrapment rates were due to the long-term effects of exposure to intense sound. Examination of the heads of two humpbacks found dead in the nets revealed that they had been exposed to significant blast trauma (Ketten *et al.* 1993). In the Caribbean, the United States military has taken responsibility for the mass stranding of 16 cetaceans (beaked and minke whales) during military exercises when mid-frequency (<10 kHz) high intensity sonars (over 200 dB re 1 μPa) were used (Evans *et al.* 2001). For comparative purposes, 215 dB in the ocean is equivalent to 150 db in air. Examination of the heads of five beaked whales that stranded during the event revealed massive trauma to the ear. Sounds produced during military exercises were also implicated in the deaths of beaked whales from the Canary Islands and Greece (Simmonds and Lopez-Jurado 1991; Frantzis 1998) and more recently in September 2002 (Jepson *et al.* 2003). A recent stranding of 13 Dall's porpoises, and a dramatic change in the behaviour of *resident* killer whales in Haro Strait in May 2003 was also associated with military exercises in the area, although the United States navy will claim, in a forthcoming report, that there is no association between the events [http://www.cpf.navy.mil/archive/].

Other sources of sounds may also present problems for marine mammals. Intense commercial fishing activity or whale watching can produce loud and constant, but localized, sound. This vessel noise may make it difficult for *transient* killer whales to locate their prey, as they rely on hunting by stealth and passive listening (Barrett-Lennard *et al.* 1996). This is a concern in Haida Gwaii, as most killer whale encounters are with *transients*.

INTERACTIONS WITH MARICULTURE

There can be conflicts between marine mammals and mariculture such as pinnipeds raiding salmon farms and damaging net pens (Jamieson and Olesiuk 2001). In British Columbia between 1995 and 1999, an average of 44 sea lions were killed by the mariculture industry annually (Angliss and Lodge 2002). Methods such as dogs and nets are used to deter predators, but, if they fail, a farm operator can apply to DFO for a permit to shoot nuisance animals. The British Columbia aquaculture industry no longer uses acoustic harassment devices (AHDs), but such devices did induce avoidance by harbour porpoises (Olesiuk *et al.* 2002). Similar results were found in the Bay of Fundy (Johnstone 2002). Morton and Symonds (2001) also found that killer whales did not enter areas where AHDs were active.

Currently, in the Haida Gwaii region there are a few small commercial and pilot shellfish culture operations, but no finfish mariculture. Mariculture could be a potentially permissible activity in the proposed Gwaii Haanas NMCA according to the *Canada NMCA Act*.

INTERACTIONS WITH COMMERCIAL FISHING

Disturbance and gear entanglement are common effects of fisheries on marine mammals worldwide, and small cetacean populations in many locations may be threatened by such activities (Perrin *et al.* 1994). In British Columbia, entanglement in salmon gillnets is an unquantified, but potentially significant source of mortality for harbour and Dall's porpoises, and Pacific white-sided dolphins (Baird and Guenther 1995; Stacey *et al.* 1997). Evidence from the drift net fisheries suggests that young animals may be particularly vulnerable to entanglement (Ferrero *et al.* 1993). Trawlers also capture small cetaceans (Baird *et al.* 1991; Angliss and Lodge 2002), although the extent of this problem is unknown. Larger cetaceans such as gray, humpback and killer whales can become entangled in nets, although fishing-related mortalities of gray whales are low in British Columbia waters (Baird *et al.* 2002). As the sea otter population expands, particularly in areas of gill-net fisheries, they may be vulnerable to entanglements, although in Alaska where sea otters and fisheries overlap, they are rarely killed (Angliss and Lodge 2002).

One method to reduce entanglement has been to attach 'pingers' to nets, to acoustically deter cetaceans and pinnipeds. In California, Barlow and Cameron (2003) found that the predicted 'dinner bell' effect - where pinnipeds may be attracted to nets with pingers- did not occur, and the bycatch of California sea lions and common dolphins was significantly reduced. However, these pingers were tested in areas where nets were not highly concentrated, so that animals may have been less likely to habituate. In other areas, cetaceans have become habituated to pingers within 10-11 days of daily use (Cox *et al.* 2001).

While effects of fishing may be difficult to measure, cetaceans and pinnipeds can compete with fishermen. The extent of this problem around Haida Gwaii is little documented, although some Steller sea lions have been shot after approaching Pacific herring ponds during the spawn-on-kelp fishery (R. Sjolund, DFO, *personal communication*). As well, there were reports of sperm whales raiding longline gear off Cape St. James (K. Heise, UBC, unpublished observation), although this fishery now uses pots. Killer whales take fish off longlines in the Bering Sea (Yano and Dahlheim 1995) and Prince William Sound (Matkin *et al.* 1986). In the Falkland Islands, sperm and killer whales raid longline gear (Nolan *et al.* 2000).

When sea otters were removed from the coast, populations of commercial invertebrates such as red sea urchins increased (Watson and Smith 1996). As sea otter numbers increase within their historic range in British Columbia, the abundance of their invertebrate prey species may, therefore, decline to the point of depressing some commercial fisheries (DFO 2002b; Watson 2000).

SMALL REMNANT POPULATIONS

Some species, such as gray whales, have recovered from commercial whaling, while others remain well below pre-exploitation numbers, such as North Pacific right and sei whales. As discussed earlier, illegal hunting by Russian and Japanese whalers may have prevented population recovery. However, these small remnant populations have intrinsically slow rates of increase, and may experience a decline in fitness caused by inbreeding (Clapham *et al.* 1999). Populations that exhibit inbreeding depression show significantly lower levels of recruitment, which may result from reduced fecundity, decreased neonatal and/or juvenile survival, or possibly reduced resistance to disease (Charlesworth and Charlesworth 1987).

Populations with the most dramatic recoveries in the eastern north Pacific (gray and humpback whales) tend to congregate to breed. Reproduction and foraging may occur over much larger geographic areas for species such as fin, sei and North Pacific right whales, species that are recovering much more slowly. As a result animals may not be able to find each other to mate, or may change their behaviour such that they are less able to protect themselves from predators or to forage (the “Allee” effect).

TOURISM AND RECREATION

Whale watching continues to expand rapidly as part of the worldwide growth in ecotourism (Duffus 1996; Williams *et al.* 2002). Early Canadian research in the “non-consumptive” uses of marine mammals reflected the changing public attitudes toward observing wildlife while minimizing disturbance to populations (Duffus and Dearden 1990, 1992; Waters 1992). Time and space are the key management variables in which seasonal access to animals in confined coastal areas must be balanced with enabling animals to pursue their life-sustaining activities (Duffus 1996).

The revised Viewing Guidelines [http://www-comm.pac.dfo-mpo.gc.ca/pages/MarineMammals/] reflect the whale-viewing component within the Marine Mammal Regulations of the *Fisheries Act*, and are currently undergoing further revisions. A key guideline is to not approach marine mammals closer than 100 m in vessels. This guideline will be in effect throughout the Haida Gwaii region and enforced within Gwaii Haanas by both Park Wardens and DFO Fishery Officers. Ideas for revising the regulations are based, in part, on invoking the precautionary approach with the intent to have whalewatching not develop faster than the knowledge of the industry’s effects on whales (Lien 2001). Knowledge gaps are particularly great for long-term effects compared to short-term effects. Work on killer whales in southern British Columbia has shown that boat traffic disrupts short-term behaviour of individual whales

(Williams *et al.* 2002). The ultimate objective of this research is to establish whether whalewatching affects whales' reproductive success.

The main ecological effects of marine tourism and recreation in Haida Gwaii are nearshore and, therefore, potential disturbance to nearshore marine mammals is relatively more important than disturbance to offshore populations. In Gwaii Haanas, levels of backcountry (wilderness) visitation are confined largely to the nearshore areas and are among the highest nation-wide for Parks Canada. In 2000, there were ~1,870 visitors comprising ~9,770 visitor-days (average ~5 days per visitor), and when guides, Gwaii Haanas staff and others are included, the total exceeded 13,700 visitor-days. Virtually all tourism in Gwaii Haanas involves small boats and occurs from April through September. This high rate of boat access means that encounters with marine mammals are likely. Some cetaceans, such as Pacific white-sided dolphin and Dall's porpoise, may be attracted to boats. Other species, such as harbour porpoises tend to avoid boats. Further, there is potential for disturbances to pinnipeds at haulouts and sea lions at the Cape St. James rookery. There is as yet no organized regional whale-watching industry, but this may change in the future.

SHIP STRIKES

Ship traffic, particularly large vessels capable of travelling >14 knots, can threaten cetaceans (Laist *et al.* 2001). Ship strikes are a major problem for right whales off Atlantic Canada and the United States (Clapham *et al.* 1999). Further, the United States National Marine Fisheries Service considers ship strikes a potentially important source of mortality for blue, fin, and sei whales (Forney *et al.* 2000). In a survey of 58 strikes, Laist *et al.* (2001) found that fin whales were the most common species struck. Small vessels can also be a threat, for example, a Stjeneger's beaked whale was killed by a jetboat in the Sea of Japan (Honma *et al.* 1999).

In British Columbia, a fin whale was struck and killed by a cruise ship in Queen Charlotte Strait in 1999, and in 2003 a cruise ship reportedly collided with a large whale in Hecate Strait, damaging the ship's stablizer (J. Ford, DFO, unpublished observation). Several killer whales have also been struck (Ford *et al.* 2000), including a juvenile in Johnstone Strait in 2003 (G.Ellis, DFO, *personal communication*). Small cetaceans can also be vulnerable to collisions. In British Columbia, there are numerous Pacific white-sided dolphins that carry propellor scars (K. Heise, UBC, unpublished observation). In 2003, a humpback whale was struck by a small boat in Gudal Bay, Haida Gwaii (VAMSC 2003).

REINTRODUCING A COMMERCIAL HARBOUR SEAL HUNT

In April 2003 the local provincial MLA and federal MP for Haida Gwaii were lobbied to pose questions in their respective Houses advocating a commercial harbour seal hunt around Haida Gwaii. The proponent made a series of points (QCI Observer 2003; April 10 [p. 9], August 28 [p.8, 19, 20]) as follows: (1) Canada's east coast has the world's largest commercial seal hunt (Johnston *et al.* 2000), while the west coast has no commercial hunt; (2) the harbour seal population has been increasing coast-wide and could sustain a hunt; (3) a commercial hunt would contribute to much-needed economic development for Haida Gwaii given the region's depressed fisheries and forestry sectors; and (4) harbour seals can negatively affect local fish stocks such as Pacific herring and migrating salmonids (particularly those constrained within estuaries). A commercial hunt would, therefore, serve two purposes simultaneously of regional economic development and protect local salmon stocks (especially small unproductive ones).

The position of the Council of the Haida Nation (CHN), as reported in the Victoria Times Colonist (p. A6, April 15, 2003), was precautionary, stating the need for more technical information on local harbour seal populations and activities, and for a public consultation process before any decision on a commercial hunt could be made. Further, at the CHN annual House of Assembly (October, 2003), the motion for a seal hunt was defeated. As previously stated, the archipelago's population has been increasing and is currently estimated at ~9,500 seals. However, it is unknown whether this is a stable number representing a recovered population after the pre-1970 hunting. Further, what little data there are on local seal diets do not enable an assessment of the effects of seals on local nearshore fish stocks. Therefore, the precautionary approach is wholly appropriate in this case and focused research would have to be done to address key population and ecological issues for a responsible assessment prior to any commercial hunt.

From a management perspective, a commercial hunt and culls to protect salmon stocks are two fundamentally different things, and different criteria would be used to evaluate proposals for each activity. Marine mammals tend to be relatively long-lived, are slow to mature, and have low reproductive rates. Depleted populations thus increase slowly, but generally maintain steady growth until populations recover. This results in a skewed production curve, which means that maximum net productivity levels, or maximum numbers of seals that could be harvested on a sustainable basis, generally occur at relatively high population levels. For harbour seals in British Columbia, Olesiuk (1999) estimated that the maximum net productivity level occurs at 70 to 75% of carrying capacity (the maximum number of a species that can live within a defined area over time). Therefore, the management objective for a sustainable commercial hunt would be to maintain a large seal population; which would do little to protect other fishery resources.

A different management approach would be required if the objective was to protect fish populations. Diet studies in other areas have shown that salmon generally comprise a minority of overall harbour seal diets; for example, in the Strait of Georgia salmon made up ~4% of the total diet (Olesiuk *et al.* 1990b; Olesiuk 1993). However, predation on salmon is not uniformly distributed, and in estuaries during autumn salmon can be an important prey, and seals can have a significant effect on local salmon stocks, especially those that are depleted. In the Puntledge River on eastern Vancouver Island for example, seals consumed up to 35% of pre-spawning adult Chinook salmon (Olesiuk *et al.* 1996). Although the estuary is inhabited by ~750 seals, telemetry studies indicated most of those foraged outside on hake, and used the logbooms in the estuary to haul out. Approximately 40 to 45 seals that habitually foraged in the river accounted for ~66% of total salmon consumption, and the same individual seals also foraged on out-migrating fry and smolts in the spring (Olesiuk *et. al.* 1995b). In this case, managers concluded that protection of chinook stocks could best be achieved by culling all the specific individual seals that were habitually foraging in-river on salmon. It is unlikely these nuisance seals would be targeted in a widespread harvest - carcasses tend to sink when shot in freshwater, and predation on salmon peaks in the autumn when animals are moulting and pelts are of little value.

OFFSHORE PETROLEUM EXPLORATION AND DEVELOPMENT

"*Accidents are inevitable companions of offshore oil and gas production and transportation*."
(Patin 1999)

The prospect of offshore petroleum exploration and development in the Hecate Strait – Queen Charlotte Sound area is a topic of high current interest [http://www.offshoreoilandgas.gov.bc.ca/]. Federal (since 1972) and provincial (since 1989) moratoria would have to be lifted for exploration to occur and production would proceed only if sufficient reserves were confirmed. The federal-provincial West Coast Offshore Exploration Environmental Assessment Panel (WCOEEAP 1986) recommended a minimum 20-km wide "*buffer*" strip along the entire north coast area between potential exploration/production sites and the shore for "*protection of nearshore waters*." Whether such a buffer would effectively protect marine mammal populations warrants investigation.

Until the 1990s, the effects of oil on marine mammals were poorly understood (Geraci and St. Aubin 1980, 1990). Limited knowledge at that time led Baker (1991) to generalize that whole populations of cetaceans and pinnipeds were relatively unaffected by oil spills, although their potential vulnerability to offshore petroleum development was generally recognized (Bolze and Lee 1989). It was known that sea otter mortalities resulted from hypothermia due to oiled fur, whereas pinnipeds and cetaceans, which rely on blubber for insulation, were considered less prone to hypothermia from oiling (Geraci and St. Aubin 1990). Further, there were few records of cetaceans being oiled, likely because of their smooth skin (Geraci and St. Aubin 1990). Knowledge from the *Exxon Valdez* Oil Spill (EVOS) of March 1989 has changed this whole field, and the lessons learned are discussed below as they are directly relevant to the species and ecosystems of the Haida Gwaii region.

Exploration

Exploration embodies several issues for marine mammals. Firstly, sonic interference can occur from seismic survey vessels using arrays of large compressed air guns that emit powerful, low frequency sound pulses (source levels of up to 260 dB re 1 ¼Pa at 1.0 m; peak frequencies in the 5 to 300 Hz range; OBS 2003). Survey vessels typically travel at ~5 knots, fire their guns every 10 to 12 seconds and can ensonify an area of ~4.25 km^2 (OSB 2003). The pulse reflections returning from geological layers of the sea floor are captured and analyzed for the presence of petroleum. Smaller air guns typically used for scientific research, rather than for commercial surveying, emit peak pulses in the range of 20 to 500 Hz (USGS 1999).

In a document prepared for the British Columbia Ministry of Energy and Mines as an update on oil and gas technology, Jacques Whitford Ltd. (2001) reviewed the potential effects of air guns on marine mammals, citing a study published by the Australian Petroleum Production and Exploration Association that suggested avoidance is the general response of whales to sound, at source levels of 140 to 180 dB re 1 μPa at 1.0 m. Boudreau (1998, p. 56) reached similar conclusions in Atlantic Canada, as did Davis *et al.* (1998) in a more detailed study. The prospect of having biological observers on seismic boats was seen as important to minimizing effects on marine mammals. The literature on behavioural responses is very limited (Davis *et al.* 1998; Harris *et al.* 2001) but as discussed in the Acoustic Interference section above, sounds of this intensity associated with naval exercises have caused significant changes in marine mammal behaviour and cetacean mortalities in the past. This information needs more analysis when considering the effects of future seismic exploration on marine mammals and fish.

Exploratory drilling may also have consequences for marine mammals. A spill or blowout can present problems, and the effects of spills can be extrapolated from EVOS-related research discussed below.

Production

If production proceeds, offshore platforms would be deployed with potential effects from platform drilling operations, oil and/or gas blowouts and the transfer and/or transport of petroleum. In Patin's (1999) overview of the environmental impacts of the offshore petroleum industry, he stressed the importance of an "*ecocentric orientation*" to give priority to ecosystem well being complimented by a "*preventive orientation*" placing priority on spill prevention. Among Patin's other conclusions were defining limits of acceptable change for marine environmental quality and mapping "*productive and ecologically vulnerable*" areas excluded from oil and gas activities.

The prime needs are, therefore, for an underlying spill-prevention ethos to drive operations and a sound science baseline. If a spill occurs along the rugged isolated coasts of Haida Gwaii, its environmental effects will be difficult to assess and remediate, and no one can state with certainty whether marine mammal protection would be achievable. Indeed, given the diversity in life histories of all the marine mammal species that occur around Haida Gwaii, it seems unlikely that all species could be protected in the event of a large spill.

Acute post-spill mortalities generate intense public concern. However, chronic, low-level pollution from ship operations (*e.g.*, from bilge-flushing or leaking tanks) and land runoff introduces more oil into the sea than episodic spills (Sloan 1999; Field *et al.* 2002, p. 144). Although acute spill effects shock the public, better communication is needed about long-term effects of chronic, low-level oil contamination that are inherently more difficult to demonstrate, particularly for highly mobile predators such as marine mammals. However it is possible that prey species which are more restricted in their movements may be affected, and that this effect could transfer up food webs (Sloan 1999).

Lessons from the *EXXON Valdez* Oil Spill

The literature on oil effects on marine mammals in cold water can be divided into pre-EVOS with its many gaps (Geraci and St. Aubin 1990), and post-EVOS. Among cold-water spills, the EVOS, is the most studied (Wells *et al.* 1995; Rice *et al.* 1996; Peterson 2001; Peterson *et al.* 2003) and has the best recorded time-series of post-spill data including the most marine mammal studies ever reported from a spill (Loughlin 1994; Wells *et al.* 1995). Further, this spill occurred in a biogeographic area comparable with Haida Gwaii. Many studies are still underway and funded by the EVOS Trustee Council [http://www.oilspill.state. ak.us/]. The EVOS science represents, therefore, a benchmark in the field of cold-water oil spills. For example, post-spill detailed sea otter observations have been used in oil spill risk assessments for sea otter populations elsewhere (Brody *et al.* 1996; Ralls *et al.* 1996). Indeed, one of the main reasons for a sea otter recovery plan for British Columbia is the populations' vulnerability to oil spills (Nichol *et al.* 2003).

Following the EVOS, there were extensive studies of marine mammals including investigations on the population impacts, rehabilitation, animal behaviour, pathology and toxicology (Loughlin 1994). The tissue pathology and toxicology samples for sea otters and harbour seals are the most detailed. As well, there were general population and behaviour studies that included killer and humpback whales, harbour seals and sea otters.

Sea Otters

Sea otters suffered the most acute effects of the spill, with ~1,000 carcasses recovered (Monson *et al.* 2000), and >120 mortalities took place in rehabilitation centres (Loughlin 1994). Extrapolating from very limited pre-EVOS data, total mortality estimates ranged widely. Loughlin (1994) and Spies *et al.* (1996) suggest 3,500 to 5,500 died. Garshelis (1997) reviewed the assumptions behind the mortality estimates from pre- and post-EVOS counts and carcass counts and revised the mortality estimate to ~750 (versus ~2,650) in Prince William Sound and a total spill area mortality of ~1,500. Oil-related death was implicated in 71% of the necropsies focusing on kidney, liver and lung, but also including gut, muscle, fat, brain and testes tissue pathology. All oiled carcasses had tissue lesions and lesion occurrence was two to eight times higher in oiled compared to unoiled carcasses (Loughlin 1994).

The charismatic nature of sea otters fostered high post-spill funding (Paine *et al.* 1996) including the establishment of rescue and rehabilitation centres. The success of this effort was limited, with 35.8% mortality and up to 21 of 45 radio-tagged released animals may have died. Costs were high and Garshelis (1997) estimated that each otter mortality at the centre represented ~$80,000 US. Low success was attributed, in part, to oil toxicity, handling stress and relocation of otters to non-home areas. Paine *et al.* (1996) felt that the negligible benefits of rehabilitation at the sea otter population level did not warrant its high costs, despite the popularity of such efforts.

For oiled sea otters not killed outright, the following course of events was constructed (Loughlin 1994):

- hypothermic otters reduce feeding while grooming frantically;
- energy stores deplete rapidly and oil may be ingested;
- pulmonary emphysema sets in;
- an acute stress reaction takes place with attendant gastric erosion; and
- profound shock leads to death.

Chronic, long-term sublethal effects have been reported from a series of post-spill surveys extending to 2000 (Monson *et al.* 2000; Bodkin *et al.* 2002), by which time populations "*had not fully recovered*" in the most oiled areas. Residual spill effects are speculated to arise from tissue pathology (especially liver and kidney), and elevated mortalities due to continued exposure in oiled areas with contaminated prey, spill-related impacts on prey populations and emigration from affected areas. For example, subtidal clam prey preferred by adult sea otters showed no oil contamination whereas the intertidal mussels preferred by juveniles were contaminated until at least 1995 (Carls *et al.* 2001) with the prospect of placing juveniles at risk of long-term contamination from their food.

Harbour Seals

The harbour seal population in Prince William Sound was studied in detail. Pre-EVOS harbour seal estimates revealed the Sound's population in appreciable decline since at least 1984 (Frost *et al.* 1999), which Peterson (2001) speculated was due to overfishing of local fish prey populations. Further, the population experienced post-EVOS decline (4.6% annually from 1990 to 1997 / 63% total population decline from 1984 to 1997– Frost *et al.* 1999). Spill-related losses of ~135 seals were inferred from reduced counts at seven oiled haulout sites known from past surveys and >300 were estimated to be missing from the Prince William Sound region (Loughlin 1994; Loughlin *et al.* 1996). Carcasses were not used to estimate mortality.

Harbour seals did not avoid oil and continued to use oiled haulouts, including for birthing, nursing and summer moulting. There was an ~25% decrease in pups recruited in 1989 and evidence of oil ingestion while nursing (Loughlin 1994). Noticeable eye damage was recorded among oiled seals. Oiled seals behaved lethargically, which was attributed to brain damage from inhalation of volatile fumes as they breathed just above the water surface (Loughlin 1994). This was particularly threatening early in the spill when the oil was fresh and the water calm. Tissue analyses revealed that oiled seals commonly had brain lesions. Although seals efficiently metabolize hydrocarbons and most tissue levels were low, high concentrations of aromatic compounds were found in bile over a year after EVOS (Laughlin 1994). Laboratory studies revealed that long-term chronic effects were not traceable to the spill but were implied by continuing population declines in oiled areas (Peterson 2001), and it was speculated that persistent contamination by residual oil in intertidal habitats was the cause (Frost *et al.* 1999; Peterson 2001). Rehabilitation success appeared good with 15 of 18 seals surviving (Loughlin 1994).

Killer Whales

Killer whales had perhaps the best pre-spill baseline of any animal population in the region. Photo-identification of individuals started in 1983 and most *resident* individuals were known. The *resident* AB pod when observed in September 1988 had 36 members, but by the spring of 1990, 13 individuals were missing and presumed dead; an exceptional loss rate, but with no carcasses (Matkin *et al.* 1998). Further, two adult AB pod males were noted with dorsal fin collapses (perhaps indicating poor health) and both later died. Nine members out of 22 of the *transient* AT1 pod have not been seen since 1990 and are presumed dead (Matkin *et al.* 1999). Loughlin *et al.* (1996) stated that "*coincidental evidence supports*" the spill as causing the *resident* killer whale pod decline. Matkin *et al.* (1998) attribute the losses of both *resident* and *transient* pods to the spill, although others question whether this connection can be made (Paine *et al.* 1996). Nonetheless, this rate of killer whale mortality remains unprecedented. Normal annual mortality for killer whales is ~2%, but following the spill it rose to ~20% in 1989 and 1990 (Matkin *et al.* 1998).

Other Marine Mammals

A humpback whale census found no anomalies that could be attributed to the EVOS (Loughlin 1994). Examination of spill-affected area beached carcasses of gray and minke whales and harbour porpoises yielded no clues as to their deaths. One of 80 Dall's porpoises seen had oil on its back and "*appeared stressed because of laboured breathing*". Steller sea lions, as with harbour seals, were already in pre-EVOS population decline (Loughlin 1994; Loughlin *et al.* 1996). No population impacts on Steller sea lions were attributable to the EVOS (Loughlin 1994).

Conclusions

Acute responses of marine mammals are now better understood due to post-EVOS research. Still, more work is needed on the linkage between tissue hydrocarbon levels, oil-related tissue damage and health status. Long-term marine mammal population status indicators remain uncertain with heavy reliance on circumstantial evidence, as was used when speculating on spill effects on killer whales. Field methodologies for mortality estimates require improvement to strengthen pre- and post-spill field counts. Marine mammals show little avoidance of oiled areas and will always be at risk in a spill.

Loughlin (1994) concluded the following recommendations, from EVOS studies, for future oil and marine mammal research:

- sound pre-spill baseline census data for reliable population impact assessments;
- wise allocation of research resources between acute and chronic impact studies;
- study design and attendant logistics arrangements on standby;
- standard field sampling protocols for timely, reliable post-spill execution; and

- link any rehabilitation centre strongly to pathology and toxicology studies.

The EVOS illustrates the highly controversial nature of post-spill environmental assessments (Paine *et al.* 1996; Peterson 2001; Peterson *et al.* 2003). The litigious situation driving post-spill science yielded an unproductive polarity and decreased opportunities for learning (Paine *et al.* 1996). Another lesson is that science cannot necessarily yield an answer unless, firstly, sound population and ecosystem baselines are established and, secondly, population well-being is monitored at regular intervals to establish a time-series as a reference for facilitating post-accident comparisons. Oil spills are essentially unrepeatable experiments that offer opportunities for social and technical learning. Those concerned for the marine mammals of the Haida Gwaii region could learn much from the post-EVOS history.

RECOMMENDATIONS

Given this overview and the prospect of establishing Gwaii Haanas NMCA, we provide recommendations for improving regional marine mammal knowledge and facilitating the application of such knowledge. Other considerations are the high level of public concern for the well-being of marine mammals, the reality that so many species are "listed" at some level of risk and the prospect of regional oil and gas exploration and development. Further, a long-term effort for studying populations is essential as most species are long-lived and reproduce relatively slowly. Meaningful information on population status and trends, therefore, will take years to collect before there is an adequate understanding of marine mammals' contribution to regional ecosystem structure and function. Finally, the trend towards multi-species ecosystem-based research is growing, and marine mammal knowledge is needed to support this holistic approach.

- **Use traditional aboriginal information to compliment natural science**

"*First nations cultures are repositories of valuable knowledge about the environment, special places and inter-species interactions*." (Jones and Ryan 2002)

In the spirit of the cooperative management commitment between Canada and the Haida Nation for Gwaii Haanas National Park Reserve and the prospect of the NMCA, opportunities to improve the aboriginal information base on marine resources such as mammals must be taken. Considering the ~10,000 years of human occupation of this region, relatively little aboriginal knowledge has been published on marine resource use. The process has begun with this review and putting Haida place names on Gwaii Haanas' GIS as the base layer. Now, other layers of information, from untapped sources such as audio tapes of elders, need to be prepared.

- **Include mammals in cooperative regional marine monitoring**

" … effective application of ecological integrity principles will require collaboration and partnerships among federal science-based departments and agencies, and between the government and its non-federal partners." (Industry Canada - IC 2000)

Cross-sectoral cooperation is particularly relevant to the marine environment where costs, technical challenges, dynamism and ecosystem complexity are so great, as underscored in Canada's Oceans Policy (DFO 2002a). Long-term cooperation between agencies, NGOs and coastal communities, and the use of protected reference locations such as Gwaii Haanas, could help achieve this. Some regional monitoring examples could be; seasonal occurrence of selected whale and pinniped species, status of local kelp forests before and after the presence of keystone sea otter predators and time series of cetacean vocalizations recorded by strategically placed hydrophones.

- **Integrate regional marine mammal and oceanographic knowledge**

Overlapping improved seasonal occurrence data with bathymetry, physical and biological oceanographic information could yield insights on habitat use by marine mammals. Although the factors that determine biological productivity may be complex, understanding processes that generate and concentrate such productivity would be important, such as which factors concentrate forage fishes (*e.g.*, herring, sand lance) so important to marine mammals.

- **Create seasonal vulnerability maps**

"…before any new industry is introduced into a specific marine ecosystem such as the Queen Charlotte Basin, action should be taken to establish a comprehensive set of pre-perturbation baseline data on the biota, including life-cycle histories of different species and their habitats …" Recommendation 3 - Scientific Review Panel, British Columbia Offshore Hydrocarbon Development Report (Anonymous 2002)

The prospect of regional oil and gas compels improving regional knowledge of where marine mammals occur, in what numbers and when. Gwaii Haanas' proposed NMCA and Langara Island could provide regional reference locations for surveys and monitoring leading to drafting seasonal vulnerability maps for locally prominent species. Maps could also be used for evaluating the potential for ship strikes of cetaceans in seasonal feeding areas. For uncommon species, however, there may never be enough data to reliably map their seasonal distributions.

- **Incorporate marine mammal habitat use data into fishery management plans**

Herring, rockfish and salmon are important fish prey for marine mammals around Haida Gwaii, yet the food requirements for marine mammals are not explicitly incorporated into DFO's Integrated Fisheries Management Plans. For example, an assessment of the reliance of sea lions on herring during the February to April spawning season should be understood when establishing quotas. Herring spawning represents a dramatic annual pulse of energy into nearshore Haida Gwaii food webs, yet the overall benefits derived by local marine species feeding on this pulse of abundance are poorly known.

- **Pursue key cetacean research topics**

· Commit to systematic cetacean surveys, particularly in nearshore waters and along the continental shelf edge nearby the western shores of Haida Gwaii. With the exception of Langara Island, systematic surveys have not been undertaken for any species, and much of the sighting data reflects the concentrations of observers, rather than the true distribution of cetaceans. There are relatively few data for the west coast that may be habitat for several species infrequently seen elsewhere along British Columbia's outer coasts.

· Survey the residence time and behaviour of cetaceans. This could be the basis of developing seasonal vulnerability maps and aid identification of critical habitat.

· Maintain ongoing collection of sighting and stranding information for the British Columbia Cetacean Sighting Network. Parks Canada should strongly encourage visitors to Gwaii Haanas to participate and maintain Warden Service involvement in photo-identification (priority for killer, humpback and any summer-resident gray whales).

- Cooperate in the collection of biopsy samples for toxicological and genetic analyses. This is topical given that some cetaceans readily bioaccumulate certain contaminants.

Pursue key pinniped research topics

- An updated estimate of the abundance of regional harbour seals is needed. No aerial surveys have been done since 1994 and there are no baseline data at all for ~20% of the Haida Gwaii coast. Seal populations in other areas of British Columbia may have stabilized, but this may not be the case in this region which was hunted more intensively and, therefore, could take longer to recover. Aerial survey coverage needs to be completed and population estimates updated.
- Steller sea lions could be used as indicators of coastal ecosystem health. The species is relatively easy to survey, long-lived, congregates at known shore locations, and resides near the top of the marine food chain. As populations in British Columbia and adjacent waters have largely recovered to historic high levels, natural population regulatory mechanisms may assume an increasingly important role. A long-term monitoring program is needed to track population trends and diets of the Haida Gwaii population.
- The data on seasonal occurrence of northern fur seals around Haida Gwaii were collected >30 years ago. Given that this abundant species is entirely pelagic during the non-breeding season and susceptible to oiling of its insulating underfur, it would be important to update seasonal distribution knowledge of these seals considering the prospect of offshore oil and gas in Hecate Strait.
- As pinniped populations are generally recovering, species such as California sea lion and northern elephant seal may become more frequent visitors with increasing effects on the ecology of Haida Gwaii waters. A more focused observation effort towards a regional time-series database is required.

Pursue key sea otter research topics

As sea otters will likely eventually establish breeding populations in Haida Gwaii, Gwaii Haanas should participate in research identified in the National Recovery Strategy (Nichol *et al.* 2003) to assist in population recovery. This could include establishing kelp forest monitoring locations to assess effects of sea otters with the same surveillance protocol used elsewhere along the British Columbia coast and incorporating concerns for sea otters into oil spill response plans. Spin-offs from such monitoring would be kelp forest, northern abalone and red sea urchin status information as well.

LITERATURE CITED

Acheson, S. 1984. Archaeological Investigations: SgA'ngwa-i Inaga'-i. Report prepared for Heritage Conservation Branch, Victoria, B.C., on file at Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C. 104 p.

Acheson, S. 1998. In the wake of the *ya'áats' xaatgáay* ['Iron People']: a study of changing settlement strategies among the Kunghit Haida. British Archaelogical Reports International Series 711: 209 p.

Acheson, S., and R.J. Wigen. 2002. Evidence for a prehistoric whaling tradition among the Haida. Journal of Northwest Anthropology 36: 155-168.

Ackerman, R.E. 1996. Early maritime culture complexes of the northern Northwest Coast. p. 123-132. In: Early human occupation of British Columbia. R.L. Carlson, and L. Dalla Bona (eds.). University of British Columbia Press, Vancouver, B.C.

Agler, B.A., J.A. Beard, R.S. Bowman, H.D. Corbett, S.E. Frohock, M.P. Hawvermale, S.K. Katona, S.S. Sadove, and I.E. Seipt. 1990. Fin whale (*Balaenoptera physalus*) photographic identification: methodology and preliminary results from the western North Atlantic. Report of the International Whaling Commission Special Issue 12: 349-356.

Aguilar, A., A. Borrell, and T. Pastor. 1999. Biological factors affecting variability of persistent pollutant levels in cetaceans. Journal of Cetacean Resource Management (Special Issue 1): 83-116.

Allen, J.A. 1880. History or North American Pinnipeds: A Monograph of Walrus, Sea Lions, Sea Bears, and Seals of North America. United States Geological and Geographical Survey, Territorial Miscellaneous Publication 12, Government Printing Office, Washington, D.C.

Allen, S.G. 1985. Mating behavior in the harbor seal. Marine Mammal Science 1: 84-87.

Allen, S.G., D.G. Ainley, J.F. Penniman, and L. Fancher. 1987. Movements and activity patterns of harbor seals in Point Reyes, California. Abstract from: 7th Biennial Conference on the Biology of Marine Mammals, December, 1987, Miami, FL.

Amano, M., M. Yoshika, T. Kuramochi, and K. Mori. 1998. Diurnal feeding by Dall's porpoise *Phoceonoides dalli*. Marine Mammal Science 14: 130-135.

Amano, M., M. Marui, T. Guenther, H. Ohizumi, and N. Miyazaki. 2000. Re-evaluation of geographic variation in the white flank patch of Dalli-type Dall's porpoises. Marine Mammal Science 16: 631-636.

Anderson, P.K. 1995. Competition, predation and the evolution and extinction of Steller's sea cow, *Hydrodamalis gigas*. Marine Mammal Science 11: 391-394.

Andrews, R.D. 1999. Preliminary progress report of Steller sea lion (SSL) foraging ecology studies. Steller Sea Lion Research Peer Review Feeding Ecology Workshop February, 1999, Seattle, WA.

Angliss, R.P., and K.L. Lodge. 2002. Alaska marine mammal stock assessments, 2001. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service NOAA Technical Memorandum, NMFS-AFSC-133: 224 p.

Anonymous 1976. Returning keystone species: the sea otter. All Alone Stone III: p. 35 only. Islands Protection Society, Masset, B.C.

Anonymous. 1982. Initial Environmental Evaluation for renewed petroleum exploration in Hecate Strait and Queen Charlotte Sound. Chevron Canada Ltd., Calgary, AB. 2 volumes.

Anonymous. 1983. Offshore Queen Charlotte Islands Initial Environmental Evaluation. Petro-Canada Inc., Calgary, AB. 3 volumes.

Anonymous. 1985. Government responses to requirements for additional information - West Coast Offshore Exploration Panel. Government of Canada / Province of British Columbia. Report on file at Gwaii Haanas National Park Reserve, Queen Charlotte, B.C.

Anonymous. 2002. Final report of the scientific review panel for the offshore oil and gas task force. British Columbia Ministry of Energy and Mines. [http://www.em.gov.bc.ca/Oil&Gas/offshore/OffshoreOilGasReport/]

Antonelis, G.A., M.S. Lowry, D.P. DeMaster, and C.H. Fiscus. 1987. Assessing northern elephant seal feeding habits by stomach lavage. Marine Mammal Science 3: 308-322.

Baird, R.W., and T. Guenther. 1995. Account of harbour porpoise (*Phocoena phocoena*) strandings and bycatches along the coast of British Columbia. Report of the International Whaling Commission Special Issue 16: 159-168.

Baird, R.W., K.M. Langelier, and P.J. Stacey. 1991 Strandings and incidental mortality of cetaceans on the B.C. coast. Paper Sc/43/01 presented to the International Whaling Commission Scientific Committee, May 1991. Unpublished. 6 p.

Baird, R.W., and P.J. Stacey. 1991 a. Status of Risso's dolphin *Grampus griseus* in Canada. Canadian Field-Naturalist 105: 233-242.

Baird, R.W., and P. J. Stacey. 1991 b. Status of the Northern Right Whale dophin, *Lissodelphis borealis*, in Canada. Canadian Field-Naturalist 105: 243-250.

Baird, R.W., and P.J. Stacey. 1993. Sightings, strandings and incidental catches of short-finned pilot whales, *Globicephala macrorhynchus*, off the British Columbia coast. International Whaling Commission Special Issue 14: 475-479.

Baird, R.W., P.J. Stacey, D.A. Duffus, and K.M. Langelier. 2002. An evaluation of gray whale (*Eschrichtius robustus*) mortality incidental to fishing operations in British Columbia, Canada. Journal of Cetacean Research and Management 4: 289-296.

Baird, R.W., P.J. Stacey, and H. Whitehead. 1993. Status of the striped dolphin, *Stenella coeruleoalba*, in Canada. Canadian Field-Naturalist 107: 4355-465.

Baker, C.S., S.R. Palumbi, R.H. Lambertsen, M.T. Weinrich, J. Calambokidas, 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., F. Cipriano, and S.R. Palumbi. 1996. Molecular genetic identification of whale and dolphin products from commercial markets in Korea and Japan. Molecular Ecology 5: 671-685.

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 novaengliae*) in the central and eastern North Pacific. Marine Ecological Progress Series 31: 105-119

Baker, C.S., G.M. Lento, F. Cipriano, and S.R. Palumbi. 2000. Predicted decline of protected whales based on molecular genetic monitoring of Japanese and Korean markets. Proceedings of the Royal Society of London, Biological Sciences Series B 267: 1191-1199.

Baker, J.M. 1991. The investigation of oil industry influences on tropical marine ecosystems. Marine Pollution Bulletin 12: 6-10.

Bannister, J.L. 2002. Baleen whales Mysticetes. p. 62-72. In: W. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Encyclopedia of marine mammals. Academic Press, San Diego, CA.

Barlow, J., and G.A. Cameron. 2003. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California driftnet fishery. Marine Mammal Science 19: 265-283.

Barrett-Lennard, L.G. 2000. Population structure and mating patterns of killer whale populations in the northeastern Pacific, as revealed by DNA analysis. Ph.D. Thesis, University of British Columbia, Vancouver, B.C.

Barrett-Lennard, L.G., K.A. Heise, and J.K.B. Ford. 1996. The mixed blessing of echolocation: difference in sonar use by fish-eating and mammal-eating killer whales. Animal Behaviour 51: 553-565.

Barrie, J.V., and K.W. Conway. 1996. Sedimentary processes and surficial geology of the Pacific margin of the Queen Charlotte Islands, British Columbia. Current Research 1996-E, Geological Survey of Canada. 6 p.

Beach, R.J., A.C.Geiger, S.J. Jeffries, S.D. Treacy, and B.L. Routman. 1985. Marine mammals and their interactions with fisheries of the Columbia River and adjacent waters, 1980-82. United States Department of Commerce, NWAFC Processed Report. 85-04.

Beals, H.K. 1989. Juan Pérez on the northwest coast – six documents of his expedition in 1774. Oregon Historic Society, Portland, OR, 150 p.

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: 95-113.

Bernard, H.J., and S. B. Reilly. 1999. Pilot whales *Globicephala* Lesson, 1828. p. 245-279. In: S.H. Ridgway and R. Harrison (eds.). Handbook of marine mammals Volume 6: The second book of dolphins and the porpoises. Academic Press, NY.

Bertram, D.F., D.L. Mackas, and S.M. McKinnell. 2001. The seasonal cycle revisited: interannual variation and ecosystem consequences. Progress in Oceanography 49: 283-307.

Best, P.A. 1979. Social organization in sperm whales. p. 227-289. In: H.E. Winn and B.L. Olla (eds.). Behaviour of marine animals. Plenum Press, NY.

Bickham, J.W., J.C. Patton, and T.R. Loughlin. 1996. High variability for control-region sequences in a marine mammal: implications for conservation and biogeography of Steller sea lions (*Eumetopias jubatus*). Journal of Mammalogy 77: 95-108.

Bigg, M.A. 1969 a. The harbour seal in British Columbia. Bulletin of the Fisheries Research Board of Canada 172: 33 p.

Bigg, M.A. 1969 b. Clines in the pupping season of the harbour seal, *Phoca vitulina*. Journal of the Fisheries Research Board of Canada 26: 449-55.

Bigg, M.A. 1973. Adaptations in the breeding of the harbour seal, *Phoca vitulina*. Journal of Reproduction and Fertility (Supplement) 19: 131-142.

Bigg, M.A. 1979. Preliminary comments on growth by length in female northern fur seals. p. 158-166. In: H. Kajimura, R.H. Lander, M.A. Perez, and A.E. York. (eds.). Preliminary analysis of pelagic fur seal data collected by the United States and Canada during 1958-74. 22nd Annual Meeting of the Standing Scientific Committee, North Pacific Fur Seal Commission, April, 1979, Washington, D.C.

Bigg, M. A. 1981. Harbour seal, *Phoca vitulina* Linnaeus, 1758 and *Phoca largha* Pallas, 1811. p. 1-27. In: S.H. Ridgway, and R.J. Harrison (eds.). Handbook of marine mammals. Vol. 2. Seals. Academic Press, London. 359 p.

Bigg, M.A. 1984. Sighting and kill data for the Steller sea lion (*Eumetopias jubatus*) and California sea lion (*Zalophus californianus*) in British Columbia, 1892-1982, with some records from Washington and southeastern Alaska. Canadian Data Report of Fisheries and Aquatic Sciences 460: 145 p.

Bigg, M.A. 1985. Status of the Steller sea lion (*Eumetopias jubatus*) and California sea lion (*Zalophus californianus*) in British Columbia. Canadian Special Publication of Fisheries and aquatic Sciences 77: 20 p.

Bigg, M.A. 1986. Arrival of northern fur seals, *Callorhinus ursinus*, on St. Paul Island, Alaska. Fisheries Bulletin 84: 383-394.

Bigg, M.A. 1988 a. Status of the Steller sea lion, *Eumetopias jubatus*, in Canada. Canadian Field-Naturalist 102: 315-3336.

Bigg, M.A. 1988 b. Status of the California sea lion, *Zalophus californianus*, in Canada. Canadian Field-Naturalist 102: 307-314.

Bigg, M.A. 1990. Migration of northern fur seals (*Callorhinus ursinus*) off western North America. Canadian Technical Report of Fisheries and Aquatic Sciences 1764: 78 p.

Bigg, M.A., G.M. Ellis, J.K.B. Ford, and K.C. Balcomb III. 1987. Killer whales: a study of their identification, genealogy and natural history in British Columbia and Washington State. Phantom Press, Nanaimo, B.C. 79 p.

Bigg, M.A., and I. Fawcett. 1985. Two biases in diet determination of Northern fur seals. In: J.R. Beddington, R.J.H. Beverton, and D.M. Lavigne (eds.). Marine mammals and fisheries. George Allen & Unwin, London. 354 p.

Bigg, M.A., P.F. Olesiuk, G.M. Ellis, J.K.B. Ford, and K.C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission, Special Issue 12: 383-405.

Bishop, R. H. 1967. Reproduction, age determination and behavior of the harbour seal, *Phoca vitulina* L., in the Gulf of Alaska. M.Sc. Thesis, University of Alaska, College, Alaska. 121 p.

Blackman, M.B. 1979. Northern Haida land and resource utilization: a preliminary overview. p. 43-55. In: Tales from the Queen Charlotte Islands. Vol. 1. Senior Citizens of the Queen Charlotte Islands, Masset, B.C.

Blackman, M.B. 1990. Haida: traditional culture. p. 240-260. In: Handbook of North American Indians Vol. 7. W. Suttles (ed.). Smithsonian Institution, Washington, D.C.

Bodkin, J.L., B.E. Ballachey, M.A. Cronin, and K.T. Scribner. 1999. Population demographics and genetic diversity in remnant and translocated populations of sea otters. Conservation Biology 13: 1378-1385.

Bodkin, J.L., B.E. Ballachey, T.A. Dean, A.K. Fukuyama, S.C. Jewett, L. McDonald, D.H. Monson, C.E. O'Clair, and V.R. VanBlaricom. 2002. Sea otter population status and the process of recovery from the 1989 '*Exxon Vladez*' oil spill. Marine Ecology Progress Series 241: 237-253.

Bolze, D.A., and M.B. Lee. 1989. Offshore oil and gas development implications for wildlife in Alaska. Marine Policy 13: 231-248.

Bonnell, M.L., M.O. Pierso, and G.D. Farrens. 1983. Pinnipeds and sea otters of central and northern California, 1980-1983: status, abundance and distribution. Final report for contract AA551-CT9-33, United States Department of Interior, Minerals Management Service. Center for Marine Studies, University of California, Santa Cruz, CA.

Boudreau, P.R. (Editor). 1998. The possible environmental impacts of petroleum exploration activities on the Georges Bank ecosystem. Fisheries and Oceans Canada (DFO) Canadian Stock Assessment Secretariat Research Document 98/170: 106 p. [http://www.dfo-mpo.gc.ca/csas/]

Boulva, J., and I.A. McLaren. 1979. Biology of the harbour seal, *Phoca vitulina*, in eastern Canada. Bulletin of the Fisheries Research Board of Canada 200: 24 p.

Bowen, W.D. 1997. Role of marine mammals in aquatic ecosystems. Marine Ecology Progress Series 158: 267-274.

Bowen, W.D., C.A. Beck, and D.A. Austin. 2002. Pinniped ecology. p. 911-921. In: Encyclopedia of marine mammals. W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Breen, P.A., T.A. Carson, J.B. Foster, and E.A. Stewart. 1982. Changes in subtidal community structure associated with British Columbia sea otter transplants. Marine Ecology Progress Series 7: 13-20.

Brody, A.J., K. Ralls, and D.B. Siniff. 1996. Potential impact of oil spills on California sea otters: implications of the *Exxon Valdez* spill in Alaska. Marine Mammal Science 12: 38-53.

Brown, R.F., and B.R. Mate. 1983. Abundance, movements, and feeding habits of harbor seals, *Phoca vitulina*, at Netarts and Tillamook Bay, Oregon. Fisheries Bulletin 81: 291-302.

Buckland, S.T., K.L. Cattanach, and R.C. Hobbs. 1993. Abundance estimates of Pacific white-sided dolphin, northern right whale dolphin, Dall's porpoise and northern fur seal in the North Pacific, 1987–1990. International North Pacific Fisheries Commission Bulletin 53: 387- 407.

Burg, T.M., A.W. Trites, and M.J. Smith. 1999. Mitochondrial and microsatellite DNA analyses of harbour seal population structure in the northeast Pacific. Canadian Journal of Zoology 77: 930-943.

Burles, D.W., A.G. Edie, and P.M. Bartier. 2004. Native land mammals and amphibian of Haida Gwaii with management recommendations for Gwaii Haanas National Park Reserve and Haida Heritage Site. Parks Canada Technical Reports in Ecosystem Science (*in press*).

Burns, J.J. 2002. Harbor seal and spotted seal *Phoca vitulina* and *P. largha.* p. 552-560. In: Encyclopedia of marine mammals. W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Burns, J.J., F.H. Fay, and G.A. Fedoseev. 1984. Craniological analysis of harbor and spotted seals of the North Pacific Region. p. 5-16. In: F.H. Fay, and G.A. Fedoseev (eds.). Soviet-American cooperative research on marine mammals, Vol. 1, Pinnipeds, National Oceanic and Atmospheric Association Technical Report NMFS 12.

Calambokidis, J., G.H. Steiger, J.C. Cubbage, K.C. Balcomb, C. Ewald, S. Kruse, R. Wells, and R. Sears. 1990. Sightings and movements of blue whales off central California 1986-1988 from photoidentification of individuals. Report of the International Whaling Commission Special Issue 12: 343-348.

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbour porpoises from Washington, Oregon and California. In: Proceedings of the Second Marine Mammal Stranding Workshop, December 1987. Miami, Florida. J.E. Reynolds III and D.K. Odell (eds.). U.S. National Marine Fisheries Service, NOAA Technical Report NMFS 98: 101-110.

Calambokidis, J., J.R. Evenson, G.H. Steiger, and S.J. Jeffries. 1994. Gray whales of Washington State: Natural history and photographic catalogue. Cascadia Research 218 ½ W. Fourth Ave., Olympia, WA 98501. 60 pp.

Calambokidis, J., G.H. Steiger, J.M. Straley, T. Quinn, L.M. Herman, S. Cerchio, D.R. Salden, M. Yamaguchi, F. Sato, J.R. Urban, J. Jacobesn, O. VonZeigesar, K.C. Balcomb, C.M. Gabriele, M.E. Dahlheim, N. Higashi, S. Uchida, J.K.B. Ford, Y. Miyamura, P. Ladrón de Guevara, S.A. Mizroch, L. Schlender, and K. Rasmussen. 1997. Abundance and population structure of humpback whales in the North Pacific. Contract Report 50ABNF500113 to Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA. Cascadia Research, 218 ½ W. Fourth Ave., Olympia, WA 98501. 72 p.

Calambokidis J., G. Steiger, J. Straley, L. Herman, S. Cerchio, D.R. Salden, J.R. Urban, J.K. Jacobsen, O. von Ziegesar, K.C. Balcomb, C. Gabriele, M.E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P.P.L. de Guevara, M. Yamaguchi, F. Sato, S.A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, T.J. Quinn II. 2001. Movements and population structure of humpback whales in the North Pacific. Marine Mammal Science 17: 769-794.

Calambokidis, J., T. Chandler, K. Rasmussen, L. Schlender, and G.H. Steiger. 2000 a. Humpback and blue whale photoidentification off California, Washington and Oregon in 1999. Final Report for the Southwest Fisheries Center, Olympic Coast National Marine Sanctuaries and Channel Islands National Marine Sanctuary. Cascadia Research 218 ½ W. Fourth Ave., Olympia, WA 98501. 39 p.

Calambokidis, J., J.D. Darling, V. Deeke, P. Gearin, M. Gosho, W. Megill, C.M. Tombach, D. Goley, C. Toropova, and B. Gisborne. 2000 b. Final Report. Range and movements of seasonal resident gray whales from California to southeast Alaska. Cascadia Research, 218 ½ W. Fourth Ave., Olympia, WA 98501. 29 p.

Calambokidis, J., J.D. Darling, V. Deecke, P. Gearin, M. Gosho., W. Megill, C.M. Tombach, D. Goley, C. Toropava, and B. Gisborne. 2002. Abundance, range and movements of a feeding aggregation of gray whales (*Eschrichtius robustus*) from California to southeastern Alaska in 1998. Journal of Cetacean Research and Management 4: 267-276.

Calkins, D.G., E.F. Becker, and K.W. Pitcher. 1998. Reduced body size of female Steller sea lions from a declining population in the Gulf of Alaska. Marine Mammal Science 14: 232-244.

Calkins, D.G., D.C. McAllister, K.W. Pitcher, and G.W. Pendleton. 1999. Steller sea lion status and trend in southeast Alaska: 1979-1997. Marine Mammal Science 15: 462-477.

Calkins, D.G., and K.W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. p. 445-546. In: Environmental assessment of the Alaskan continental shelf: final reports of principal investigators, Vol. 19. United States Department of Commerce, National Oceanic and Atmospheric Association, Juneau, AK.

Cameron, W.M. 1941. Killer whales stranded near Masset. Fisheries Research Board of Canada Pacific Progress Report 49: 17.

Campbell, A. 2000. Review of northern abalone, *Haliotis kamtschatkana*, stock status in British Columbia. Canadian Special Publication of Fisheries and Aquatic Sciences 130: 41-50.

Carretta, J.V., M.M. Muto, J. Barlow, J. Baker, K.A. Forney, and M. Lowry. 2002. U.S. Pacific marine mammal stock assessments: 2002. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service NOAA Technical Memorandum NMFS-SWFSC-346. 286 p.

Carlton, J.T., and J. Hodder. 2003. Maritime mammals: terrestrial mammals as consumers in marine intertidal communities. Marine Ecology Progress Series 256: 271-286.

Carls, M.G., M.M. Babcock, P.M. Harris, G.V. Irvine, J.A. Cusick, and S.D. Rice. 2001. Persistence of oiling in mussel beds after the *Exxon Valdez* oil spill. Marine Environmental Research 51: 167-190.

Charlesworth, D., and B. Charlesworth. 1987. Inbreeding depression and its evolutionary consequences. Annual Review of Ecology and Systematics 18: 237-268.

Chivers, S.J., A.E. Dizon, P.J. Gearin, and K.M. Robertson. 2002. Small scale population structure of eastern North Pacific harbour porpoises (*Phocoena phocoena*) indicated by molecular genetic analyses. Journal of Cetacean Research and Management 4: 111-122.

Christal, J., H. Whitehead, and E. Lettevall. 1998. Sperm whale social units: Variation and change. Canadian Journal of Zoology 76: 1431-1440.

Christensen, T. 2000. Massett Reserve # 2 Hiellen Village/Tow Hill clam cannery archaeological impact assessment. Report prepared for Economic Development and Heritage Resources, Old Massett Village Council, Old Massett, B.C., on file at Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C.

Clapham, P.J. 2001. Why do baleen whales migrate? A response to Corkeron and Connor. Marine Mammal Science 17: 432-436.

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

Clinton, W.L., and B.J. LeBoeuf. 1993. Sexual selection's effects on male life history and pattern of male mortality. Ecology 74: 1884-1892.

Cockeron, P.J., and Connor, R.C. 1999. Why do baleen whales migrate? Marine Mammal Science 15: 1228-1245.

Condit, R., and B.J. LeBoeuf. 1984. Feeding habits and feeding grounds of the northern elephant seal. Journal of Mammalogy 65: 281-290.

Connor, R.C., and P.J. Cockeron. 2001. Predation past and present: killer whales and baleen whale migration. Marine Mammal Science 17: 436-439.

Cottrell, P.E. 1995. Diet, activity budgets, and movement patterns of harbour seals (*Phoca vitulina*) in Cowichan Bay and adjacent areas. M.Sc. Thesis, University of Victoria, Victoria, B.C. 118 p.

Cottrell, P.E., S. Jeffries, B. Beck, and P.S. Ross. 2002. Growth and development in free-ranging harbor seal (*Phoca vitulina*) pups from southern British Columbia, Canada. Marine Mammal Science 18: 721-733.

Cox, T.M., A.J. Reed, A. Solow, and N. Tregemza. 2001. Will harbour porpoises (*Phocoena phocoena*) habituate to pingers? Journal of Cetacean Research and Management 3: 81-86.

Crawford, W.R. 1997. Physical oceanography of the waters around the Queen Charlotte Islands. In: The ecology, status and conservation of marine and shoreline birds of the Queen Charlotte Islands. K. Vermeer, and K.H. Morgan (eds.). Canadian Wildlife Service Occasional Paper 93: 8-17.

Crawford, W.R. 2000. Oceans of the Queen Charlotte Islands and Gwaii Haanas National Marine conservation Area Reserve. CD-ROM. Fisheries and Oceans Canada, Canadian Hydrographic Service, Institute of Ocean Sciences, Sidney, B.C.

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

Croll, D.A., C.W. Clark, J. Calambokidas, W.T. Ellison, and B.R. Tershy. 2001. Effects of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. Animal Conservation 4: 13-27.

Cryer, M., B. Hartill, and S. O'Shea. 2002. Modification of marine benthos by trawling: toward a generalization for the deep ocean? Ecological Applications 12: 1824-1839.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2000. Canadian Species at Risk, November 2000. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 24 p.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2003. COSEWIC assessment and status report on the sei whale (*Balaenoptera borealis*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 27 p.

CWS MPAs (Canadian Wildlife Service Marine Protected Areas) Working Group. 1999. Marine protected areas - opportunities and options for the Canadian Wildlife Service. Canadian Wildlife Service, Ottawa. 46 p.

Dady, P., and T. Christensen. 2000. Archaeological inventories at select Department of National Defense properties, C.F.B. Esquimalt - Volume 2: Heals Rifle Range (Saanich), Nanaimo Rifle Range, C.F.M.E.T.R. Nanoose Bay, C.F.S. Masset. Report prepared for Archaeological Branch, Ministry of Sustainable Resource Management, Victoria, B.C. on file at Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C.

Dalebout, M.L., G.M. Lento, F. Cipriano, N. Funahashi, and S.C. Baker. 2002. How many protected minke whales are sold in Japan and Korea? A census by microsatellite DNA profiling. Animal Conservation 5: 143-152.

Dalzell, K.E. 1988. The Queen Charlotte Islands, Volume 1. 1774-1966 (2nd paperback edition). Bill Ellis Publisher, Queen Charlotte City. 340 p.

Dalzell, K.E. 1993. The Queen Charlotte Islands, Volume 2. Places and names (1st paperback edition, 3rd printing). Harbour Publishing, Madeira Park, B.C. 472 p.

Darling, J.D. 1983. Migrations, abundance and behaviour of Hawaiian humpback whales, *Megaptera novaengliae* (B.). Ph.D. Dissertation, University of California, Santa Cruz.

Darling, J.D., J.Calambokidas, K.C. Balcomb, P. Bloedel, K. Flynn, A. Mochizuki, K. Mori, F. Sato, and M. Yamaguchi. 1996. Movement of a humpback whale (*Megaptera novaengliae*) from Japan to British Columbia and return. Marine Mammal Science 12: 281-287.

Darling, J.D., K.E. Keough, and T.E. Steeves. 1998. Gray whale (*Eschrichtius robustus*) habitat utilization and prey species off Vancouver Island, B.C. Marine Mammal Science 14: 692-720.

Darling, J.D., and C.M. Jurasz. 1983. Migratory destinations of North Pacific humpback whales (*Megaptera novaengliae*). p. 359-368. In: Communication and behaviour of whales. R. Payne (ed.). Westview Press, Boulder, CO. 643 p.

Darling, J.D., K.E. Keogh, and T.E. Steeves. 1998. Gray whale (*Eschrictius robustus*) habitat utilization and prey species off Vancouver Island, B.C. Marine Mammal Science 14: 692-720.

da Silva, J., and J.M. Terhune. 1985. Harbour seal grouping as an anti-predator strategy. Abstract in 6th Biennial Conference on the Biology of Marine Mammals, Vancouver, B.C., November, 1985.

Davis, G.E. 1993. Design elements for monitoring programs: the necessary ingredients for success. Environmental Monitoring and Assessment 26: 99-105.

Davis, R.A., D.H. Thomson, and C.I. Malme. 1998. Environmental assessment of seismic exploration on the Scotian Shelf. Report prepared for Canada/Nova Scotia Offshore Petroleum Board, Halifax, N.S. [http://www.cnsopb.ns.ca/environment/].

Dawson, G.M. 1880. Report on the Queen Charlotte Islands 1878. Geological Survey of Canada, Ottawa and Dawson Brothers, Montreal. 239 p. [Appendix A. On the Haida Indians of the Queen Charlotte Islands. p. 103-175].

Dayton, P.K. 1998. Reversal of the burden of proof in fisheries management. Science 279: 821-822.

Deecke, V. 1997. Abundance, distribution and movement pattern of summer resident gray whales (*Eschrichtius robustus*) on the central coast of British Columbia, Canada. Preliminary report, Marine Mammal Research Unit, University of British Columbia, Vancouver, B.C. 34 p.

DeLong, R.L, and B.S. Stewart. 1991. Diving patterns of northern elephant seal bulls. Marine Mammal Science 7: 369-384.

DeMaster, D.P., and S. Atkinson. (Editors). 2002. Steller sea lion decline: is it food II. Proceedings of the Workshop Is It Food II, Seward, AK, 2001. University of Alaska Sea Grant College Program, Fairbanks AK-SG-02-02: 78 p.

DeMaster, D.P., R.L. DeLong, B.S. Stewart, P.K. Yochem, G.A. Antonelis, and W. Perryman. 1988. Pinniped monitoring handbook - Channel Islands National Park, California. National Park Service, Channel Islands National Park, Ventura, CA. 10 p.

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: 641-651.

Deutsch, C.J., D.E. Crocker, D.P. Costa, and B.J. LeBoeuf. 1994. Sex- and age-related variation in reproductive effort of northern elephant seals. Chapter 10 In: B.J. LeBoeuf, and R.M. Laws (eds.). Elephant seals: population ecology, behavior, and physiology. University of Calfifornia Press, Berkeley, CA.

DFO (Fisheries and Oceans Canada) 2000. Marine environmental quality – together, towards healthy oceans. Fisheries and Oceans Canada, Marine Ecosystems Conservation Branch, Ottawa, ON. (Looseleaf)

DFO (Fisheries and Oceans Canada) 2002 a. Canada's ocean strategy. Our oceans: our future – policy and operational framework for integrated management of estuarine, coastal and marine environments in Canada. Fisheries and Oceans Canada, Ottawa. 36 p. [http://www.cos-soc.gc.ca/docs/cos-soc/]

DFO (Fisheries and Oceans Canada) 2002 b. National Recovery Strategy for the northern abalone (*Haliotis kamtschatkana*) in British Columbia [Final Draft]. 36 p. [http://www-comm.pac.dfo-mpo.gc.ca/pages.consultations/fisheriesmgmt/abalone/AbaloneRecovStrategy_e.htm].

Domning, D.P. 1972. Steller's sea cow and the origin of North Pacific aboriginal whaling. Syesis 5: 187-189.

Donovan, G.P. 1991. A review of IWC stock boundaries. Report of the International Whaling Commission Special Issue 13: 39-68.

Doroff, A.M., J.E. Estes, M.T. Tinker, D.M. Burn, and T.J. Evans. 2003. Sea otter population declines in the Aleutian archipelago. Journal of Mammalogy 84: 55-64.

Dorsey, E.M., S.J. Stern, A.R. Hoelzel, and J. Jacobsen. 1990. Minke whales (*Balaenoptera acutorostrata*) from the west coast of North America: individual recognition and small-scale site fidelity. Report of the International Whaling Commission Special Issue 12: 357-368.

Duffus, D.A. 1996. The recreational use of grey whales in southern Clayoquot Sound, Canada. Applied Geography 16: 179-190.

Duffus, D.A., and P. Dearden. 1990. Non-consumptive wildlife-oriented recreation: a conceptual framework. Biological Conservation 53: 213-231.

Duffus, D.A., and P. Dearden. 1992. Whales, science and protected area management in British Columbia, Canada. George Wright Forum 9: 79-87.

Dunham, J.S., and D.A. Duffus. 2002. Foraging patterns of gray whales in central Clayoquot Sound, British Columbia, Canada. Marine Ecology Progress Series 223: 299-310.

Eberhardt, L.L. 1985. Assessing the dynamics of wild populations. Journal of Wildlife Management 49: 997-1012.

Edie, A.G. 1973. Sea otter sighting at Cape St. James, British Columbia. Syesis 6: 265 only.

Edie, A.G. 1977. Distribution and movements of Steller sea lion cows (*Eumetopias jubatus*) on a pupping colony. M.Sc. thesis, University of British Columbia, Vancouver, B.C.

Eguchi, T. and J. T. Harvey. 1985. Diving behavior and movements of the Pacific harbor seal *(Phoca vitulina richardsi*) in Monterey Bay, California. Abstract: 11th Biennial Conference on the Biology of Marine Mammals, December, 1995, Orlando, FL.

Ellis, R. 2003. The empty ocean. Island Press/Shearwater Books, Washington, D.C. 367 p.

Endo, T., Y. Hotta, K. Haraguchi, and M. Sakata. 2003. Mercury contamination in the red meat of whales and dolphins marketed for human consumption in Japan. Environmental Science and Technology 37: 2681-2685.

Enrico, J. 1989. The Haida language. p. 223-247. In: The Outer Shores. G.G.E. Scudder, and N. Gessler (eds.). Queen Charlotte Islands Museum Press, Skidegate, B.C.

Escorza-Trevino, S., and A. E. Dizon. 2000. Phylogeography, intraspecific structure and sex-biased dispersal of Dall's porpoise, *Phocoenoides dalli*, revealed by mitochondrial and microsatellite DNA analyses. Molecular Ecology 9: 1049-1060.

Estes, J.A., and J.L. Bodkin. 2002. Otters. p. 842-858. In: Encyclopedia of marine mammals. W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Academic Press, San Diego, CA.

Estes, J.A., and D.O. Duggins. 1995. Sea otters and kelp forests in Alaska: generality and variation in - a community ecological paradigm. Ecological Monographs 65: 75-100.

Estes, J.A., D.O. Duggins, and G.B. Rathbun. 1989. The ecology of extinctions in kelp forest communities. Conservation Biology 3: 252-264.

Estes, J.A., M.T. Tinker, E.M. Williams, and D.F. Doak. 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. Science 282: 473-476.

Evans , D.L., C.C. Lautenbacker Jr., W.T. Hogarth, G.R. England, S. Morrisey, Livingstone, and H.T. Johnson. 2001. Joint Interim Report: Bahamas Marine Mammal Stranding Event of 15-16 March 2000. United States Department of Commerce [www.nmfs.noaa.gov/prot_res].

Evans, P.G.H. 1987. The natural history of whale and dolphins. Facts on File Publications, New York. 343 p.

Faucher, A., and L.S. Weilgart. 1992. Critical marine mammal habitat in offshore waters: the need for protection. p. 75-78. In: Science and Management of Protected Areas. J.H.M. Willison, S. Bodrup-Nielsen, C. Drysdale, T.B. Herman, and N.W.P. Munro. (eds.). Elsevier, Amsterdam.

Fedje, D.W. 2002. The early post-glacial history of the northern northwest coast: a view from Haida Gwaii and Hecate Strait. Athena Review 3(2): 28-30.

Fedje, D.W., and T. Christensen. 1999. Modeling paleoshorelines and locating early Holocene coastal sites in Haida Gwaii. American Antiquity 64: 635-652.

Fedje, D.W., and I.D. Sumpter. 1996. 1994/1995 archaeological resource management program: Gwaii Haanas National Park Reserve/Haida Heritage Site. Report prepared for Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C., by Cultural Resource Services, Western Canada Service Centre, Parks Canada, Victoria, B.C. 59 p.

Fedje, D.W. and I.D. Sumpter, 1999. 1997/98 archaeological resource management program: Gwaii Haanas National Park Reserve/Haida Heritage Site. Report prepared for Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C., by Cultural Resource Services, Western Canada Service Centre, Parks Canada, Victoria, B.C. 81 p.

Fedje, D.W., and I.D. Sumpter. 2001. 2000/01 archaeological resource management program: Gwaii Haanas National Park Reserve/Haida Heritage Site. Report prepared for Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C., by Cultural Resource Services, Western Canada Service Centre, Parks Canada, Victoria, B.C. 25 p.

Fedje, D.W., R.J. Wigen, Q. Mackie, C.R. Lake, and I.D. Sumpter. 2001 a. Preliminary results from investigations at Kilgii Gwaay: an early Holocene archaeological site on Ellen Island, Haida Gwaii, British Columbia. Canadian Journal of Archaeology 25: 98-120.

Fedje, D.W., I.D. Sumpter, and J. Morton. 2001 b. Gwaii Haanas archaeological resource description and analysis. Report prepared for Gwaii Haanas National Park Reserve, Queen Charlotte, B.C. by Parks Canada: Cultural Resource Services, Western Canada Service Centre, Calgary, AB. 128 p.

Ferrero, R.C., and W.A. Walker. 1999. Age, growth and reproductive patterns of Dall's porpoises (*Phocoenoides dalli*) in the central North Pacific Ocean. Marine Mammal Science 15: 273-313.

Ferrero, R.C., D.P. DeMaster, P.S. Hill, and M. Muto. 2000 Alaska marine mammal stock assessments. NOAA Technical Memorandum NMFS-AFSC. 176 p.

Ferrero, R.C., Walker, W.A., and Gosho, M. 1993. Preliminary analysis of northern right whale dolphin (*Lissodelphis borealis*) and Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) age and reproductive parameters from the Japanese squid driftnet fishery, June-November 1990. International North Pacific Fisheries Commission Bulletin 53: 297-312.

Field, J.G., G. Hempel, and C.P. Summerhayes. (Editors). 2002. Oceans 2020 science, trends, and the challenge of sustainability. Island Press, Washington, D.C. 365 p.

Fields, P., J. Graham, R. Rosenblatt, and G. Somero. 1993. Effects of global climate change on marine faunas. Trends in Ecology and Evolution 8: 361-367.

Finn, R.D., A.W. Trites, E.J. Gregr, and R.I. Perry. 2002. Diets of fin, sei, and sperm whales in British Columbia: an analysis of commercial whaling records, 1963-1967. Marine Mammal Science 18: 663-679.

Fiscus, C.H., H.W. Braham, R.W. Mercer, R.D. Everitt, B.D. Krogman, P.D. McGuire, C.E. Peterson, R.M. Sonntag, and D.E. Withrow. 1976. Seasonal distribution and relative abundance of marine mammals in the Gulf of Alaska. United States Department of Commerce, National Oceanic and Atmospheric Association , OCSEAP, Environ. Assess. Alaskan Continental Shelf Report, October-December, 1: 19-264.

Fisher, H.D. 1952. The status of the harbour seal in British Columbia, with particular reference to the Skeena River. Bulletin of the Fisheries Research Board of Canada 93: 58 p.

Fisher, H.D. 1981. Studies on the biology of sea lions in British Columbia. National Geographic Society Research Report 13: 215-219.

Fisher, R.A. 1958. The genetical theory of natural selection. Dover, New York, NY.

Fladmark, K.R. 1973. The Richardson Ranch site: a 19th century Haida house. p. 53-95. In: Historical archaeology in northwestern North America. R.M. Getty and K.R. Fladmark (eds.). Department of Archaeology, University of Calgary, Calgary, AB.

Ford, J.K.B. 1989. Acoustic behaviour of resident killer whales (*Orcinus orca*) off Vancouver Island, British Columbia. Canadian Journal of Zoology 67: 727-745.

Ford, J.K.B. 1991. Vocal traditions among resident killer whales (*Orcinus orca*) in coastal waters of British Columbia. Canadia Journal of Zoology 69: 1454-1483.

Ford, J.K.B. 2002. Killer whale *Orcinus orca*. p. 669-676. In: W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Encyclopedia of marine mammals. Academic Press, San Diego, CA.

Ford, J.K.B., K.Heise, L.G. Barrett-Lennard, and G.M. Ellis. 1994. Killer whales and other cetaceans of the Queen Charlotte Islands/ Haida Gwaii. Report prepared for Gwaii Haanas National Park Reserve, Queen Charlotte, B.C. by Vancouver Public Aquarium, Vancouver, B.C. 65 p.

Ford, J.K.B., G.M.Ellis, L.G. Barrett-Lennard, A.B. Morton, R.S. Palm, and K.C. Balcomb III. 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of Zoology 76: 1456-1471.

Ford, J.K.B., G.M. Ellis, and L.M. Nichol. 1992. Killer whales of the Queen Charlotte Islands. A preliminary study of the abundance, distribution and population identity of *Orcinus orca* in the waters of Haida Gwaii. Report prepared for South Moresby/Gwaii Haanas National Park Reserve, Queen Charlotte City, B.C.

Ford, J.K.B., and G.M. Ellis. 1999. Transients: mammal hunting killer whales of British Columbia, Washington and southeastern Alaska. University of British Columbia Press, Vancouver, B.C. 97 p.

Ford, J.K.B., G.M. Ellis, and K.C. Balcomb. 2000. Killer Whales: the natural history and genealogy of *Orcinus orca* in British Columbia and Washington. University of British Columbia Press, Vancouver, B.C. 104 p.

Forney, K.A., J. Barlow, and J.V. Caretta. 1995. The abundance of cetaceans in California waters. Part II. Aerial surveys in winter and spring of 1991 and 1992. Fishery Bulletin 93: 15-26).

Forney, K. A., and R. L. Brownell 1996. Preliminary report of the 1994 Aleutian Island marine mammal survey. Unpublished document submitted to the International Whaling Commission (SC/48/011) 15 p.

Forney, K.A., J. Barlow, M.M. Muto, M. Lowry, J. Baker, G. Cameron, J. Mobeley, C. Stinchcomb, and J.V.Caretta. 2000. U.S. Pacific marine mammal stock assessments: 2000. NOAA Technical Memorandum NMFS NOAA-TM-NMFS-SWFSC-300. 276 p.

Foster, J.B. 1989. Conservation on the Queen Charlotte Islands. p. 281-301. In: The outer shores. G.G.E. Scudder and N. Gessler (eds.). Queen Charlotte Islands Museum Press, Skidegate, B.C.

Foster, M. 1990. Organization of macroalgal assemblages in the Northeast Pacific: the assumption of homogeneity and the illusion of generality. Hydrobiologia 192: 21-33.

Fowler, C.W. 1987. A review of density dependence in populations of large mammals. In: H.H. Genoways (ed.). Current Mammalogy Vol. 1. Plenum Press, New York.

Frantzis, A. 1998. Does acoustic testing strand whales? Nature 392: 29 only.

Fraser, C.M. 1938. The relation of the marine fauna to the physiography of the west coast of the Queen Charlotte Islands. Canadian Field-Naturalist 52: 88-93.

Friedheim, R.L. (Editor). 2001. Toward a sustainable whaling regime. University of Washington Press, Seattle, WA and Canadian Circumpolar Institute Press, Edmonton, AB. 382 p.

Fritz, L.W., V.G. Wespestad, and J.S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. p. 30-43. In: Is it food? Addressing marine mammal and seabird declines: Workshop Summary, Alaska Sea Grant Report 93-01. Fairbanks, Alaska.

Frost, K.L, L.F. Lowry, J.M. Ver Hoef, and S.J. Iverson. 1997. Monitoring, habitat use, and trophic interactions of harbor seals in Prince William Sound, Alaska. *Exxon Valdez* Oil Restoration Project Annual Report (Restoration Project 96064), Alaska Department of Fish and Game, Division of Wildlife Conservation, Fairbanks, AK.

Frost, K.J., L.F. Lowry, and J. van Hoef. 1999. Monitoring the trend of harbor seals in Prince William Sound, Alaska, after the "Exxon Valdez" oil spill. Marine Mammal Science 15: 494-506.

Gabrielle, C.M., J.M. Straley, L. M. Herman, and R.J. Coleman. 1996. Fastest documented migration of a North Pacific humpback whale. Marine Mammal Science 12: 457-464.

Garcia, S.M. 1996. The precautionary approach to fisheries and its implications for fisheries research, technology and management: an updated review. FAO (Food and Agricultural Organization of the United Nations) Fisheries Technical Paper 350/2: 75 p.

Garshelis, D.L. 1997. Sea otter mortality estimated from carcasses collected after the *Exxon Valdez* oil spill. Conservation Biology 11: 905-916.

Gaskin, D.E. 1984. The harbour porpoise *Phocoena phocoena* (L.): regional populations, status and information on direct and indirect catches. Report of the International Whaling Commission 34: 569-586.

Gaston, A.J., and I.L. Jones. 1991. Seabirds and marine mammals recorded in western Hecate Strait, British Columbia, in spring and early summer, 1984-1989. Canadian Field-Naturalist 105: 550-560.

Gentry, R.L. 1970. Social behavior of the Steller sea lion. Ph.D dissertation, University of California, Santa Cruz, CA.

Gentry, R.L. 1981 a. Seawater drinking in eared seals. Comparative Biochemistry and Physiology 68A: 81-86.

Gentry, R.L. 1981 b. Northern fur seal – *Callorhinus ursinus* (Linneaus, 1758). In: S.H. Ridgway, and R.J. Harrison (eds.). Handbook of Marine Mammals, Vol. 1: The walrus, sea lions, fur seals and sea otter. Academic Press, New York.

Gentry, R.L. 2002 a. Eared seals *Otariidae*. p. 348-351. In: Encyclopedia of Marine Mammals. W.F. Perrin, B. Wursig and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Gentry, R.L. 2002 b. Northern fur seals. p. 813-816. In: Encyclopedia of Marine Mammals. W.F. Perrin, B. Wursig and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Gentry, R.L., and J.R. Holt. 1986. Attendance behaviour of northern fur seals. In: R.L. Gentry, and G.L. Kooyman (eds.). Fur seals: maternal strategies on land and at sea. Princeton University Press, Princeton, NJ.

Gentry, R.L., and J.H. Johnson. 1981. Predation by sea lions on northern fur seal neonates. Mammalia 45: 423-430.

Geraci, J.R. and D.J. St. Aubin. 1980. Offshore petroleum development and marine mammals: a review and research recommendations. Marine Fisheries Review **42(11)**: 1-12.

Geraci, J.R. and D.J. St. Aubin. (Editors). 1990. Sea mammals and oil: Confronting the risks. Academic Press, San Diego, CA.

Gerber, L.R., D.P. DeMaster, and P.M. Kareiva. 1999. Gray whales and the value of monitoring data in implementing the U.S. Endangered Species Act. Conservation Biology 13: 1215-1219.

Gibson, J.R. 1992. Otter skins, Boston ships, and China goods - The maritime fur trade of the Northwest coast 1785-1841. McGill-Queen's University Press, Montreal, QB and Kingston, ON.

Gisiner, R.C. 1985. Male territorial and reproductive behaviour in the Steller sea lion, *Eumetopias jubatus*. Ph.D. dissertation, University of California, Santa Cruz, CA.

Goddard, P.C., and D.J. Rugh. 1998. A group of right whales seen in the Bering Sea in July 1996. Marine Mammal Science 14: 344-349.

Green, G., J.J. Brueggeman, R.A. Grotefendt, C.E. Bowlby, M.L. Bonnell, and K.C. Balcomb III. 1992. Cetacean distribution and abundance off Oregon and Washington. Oregon and Washington Marine Mammal and Seabird Surveys- PCS Study 91-0093. Final Report to the Pacific OCS Region, Minerals Management Service, United States Deptment of the Interior, Los Angeles, CA.

Gregr, E.J. 2002. Whales in northern BC: past and present. University of British Columbia Fisheries Centre Research Report 10(1): 74-78.

Gregr, E.J. in press. Marine mammals in the Hecate Strait ecosystem. Canadian Technical Report of Fisheries and Aquatic Sciences.

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

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 Sciences 58: 1265-1285.

Guenther, T.J., R.W. Baird, J.K.B. Ford, K.M. Langelier, M. McAdie, S.G. Wishniowski, and T.E. Cornish. 1993. Cetacean strandings and entanglement in fishing gear on the west coast of Canada during 1992. International Whaling Commission Document SC/45/04. May 1993. 7 p.

Guiguet, C.J. 1953. California sea lions in British Columbia. Canadian Field-Naturalist 67: 140 only.

Guiguet, C.J. 1954. A record of Baird's dolphin (*Delphinus bairdi* Dall) in British Columbia. Canadian Field-Naturalist 68: 136 only.

Guiguet, C.J. 1971. An apparent increase in California sea lion, *Zalophus californianus* (Lesson) and elephant seal, *Mirounga angustirostris* (Gill), on the coast of British Columbia. Syesis 4: 263 only.

Hagelund, W.A. 1987 a. Whalers no more a history of whaling on the west coast. Harbour Publishing Co., Madeira Park, B.C. 211 p.

Hagelund, W.A. 1987 b. Whaling stations of the Queen Charlottes. p. 61-65. In: Raincoast Chronicles - Forgotten Villages of the BC Coast. H. White (ed.). Harbour Publishing Co., Madeira Park, B.C.

Haley, M. P., C. J. Deutsch, and B. J. Le Boeuf. 1994. Size, dominance, and copulatory success in male northern elephant seals, *Mirounga angustirostris*. Animal Behavior 48: 1249–1260.

Ham, L.C. 1990. The Cohoe Creek site: a late Moresby Tradition shell midden. Canadian Journal of Archaeology 14: 199-221.

Hammill, M.O. 2002. Earless seals *Phocidae*. p. 352-358. In: Encyclopedia of marine mammals. W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Hammond, P.S., S.A. Mizroch, and G.P. Donovan (Editors). 1990. Individual recognition of cetaceans: use of photo-identification and other techniques to estimate population parameters. International Whaling Commission Special Issue 12: 440 p.

Hanan, D. A. 1996. Dynamics of abundance and distribuition for Pacific harbor seal, *Phoca vitulina richardsi*, on the coast of California. Ph.D. dissertation, University of California. 157 p.

Hancock, D. 1970. California sea lion as a regular winter visitant off the British Columbia coast. Journal of Mammalogy 51: 614.

Harbour Publishing. 2001. Marine mammals of the Pacific northwest including Oregon, Washington, British Columbia and southern Alaska a concise and comprehensive waterproof guide. Harbour Publishing, Madeira Park, B.C.

Harfenist, A., N.A. Sloan, and P.M. Bartier. 2002. Living marine legacy of Gwaii Haanas. III: marine bird baseline to 2000 and bird-related management issues throughout the Haida Gwaii region. Parks Canada Technical Reports in Ecosystem Science No. 36: 164 pp.

Harper, J.R., W.C. Austin, M. Morris, P.D. Reimer, and R. Reitmeier. 1994. Ecological Classification of Gwaii Haanas - Biophysical Inventory of Coastal Resources. Report prepared for Parks Canada, Calgary, AB by Coastal & Ocean Resources Ltd., Sidney, B.C. 115 p.

Harris, R.E., G.W. Miller, and J.W. Richardson. 2001. Seal responses to airgun sounds during seismic surveys in the Alaska Beaufort Sea. Marine Mammal Science 17: 795-812.

Härkonen,T., and K.C. Harding. 2001. Spatial structure of harbour seal populations and the implications thereof. Canadian Journal of Zoology 79: 2115-2127.

Hart, J.L. 1973. Pacific Fishes of Canada. Bulletin of the Fisheries Research Board of Canada 180: 740 pp.

Harvey, J.T. 1987. Population dynamics, annual food consumption, movements and dive behaviors of harbor seals, *Phoca vitulina richardsi*, in Oregon. Ph.D. dissertation, Oregon State University. 177 p.

Hatler, D. 1972. The mammals of the Pacific Rim Park. National and Historic Parks Branch, Western Region, Calgary, Alberta 223p. report on file at Pacific Biological Station, Nanaimo, B.C.

Heath, C.B. 2002. California, Galapagos, and Japanese sea lions *Zalophus californianus, Z. wollebaeki,* and *Z. japonicus*. p. 180-186. In: Encyclopedia of marine mammals. W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Hebda, R., and S.G. Frederick. 1990. History of marine resources of the Northeast Pacific since the last glaciation. Transactions of the Royal Society of Canada, Series I 1: 319-342.

Heide-Jørgensen, M.-P. and T. J. Härkönen. 1988. Rebuilding seal stocks in the Kattegat-Skagerrak. Marine Mammal Science. 4: 231-46.

Heise, K.A. 1996. Life history parameters of the Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) and its diet and occurrence in the coastal waters of British Columbia. M.Sc. Thesis. University of British Columbia. 95 p.

Heise, K.A., 1997 a. Diet and feeding behaviour of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) as revealed through the collection of prey fragments and stomach content analyses. Report of the International Whaling Commission 47: 807-815.

Heise, K.A. 1997 b. Life history and population parameters of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*). Report of the International Whaling Commission 47: 817-825.

Heise, K., L. Barrett-Lennard, J.K.B. Ford, and G.Ellis. 1993. Killer whales of the Queen Charlotte Islands – Results of research on the abundance, distribution, and population identity of *Orcinus orca* in the haters of Haida Gwaii in 1992. Report prepared for South Moresby/Gwaii Haanas National Park Reserve, Queen Charlotte City, B.C. 36 p.

Heise, K., L.G. Barrett-Lennard, E. Saultitis, C.O Matkin, and D. Bain. 2003. Examining the evidence for killer whale predation on Steller sea lions in British Columbia and Alaska. Aquatic Mammals 29: (in press).

Heise, K., and J.K.B. Ford. 2002. Cetaceans of Haida Gwaii. Report prepared for Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C. 79 p.

Higgins, L. 1984. Maternal behavior and attendance patterns of the Steller sea lion in California. M.Sc. thesis, University of California, Santa Cruz, CA.

Hindell, M.A. 2002. Elephant seals *Mirounga augustirostris*. p. 370-373. In: Encyclopedia of marine mammals. W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Hilborn, R., J-J. Macguire, A.M. Parma, and A.A. Rosenberg. 2001. The Precautionary Approach and risk management: can they increase the probability of successes in fishery management? Canadian Journal of Fisheries and Aquatic Sciences 58: 99-107.

Hiramatsu, K. 1993. Estimation of population abundance of northern right whale dolphins in the North Pacific using the bycatch data from the Japanese squid driftnet fishery. International North Pacific Fisheries Commission Bulletin 53: 381- 386.

Hobbs, R.C., and L.L. Jones. 1993. Impact of high seas driftnet fisheries on marine mammal populations in the North Pacific. International North Pacific Fisheries Commission Bulletin 53: 409-434.

Hoelzel, R., E.M. Dorsey, and S.J. Stern. 1989. The foraging specialization of individual minke whales. Animal Behaviour 38: 786-794.

Holt, S.J. 2003. The tortuous history of "scientific" Japanese whaling.BioScience 53: 204-206.

Honma, Y., T. Ushiki, M. Takeda, E. Naito, K. Dewa, and H. Yamanouchi. 1999. Identification by histological and microsatellite analyses of a stranded beaked whale as that struck previously by a jetfoil operating in the Sea of Japan. Fisheries Science 65: 547-552.

Holt, S.J. 2003. The tortuous history of "scientific" Japanese whaling. BioScience 53: 204-206.

Hood, W.R., and K.A. Ono. 1997. Variation in maternal attendance patterns and pup behaviour in a declining population of Steller sea lions (*Eumetopias jubatus*). Canadian Journal of Zoology 75: 1241-1246.

Hooker, S.K., H. Whitehead, and S. Gowans. 1999. Marine protected area design and the spatial and temporal distribution of cetaceans in a submarine canyon. Conservation Biology 13: 592-602.

Hoover-Miller, A.A. 1994. Harbor seal (*Phoca vitulina*) biology and management in Alaska. Final Report for Contract T75134749. Marine Mammal Commission, Washington, D.C. 45 p.

Horwood, J. 2002. Sei whale *Balaenoptera borealis*. p. 1069-1071. In: W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Encyclopedia of marine mammals. Academic Press, San Diego, CA.

Houck, W.J., and T.A. Jefferson. 1999. Dall's porpoise – *Phocoenoides dalli* (True, 1885). p. 443-472. In: Handbook of marine mammals. Volume 6: the second book of dolphins and porpoises. S.H. Ridgway and R. Harrison (eds.). Academic Press, San Diego, CA.

Houston, J. 1991, Status of Cuvier's beaked whales, *Ziphius cavirostris*, in Canada. Canadian Field-Naturalist 105: 215-218.

Huber, H.R. 1987. Natality and weaning success in relation to age of first reproduction in northern elephant seals. Canadian Journal of Zoology 65: 1311-1316.

Huber, H.R., A.C. Rovetta, L.A. Fry, and S. Johnston. 1991. Age-specific natality of northern elephant seals at the South Farallon Islands, California. Journal of Mammalogy 72: 525-534.

Huelsbrek, D.R. 1988. The surplus economy of the central northwest coast. Research in Economic Anthropology Supplement 3: 149-178.

Hunter, A.M.J., and A.W. Trites. 2001. An annotated bibliography of scientific literature (1751-2000) pertaining to Steller sea lions (*Eumetopias jubatus*) in Alaska. University of British Columbia Fisheries Centre Research Reports 9(1): 45 p.

IC (Industry Canada). 2000. Forging ahead: a report on science and technology – 1999. Industry Canada, Ottawa. 69 p. [http://strategis.ic.gc.ca/SSG/].

Ikonomou, M.G., S. Rayne, M. Fisher, M.P. Fernandez, and W. Cretney. 2002. Occurrence and congener profiles of polybrominated diphenyl ethers (PBDEs) in environmental samples from coastal British Columbia. Chemosphere 46: 649-663.

IWC (International Whaling Commission). 1997. Annex E. Report of the sub-committee on southern hemisphere baleen whales. Report of the International Whaling Commission 47: 128-139.

IWC (International Whaling Commission). 1998. Annex J. Report of the sub-committee on aboriginal subsistence whaling. Report of the International Whaling Commission 48: 237-245.

Jacques Whitford Environment, Ltd. 2001. British Columbia Offshore Oil and Gas Technology Update. Report prepared for the British Columbia Ministry of Energy Mines and Resources, Victoria, B.C. 187 p.

Jameson, R.J., and K.W. Kenyon. 1977. Prey of sea lions in the Rogue River, Oregon. Journal of Mammalogy 58: 672.

Jameson, R.J., K.W. Kenyon, A.M. Johnson, and H.M. Wright. 1982. History and status of translocated sea otter populations in North America. North America Wildlife Society Bulletin 10: 100-107.

Jamieson, G.S., and A. Campbell. 1995. Red sea urchins and kelp in northern British Columbia. p. 537-547. In: Ecology of fjords and coastal waters. H.R. Skjoldal, C. Hopkins, K.E. Erikstad, and H.P. Lrinaas (eds.). Elsevier Science, Amsterdam.

Jamieson, G.S., and P.F. Olesiuk. 2001. Salmon farm - pinniped interactions in British Columbia: an analysis of predator control, its justification and alternative approaches. Canadian Science Advisory Secretariat Research Document 2001/142.

Jarman, W.M., R.J. Nostrom, D.C.G. Muir, B. Rosenberg, M. Simon, and R.W. Baird. 1996. Levels of organochlorines in blubber of cetaceans from the west coast of North America. Marine Pollution Bulletin 32: 426-436.

Jefferies, S.J. 1986. Seasonal movements and population trends of harbour seals (*Phoca vitulina richardsi*) in the Columbia River and adjacent waters of Washington and Oregon: 1976-82. Final Report of the Marine Mammal Commission MM2079357-5: 41 p.

Jeffries, S.J., and T.C. Newby. 1986. Pacific harbour seal. p.209-215 In: D. Haley (ed.). Marine Mammals of Eastern North Pacific and Arctic Waters (2nd ed.) Pacific Search Press, Seattle, WA.

Jefferson, T.A. 1990. Status of Dall's porpoises, *Phocoenoides dalli*, in Canada. Canadian Field-Naturalist 104: 112-116.

Jepson, P.D., M. Arbelo, R. Deaville, I.A.P. Patterson, P. Castro, J.R. Baker, E. Degollada, H.M. Ross, P. Herraez, A.M. Pockwell, F. Rodriguez, F.E. howie, A. Espnosa, R.J. Reid, J.R. Jaber, V. Martin, A.A. Cunningham, and A. Fernandez. 2003. Gas-bubble lesions in stranded cetaceans. Nature 425: 575-576.

Johannessen, O., E. Shalina, and M. Miles. 1999. Satellite evidence for an Arctic sea ice cover transformation. Science 286: 1937-1939.

Johnston, D.W., P. Meisenheimer, and D.M. Lavigne. 2000. The evaluation of management objectives for Canada's commercial harp seal hunt, 1996-1998. Conservation Biology 14: 729-737.

Johnston, D.W. 2002. The effect of acoustic harassment devices on harbour porpoises (*Phocoena phocoena*) in the Bay of Fundy, Canada. Biological Conservation 108:113-118.

Jonaitis, A. 1999. The Yuquot whalers' shrine. University of Washington Press, Seattle, WA. 233 p.

Jones, M.L., and S.L. Swartz. 2002. Gray Whale. p. 813-816. In: Encyclopedia of Marine Mammals. W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Jones, R.R. 1999. Haida names and utilization of common fish and marine mammals. University of British Columbia Fisheries Centre Research Report 7(3): 39-48.

Jones, R.R., and T. Ryan. 2002. Using traditional ecological knowledge in "Back to the Future" modelling. University of British Columbia Fisheries Centre Research Report 10(1): 112-114..

Jones, R.R., and Guujaaw. 2000. Haida abalone issues. Canadian Special Publication of Fisheries and Aquatic Sciences 130: 5-6.

Josenhans, H., D. Fedje, R. Pienitz, and J. Southon. 1997. Early humans and rapidly changing Holocene sea levels in the Queen Charlotte Islands – Hecate Strait, British Columbia, Canada. Science 277: 71-74.

Kajimura, H., and T.R. Loughlin 1988. Marine mammals in the oceanic food web of the eastern subarctic Pacific. Bulletin of the Ocean Research Institute, University of Tokyo 26: 187-223.

Katona, S., B.Baxter, O. Brazier, S. Kraus, J. Perkins, and H. Whitehead. 1979. Identification of humpback whales by fluke photographs. In: Behaviour of Marine Animals, Volume 3: 33-44. H.E.Winn and B.L. Olla (eds.). Plenum Press, New York.

Kelly, B.P. 1981. Pelage polymorphism in Pacific harbour seals. Canadian Journal of Zoology 59: 1212-1219.

Kenney, R.D. 2002. North Atlantic, north Pacific, and southern right whales *Eubaleana glacialis*, *E. japonica*, and *E. australis*. p. 806-812. In: Encyclopedia of Marine Mammals. W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Kenyon, K.W. 1969. The sea otter in the eastern Pacific Ocean. United States Fish and Wildlife Service, North American Fauna Report 68: 352 p. [reprinted unabridged in1975 by Dover Publications, Inc., New York].

Kenyon, K.W., and D.W. Rice. 1961. Abundance and distribution of the Steller sea lion. Journal of Mammalogy 42: 223-234.

Ketten, D.R., J. Lien, and S. Todd. 1993. Blast injury in humpback whale ears: evidence and implications. Journal of the Acoustic Society of America. 94: 1849-1850.

Kimball, L.A. 2003. International ocean governance – using international law and organizations to manage marine resources sustainably. World Conservation Union (IUCN), Gland, Switzerland and Cambridge, UK, 124 p.

Knudtson, P. M. 1974. Birth of a harbor seal. Natural History 83: 30-37.

Knudtson, P. M. 1977. Observations on the breeding behavior of the harbor seal in Humboldt Bay, California. California Fish and Game 63: 66-70.

Kraus, S.A., A.J. Read, A. Solow, K. Baldwin, T. Spradlin, E., and J. Williamson. 1997. Acoustic alarms reduce porpoise mortality. Nature 388: 525.

Kvitek, R.G., J.S. Oliver, A.R. Grange, and B.S. Aderson. 1992. Changes in Alaskan soft-bottom prey communities along a gradient in sea otter predation. Ecology 73: 413-428.

Laake, J., J. Calambokidis, and S. Osmek. 1998. Survey report for the 1997 aerial surveysfor harbor porpoise and other marine mammals of Oregon, Washington, and British Columbia outside waters. Pacific Stock Assessment Working Paper 98-PSRG-1. 20 p.

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

Lander, R.H. 1980. Summary of northern fur seal data and collection procedures. Vol.1: Land Data of the United States and Soviet Union (excluding tag and recovery records). NOAA Technical Memorandum NMFS F/NWC-3: 315 p.

Lander, R.H. and H. Kajimura. 1976. Status of northern fur seals. Food and Agricultural Organization (FAO; United Nations), Advisory Committee on Marine Resource Research, FAO Scientific Consultation of Marine Mammals, Bergen, Norway, 31 August – 9 September, 1976. ACMRR/MM/SC/34, 50 p.

Laws, R.M. 1956. The elephant seal (*Mirounga loenina* Linn.). II. General, social and reproductive behavior. Falkland Islands Dependencies Survey, Scientific Report 13: 1-88.

Leatherwood, S., W.F. Perrin. V.L. Kirby, C.L. Hubbs, and M. Dahlheim. 1980. Distribution and movements of Risso's dolphin, *Grampus griseus*, in the eastern North Pacific. Fishery Bulletin 77: 951-963.

Leatherwood, S., and R.R. Reeves. 1983. The Sierra Club handbook of whales and dolphins. Sierra Club, San Francisco, CA. 302 p.

Leatherwood, S., R.R. Reeves, W.F. Perrin, and W.E. Evans. 1982. Whales dolphins and porpoises of the eastern North Pacific and adjacent Arctic waters. A guide to their identification. NOAA Technical Report NMFS Circular 444: 245 p.

LeBoeuf, B.J. 1994. Variation in the diving pattern of northern elephant seals with age, mass, sex, and reproductive condition. Chapter 13. In: B.J. LeBoeuf, and R.M. Laws (eds.). Elephant seals: population ecology, behavior, and physiology. University of California Press, Berkeley, CA.

LeBoeuf, B.J., D.E. Crocker, D.P. Costa, S.B. Blackwell, P.M. Webb, and D.S. Houser. 2000. Foraging ecology of northern elephant seals. Ecological Monographs 70: 353-382

LeBoeuf, B.J., and R.M. Laws. 1994. Elephant seals: population ecology, behaviour and physiology. University of California Press, Berkeley, CA.

Lien, J. 2001. The conservation basis for the regulation of whale watching in Canada by the Department of Fisheries and Oceans: a precautionary approach. Canadian Technical Report of fisheries and Aquatic Sciences 2363: 24 p.

Loughlin, T.R. (Editor). 1994. Marine mammals and the Exxon Valdez. Academic Press, New York. 395 p.

Loughlin, T.R. 1997. Using the phylogeographic method to identify Steller sea lion stocks. p. 159-171. In: A. Dizon, S. J. Chivers, and W. F. Perrin (eds.). Molecular genetics of marine mammals. Special Publication No. 3, Society for Marine Mammalogy.

Loughlin, T.R. 2002. Steller's sea lion *Eumetopias jubatus*. p. 1181-1185. In: Encyclopedia of marine mammals. W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Academic Press, San Diego.

Loughlin, T.R., B.E. Ballachey, and B.A. Wright. 1996. Overview of studies to determine injury caused by the *Exxon Valdez* oil spill to marine mammals. In: Proceedings of the Exxon Valdez Oil Spill Symposium. S.D. Rice, R.B. Spies, D.A. Wolfe. and B.A. Wright (eds.). American Fisheries Society Symposium 18: 798-808.

Loughlin, T.R., A.S. Perlov, J.D. Baker, S.A. Blokhin, and A.G. Makhnyr. 1998. Diving behavior of adult female Steller sea lions in the Kuril Islands, Russia. Bios Conservation 1: 21-31.

Lux, C.A., A.S. Costa, and A.E. Dizon. 1997. Mitochondrial DNA population structure of the Pacific white-sided dolphin. Report of the International Whaling Commission 47: 645-652.

Lyrholm, T., O. Leimar, B. Johanneson, and U. Gyllensten. 1999. Sex-biased dispersal in sperm whales: Contrasting mitochondrial and nuclear genetic structure of global populations. Proceedings of the Royal Society of London - Series B: Biological Sciences. 266: 347-354.

MacLeod, C.D., M.B. Santo, and G.J. Pierce. 2003. Review of data on diets of beaked whales: evidence of niche separation and geographic segregation. Journal of the Marine Biological Association of the United Kingdom 2003: 651-665.

Madsen, P.T., B. Mohl, B.K. Nielsen, and M. Wahlberg. 2002. Male sperm whale behaviour during exposure to distance survey pulses. Aquatic Mammals 28: 231-240.

Mandryk, C.A.S., H. Josenhans, D.W. Fedje, and R.W. Mathewes. 2001. Late quaternary paleoenvironments of Northwestern North America: implications for inland versus coastal migration routes. Quaternary Science Reviews 20: 301-314.

Maniscalco, J.M., K. Wynne, K. Pitcher, M. B. Hanson, S.R. Melin, and S. Atkinson. The occurrence of California sea lions (*Zalophus californianus*) in Alaska. Canadian Field-Naturalist. *In Review*.

Manzer, J.I., G.C. Pike, and I.B. MacAskie. 1969. Distribution and migration of northern fur seals in the northeast Pacific Ocean. Unpublished report on file at Pacific Biological Station (DFO), Nanaimo, B.C. 41 p.

Marrett, R. 1992. Underwater noise from tourist operations. Conservation Advisory Science Notes 1: 6 p. New Zealand Department of Conservation, Wellington, NZ.

Mate, B.R. 1975. Annual migration of the Steller sea lion and California sea lion along the coast of Oregon. Journal de Conseil International Exploration de la Mer 169:455-461.

Mate, B.R. and D.P. DeMaster. 1986. California sea lion. In: Haley, D. (ed.). Marine mammals of eastern north Pacific and arctic waters. Pacific Search Press, Seattle, WA.

Matkin, C.O., G.M. Ellis, O. von Ziegesar, and R. Steiner. 1986. Killer whales and longline fisheries in Prince William Sound, Alaska 1986. Report for the U.S. Department of Commerce, NOAA, National Marine Fisheries Service Northwest and Alaska Fisheries Center, National Marine Mammal Laboratory, Seattle, Washington. Contract 40ABNF6-2262. 15 p.

Matkin, C.O., G. Ellis, E. Saulitis, L.G. Barrett-Lennard, and D. Matkin. 1999. Killer Whales of Southern Alaska. North Gulf Oceanic Society, Homer, Alaska. 96 p.

Matkin, C.O., D. Scheel, G. Ellis, L. Barrett-Leonard, H. Jurk, and E. Saulitis. 1998. Comprehensive killer whale investigation. *Exxon Valdez* Oil Spill Restoration Project Annual Report, Restoration Project 97012. Report for the *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK by the North Gulf Oceanic Society, Homer, AK. 58 p.

Matson, M., and Mclay, M. 1996. Preliminary report on the 1995 archaeological investigation of Shingle Point (drgv2), Valdez Island. Report to the Lyacksun Band, Chemainus, B.C. and the B.C. Archaeology Branch, Victoria.

McAskie, I. 1987. Updated status of the sea otter, *Enhydra lutris*, in Canada. Canadian Field-Naturalist 101: 279-283.

McCartney, A.P. (Editor). 1995. Hunting the largest animals - native whaling in the Western Arctic and subarctic. Studies in Whaling No. 3, Occasional Publication No. 36. Canadian Circumpolar Institute, University of Alberta, Edmonton, 345 p.

McTaggart- Cowan, I., and C.J. Guiget. 1956. The mammals of British Columbia, British Columbia Provincial Museum Handbook No. 11 (2nd ed.). 415 p.

Mercier, F., and C. Mondor. 1995. Sea to sea to sea – Canada's National Marine Conservation Areas system plan. Parks Canada, Hull, P.Q. 106 p.

Merrick, R.L. 1987. Behavioral and demographic characteristics of northern sea lion rookeries. M.Sc. thesis, Oregon State University, Corvallis, OR.

Merrick, R.L., and T.R. Loughlin. 1997. Foraging behavior of adult female and young-of-year Steller sea lions in Alaskan waters. Canadian Journal of Zoology 75: 776-786.

Milette, L.L., and A.W. Trites. 2003. Maternal attendance patterns of lactating Steller sea lions (*Eumetopias jubatus*) from a stable and a declining population in Alaska. Canadian Journal Zoology 81: 340-348.

Minh, T.B., H. Nakata, M.Watanabe, S. Tanabe, N. Miyazaki, T.A. Jefferson, M. Prudente, and A. Subramanian. 2000. Isomer-specific accumulation and toxic assessment of polychlorinated biphenyls, including coplanar congeners, in cetaceans from the North Pacific and Asian coastal waters. Archives of Environmental Contamination and Toxicology 39: 398-410.

Mitchell, D. 1988. Changing patterns of resource use in the prehistory of Queen Charlotte Strait. Research in Economic Anthropology Supplement 3: 245-290.

Mitchell, E. 1975. Report on the meeting on smaller cetaceans, Montreal April 1-11, 1974, Subcomittee on Small Cetaceans, Scientific Committee, International Whaling Commission. Journal of the Fisheries Research Board of Canada 32: 888-944.

Miyashita, T. 1993. Distribution and abundance of some dolphins taken in the North Pacific driftnet fisheries. International North Pacific Fisheries Commission Bulletin 53: 435-449.

Monson, D.H., D.F. Doak, B.E. Ballachey, A. Johnson, and J.L. Bodkin. 2000. Long-term impacts of the *EXXON Valdez* oil spill on sea otters, assessed through age-dependent mortality patterns. Proceedings of the U.S. National Academy of Science 97: 6562-6567.

Moore, K. 1988. Problem, Issue or Concern (PIC) Statement: Proposed sea otter re-introduction to the west coast of the Queen Charlotte Islands is delayed – the South Moresby National Park Reserve is an alternative site for a re-introduction of sea otters. Report prepared for Canadian Park Service (on file at Gwaii Haanas National Park Reserve, Queen Charlotte City, B.C.) by Moore Resource Management, Queen Charlotte City, B.C., 6 p.

Moore, S.E., and J.T. Clarke. 2002. Potential impact of offshore human activities on gray whales (*Eschrichtius robustus*). Journal of Cetacean Research and Management 4: 19-25.

Moore, S.E., J.M. Grebmeier, and J.D. Davies. 2003. Gray whale distribution relative to forage habitat in the northern Bering Sea: current conditions and retrospective summary. Canadian Journal of Zoology 81: 734-742.

Morton, A. 2000. Occurrence, photo-identification and prey of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) in the Broughton Archipelago, Canada 1984-1998. Marine Mammal Science 16: 80-93.

Morton, A.B., and H. K. Symonds. 2001. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. ICES Journal of Marine Science 58: 1-10.

Morton, J. 1992. Homeland to hinterland: the southern archipelago of the Queen Charlotte Islands since European contact. Historical Services, Western Regional Office, Canadian Parks Service (Environment Canada). 211 p.

Murdock, G.P. 1934. Our primitive contemporaries. MacMillan Co., New York. 614 p.

Murie, D.J. 1981. The migration of the northern fur seal, *Callorhinus ursinus* Linneaus 1758, in the eastern north Pacific Ocean and eastern Bering Sea: An analysis of pelagic sealing logs of the years 1886 to 1911. BSc. Honours Thesis, University of Victoria, B.C.

Nemoto, T. 1959. Food of baleen whales with reference to whale movements. Scientific Reports of the Whales Research Institute, Tokyo 14: 149-290.

Newcombe, C.F., Greenwood, W.H., and C. McLean. 1918. Preliminary report of the Commission on the sea-lion question, 1915. B.C. sea lion investigation, special commissioner's preliminary and main reports. Contributions to Canadian Biology (Studies from the Biological Stations of Canada 1917-1918), Supplement to the 7th Annual Report of the Department of the Naval Service, Fisheries Branch (8 George V, Session Paper No. 38a).

Newcombe, C.F., and W.A. Newcombe. 1914. Sea lions on the coast of British Columbia. Annual Report, British Columbia Commission of Fisheries for 1913: 131-145.

Niblack, A.P. 1890. The coast Indians of southern Alaska and northern British Columbia. Report of the United States National Museum (Smithsonian Institution) 1887-1888: 255-386.

Nichol, L.M., M. Badry, J. Broadhead, L. Convey, C. Cote, C. Eros, J.K.B. Ford, R. Frank, F. Gillette, M. James, R.J. Jameson, S. Jefferies, M. Joyce, D. Lawseth, D. Lynch, M. Patterson, P. Shepherd, and J.C. Watson. 2003. National Recovery Strategy for the sea otter (*Enhydra lutris*) in British Columbia [Final Draft, June]. 59 p. [http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/sea-otters/default_e.htm].

Nichol, L.M., E.J. Gregr, R. Flinn, J.K.B. Ford, R. Gurney, L. Michaluk, and A. Peacock. 2002. British Columbia commercial whaling catch data 1908 to 1967: a detailed description of the B.C. historical whaling database. Canadian Technical Report of Fisheries and Aquatic Sciences 2371: 77 p.

Nichol, L.M., and K. Heise. 1992. The historical occurrence of large whales off the Queen Charlotte Islands. Report prepared for Gwaii Haanas National Park Reserve, Queen Charlotte, B.C. 67 p.

Nichol, L.M., P.F. Wainwright, P.F. Olesiuk, and B.D. Smiley. 1993. West coast data inventory and appraisal. Volume 4. Dixon Entrance, Hecate Strait, Queen Charlotte Sound and adjoining B.C. coastal waters: biological oceanography – marine mammals 1862 through 1991. Canadian Data Report of Hydrography and Ocean Sciences 37: 321 p.

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

NMFS (U.S. National Marine fisheries Service). 2003. Atka mackeral study points towards effectiveness of no-trawl zones. National Marine Fisheries Service Alaska Region News Release NMFS 03-AKR September 9, 2003. [www.fakr.noaa.gov].

Nolan, C.P., G.M. Liddle, and J. Elliot. 2000. Interactions between killer whales (*Orcinus orca*) and sperm whales (*Physeter macrocephalus*) with a longline fishing vessel. Marine Mammal Science 16: 658-664.

Norris, T.F., M. McDonald, and J. Barlow. 1999. Acoustic detections of singing humpback whales in the eastern North Pacific during their northbound migration. Journal of the Acoustic Society of America 106: 506-514.

NRC (National Research Council). 2001. Marine Protected Areas: Tools for Sustaining Ocean Ecosystems. National Academy Press, Washington, D.C. 272 p.

O, M., and J.K.B. Ford. 2003. National recovery strategy for the North Pacific right whale in Pacific Canadian waters. Final Draft (August 15, 2003). [http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/rightwhale/default_e.htm].

O'Corry-Crowe, G.M., K.K. Martien, and B.L. Taylor. 2003. The analysis of population genetic structure in Alaskan harbor seals, *Phoca vitulina*, as a framework for the identification of management stocks. National Oceanic and atmospheric Administation Administrative Report LJ-03-08.

O'Daniel, D., and J.C. Schneeweis. 1992. Steller sea lion, *Eumetopias jubatus*, predation on Glaucous-winged gulls, *Larus glaucescens*. Canadian Field-Naturalist 106: 268.

Odell, D.K. 1972. Studies on the biology of the California sea lion and the northern elephant seal on San Nicolas Island, California. Ph.D. Dissertation, University of California, Los Angeles, CA.

Oftedal, O. T., W. D. Bowen, E. M. Widdowson, and D. J. Boness. 1991. The prenatal molt and its ecological significance in hooded and harbour seals. Canadian Journal of Zoology 69: 2489-2493.

Ohizumi, H., T. Isoda, T. Kishiro, and H. Kato. 2003. Feeding habits of Baird's beaked whale *Berardius bairdii*, in the western North Pacific and Sea of Okhotsk off Japan. Fisheries Science 69: 11-20.

Ohsumi, S., and S. Wada 1974. Status of whale stocks in the North Pacific. Report of the International Whaling Commission 24: 114-126.

O'Leary, B.L. 1984. Aboriginal whaling from the Aleutian Islands to Washington State. p. 79-120. In: The gray whale *Eschrichtius robustus*. M.L. Jones, S.L. Swartz,and S. Leatherwood (eds.). Academic Press, Orlando, FL.

Olesiuk, P.F. 1993. Annual prey consumption by harbor seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia. Fishery Bulletin 91: 491-515.

Olesiuk, P.F. 1999. An assessment of the status of harbour seals (*Phoca vitulina*) in British Columbia. Canadian Stock Assessment Secretariat Research Document 99/033: 71 p.

Olesiuk, P.F. 2003. Recent trends in the abundance of Steller sea lions (*Eumetopias jubatus*) in British Columbia. North Pacific Marine Mammal Research Consortium Working Paper No. 2003-10.

Olesiuk, P.F. In preparation a. Compilation of kill statistics and reconstruction of historic population trends for harbour seals (*Phoca vitulina*) in British Columbia.

Olesiuk, P.F. In preparation b. Biology and status of California sea lions (*Zalophus californianus*) and Steller sea lions (*Eumetopias jubatus*) wintering off southern Vancouver Island.

Olesiuk, P.F., and M.A. Bigg. 1987. Seasonal changes in condition of male Steller sea lions, *Eumetopias jubatus*. Report on file at Pacific Biological Station (DFO), Nanaimo, B.C.

Olesiuk, P.F., and M.A. Bigg. 1988. Seals and sea lions in British Columbia. Department of Fisheries and Oceans Publication, Catalogue No. Fs 23-130/1988E. 12 p.

Olesiuk, P.F., M.A. Bigg, and G.M. Ellis. 1990 a. Recent trends in abundance of harbour seals, *Phoca vitulina*, in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 47: 992-1003.

Olesiuk, P.F., M.A. Bigg, G.M. Ellis, S.J. Crockford and R.J. Wigen. 1990 b. An assessment of the feeding habits of harbour seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia, base on scat analysis. Canadian Technical Report of Fisheries and Aquatic Sciences 730: 135 p.

Olesiuk, P.F., M.A. Bigg, and G.M. Ellis. 1990 c. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission, Special Issue 12: 209-242.

Olesiuk, P.F., D. Burles, G. Horonowitsch, and T.G. Smith. 1993. Aerial censuses of pinnipeds in the Queen Charlotte Islands, 1 July-1 August, 1992. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2217: 27 p.

Olesiuk, P.F., D.G. Calkins, K.W. Pitcher, W.L. Perryman, C. Stinchcomb, and M. Lynn. 2003. An evaluation of Steller sea lion (*Eumetopias jubatus*) pup counts from 35mm oblique photographs. North Pacific Marine Mammal Research Consortium Working Paper No. 2001-09.

Olesiuk, P.F., P.E. Cottrell, and C.E. Neville. 1996. An assessment of harbour seal (*Phoca vitulina*) predation on pre-spawning adult salmon (*Oncorhynchus* spp.) in Comox Harbour and the lower Puntledge River, British Columbia. Pacific Stock Assessment Review Committee Working Paper S96-18. Report on file with the senior author, Pacific Biological Station (DFO), Nanaimo.

Olesiuk, P.F., L.M. Nichol, M.J. Sowden, J.K.B. Ford. 2002. Effect of the sound generated by an acoustic harassment device on the relative abundance and distribution of harbor porpoises (*Phocena phocena*) in Retreat Passage, British Columbia. Marine Mammal Science 18: 843-862.

Olesiuk, P.F., T.G. Smith, G. Horonowitch, and G.M. Ellis. 1995 a. Translocation of harbour seals (*Phoca vitulina*): A demonstration of homing ability and site fidelity. Abstract: 10th Biennial Conference on the Biology of Marine Mammals, Orlando, FL.

Olesiuk, P.F., G. Horonowitsch, G.M. Ellis, T.G. Smith, L. Flostrand, and S. Warby. 1995 b. Predation by harbour seals (*Phoca vitulina*) on outmigrating salmon (*Oncorhynchus* spp.) fry and smolts in the lower Puntledge River, British Columbia. DFO - Pacific Stock Assessment Review Committee Working Paper S95-10. Report on file with the senior author, Pacific Biological Station (DFO), Nanaimo.

Orchard, T.J. 2003. Gwaii Haanas environmental archaeology project 2002: report on 2002 field activities. Report prepared for Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C. by Department or archaeology, University of Toronto. 67 p.

Orians, G., F. Briand, J. Diamond, T. Colborn, E. Gomez, R. Guillemin, A. Klug, M. Konishi; J. Lubchenco, L. Mee, E. Norse, G. N. Di Sciara, R. Payne, C. Safina, D. Suzuki, E.O. Wilson, and G. Woodwell. 2003. "Scientists versus Whaling": Whose errors of judgment? BioScience 53: 202-203.

Orr, R.T., and T.C. Poulter. 1967. Some observations on reproduction, growth, and social behavior in the Steller sea lion. Proceedings of the California Academy of Sciences 35: 193-226.

OSB (Ocean Studies Board). 2003. Ocean Noise and Marine Mammals. National Academies Press, Washington, D.C. 208 p.

Osgood, W.H. 1901. Natural History of the Queen Charlotte Islands, British Columbia, Natural History of the Cook Inlet region, Alaska. North American Fauna 21. 50 p.

Oxman, D.S. 1995. Seasonal abundance, movements, and food habits of harbor seals (*Phoca vitulina richardsi*) in Elkhorn Slough, California. M.Sc. Thesis, California State University, Stanislaus, CA. 126 p.

Paine, R.T. 1995. A conversation on refining the concept of keystone species. Conservation Biology 9: 926-964.

Paine, R.T., J.L. Ruesink, A. Sun, E.L. Soulanille, M.J. Wonham, C.D.G. Harley, D.R. Brumbaugh, and D.L. Secord. 1996. Trouble on oiled waters: lessons from the *Exxon Valdez* oil spill. Annual Reviews of Ecology and Systematics 27: 197-235.

Parks Canada. 1994. Guiding principles and operational policies. Parks Canada, Hull, QB. 125 p.

Parks Canada Agency. 2000. Unimpaired for future generations? Protecting ecological integrity with Canada's national parks. Volume I. A call to action. Volume II. Setting a new direction for Canada's national parks. Report of the Panel on the Ecological Integrity of Canada's National Parks. Parks Canada Agency, Ottawa, ON.

Patch, C.A. 1922. A biological reconnaissance on Graham Island, Queen Charlotte group. Canadian Field-Naturalist 36: 101-105, 133-136.

Patin, S. 1999. Environmental impact of the offshore oil and gas industry. EcoMonitor Publishing, East Northport, NY. 425 p.

Pauly, D., A.W. Trites, E. Capuli, and V. Christensen. 1998. Diet composition and trophic levels of marine mammals. ICES Journal of Marine Science 55: 467-481.

Payne, R.S., and S. McVay. 1971. Songs of humpback whales. Science 173: 585-597.

Perez, M.A., and M.A. Bigg. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fisherias Bulletin 84: 957-971.

Perrin, W.F., and S.B.Reilly. 1984. Reproductive parameters of dolphins and small whales of the family Delphinidae. Report of the International Whaling Commission Special Issue 6: 97-134.

Perrin, W.F., G.P. Donovan, and J. Barlow. (Editors). 1994. Gillnets and Cetaceans. Report of the International Whaling Commission Special Issue 15.

Perrin, W.E., B. Würsig, and J.G.M. Thewissen (Editors). 2002. Encyclopedia of marine mammals. Academic Press, San Diego, CA. 1414 p.

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.

Peterson, C.H. 2001. The “Exxon Valdez” oil spill in Alaska: acute, indirect and chronic effects on the ecosystem. Advances in Marine Biology 39: 1-103.

Peterson, C.H., S.D. Rice, J.W. Short, D. Esler, J.L. Bodkin, B.E. Ballachey, and D.B. Irons. 2003. Long-term ecosystem response to the *Exxon Valdez* oil spill. Science 302: 2082-2086.

Peterson, R.S. 1968. Social behavior in pinnipeds with particular reference to the northern fur seal. In: R.J. Harrison, R.C. Hubbard, R.S. Peterson, C.E. Rice, and R.J. Schusterman (eds.). The behavior and physiology of pinnipeds. Appleton-Century-Crofts, New York.

Peterson, R.S. and G. A. Bartholomew. 1967. The natural history and behavior of the California sea lion. American Society of Mammalogy Special Publication No. 1.

Pike, G.C. 1956. Age, growth and maturity studies on fin whales from the coast of British Columbia. Report on file at Pacific Biological Station (DFO), Nanaimo, B.C. 56 p.

Pike, G.C. 1958. Food of the northern sea lion. Fisheries Research Board of Canada, Progress Report of the Pacific Coast Biological Station, Nanaimo 112.

Pike, G.C. 1965. Schooling and migration of sperm whales off British Columbia. Unpublished report on file at Pacific Biological Station (DFO), Nanaimo, B.C.

Pike, G.C., and I. B. MacAskie. 1969. Marine mammals of British Columbia. Bulletin of the Fisheries Research Board of Canada 171: 54 p.

Pike, G.C., and B.E. Maxwell. 1958. The abundance and distribution of the northern sea lion (*Eumetopias jubata*) on the coast of British Columbia. Journal of the Fisheries Research Board of Canada 15: 5-17.

Pitcher, K.W., and D.G. Calkins. 1979. Biology of the harbour seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Uuited States Department of Commerce, National Oceanic and Atmospheric Administration, OCSEAP Final Report 19: 231-310.

Pitcher, K.W., D.G. Calkins, and G. Pendleton. 1998. Reproductive performance of female Steller sea lions: an energetics-based reproductive strategy? Canadian Journal of Zoolgy 76: 2075-2083.

Pitcher, K.W., and F.H. Fay. 1982. Feeding by Steller sea lions on harbor seals. The Murrelet 63: 70-71.

Pitcher, K.W., and D.C. McAllister. 1981. Movements and haulout behaviour of radio-tagged harbour seals, *Phoca vitulina*. Canadian Field-Naturalist 95: 292-297.

Pitcher, K.W., P.F. Olesiuk, R.F. Brown, M. Lowry, J. Sease, W. Perryman, C. Stinchcomb, and L. Lowry. 2003. Status and trend of the eastern population of Steller sea lions. Marine Sciences in the Northeast Pacific Symposium, January, 2003, Anchorage, Alaska.

Pitcher, T.J. 1998. Pleistocene pastures: Steller’s sea cow and sea otters in the Strait of Georgia. In: Back to the future: reconstructing the Strait of Georgia. University of British Columbia Fisheries Centre Research Report 6(5): 48-52.

Porter, B. 1997. Winter ecology of Steller sea lions (*Eumetopias jubatus*) in Alaska. M.Sc. thesis, University of British Columbia, Vancouver, B.C.

Poulter, T.C. 1965. Localization of the point of origin of the vocalization of the California sea lion, *Zalophus californianus*. Proceedings of the 2nd Annual Conference on Biology and Sonar Diving Mammals. p. 41-48. Stanford Research Institute, Menlo Park, CA.

QCI (Queen Charlotte Islands) Observer, 2003. January 23 issue, p. 3. // April 10 issue, p. 9 // August 28 issue, p. 8, 19, 20. Published weekly in Queen Charlotte City, B.C.

Ralls, K., D.P. DeMaster, and J.A. Estes. 1996. Developing a criterion for delisting the southern sea otter under the U.S. Endangered Species Act. Conservation Biology 10: 1528-1537.

Ralls, K, and B.L. Taylor. 2000. Better policy and management decisions through explicit analysis of uncertainty: new approaches from marine conservation. Conservation Biology 14: 1240-1242.

Raum-Suryan, K.L., K.W. Pitcher, D.G. Calkins, J.L. Sease, and T.R. Loughlin. 2002. Dispersal, rookery fidelity, and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. Marine Mammal Science 18: 746-764.

Read, A. 1999. Harbour porpoise – *Phocoena phocoena* (Linnaeus, 1758). p. 323-355. In: Handbook of Marine Mammals. Volume 6: The second book of dolphins and the porpoises. S.H. Ridgway, and R. Harrison (eds.). Academic Press, New York. 486 pp.

Read, A.J., and P.R. Wade. 2000. Status of marine mammals in the United States. Conservation Biology 14: 929-940.

Reeves, R.R. 2002. The origins and character of 'aboriginal subsistence whaling: A global review. Mammal Review 32: 71-106.

Reeves, R.R., and E. Mitchell. 1993. Status of Baird's beaked whale, *Berardius bairdii*. Canadian Field-Naturalist 107: 509-523.

Reeves, R.R., and H. Whitehead. 1997. Status of the sperm whale, *Physeter macrocephalus*, in Canada. Canadian Field-Naturalist 111: 293-307.

Rehberg, M.J., K.L. Raum-Suryan, K.W. Pitcher, and T.S. Gelatt. 2001. Development of juvenile Steller sea lion (*Eumetopias jubatus*) diving behavior in Alaska. Abstract in: . Proceedings of the 14th Biennial Conference on the Biology of Marine Mammals, December, 2001, Vancouver, B.C.

Reijnders, P.J.H., A. Aguilar, and G.P. Donovan (eds.). 1999. Chemical Pollutants and Cetaceans. Journal of Cetacean Research and Management (Special Issue 1).

Reimchen, T. 1980. Sightings of Risso's dolphins (*Grampus griseus*) off Queen Charlotte Islands, British Columbia. The Murrelet 61:44-45.

Reiter, J., N.L. Stinson, and B.J. LeBoeuf. 1978. Northern elephant seal development: the transition from weaning to nutritional independence. Behavioral Ecology and Sociobiology 3: 337-367.

Rendell, L.E. and H. Whitehead. 2003. Comparing repertoires of sperm whale codas: A multiple methods approach. Bioacoustics 14: 61-81.

Repenning, C.A. 1975. Adaptive evolution of sea lions and walruses. Systematic Zoology 25: 375-390.

Rice, D.W. 1977. Synopsis of biological data on the sei whales and Bryde's whale in the eastern North Pacific. Report of the International Whaling Commission Special Issue 1: 92-97.

Rice, D.W. 1978. The humpback whale in the North Pacific: distribution, exploitation and numbers. Appendix 4: 29-44. In: Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. K.S. Norris, and R.R. Reeves (eds.). U.S. Department of Commerce National Technical Information Service PB-280 794. 90 p.

Rice, D.W. 1986. The gray whale. p. 64-71. In: Marine Mammals. D. Haley (ed). Pacific Search Press, Seattle. 295 p.

Rice, S.D., Spies, R.B., D.A. Wolfe, and B.A. Wright (eds.). 1996. Proceedings of the *Exxon Valdez* oil spill symposium. American Fisheries Society Symposium 18: 931 p.

Richardson, M., and B. Green. 1989. The fisheries co-management initiative in Haida Gwaii. p. 249-261. In: Co-operative management of local fisheries – new directions for improved management and community development. E. Pinkerton (ed.). University of British Columbia Press, Vancouver, B.C.

Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. Academic Press, San Diego, CA. 576 p.

Riley, F. 1967. Fur seal industry of the Pribilof Islands, 1786-1965. United States Fish and Wildlife Service, Circular 275: 12 p.

Robbins, L.L., F.K. Oldham, and E.M.K. Geiling. 1937. The stomach contents of sperm whales caught off the west coast of British Columbia. Report of the British Columbia Provincial Museum 1937: 19-20.

Robinson, C.L.K., R. Douglas, and D.M. Ware. 1999. A synthesis of oceanographic and biological information for Gwaii Haanas NMCA continental shelf ecosystems. Report prepared for Gwaii Haanas National Park Reserve, Queen Charlotte, B.C. by Northwest Ecosystem Institute, Lantzville, B.C. 122 p.

Robinson, M.P. 1996. Sea otter chiefs. Bayeux Arrts, Calgary, AB. 94 p.

Roemmich, D., and J. McGowan. 1995. Climate warming and the decline of zooplankton in the California current. Science 267: 1324-1326.

Roffe, T.J., and B.R. Mate. 1984. Abundances and feeding habits of pinnipeds in the Rogue River, Oregon. Journal of Wildlife Management 48: 1261-1274.

Roman, J., and S.R. Palumbi. 2003. Whales before whaling in the North Atlantic. Science 301: 508-510.

Rosel, P.E., A.E. Dizon, and J.E. Heyning. 1994. Population genetic analysis of two forms of the common dolphin (genus *Delphinus*) utilizing mitochondrial DNA control region sequences. Marine Biology 119: 159-167.

Rosen, D.A.S., and A.W. Trites. 2000. Pollock and the decline of Steller sea lions: testing the junk food hypothesis. Canadian Journal of Zoology 78: 1243-1250.

Ross, P.S. 2000. Marine mammals as sentinels in ecological risk assessment. Human and Ecological Risk Assessment 6: 29-46.

Ross, P.S., G.M. Ellis, M.G. Ikonomu, L.G. Barrett-Lennard, and R.F. Addison. 2000. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: effects of age, sex and dietary preference. Marine Pollution Bulletin 40: 504-515.

Ross, P.S., R.D. Swart, P.J.H. Reijnders, H.V. Loveren, J.G. Vos, and A.D.M.E. Osterhaus. 1995. Contaminant-related suppression of delayed-type hypersensitivity and antibody responses in harbour seals fed herring from the Baltic Sea. Environmental Health Perspectives 103: 162-167.

Rowley, J. 1929. Life history of sea lions on the California coast. Journal of Mammalogy 10: 1-36.

Ruby, S., L.T. Mendoza, M.Fournier, P. Brousseau, and V. Degas. 2003. Reproductive system impairment of mice fed diets containing beluga whale blubber from the St. Lawrence estuary and Arctic populations. Journal of Toxicology and Environmental Health Part A. 66: 1073-1085.

Safina, C. 2002. Eye of the albatross: visions of hope and survival. Henry Holt, New York. 377 p.

Sala, E., C.F. Boudouresque, and M. Harmelin-Vivien. 1998. Fishing, trophic cascades, and the structure of algal assemblages: evaluation of an old but untested paradigm. Oikos 82: 425-439.

Sandegren, F.E. 1970. Breeding and maternal behaviour of the Steller sea lion (*Eumetopias jubatus*) in Alaska. M.Sc thesis, University of Alaska, Fairbanks, AK.

Sandegren, F.E. 1976. Courtship display, agonistic behavior and social dynamics in the Steller sea lion. Behaviour 57: 136-158.

Saulitis, E., C.Matkin, L. Barrett-Lennard, K. Heise, and G. Ellis. 2000. Foraging strategies of sympatric killer whale (*Orcinus orca*) populations in Prince William Sound, Alaska. Marine Mammal Science 16: 94-109.

Scammon, C.M. 1874. The marine mammals of the North-western coast of North America, described and illustrated: together with an account of the American whale-fishery. J.H. Carmany & Co., San Francisco 319 p. [reprinted unabridged in 1968 by Dover Publications, Inc., New York].

Scarff, J. 1986. Right whale. p. 72-81. In: Marine Mammals (2nd edition). D. Haley (ed.). Pacific Search Press, Seattle, WA. 295 p.

Scheffer, V.B., and J.W. Slipp. 1944. The harbor seal in Washington State. American Midland Naturalist 32: 373-416.

Scheffer, V.B., and J.W. Slipp. 1948. The whales and dolphins of Washington State with a key to the cetaceans of the west coast of North America. American Midland Naturalist 39: 257-337.

Schmitt, R.J., and C.W. Osenberg (Editors). 1996. Detecting ecological impacts concepts and applications in coastal habitats. Academic Press, San Diego, CA. 401 p.

Scholin, J. 2000. Mortality of sea lions along the central California coast linked to a toxic diatom bloom. Nature 403: 80-84.

Schusterman, R.J., F. Balliet, and S.S. John. 1970. Vocal displays underwater by the grey seal, the harbor seal and the Steller sea lion. Psychological Science 18: 303-305.

Schusterman, R.J., and R.L. Gentry. 1971. Development of a fatted male phenomenon in California sea lions. Developmental Psychobiology 4: 333-338.

Sears, R., J.M. Williamson, F.W. Wenzel, M. Berube, D. Gendron, and P. Jones. 1990. Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada. Report of the International Whaling Commission Special Issue 12: 335-342.

Severs, P.D.S. 1974 a. Preliminary report on archaeological investigations at Tow Hill, GaTw-5, in Naikoon Park, Queen Charlotte Islands. Report on file, Cultural Resources, Western Canada Service Centre, Parks Canada, Victoria, B.C. 26 p.

Severs, P.D.S. 1974 b. Archaeological investigations at Blue Jackets Creek, FlUa-4, Queen Charlotte Islands, British Columbia, 1973. Canadian Archaeological Association Bulletin 6: 165-205.

Shaughnessey, P.D., and F.H. Fay. 1977. A review of the taxonomy and nomenclature of North Pacific harbour seals. Journal of Zoology (London). 182: 385-419.

Simmonds, M.P., and L.F. Lopez-Jurado. 1991. Whales and the military. Nature 351: 448.

Simpson, S.L. 1971. Of whales and crabs – Naden Harbour 1919 to 1923. In: The Charlottes a Journal of the Queen Charlotte Islands No. 1: 9-12. (published by the Queen Charlotte Islands Museum Society).

Sinclair, E.H., and T.K. Zeppelin. 2002. Seasonal and spatial differences in diet in the western stock of Steller sea lions (*Eumetopias jubatus*). Journal of Mammalogy 83: 973-990.

Smiley, B., D. Thomas, W. Duvall, and A. Eade. 1998. Selecting indicators for marine ecosystem health: a conceptual framework and an operational procedure. State of the Environment Reporting Occasional Paper Series 9: 33 p. Prepared for the National Marine Indicators Working Group (Environment Canada and Fisheries and Oceans Canada), Ottawa.

Smith, L.N. 1988. The influence of rookery terrain on population structure, territorial behavior, and breeding success of Steller sea lions in the Gulf of Alaska. M.Sc. Thesis, University of Alaska, Fairbanks, AK. 100 p.

Sloan, N.A. 1999. Oil impacts on cold-water marine resources: a review relevant to Parks Canada's evolving marine mandate. Parks Canada - National Parks Occasional Paper 11: 67 p. [http://www.parkscanada.gc.ca/library/DownloadDocuments/].

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

Sloan, N.A. 2004. Northern abalone: using an invertebrate to focus marine conservation ideas and values. Coastal Management 32: *in press*.

Sloan, N.A., and P.M. Bartier. 2000. Living marine legacy of Gwaii Haanas. I: marine plant baseline to 1999 and plant-related management issues. Parks Canada Technical Reports in Ecosystem Science No. 27: 104 pp.

Sloan, N.A., P.M. Bartier, and W.C. Austin. 2001. Living marine legacy of Gwaii Haanas. II: marine invertebrate baseline to 2000 and invertebrate-related management issues. Parks Canada Technical Reports in Ecosystem Science No. 35: 331 pp.

Sloan, N.A., and P.A. Breen. 1988. Northern abalone, *Haliotis kamtschatkana*, in British Columbia: fisheries and synopsis of life history information. Canadian Special Publication of Fisheries and Aquatic Sciences 103: 46 p.

Spalding, D.J. 1964. Comparative feeding habits of the fur seal, sea lion and harbour seal on the British Columbia coast. Bulletin of the Fisheries Research Board of Canada. 146: 52 p.

Spies, R.B., S.D. Rice, D.A. Wolfe, and B.A. Wright. 1996. The effects of the *Exxon Valdez* oil spill on the Alaskan coastal environment. In: Proceedings of the Exxon Valdez Oil Spill Symposium. S.D. Rice, R.B. Spies, D.A. Wolfe, and B.A. Wright (eds.). American Fisheries Society Symposium 18: 1-16.

Springer, A.M., G.B. van Vliet, T.M. Wiliams, D.F. Doak, E.M. Danner, K.A. Forney, and B. Pfister. 2003. Sequential megafaunal collapse in the North Pacific Ocean: an ongoing legacy of industrial whaling? Proceedings of the National Academy of Sciences 100: 12223-12228.

Stacey, P.J., and R.W. Baird. 1991. Status of the Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, in Canada. Canadian Field-Naturalist 105: 219-232.

Stacey, P.J., and R.W. Baird. 1993. Sightings, strandings and incidental catches of short-finned pilot whales, *Globicephala macrohynchus*, off the British Columbia coast. Report of the International Whaling Commission Special Issue 14: 475-479.

Stacey, P.J., D.A. Duffus, and R.W. Baird. 1997. A preliminary evaluation of incidental mortality of small cetaceans in coastal fisheries in British Columbia, Canada. Marine Mammal Science 13: 321-326.

Stacey, P.J., S. Leatherwood, and R.W. Baird. 1994. *Pseudorca crassidens*. Mammalian Species No. 456: 6 p.

Stafford, K.M., S. L. Nieukirk, and C.G. Fox. 1999. An acoustic link between blue whales in the Eastern Tropical Pacific and the Northeast Pacific. Marine Mammal Science 15: 1258-1268.

Stewart, B.S., and P. K. Yochem. 1989. Diving and foraging ecology of harbour seals in southern California waters. Abstract in: 8th Biennial Conference on the Biology of Marine Mammals, December, 1989, Pacific Grove, CA.

Stewart, B.S., P.K. Yochem, H.R. Huber, R.L. DeLong, R.J. Jameson, W.J. Sydeman, S.G. Allen, and B.J. LeBoeuf. 1994. History and present status of the northern elephant seal population. Chapter 2. In: B.J. LeBoeuf, and R. M. Laws (eds.). Elephant seals: population ecology, behavior, and physiology. University of California Press, Berkeley, CA.

Stirling, I., N. Lunn, and J.Iacozza. 1999. Long-term trends in the population ecology of polar bears in western Hudson Bay in relation to climate change. Arctic 52: 294-306.

Stroud, R.K., C.H.Fiscus, and R.K. Kajimura. 1981. Food of the Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, Dall's porpoise, *Phocoenoides dalli*, and northern fur seal, *Callorhinus ursinus*, off California and Washington. Fishery Bulletin 78: 951-959.

Stutz, S.S. 1967. Pelage patterns and population distribution in the Pacific harbour seal (*Phoca vitulina richardi*). Journal of the Fisheries Research Board of Canada 24: 451-455.

Sullivan, R.M. 1981. Aquatic displays and interactions in harbor seals, *Phoca vitulina*, with comments on mating systems. Journal of Mammalogy 62: 825-831.

Sumpter, I.D. 1999. 1998 archaeological investigations – Site 922T *Gunlia Kin* (Hotspring Island), Gwaii Haanas. Report on file, Cultural Resource Services, Parks Canada Western Service Centre, Victoria, B.C.

Suryan, R.M. and J.T. Harvey. 1998. Tracking harbor seals (*Phoca vitulina richardsi*) to determine dive behavior, foraging activity, and haul-out site use. Marine Mammal Science 14: 361-372.

Swain, U.G. 1999. Steller sea lion foraging studies in Southeast Alaska during 1998. Presentation to the Steller Sea Lion Research Peer Review Feeding Ecology Workshop. February, 1999, Seattle, WA.

Swain, U.G., and D.G. Calkins. 1997. Foraging behaviour of juvenile Steller sea lions in the northeastern Gulf of Alaska: diving and foraging trip duration. p. 92-106. In: Steller sea lion recovery investigations in Alaska, 1995-1996. Division of Wildlife Conservation. Alaska Department of Fish and Game, Anchorage, AK.

Swain, U.G., J.P. Lewis, and G.W. Pendleton. 1996. Movements, haulout, and diving behavior of harbor seals in southeast Alaska and Kodiak Island. p 59-144. In: Annual report of harbor seal investigations in Alaska. Final Report for National Oceanic and Atmospheric Administration Grant NA57FX0367. Alaska Department of Fish and Game, Anchorage, AK. 203 p.

Swain, U.G., and R.J. Small. 1997. Movements and diving behavior of harbor seals in southeast Alaska and the Kodiak Archipelago. p. 119-175. In: Annual report of harbor seal investigations in Alaska, National Oceanic and Atmospheric Administration Grant NA557FX0367, Alaska Department of Fish and Game, Anchorage, AK. 291 p.

Tanaka, E. 1993. Population trajectories and effects of incidental takes by driftnet on some dolphin populations using the Hitter/ Fitter model. International North Pacific Fisheries Commission Bulletin 53: 451-460.

Taylor, R., and B. Gough. 1977. New sighting of sea otter reported for Queen Charlotte Islands. Syesis 10: 177 only.

Temte, J.L., M.A. Bigg, and O. Wiig. 1991. Clines revisited: the timing of pupping in the harbour seal (*Phoca vitulina*). Journal of Zoology (London) 224: 617-632.

Thomson, R.E. 1989. Physical oceanography. p. 27-63. In: The Outer Shores. G.G.E. Scudder, and N. Gessler (eds.). Queen Charlotte Island Museum Press, Skidegate, B.C.

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

Thompson, P.M., and P. Rothery. 1987. Age and sex difference in the timing of moult in the common seal, *Phoca vitulina.* Journal of Zoology (London) 212: 597-603.

Townsend, C.H. 1899. Pelagic sealing. p.223-274. In: D.S. Jordan, L. Stejneger, F.A. Lucas, J.F. Moser, C.H. Townsend, G.A. Clark, and J. Murray (eds.). The fur seals and fur-seal islands of the North Pacific Ocean. United States Treasury Department Document 2017 (Part 3): 629 p. (in 4 parts).

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica (Scientific Contributions of the New York Zoological Society) 19(1): 50 p. (and four separate map plates).

Trites, A.W. 1990. The northern fur seal: Biological relationships, ecological patterns and population management. Ph.D. Dissertation, University of British Columbia, Vancouver, B.C. 330 p.

Trites, A.W. 2002. Diet of Stellar sea lions at Gwaii Haanas National Park: Summer 2000. Report prepared by University of British Columbia Mammal Research Unit on file at Gwaii Haanas National Park Reserve, Queen Charlotte, B.C. 6 p.

Trites, A.W., and M.A. Bigg. 1996. Physical growth of northern fur seals (*Callorhinus ursinus*): seasonal fluctuations and migratory influences. Journal of Zoology, London 238: 459-482.

Trites, A.W, V. Christensen, and D. Pauly. 1997. Competition between fisheries and marine mammals for prey and primary production in the Pacific Ocean. Journal of the Northwest Atlantic Fishery Science 22: 173-187.

Trites, A.W., and C.P. Donnelly. 2003. The decline of Steller sea lions in Alaska: a review of the nutritional stress hypothesis. Mammal Reviews 33: 3-28.

Trites, A.W., and P. A. Larkin. 1996. Changes in the abundance of Steller sea lions (*Eumetopias jubatus*) in Alaska from 1956 to 1992: how many were there? Aquatic Mammals 22: 153-166.

Trites, A.W., P.A. Livingston, M.C. Vasconcellos, S. MacKinson, A.M. Springer, and D. Pauly. 1999. Ecosystem change and the decline of marine mammals in the eastern Bering Sea: testing the ecosystem shift and commercial whaling hypotheses. University of British Columbia Fisheries Centre Research Report 7(1): 106 p.

Trites, A.W., and D. Pauly. 1998. Estimating mean body masses of marine mammals from maximum body lengths. Canadian Journal of Zoolgy 76: 886-896.

Trites, A.W., and B.T. Porter. 2002. Attendance patterns of Steller sea lions (*Eumetopias jubatus*) and their young during winter. Journal of Zoolgy (London) 256: 547-556.

Turnock, B.J., and S.T. Buckland. 1995. Trends in abundance of Dall's porpoise in the western North Pacific, 1979 to 1989. Report of the International Whaling Commission Special Issue 16: 399-405.

Turnock, B.J., and T.J. Quinn. 1991. The effect of responsive movement on abundance estimation using line transect sampling. Biometrics 47: 701-715.

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

Tyack, P.L., and C.W. Clark. 2000. Acoustic communication in whales and dolphins. p. 156-224. In: W.W.L. Au, A.N. Popper, and R.R. Fay (eds.). Hearing by whales and dolphins. Springer Verlag, New York.

USGS (United States Geological Survey). 1999. Seismic survey to map earthquake faults and other subsea stratigraphic information. [http://geopubs.wr.usgs.gov/open-file/of99-572/doc9.pdf].

VAMSC (Vancouver Aquarium Marine Science Centre). 2003. Encounter with humpback whale scary. [www.vanaqua.org/aquanews].

Vandermeulen, H. 1998. The development of marine indicators for coastal zone management. Ocean and Coastal Management 39: 63-71.

Vania, J.S., and E. Klinkhart. 1967. Sea lions. Marine mammal report. Vol. VIII. Alaska Department of Fish and Game, Fedral Aid Wildlife Restoration Annual Project Segment Report. Anchorage, AK.

Vinnikov, K.Y., A. Robock, R.J. Stouffer, J.E. Walsh, C.L. Parkinson, D.J. Cavalier, J.F.B. Mitchell, D. Garrett, and V.F. Zakharov. 1999. Global warming and Northern Hemisphere sea ice extent. Science 286: 1934-1936.

Wada, S. 1973. The ninth memorandum on the stock assessment of whales in the North Pacific. Report of the International Whaling Commission 23: 164-169.

Wailes, G.H., and W.A. Newcombe. 1929. Sea lions. Museum and Art Notes 4: 1-10. Art, History and Science Association, Vancouver, B.C.

Waite, J.M., M.E. Dahlheim, R.C. Hobbs, S.A. Mizroch, O. von Ziegesar, J.M. Straley, L.M. Herman, and J. Jacobsen. 1999. Evidence of a feeding aggregation of humpback whales (*Megaptera novaengliae*) around Kodiak Island, Alaska. Marine Mammal Science 15: 210-220.

Walker, W.A. 1996. Summer feeding habits of Dall's porpoises, *Phocoenoides dalli*, in the southern Sea of Okhotsk. Marine Mammal Science 12: 167-181.

Walker, W.A., and L. Jones. 1993. Food habits of northern right whale dolphin, Pacific white-sided dolphin and northern fur seal caught in the high seas driftnet fisheries off the North Pacific Ocean. International Pacific Fisheries Commission Bulletin 53: 285-296.

Walker, W.A., S. Leatherwood, K.R. Goodrich, W.F. Perrin, and R.K. Stroud. 1986. Geographical variation and biology of the Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, in the northeastern Pacific. p. 441-465. In: Research on Dolphins. M.M. Bryden, and R. Harrison (eds.). Oxford University Press, Oxford.

Walker, W.A., J.G. Mead, and R.L. Brownell Jr. 2002. Diet of Baird's beaked whales, *Beriaedius bairdii*, in the southern Sea of Ohkotsk and off the Pacific coast of Honshu, Japan. Marine Mammal Science 18: 902-919.

Waters, S.L. 1992. Non-consumptive utilization of marine mammals in Canada: international and national regulation. p. 141-172. In: Canadian ocean law and policy. D. Vander Zwaag (ed.). Butterwoeths, Toronto, ON.

Watkins, W.A., and W.E. Schevill. 1977. Sperm whale codas. Journal of the Acoustic Society of America 62: 1486-1490.

Watling, L., and E.A. Norse. 1998. Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. Conservation Biology 12: 1180-1197.

Watson, J.C. 1993. The effects of sea otter (*Enhydra lutris*) foraging on shallow rocky communities off northwestern Vancouver Island, British Columbia. Ph.D. dissertation University of California, Santa Cruz. 169 p.

Watson, J.C. 2000. The effects of sea otters (*Enhydra lutris*) on abalone (*Haliotis* spp.) populations. Canadian Special Publication of Fisheries and Aquatic Sciences 131: 123-132.

Watson, J.C., G.M. Ellis, T.G. Smith, and J.K.B. Ford. 1997. Updated status of the sea otter, *Enhydra lutris*, in Canada. Canadian Field-Naturalist 11: 277-286.

Watson, J.C., and T.G. Smith. 1996. The effects of sea otters on invertebrate fisheries in British Columbia: a review. Canadian Technical Report of Fisheries and Aquatic Sciences 2089: 262-303.

Watts, P. 1991. Hauling out behaviour of harbour seals (*Phoca vitulina richardsi*) with particular attention to thermal constraints. Ph.D. Dissertation. University of British Columbia, Vancouver, B.C. 196 p.

Watts, P. 1992. Thermal constraints on hauling out by harbour seals (*Phoca vitulina*). Canadian Journal of Zoology 70: 553-560.

WCOEEAP (West Coast Offshore Exploration Environmental Assessment Panel) 1986. Offshore hydrocarbon exploration report and recommendations of the West Coast Offshore Exploration Environmental Assessment Panel. Supply and Services Canada, Ottawa. 123 p. [*Federal-B.C. Provincial Panel conducted a public review process*].

Webb, R.L. 1988. On the Northwest - Commercial whaling in the Pacific northwest 1790-1967. University of British Columbia Press, Vancouver, B.C. 425 p.

Weilgart, L. S., and H. Whitehead. 1997. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. Behavioural Ecology and Sociobiology 40: 277-285.

Wells, P.G., J.N. Butler, and J.S. Hughes (Editors). 1995. *Exxon Valdez* oil spill: Fate and effects in Alaskan waters. American Society for Testing and Materials (ASTM) STP 1219. American Society for Testing and Materials, Philadelphia, PA. 955 p.

Whitehead, H. 2002. Sperm whale *Physter macrocephalus*. p. 1165-1172. In: W. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Encyclopedia of marine mammals. Academic Press, San Diego, CA.

Whitehead, H., and L.S. Weilgart. 1991. Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. Behaviour 118: 275-296.

Whitehead, H., and L. Weilgart. 2000. The sperm whale: social females and roving males. p. 154-172. In: Cetacean Societies: field studies of dolphins and whales. R.C. Connor, P.L. Tyack, and H. Whitehead (eds.). University of Chicago Press, Chicago.

Wigen, R.J. 1982. Faunal analysis from FaTt-1, Anthony Island. Appendix 1 of Archaeological Investigations: SgA'ngwa-i Inaga'-i. Report on file at Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C.

Wigen, R.J., 1999 a. Analysis of bone from 922T, Hotspring Island, Units 7 and 9. Appendix A. In: Fedje and Sumpter (1999). Report prepared for Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C., by Cultural Resource Services, Western Canada Service Centre, Parks Canada, Victoria, B.C. 81 p.

Wigen, R.J. 1999 b. Analysis of fauna from Second Beach Site, FhTx-19. Report prepared for Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C. by Pacific ID on subcontract to Millennia Research, Victoria, B.C.

Wilke, F., and K.W. Kenyon. 1952. Notes on the food of fur seal, sea-lion, and harbor porpoise. Journal of Wildlife Management 16: 396-397.

Williams, R., A.W. Trites, and D.E. Bain. 2002. Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: opportunistic observations and experimental approaches. Journal of Zoology, London 256: 255-270.

Willis, P.J., and R.W. Baird. 1998. Sightings and strandings of beaked whales on the west coast of Canada. Aquatic Mammals 24: 21-25.

Winship, A.J., A.W. Trites, and D.G. Calkins. 2001. Growth in body size of the Steller sea lion (*Eumetopias jubatus*). Journal of Mammalogy 82: 500-519.

Winship, A., and A.W. Trites. 2003. Prey consumption by Steller sea lions in Alaska: How much do they require? Fisheries Bulletin 101: 147-163.

Winship, A.J., A.W. Trites, and D.A.S. Rosen. 2002. A bioenergetic model for estimating the food requirements of Steller sea lions (*Eumetopias jubatus*) in Alaska, USA. Marine Ecology Progress Series 229: 291-312.

Woodby, D., R. Larson, and J. Rumble. 2000. Decline of the Alaska abalone (*Haliotis* spp.) fishery and prospects for rebuilding the stock. Canadian Special Publication of Fisheries and Aquatic Sciences 131: 25-31.

Woodley, S. 1993. Monitoring and measuring ecosystem integrity in Canadian National Parks. p. 155-176. In: Ecosystem integrity and the management of ecosystems. S. Woodley, G. Francis, and J. Kay (eds.). St. Lucie Press, FL.

Wooster, W.S. 1993. Is it food? An overview. In: Is is food? Addressing marine mammal and seabird declines, workshop summary. Alaska Sea Grant College Program Report AK-SG-93-01: 1-3.

Wynne, K. 1997. Guide to marine mammals of Alaska. 2nd Edition. Alaska Sea Grant College Program Marine Advisory Bulletin 44: 75p. Fairbanks, AK.

Yablokov, A.V. 1994. Validity of whaling data. Nature 367: 108 only.

Yano, K., and M.E. Dahlheim. 1995. Killer whale, *Orcinus orca*, depredation on longline catches of bottomfish in the southeastern Bering Sea and adjacent waters. Fishery Bulletin 93: 355-372.

Yochem, P.K., B.S. Stewart, R.L. DeLong, and D.P. DeMaster. 1987. Diel haul-out patterns and site fidelity of harbor seals (*Phoca vitulina richardsi*) on San Miguel Island, California, in autumn. Marine Mammal Science 3: 323-332.

York, A. 1987. Northern fur seal, *Callorhinus ursinus*, Eastern Pacific Population (Pribilof Islands, Alaska, and San Miguel Island, California). p. 9-21. In: Status, biology and ecology of fur seals. Proceedings of an International Symposium and Workshop Cambridge, England, 23-27 April 1984. United States NOAA Technical Report NMFS 51.

Zacharias, S.K., and Wanagun (now Captain Gold). 1993. Gwaii Haanas 91 Archaeology: 1991 archaeological resource inventory of southeastern Moresby Island within the Gwaii Haanas/South Moresby National Park Reserve. Canadian Parks Service, Western Region. Report prepared for Gwaii Haanas National Park Reserve and Haida Heritage Site, Queen Charlotte City, B.C. 97 p.

Parcs Canada, région de l'Atlantique, produira trois séries de rapports en sciences des écosystèmes afin de communiquer de nouvelles données scientifiques, de consigner des données scientifiques, et de résumer les connaissances existantes ou de formuler des recommandations d'ordre technique. La fonction principale et le public visé détermineront la série dans laquelle un rapport sera publié. Chaque série contiendra des informations scientifiques et techniques qui viendront enrichir les connaissances existantes, mais ne pourraient être publiées dans les revues professionnelles en raison de leur présentation.

- ***Les Rapports techniques en sciences des écosystèmes - Parcs Canada*** favoriseront la diffusion à grande échelle d'information scientifique et technique tirée des études spéciales effectuées par Parcs Canada. La matière traitée et la série reflètent l'intérêt et les politiques de Parcs Canada dans de nombreux aspects des sciences des écosystèmes. La série comprendra des inventaires d'écosystèmes, des inventaires de ressources, des études diverses, des relevées sur des espèces ou des guildes et des concepts innovateurs de gestion.
- ***Les Rapports d'études en matière de sciences des écosystèmes - Parcs Canada*** permetteront la publication de comptes rendus, de bibliographies et d'études d'options en matière de gestion faites par Parcs Canada. Les descriptions et les analyses de ressources sont aussi publiées dans cette série, en entier ou en partie.
- ***Les Rapports de surveillance et de données relatives aux écosystèmes - Parcs Canada*** offriront un moyen de présenter des compilations de données sans analyse détaillée. En général, ce genre de compilation sert à appuyer des publications scientifiques ou des rapports techniques en sciences des écosystèmes. Parcs Canada publiera dans cette série des données brutes qui ne sont pas inclues dans une banque de données nationale et qui méritent l'archivage.

Rapports en sciences des ecosystèmes sont publiés dans la langue officielle choisie par l'auteur en fonction du public visé, avec un résumé dans la deuxième language officielle.

Objectifs
Ces séries de rapports serviront à :

- communiquer les résultats des recherches effectuées en sciences des écosystèmes aux scientifiques et aux gestionnaires, ainsi qu'aux membres du public que les activités enterprises par Parcs Canada en écologie et en conservation intéressent.
- offrir des publications professionnelles, crédibles et précises qui seront soumises à l'évaluation par les pairs.
- favoriser la diffusion de l'information, la créativité, l'efficacité et le travail d'équipe dans les projets de recherche.

Évaluation par les pairs
Le rédacteur nommera deux lecteurs choisis, dans la mesure du possible, parmi le personnel scientifique de Parcs Canada, qui seront chargés de faire une critique de chaque manuscrit. On fera appel à des lecteurs de l'extérieur en raison de l'expertise exigée, du temps disponible et de l'objectivité nécessaire. Les lecteurs renverront le manuscrit au rédacteur en y joignant leurs commentaires par écrit. Le rédacteur renverra le manuscrit à son ou à ses auteurs avec les commentaires des lecteurs. L'auteur prendra connaissance des commentaires et tiendra compte de ceux avec lesquels il est d'accord, puis il retournera le manuscrit révisé au rédacteur en lui expliquant par écrit pourquoi il n'a pas tenu compte de certains commentaires. Le rédacteur enverra ensuite le manuscrit au garde de parc en chef, ou, s'il s'agit d'employés du bureau régional, au superviseur immédiat de l'auteur, pour faire approuver la publication et l'impression du manuscrit. Dans le cas de publications de moindre importance, le rédacteur peut, à sa discrétion, décider de ne pas avoir recours à des lecteurs; lui-même et le superviseur immédiat de l'auteur serviront alors de lecteurs. En cas de désaccord entre l'auteur et le rédacteur au sujet du manuscrit, c'est le gestionnaire ministériel principal qui tranchera.

Directives à l'intention des auteurs
Ces séries de rapports seront consacrées à la publication de travaux effectués dans la région de l'Atlantique en science des écosystèmes et seront mises à la disposition de tous les employés de Parcs Canada, du ministère du Patrimoine canadien, de leurs collaborateurs ou de toute personne qui travaille pour le compte de Patrimoine canadien.

Les auteurs soumettront au rédacteur régional une copie de leur manuscrit sur support en papier, une version sur disquette en WordPerfect Windows ou DOS et le nom de trois lecteurs éventuels qui ne connaissent pas le manuscrit.

Pour de plus amples renseignements, communiquez avec :

Neil Munro
Rédacteur des séries de Rapports

Parcs Canada
Historic Properties
Halifax (Nouvelle-Écosse)
B3J 1S9

(902) 426-2797
(FAX) 426-2728

Parks Canada
Technical Reports
in Ecosystem Science

ISSN 1200-3298

Parcs Canada
Rapports techniques
en matière de sciences
des écosystèmes

ISSN 1200-3298