BOWIE SEAMOUNT PILOT MARINE PROTECTED AREA: AN ECOSYSTEM OVERVIEW REPORT

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by

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AES	Atmospheric Environment Services
AOI	Area of Interest
BCMEC	British Columbia Marine Ecological Classification
CCG	Canadian Coast Guard
CCMA	Coastal Community Management Area
CHS	Canadian Hydrographic Service
CPUE	Catch per Unit Effort
CTD	Current Temperature Depth
CWS	Canadian Wildlife Service
DFO	Fisheries and Oceans Canada
DND	Department of National Defense
DWT	Dead Weight Tonnes
EEZ	Exclusive Economic Zone
GSC	Geological Survey of Canada
ICES	International Council for the Exploration of the Sea
IOS	Institute of Ocean Sciences
IFMP	Integrated Fishery Management Plan
IPHC	International Pacific Halibut Commission
IUCN	International Union for the Conservation of Nature
LOMA	Large Ocean Management Regions
MEC	Marine Ecological Classification
MEOS	Moored Ecosystem Observatory
MEQAG	Marine Environmental Quality Advisory Group
MGL	Molecular Genetics Lab
MLA	Member of the Legislative Assembly
MPA	Marine Protected Area
NGS	National Geographic Society
NOAA	National Oceanic and Atmospheric Administration
PBS	Pacific Biological Station
PMEL	Pacific Marine Environmental Laboratory
SAR	Search and Rescue
TAC	Total Allowable Catch
TAPS	Trans Alaska Pipeline System
WCOVTRM	West Coast Offshore Vessel Traffic Risk Management

Abstract

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In December 1998, the Bowie Seamount Area, known to the Haida people as Sgaan Qintlas (translated as meaning ‘supernatural, looking outward’), was announced as a Pilot Marine Protected Area. The 15,000 km^2 Area of Interest encompasses the Bowie, Hodgkins and Davidson seamounts range and surrounding abyssal plain. The seamounts lie between 180 km and 230 km west of Haida Gwaii (Queen Charlotte Islands), British Columbia. Canada's National Framework for the development of Marine Protected Areas (MPAs) includes a Code of Practice that encourages Integrated Ocean Managers to use all the available scientific and traditional ecological knowledge when preparing management plans for prospective MPAs. Ecosystem Overviews are one component of the Ecological and Socio-Economic Assessment step. This Technical Report forms the basis of the Ecosystem Overview for the Bowie Seamount Area. Though the area is not well studied, this overview synthesizes the limited information available for its marine ecosystems, and includes relevant knowledge from other Pacific seamounts such as Cobb. Descriptions of socio-economic and cultural, as well as environmental components of Bowie Seamount Area are provided, including data gaps and recommended work.

Résumé

On a annoncé, en décembre 1998, la désignation à titre de zone pilote de protection marine de la région du mont sous-marin Bowie, à laquelle le peuple haïda donne le nom de Sgaan Qintlas (qui signifie ‘surnaturel, tourné vers l’extérieur’). Ce site d’intérêt de quelque 15 000 km^2 englobe les monts sous-marins Bowie, Hodgkins et Davidson ainsi que la plaine abyssale environnante. Ces monts sous-marins se trouvent de 180 à 230 km à l’ouest de Haida Gwaii (les îles de la Reine-Charlotte), Colombie-Britannique. Le Cadre national pour l’établissement et la gestion des zones de protection marines (ZPM) comprend un Code de pratiques qui encourage les responsables de la gestion intégrée des océans à utiliser toutes les connaissances scientifiques, traditionnelles et écologiques disponibles dans le cadre de la préparation de plans de gestion pour les ZPM potentielles. Les Aperçus écosystémiques sont une des composantes de la phase d’évaluation écologique et socio-économique. Ce Rapport technique est à la base de l’aperçu écosystémique de la région du mont sous-marin Bowie. Bien que la région n’ait pas fait l’objet d’études approfondies, cet aperçu présente la synthèse de l’information restreinte disponible sur ses écosystèmes marins et renferme des connaissances pertinentes sur d’autres monts sous-marins du Pacifique tels que le mont Cobb. Des descriptions des éléments socio-économiques, culturels et environnementaux de la région du mont sous-marin Bowie sont présentée; elles signalent, entre autres, les données qui manquent et les travaux qu’il convient d’effectuer.

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1.0 INTRODUCTION

1.1 MARINE PROTECTED AREA DESIGNATION PROCESS

Marine protected areas (MPAs) have long been regarded as appropriate management tools for sustaining marine ecosystems (National Academy of Sciences 2001). In British Columbia, the establishment of MPAs is set within various statutes such as Canada's *Oceans Act* (Government of Canada 1996), Fisheries and Oceans Canada's (DFO) national framework (DFO 1999a), and a joint federal-provincial strategy for the Pacific Region (Government of Canada and Province of British Columbia 1998).

Canada's *Oceans Act* provides for the establishment of marine protected areas within a broader integrated management program for coastal waters. Within the Act, MPAs are defined as legally designated areas designed and managed to conserve and protect the ecological integrity of marine ecosystems, species and habitats. More specifically, the Act identifies five reasons for establishing marine protected areas:

- the conservation and protection of commercial and non-commercial fishery resources, including marine mammals, and their habitats;
- the conservation and protection of endangered or threatened marine species, and their habitats;
- the conservation and protection of unique habitats;
- the conservation and protection of marine areas of high biodiversity or biological productivity; and
- the conservation and protection of any other marine resource or habitat as is necessary to fulfill the mandate of the Minister of Fisheries and Oceans (Government of Canada 1996).

DFO's process for designating MPAs is laid out in a framework designed to provide a consistent approach to establishing and managing MPAs while still allowing for regional flexibility. The MPA framework is founded on:

- effective partnering with aboriginal communities and organizations, coastal communities, non-government organizations, coastal industries, provincial and municipal governments and federal departments;
- a sound information base from a variety of sources, and a precautionary approach where information is lacking;
- placing MPAs within an ecosystem context;
- public awareness and education; and
- a learn by doing approach based on pilot MPAs (DFO 1999a).

Recognizing the multi-jurisdictional nature of MPAs and the need to coordinate efforts towards common marine protection and conservation goals, several federal and provincial government agencies established a working group to develop a marine protected areas strategy for the Pacific region. The hallmark of the strategy is:

- federal-provincial collaboration in protecting marine areas;
- shared decision making with First Nations, marine stakeholders, coastal communities and the public; and
- establishment of an extensive system of protected areas by 2010 (Government of Canada and Province of British Columbia 1998).

Within this context, DFO, in cooperation with the Province of British Columbia, First Nations and public interest groups, has identified four[4] pilot areas in the Pacific region under consideration for inclusion in a national system of MPAs (Anderson 1998a, Anderson 1998b). Among these is the Bowie Seamount Area, an offshore volcanic formation located in the Pacific Ocean off the west coast of Haida Gwaii (Queen Charlotte Islands), British Columbia (Figure 1). The proposed designation of a Bowie Seamount MPA was prompted by:

- reports of apparent rich biological productivity due to the surrounding oceanographic interactions;
- possible function as a biological oasis supporting unique plant and animal communities;
- possible role as a staging post for migrating marine mammals and seabirds; and
- uniquely close proximity to the sea surface (Bowie Seamount rises to within 25 m of the surface from a depth of more than 3000 m).

[4] These are Race Rocks, Gabriola Passage, Bowie Seamount and the Endeavor Hot Vents. A fifth, the Gully on the Scotian Shelf, is located off Canada's east coast. Additionally, seven Areas of Interest have been identified: Leading Tickles, East Port and Gilbert Bay, NF; Musquash Estuary NB; Basin Head PEI; Manicouagan PQ; and the Beaufort Sea, NWT.

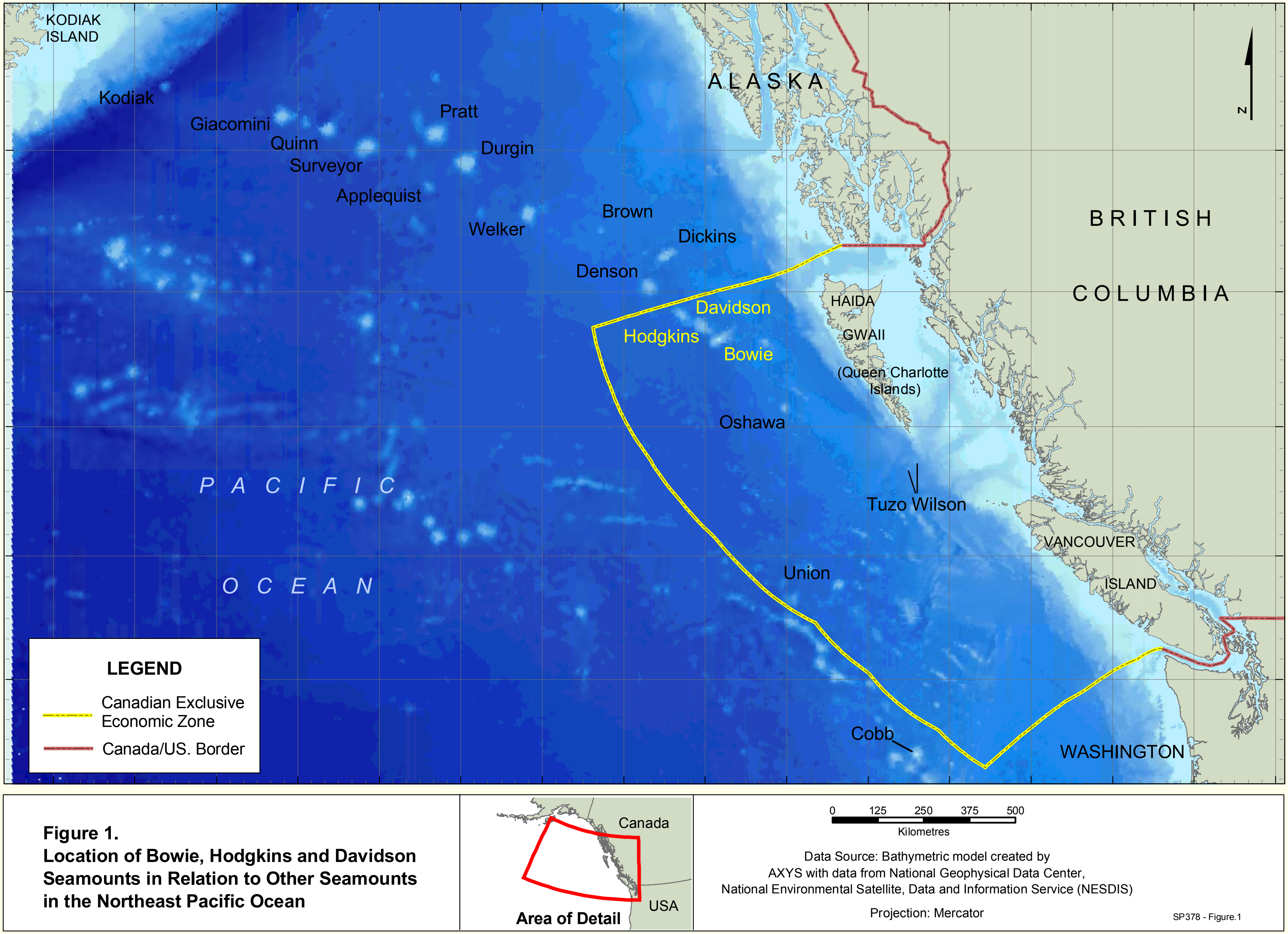


Figure 1.
Location of Bowie, Hodgkins and Davidson Seamounts in Relation to Other Seamounts in the Northeast Pacific Ocean

Data Source: Bathymetric model created by AXYS with data from National Geophysical Data Center, National Environmental Satellite, Data and Information Service (NESDIS)

Projection: Mercator

SP378 - Figure.1

Both the national MPA framework and the joint federal-provincial strategy lay out a comparable process for MPA designation. Currently, DFO and relevant stakeholders (see Appendix E) are discussing key considerations of the Bowie Seamount Area as a potential MPA. This process includes:

- an assessment of the ecological merits of the Area of Interest (AOI);
- a technical assessment of management feasibility and stakeholder support; and
- a socio-economic assessment of affected human activities and socio-economic benefits.

Together these assessments comprise an ecosystem overview of the Bowie Seamount Area. In addition to characterizing the ecological communities and socio-economic values, the ecosystem overview aims to:

- assist managers in defining objectives for the MPA;
- provide a basis for delineating boundaries of a marine protected area;
- identify research priorities and monitoring requirements;
- identify issues relevant for planning and managing human activities;
- address enforcement requirements; and
- communicate information to the public and other agencies.

1.2 THE BOWIE SEAMOUNT AREA

The AOI for this ecosystem overview encompasses an area of approximately 15,000 km^2 and includes Bowie, Hodgkins, and Davidson seamounts and surrounding abyssal plain, hereafter referred to as the Bowie Seamount Area (see Figure 1). Consideration of this area represents an expansion of the original AOI announced in December 1998, the rationale for which originates from consultations during the stakeholder workshop held in Vancouver, British Columbia March 2000. Participants of the workshop recommended that adopting an ecosystem approach should warrant consideration of incorporating neighbouring seamounts into a protected area (AXYS 2000).

The Bowie Seamount Area is near the southern extent of the seamount chain stretching from the Aleutian Trench off Kodiak Island (see Figure 1).

Although the origin of the name ‘Bowie’ is unknown, it was officially approved in 1979 (Sheila Acheson, Secretary of the Advisory Committee on Names of Undersea and Maritime Features, Geographical Names Board of Canada, personal communication). Preliminary oceanographic studies and observations have shown that Bowie Seamount is biologically diverse and a relatively rich and productive marine area (see Section 2.4). As a shallow-water habitat located far from the coast, this seamount represents a relatively uncommon habitat, and is one of only five shallow seamounts - and the shallowest - in the northeast Pacific Ocean (see Table 2). Although Bowie’s distance from shore limits most types of human activity, the fish productivity of the site is attractive to some of the commercial fishing fleets. Additionally, the proximity of the Bowie summit to the sea surface, along with its high biological values, have generated interest from numerous research agencies over the past 30 years.

Widow Rockfish, *Sebastes entomelas*
© L. Yamanaka

1.3 ECOSYSTEM CLASSIFICATION

Canada's offshore Pacific region, within which the Bowie Seamount Area lies, has been described in several different international, national, and regional marine ecosystem classification systems (Table 1). The following sections provide an overview of the Bowie Seamount Area relative to these classification systems.

1.3.1 International Classification Systems[5]

The International Union for the Conservation of Nature (IUCN) classification system was designed to categorize and incorporate marine protected areas into a network that is representative of the world’s marine ecosystems (Hayden *et al.* 1984). Under this system, coastal and marine habitats are classified according to oceanic currents, climate patterns and zoogeographic characteristics. The system describes

[5] The Bowie Seamount Area lies beyond the seaward extent of the Large Marine Ecosystem classification system which is, therefore, not included here.

four Biomes: Open Oceans, Coastal Margins, Marginal Seas, and Marginal Archipelagos. Based on seasonal variations in ocean surface currents and wind direction, the Open Ocean biome is divided into seven oceanic Realms, and the coastal Biomes into thirteen coastal Realms. Realms were further divided into zoogeographic Provinces based on the distribution of marine fauna. Under this system, the Bowie Seamount Area lies within Ocean Realm I, classified as having variable eastward currents (Hayden *et al.* 1984).

1.3.2 National Classification Systems

In 1979, Parks Canada developed a marine parks policy, part of which included establishing a system for identifying potential marine parks (Harper *et al.* 1983). Under this system, Canadian waters were divided into areas based on similarities in physical and biological characteristics (*e.g.*, oceanography, physiography, coastal features, marine vertebrate and invertebrate populations). Three major Marine Areas were defined - Atlantic, Arctic, and Pacific – and from these, six Marine Regions were delineated. This scheme was named the Canadian Parks Service Marine Regions system. The system was subsequently revised and used as the basis for the current Parks Canada National Marine Conservation Area Natural Regions classification system (Watson 1998). Under this system, the Bowie Seamount Area is included in the Queen Charlotte Shelf Natural Region (Parks Canada 1997).

Harper *et al.* (1994) later designed a hierarchical classification system for the purpose of monitoring changes in environmental quality of Canada's marine areas. Under this system, Marine Regions were delineated based on physical features that were considered to be ecologically significant and that limited biological systems (Levings *et al.* 1998). Four levels of classification were established based on those used by Wiken (1986) to classify terrestrial areas in the Canadian Ecological Land Classification System (Levings *et al.* 1998).

At the first level of classification were Marine Ecozones, based on ice regimes and oceanic basins. Marine Ecoprovinces were then designated based on oceanic surface circulation and continental margins. From there, Marine Ecoregions were defined according to regional variations in salinity and marine flora, fauna and production. Marine Ecodistricts, the final level in the system, were then delineated based on their unique oceanic mixing processes and biological communities (Levings *et al.* 1998).

Harper *et al.*'s (1994) system was later revised by the Marine Environmental Quality Advisory Group (MEQAG 1994) and named the Marine Ecological Classification system (MEC). Under this system, the Bowie Seamount Area lies within the Pacific Ecozone, and the Northeast Pacific Ecoprovince, Ecoregion, and Ecodistrict. The Pacific Ecozone is dominated by west winds, while the Northeast Pacific Ecoprovince, Ecoregion, and Ecodistrict are distinguished by having a general northward current, abyssal plain, continental rise and continental shelf, a boreal plankton community, and summer feeding grounds for pelagic fish.

DFO has adopted a two-tiered approach to the integrated management of Canada's oceans. Large Ocean Management Areas (LOMAs) form the broadest scale of integrated management planning under Canada's *Oceans Act*. Their boundaries are defined by management needs and commonly recognized marine ecosystem boundaries (DFO 2001b). While these areas are primarily planning regions, they reflect a variety of oceanographic conditions, physiography, management issues and communities along Canada's coasts. Ecosystem management objectives for LOMAs include such things as maintenance of marine ecosystem structure, function and genetic variability. Environmental quality guidelines and industrial regulations are also associated with this level of management. These objectives are then used to develop more specific integrated management plans that are generally applied to smaller Coastal Community Management Areas (CCMAs) and MPAs (DFO 2001b).

DFO has proposed six LOMAs for the Pacific coast as part of the framework for establishing a MPA system. Bowie, Hodgkins and Davidson seamounts fall within the Offshore LOMA.

World Wildlife Fund Canada is in the process of developing a national hierarchical classification system for marine conservation (Day and Roff 2000). However, it has not yet been refined for the Pacific coast (Michele Patterson, World Wildlife Fund Canada, personal communication).

1.3.3 Regional Classification Systems

The British Columbia Marine Ecological Classification (BCMEC) is modeled after the national MEC scheme and is intended for use in coastal zone management, and marine and marine protected area planning (Zacharias and Howes 1998). BCMEC, however, replaces Ecodistricts with Ecosections, and adds a fifth level – the Ecounit – to the hierarchy. Benthic ecounits, defined by depth, slope, bottom temperature, nearshore wave exposure, relief, nearshore tidal current, and substrate, are distinguished from pelagic ecounits which are defined by stratification and surface salinity (AXYS 2001).

Under BCMEC, the Bowie Seamount Area lies within the Pacific Ecozone, the Northeast Pacific Ecoprovince, and the Subarctic Pacific Ecoregion and Ecosection (Zacharias and Howes 1998). Characteristic physiographic features of this ecosection include abyssal plain and continental rise, a major transform fault along the west margin, and a seamount chain that runs from northwest to southeast. Oceanographically, the ecosection is characterized by an eastward flowing subarctic current that bifurcates at the coast and joins the northerly flowing Alaska Current. Current flow is generally northward throughout the year. Biological features include a summer feeding ground for Pacific salmon; an abundance of pomfret, Pacific saury, albacore tuna and jack mackerel during the summer; and a boreal plankton community (Levings *et al.* 1998). With respect to Benthic Ecounit designation, the Bowie Seamount Area is defined as being deep, sloping, cold, and having high wave exposure, low relief, low tidal current, and unknown substrate. Bowie Seamount itself was identifiable as a distinct feature based on depth and slope. Relief was intended to describe the overall 'lay of the land' rather than identify by specific features such as trenches and seamounts. Therefore, the generalization process applied to model relief did not isolate the Bowie Seamount Area. In terms of Pelagic Ecounit designation, the seamount area is defined as being stratified and euhaline (28-33 ppt) (AXYS 2001).

Table 1. Summary of ecological classification of the Bowie Seamount Area.

Classification System	Classification	Description
	International	
International Union of the Conservation of Nature (IUCN)	Ocean Realm I	Variable eastward currents
	National	
Parks Canada National Marine Conservation Area Natural Regions	Queen Charlotte Shelf Natural Region	
Marine Ecological Classification	Pacific Ecozone	**Climatic:** dominated by west winds
	Northeast Pacific Ecoprovince	**Physiographical:** abyssal plain; continental rise; continental shelf **Oceanographic:** general northward water flow **Biological:** boreal plankton community; summer feeding ground for pelagic fish
	Northeast Pacific Ecoregion	
	Northeast Pacific Ecodistrict	
Large Ocean Management Areas (LOMA)	Offshore	
	Regional	
British Columbia Marine Ecological Classification (BCMEC)	Pacific Ecozone	
	Northeast Pacific Ecoprovince	
	Subarctic Pacific Ecoregion	
	Subarctic Pacific Ecosection	**Physiographic:** abyssal plain; continental rise; major transform fault along west margin; seamount chain that runs northwest to southeast **Oceanographic:** general northward flowing current throughout the year; eastward flowing subarctic current bifurcates at the coast and joins the northward flowing Alaska Current **Biological:** boreal plankton community; abundance of pomfret, Pacific saury, albacore tuna and jack mackerel in summer; summer feeding ground for Pacific salmon stock
	Benthic Ecounit	**Substrate**: Unknown **Exposure**: High **Current:** Low **Slope**: Sloping 5-20% **Depth:** Deep 200-1000 m **Temperature**: Cold < 9° C
	Pelagic Ecounit	**Salinity**: Euhaline 28-35 ppt **Stratification**: Stratified

2.0 ENVIRONMENTAL COMPONENTS

This section summarizes the available information on the Bowie Seamount Area biophysical environment although much of the information relates specifically to Bowie Seamount (see Appendix A for a glossary of environmental terms). It discusses the geological history, the oceanographic parameters that play an important role in biological productivity, and the flora and fauna that live on and around the seamount.

2.1 GEOLOGY AND PHYSIOGRAPHY

The Kodiak-Bowie chain[6] is a linear array of seamounts stretching from the Aleutian Trench off Kodiak Island to an area just west of the Haida Gwaii (Queen Charlotte Islands) (Table 2 and see Figure 1). Geologically, this chain is interesting because of the unusual basement ridge that underlies it[7]. The only other chain of seamounts with a comparable underlying basement ridge is the Hawaiian Islands. Several other groups of seamounts are also found in this part of the northeast Pacific, including the Tuzo-Wilson seamounts and the Dellwood Knolls. The high density of seamount chains in the region is testimony to the high tectonic activity of the northeast Pacific, especially in the region near the tri-partite juncture of the Juan de Fuca, the Pacific and the American plates.

The oldest portion of Bowie Seamount is believed to have been formed at least 600,000 years ago. However, based on potassium-argon dating, the summit appears to be much younger (about 75,000 years), and shows signs of having been volcanically active as recently as 18,000 years ago. In fact, during the last ice age it is likely that Bowie Seamount stood well above sea level as a volcanically active oceanic island. This is based on the fact that (i) Bowie Seamount currently penetrates to within 25 m of the surface, (ii) there is clear evidence of subsidence at its base and (iii) wave-cut terraces have been observed near its summit. Interestingly, it appears that Bowie Seamount remained volcanically active even after sea level increased and covered the summit. This is demonstrated by the fact that the existing summit is composed of a weakly cemented volcanic tephra. Had this tephra formed while Bowie Seamount stood above sea level, it would have been eroded by waves.

Table 2. Summit locations and water depths for selected seamounts in the northeast Pacific Ocean, listed from north to south.

Seamount	Position	Summit Depth (m)
Kodiak[a]	56°52'N, 49°16'W	2025
Giacomini	56°27'N, 146°42'W	661
Quinn	56°18'N 145°13'W	671
Surveyor	56°03'N 144°19'W	540
Durgin	55°50'N 141°51'W	617
Welker	55°07'N 140°21'W	693
Dickins	54°31'N 136°56'W	410
Denson	54°05'N 137°24'W	280
Davidson[b]	53°40'N 136°34'W	1146
Hodgkins[c]	53°30'N 136°04'W	596
Bowie[c]	53°18'N 135°39'W	24
Oshawa[b]	52°22'N 134°05'W	919
Union	49°32'N 132°41'W	160
Cobb[d]	46°46'N 130°48'W	< 25

Sources:
[a] Eakins *et al.* 1999.
[b] CHS Environmental Data Set
[c] NOAA and CHS Multi beam survey. 2000
[d] Dower and Perry 2001

The difficulty of ascertaining how Bowie, Hodgkins and Davidson seamounts were formed relates to the peculiar geochemical composition of the basalts dredged from the Bowie Seamount. These basalts are enriched in the 'incompatible' elements that characterize hot spot volcanoes, such as Kodiak, Giacomini, Cobb, Dickins, Denson, and Davidson. This, along with the characteristic linearity of the Kodiak-Bowie seamount chain, much like the Emperor-Hawaiian volcanic chain stretching from the western Aleutian Islands to the Hawaiian Islands, supports the theory that Bowie, Hodgkins and Davidson seamounts were formed via hotspot volcanism. However, Bowie and Hodgkins seamounts are also isotopically similar to some mid-ocean ridge basalts, which are typically formed via a spreading ridge, originate in the upper mantle, and therefore, are depleted in incompatible elements. The particular isotopic profile of Bowie Seamount is typical of the basalts originating at the nearby Juan de Fuca ridge. Thus, the Bowie Seamount basalts appear to share characteristics of both types of seamount

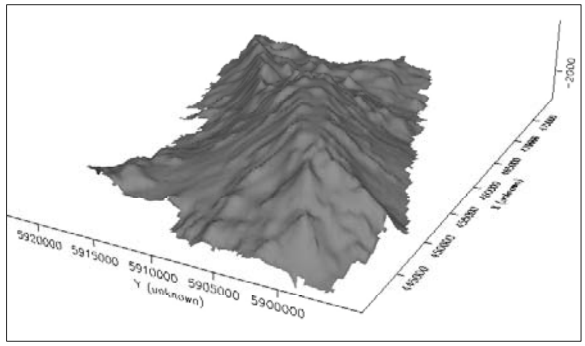
[6] While the seamount chain may extend to include Oshawa and Tuso Wilson seamounts, the chain is commonly known as Kodiak-Bowie (Ralph Curran, Head Sidney Division, Geologic Survey of Canada, personal communication).
[7] The following discussion on geology was compiled and written by John Dower and Frances Fee (Dower and Fee 1999). A list of their cited references is provided in Appendix C.

formation. Furthermore, the geochemical composition of some other seamounts such as Heckle, Explorer, Dellwood and Union suggest a non-hot spot origin.

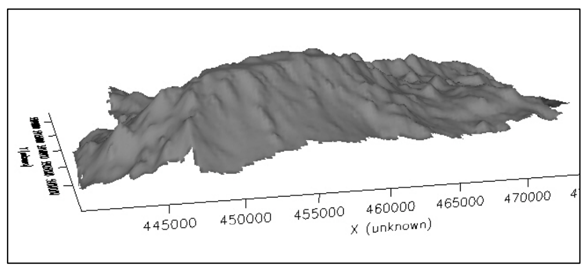
The bathymetry of Bowie Seamount was first surveyed in 1969 (Scrimger and Bird 1969). More detailed multibeam bathymetry data for Bowie and Hodgkins seamounts were collected in 2000 through a collaboration between the Canadian Hydrographic Service (CHS) of DFO and the Hydrographic Surveys Division of the US National Oceanic and Atmospheric Administration (NOAA). In exchange for survey work performed by the CHS in Puget Sound, Washington, the NOAA Research Vessel *Rainier* and four launches performed multibeam surveys of Bowie and Hodgkins seamounts over a 1046 km^2 (305 square nautical mile) area in depths ranging from 24.3 m to 2835 m. Two launches used 240 kHz multibeam sounders to sound to a depth of 200 m, and two launches used 180 kHz multibeam sounders to sound to a depth of 400 m. The remaining area was sounded using the 180 kHz/ 50 kHz multibeam sounder aboard the Rainier. Backscatter data were collected to a depth of 200 m.

Using these data, a bathymetric model for Bowie and Hodgkins seamounts was developed (see images at right, Figure 2 and Figure 3). There is complete bathymetric coverage of both seamounts to a uniform depth of 1000 m. The deeper portion of Hodgkins Seamount on the western edge of the survey is truncated. For Bowie Seamount, uniform bathymetric coverage extends to 2000 m with maximum depths of approximately 2800 m. Nevertheless, the data provide a detailed impression of the morphology of the seamounts.

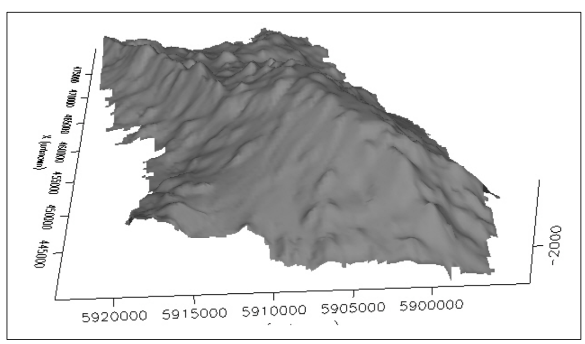
Bowie Seamount is oriented in a southwest/northeast direction and measures about 24 km by 55 km at its base. It is the shallowest seamount in the northeast Pacific Ocean, rising from a bottom depth of nearly 3100 m to a peak of 24.3 m from the surface. By comparison, if it were on land, Bowie Seamount would stand about 600 m higher than the summit of Whistler Mountain, and 800 m below that of Mount Robson, the highest peak in the Canadian Rockies (Dower and Fee 1999). The seamount summit is remarkably flat, and includes two distinct terraces at depths of 220-250 m and 65-100 m, the latter and shallower of which is dotted with smaller pinnacles (Figure 4). An extensive ridge structure extends northeast from the shallow summit area of Bowie Seamount. This narrow ridge extends over 20 km and is almost perfectly straight, beginning near the summit at 800 m in depth and reaching to 2000 m in depth at the extreme northeast edge of the depth survey. The seamount sides fall steeply to the northwest and southeast, reaching depths of more than 2000 m over a horizontal distance of less than 6 km, achieving a slope of 20° or more over large areas. The calculated mass of Bowie Seamount above 1000 m covers a planimetric area of over 121 km^2 and a surface area of over 144 km^2, constituting a volume of over 52 km^3. In comparison, the mass above 200 m covers a planimetric area of over 9.3 km^2 and a surface area of over 10 km^2, constituting a volume of over 0.65 km^3 (Table 3).



(a) Looking due northeast (Vertical exaggeration 1:1.5)



(b) Looking due north (Vertical exaggeration 1:1.5)



(c) Looking due west (Vertical exaggeration 1:1.5)

Several views of Bowie Seamount (Terry Curran, Canadian Hydrographic Service)

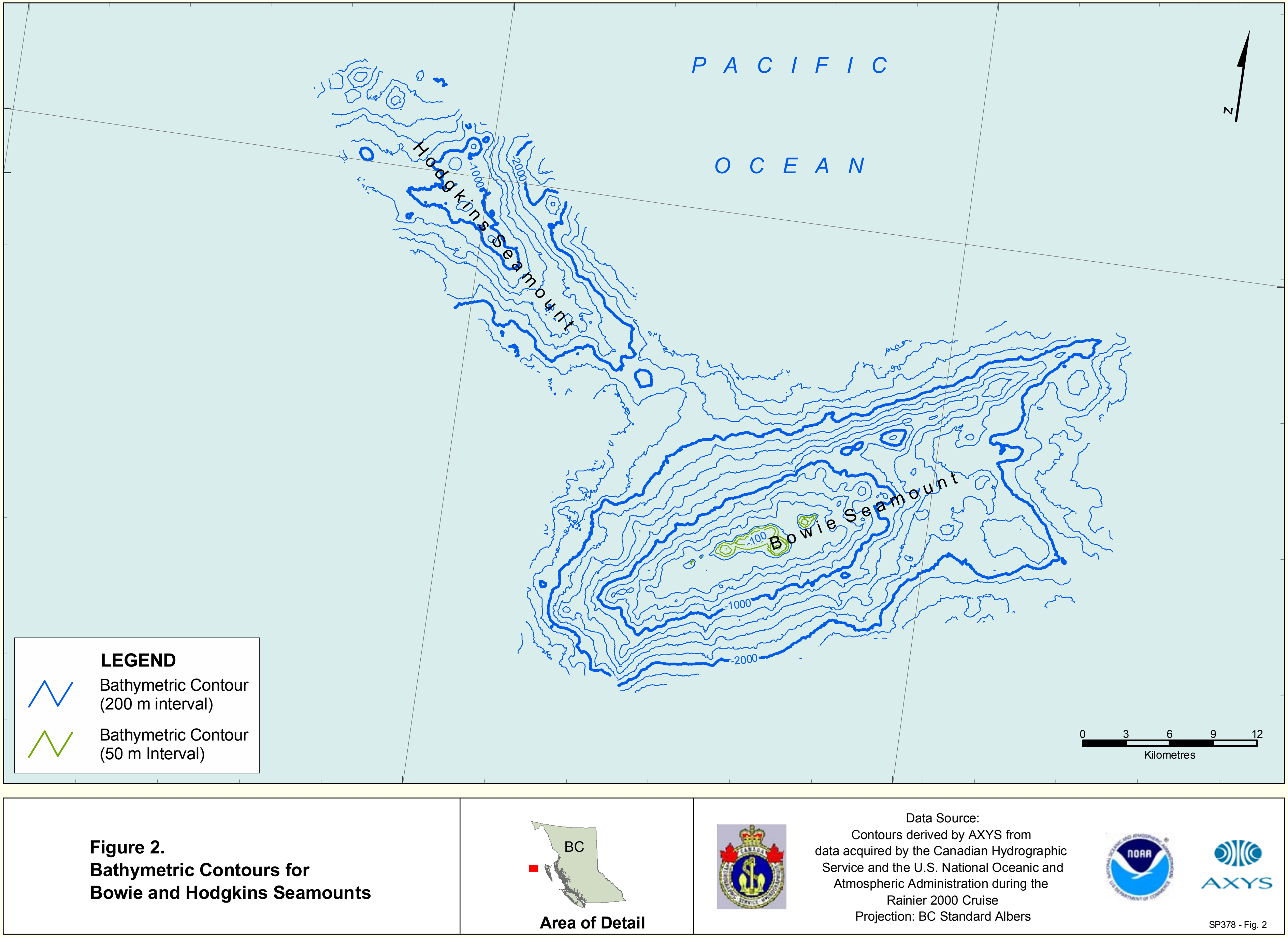


Figure 2.
Bathymetric Contours for
Bowie and Hodgkins Seamounts

Data Source:
Contours derived by AXYS from data acquired by the Canadian Hydrographic Service and the U.S. National Oceanic and Atmospheric Administration during the Rainier 2000 Cruise
Projection: BC Standard Albers

SP378 - Fig. 2

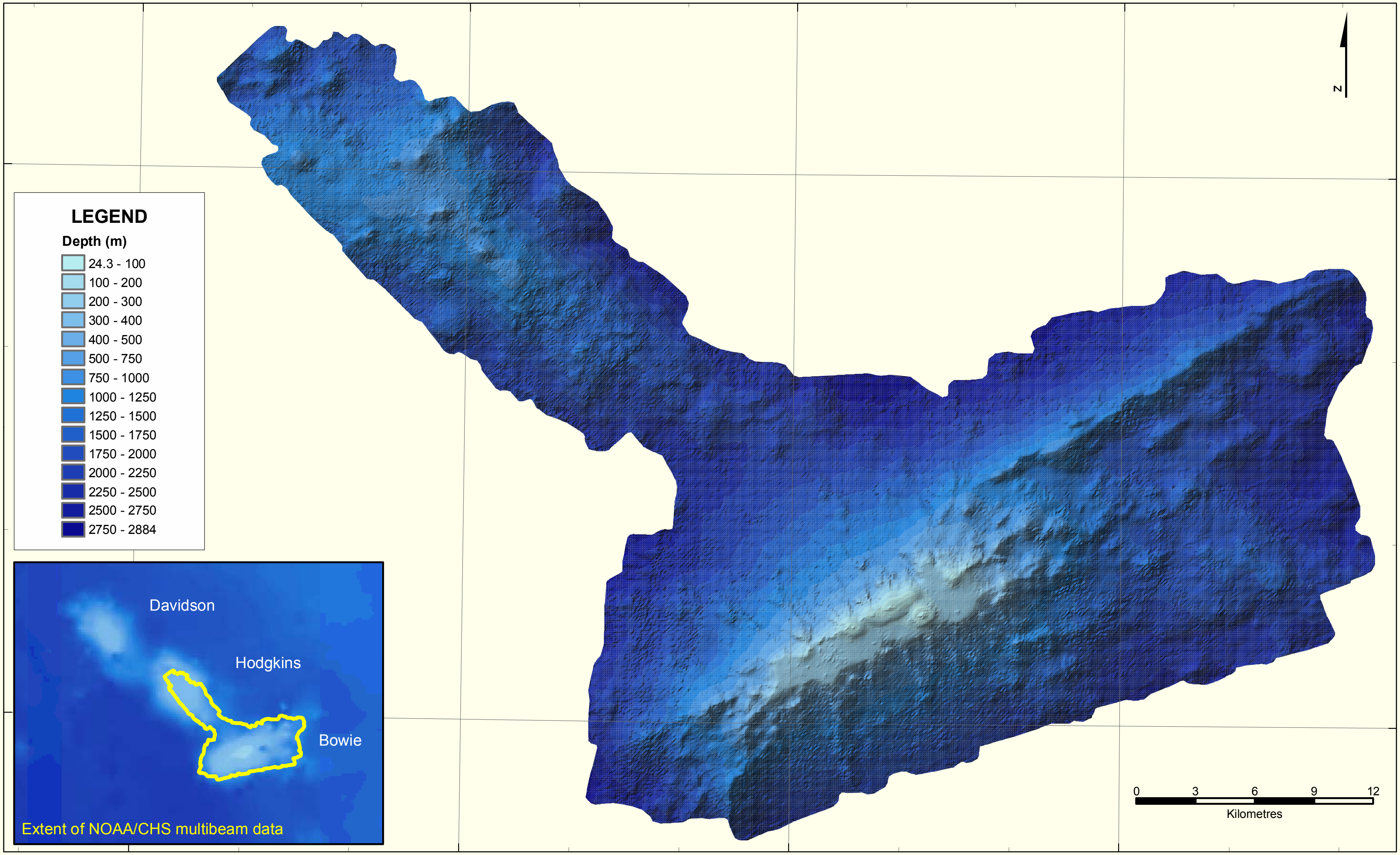
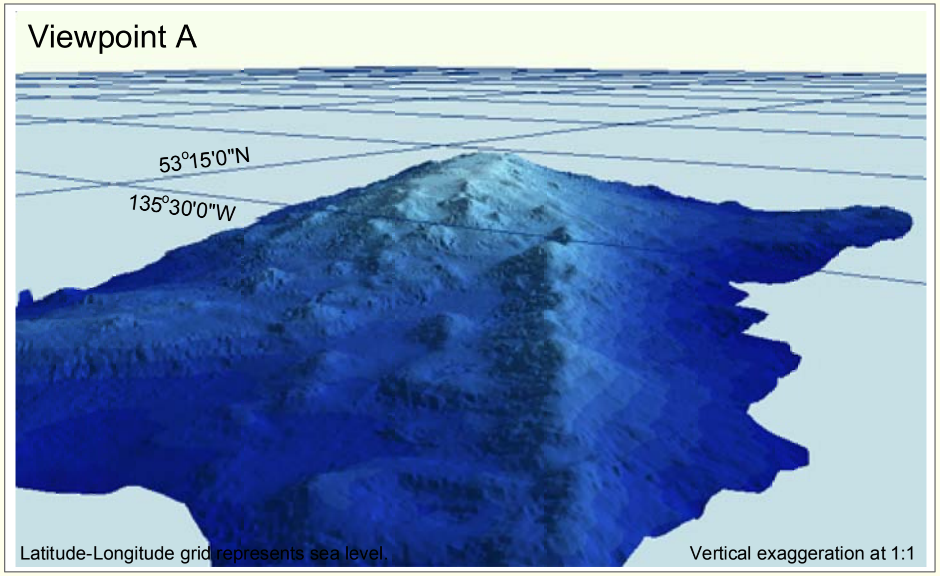


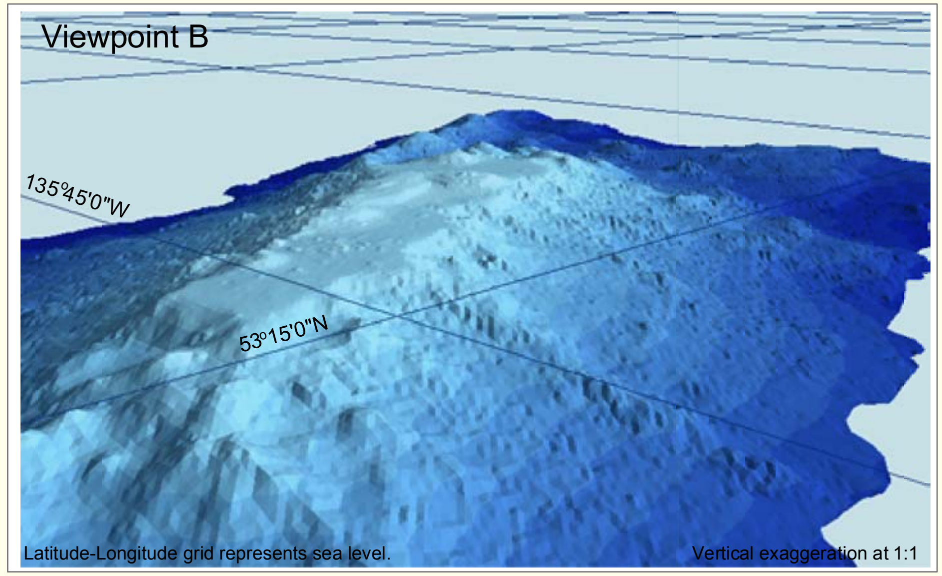
Figure 3.
Bowie and Hodgkins Seamounts Bathymetry

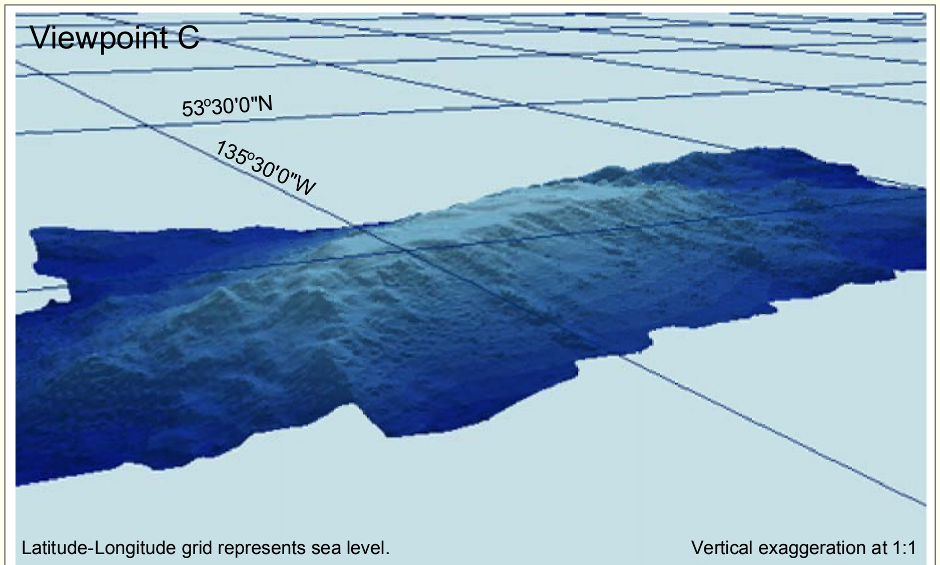
Area of Detail

Data Source:
Bathymetric model created by AXYS from data acquired by the Canadian Hydrographic Service and the U.S. National Oceanic and Atmospheric Administration during the Rainier 2000 Cruise
Projection: UTM Zone 8 Datum: NAD83

SP378 - Fig. 3







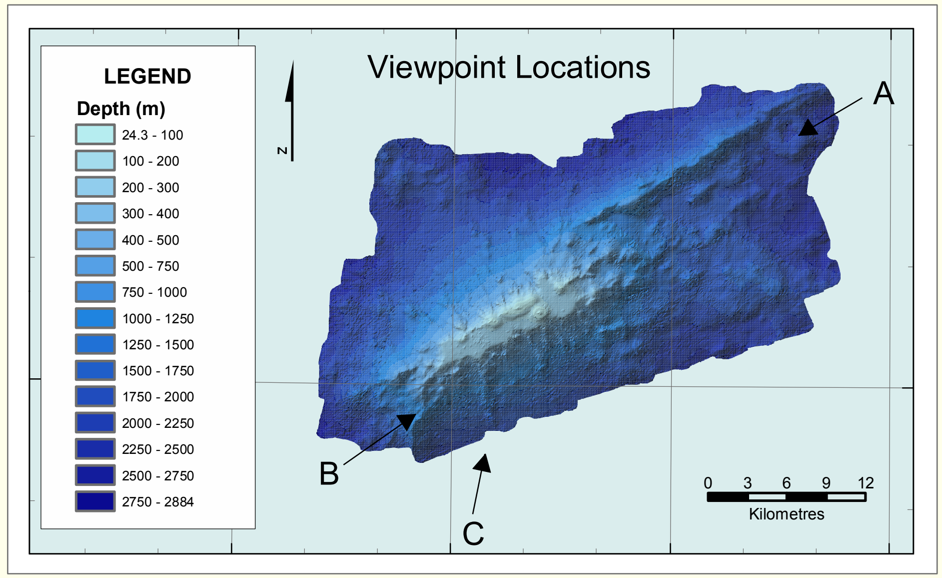


Figure 4.
Bowie Seamount Topography
From Varying Viewpoints

Area of Detail

Data Source:
Bathymetric model created by AXYS from data acquired by the Canadian Hydrographic Service and the U.S. National Oceanic and Atmospheric Administration during the Rainier 2000 Cruise
Projection: UTM Zone 8 Datum: NAD83

SP378 - Fig. 4

To the northwest of Bowie Seamount lies Hodgkins Seamount, connected by a saddle approximately 2300 m in depth. Hodgkins Seamount's summit is deeper than Bowie Seamount, its highest point rising to 596 m from the sea surface. Hodgkins Seamount is oriented almost perpendicular to Bowie Seamount in a northwest/southeast direction. The seamount's base measures about 12 km by 32 km, although it probably extends toward Davidson Seamount in the northwest, beyond the limits of existing high resolution depth surveys. The summit surface of Hodgkins Seamount is far more irregular than that of Bowie Seamount, being very rough in relief and having a number of pinnacles (Figure 5). At least ten of these pinnacles are easily identifiable across the surface of Hodgkins Seamount without a discernable orientation. The larger of these pinnacles thrusts over 300 m from the surface of the seamount. Hodgkins Seamount also rises less steeply from its base than does Bowie Seamount, appearing more undulating with most slopes in the range of 10–20°. The steepest area of Hodgkins Seamount lies on its northeast face, where slopes over 20° are found. The calculated mass of Hodgkins Seamount above 1000 m is an order of magnitude smaller than that of Bowie Seamount, having a planimetric area of just over 20 km^2, a surface area of almost 25 km^2 and a volume of approximately 1.3 km^3 (Table 3).

Table 3. Some physiographic characteristics of Bowie, Hodgkins and Davidson seamounts.

	Bowie	Hodgkins	Davidson
Min. depth	24 m	596 m	1,146 m
Max. depth	3,100 m	*	*
Slope	> 20°	10°–20°	*
Base dimensions	W: 24 km L: 55 km	W: 12 km L: 32 km	*
Base area	1,320 km^2	*	*
Mass of summit < 200 m depth:			
Planimetric	9.3 km^2	NA	NA
Surface	10 km^2	NA	NA
Volume	0.65 km^3	NA	NA
Mass of summit < 1000 m depth:			
Planimetric	121 km^2	20 km^2	*
Surface	144 km^2	25 km^2	*
Volume	52 km^3	1.2 km^3	*

Notes:
NA - Not Applicable, summits are deeper than 200 m.
* - Data of insufficient resolution to accurately calculate
Source: derived from NOAA and CHS multibeam survey, 2000.

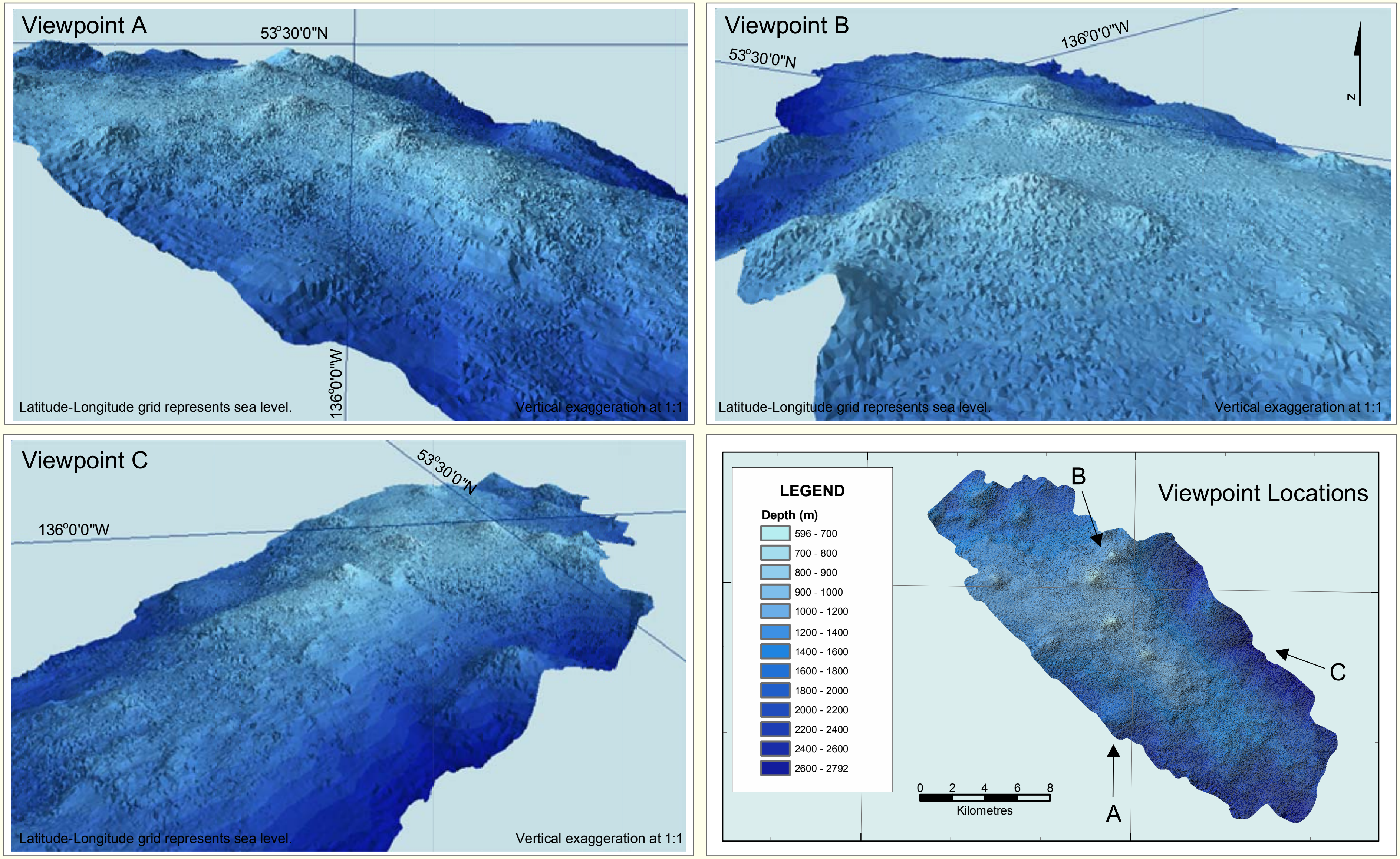


Figure 5.
Hodgkins Seamount Topography
From Varying Viewpoints

Area of Detail

Data Source:
Bathymetric model created by AXYS from data acquired by the Canadian Hydrographic Service and the U.S. National Oceanic and Atmospheric Administration during the Rainier 2000 Cruise
Projection: UTM Zone 8 Datum: NAD83

SP378 - Fig. 5

2.2 CLIMATE AND WEATHER

The Bowie Seamount Area lies in Environment Canada's forecast region which begins at the central coast of British Columbia, extends offshore from the outer edge of the influence of coastal topography, and to the 200 Nautical Mile international limit of Canada's Exclusive Economic Zone (EEZ). In this region, latitude is the main influence on the wind, waves and weather. Lows coming south from the Gulf of Alaska frequently pass into the Bowie Seamount Area causing water temperature to decrease, which in turn, contributes to precipitation, high winds and seas, and foggy conditions. Most weather systems from the north that affect this region have traveled across vast sections of the north Pacific Ocean, and as a result, air temperatures have had time to converge to the temperature of the water (Environment Canada 2000) (see Section 2.3).

Environment Canada maintains 16 moored weather buoys along Canada's Pacific coast (Figure 9). The buoys provide hourly measurements on winds, atmospheric pressure, wave height and period, and air/sea sea temperature. Four of these buoys, North Nomad (46184), Middle Nomad (46004), West Dixon Entrance (46205), and West Morseby (46208) circumscribe the Bowie Seamount Area within distances of 138 to 287 km (Figure 9). They provide a more detailed day-to-day and year-to-year picture of the area's climate and weather. Throughout the year, wind speeds around the Bowie Seamount Area range from 5.5 m/s to about 9 m/s (Figure 6). Figure 7 and Figure 8 show monthly reports, averaged for the past ten years, of wind speeds between 20 and 33 knots and greater than 33 knots respectively, as measured from the North Nomad and Middle Nomad weather buoys. Wind speeds typically increase dramatically between October and December when 10-15% of winds reported are greater than 33 knots (Figure 8). Even in the calmer months of June, July and August, over 10% of winds reported are greater than 20 knots (Figure 7).

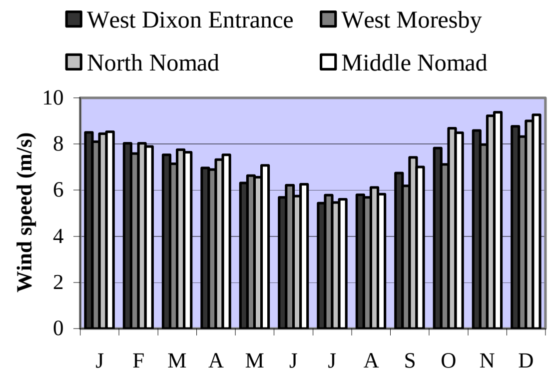


Figure 6. Average monthly wind speed measured from offshore buoys near the Bowie Seamount Area (IOS wave buoy archive).

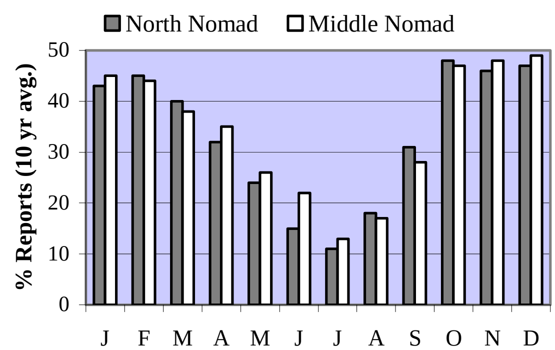


Figure 7. Average monthly occurrence of 20-33 knot winds measured from offshore buoys near the Bowie Seamount Area (Environment Canada 2000).

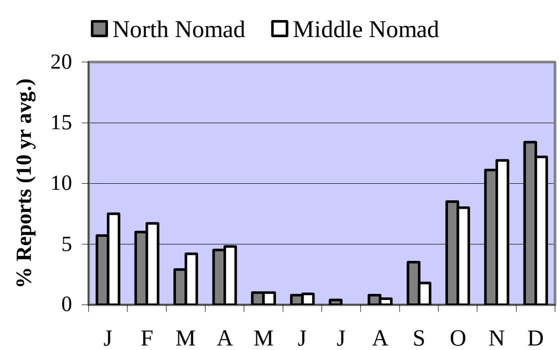


Figure 8. Average monthly occurrence of >33 knot winds measured from offshore buoys near the Bowie Seamount Area (Environment Canada 2000).

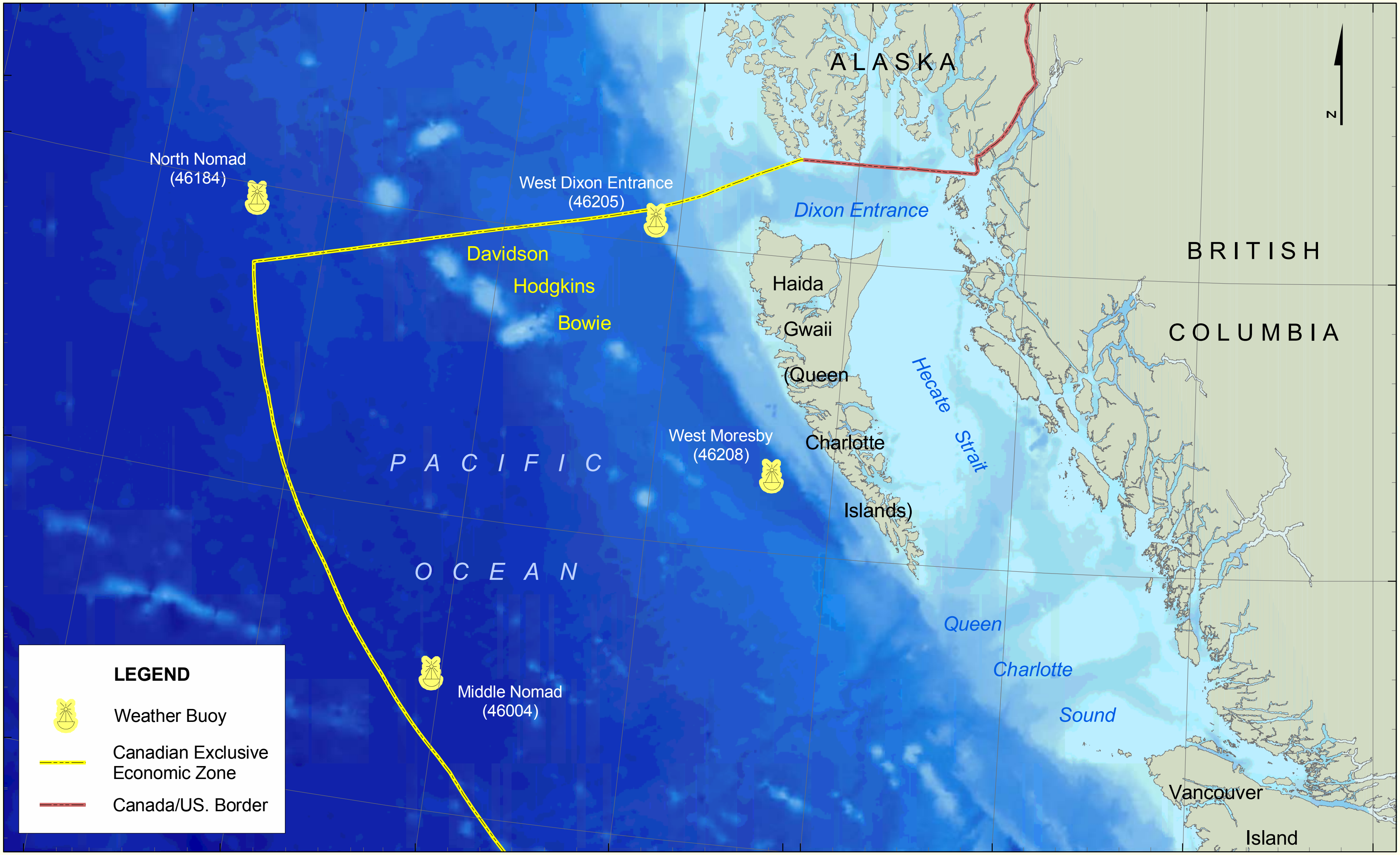
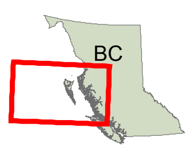


Figure 9.
Moored Weather Buoys in the Vicinity of the Bowie Seamount Area



Area of Detail

0 40 80 120 160
Kilometres

Data Sources: AXYS Technologies Inc; Bathymetric model created by AXYS with data from National Geophysical Data Center, National Environmental Satellite, Data and Information Service (NESDIS)
Projection: BC Standard Albers

SP378 - Fig. 9

2.3 PHYSICAL AND CHEMICAL OCEANOGRAPHY

2.3.1 Waves

As was mentioned above, the Bowie Seamount Area is subject to strong winds that generate high seas. Wave height measurements from the weather buoys surrounding the area show monthly average wave heights range from 1.5 m in summer to 4 m in winter (Figure 10). Between October and April, at least 80% of reports indicate waves are greater than 2 m, and at least 20% of these are greater than 4 m (Figure 11 and Figure 12). The greatest occurrence of waves over 4 m is in December. May to August are comparably calmer months with less that 3% of reports, on average, indicating wave heights greater than 4 m. Based on a preliminary examination and verification of the IOS wave buoy archive for West Moresby, West Dixon Entrance and North Nomad buoys, maximum wave heights of 27.9 m, 26.9 m and 21.9 m respectively were recorded, extreme conditions under which the Bowie's 25 m summit could be periodically exposed by the waves' troughs (Jim Gower, Institute of Ocean Sciences, DFO personal communication). Due to the strong ocean currents including eddies (see Section 2.3.2) that magnify ocean waves, Environment Canada has identified Bowie Seamount as a potentially hazardous area (Environment Canada 2000).

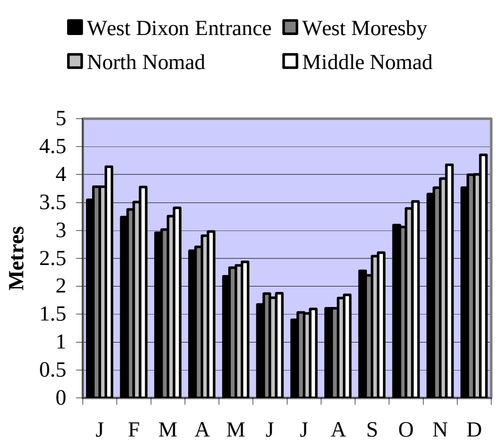


Figure 10. Average monthly waves height measured from offshore buoys near the Bowie Seamount Area (IOS wave buoy archive).

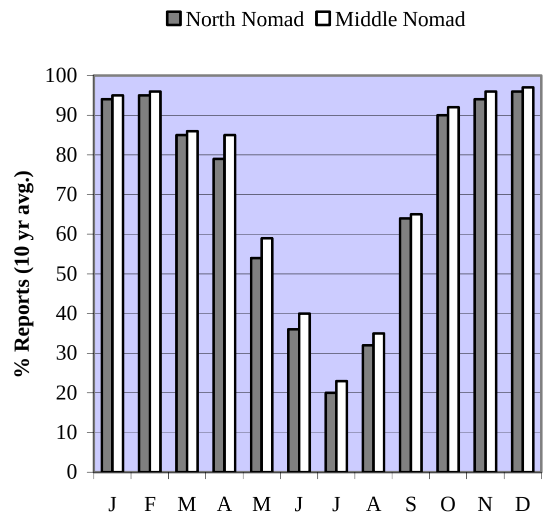


Figure 11. Average monthly occurrence of waves > 2 m measured from offshore buoys near the Bowie Seamount Area (Environment Canada 2000).

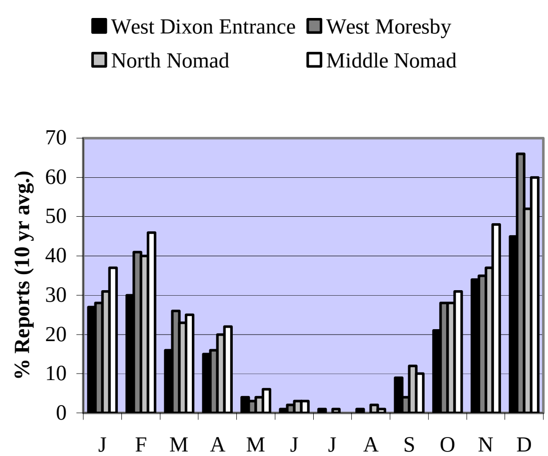


Figure 12. Average monthly occurrence of waves > 4 m measured from offshore buoys near the Bowie Seamount Area (Environment Canada 2000).

2.3.2 Currents and Circulation

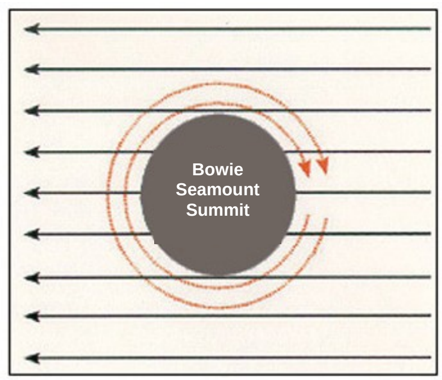
To date, no specific scientific research has been conducted on the types of water flow phenomena that occur at and near Bowie, Hodgkins and Davidson seamounts. However, some inferences can be made based on other seamounts of similar depth and latitude.

In particular, Cobb Seamount, which shares many characteristics with Bowie Seamount, has been comparatively well studied in recent years[8]. Cobb Seamount is located 500 km southwest of Vancouver Island at 46° 46' N, 130° 48' W (see Figure 1). Like Bowie Seamount, Cobb Seamount is one of the shallowest of the seamounts in the northeast Pacific, having a summit that extends to within 25 m of the ocean surface. Cobb Seamount is approximately symmetrical, with several wave-cut terraces and a central steep pinnacle, much like Bowie Seamount. Examining information gathered at Cobb Seamount may approximate what likely happens at Bowie Seamount.

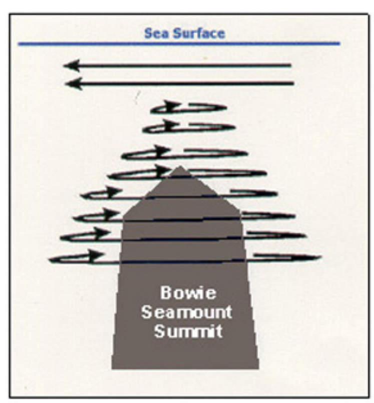
Between 1989-1994, Cobb Seamount was the focus of a major oceanographic research program that studied the physical, chemical and biological environment of the seamount. This program included a series of four research cruises. During each of these cruises, a dome of cold, up-welled water was observed over the seamount. Due to stratification in the water, the dome did not penetrate all the way to the surface, but was instead blocked at about the 85 m depth. Researchers also noted evidence of increased internal wave action over the seamount summit with a concomitant increase in turbulent mixing.

Perhaps the most important finding was evidence of a closed eddy, a Taylor cone, over the seamount. During the first cruise, this eddy was seen to persist for almost a month. Since a similar eddy was observed throughout each of the other cruises to Cobb Seamount, researchers believe that this closed eddy might be a permanent feature. In general, the closed eddy penetrated to within about 80 m of the sea surface. Given that Taylor cones rotate in a clockwise direction, over time the water within the cone is drawn down and is flushed out near the bottom layer. Researchers calculate that this flushing time is about seventeen days. Because Cobb Seamount is so shallow, this closed eddy penetrates well within the euphotic zone, the upper layer of the ocean that sunlight can penetrate and where most biological activity takes place.

Although the depth of Cobb Seamount has not been surveyed, it is known that Bowie and Cobb seamounts both rise to within 25 m of the surface. Thus, assuming that similar flow phenomena occur at Bowie Seamount (and this does seem likely), then there is probably an area of cold, nutrient rich water in the upper euphotic zone with a high level of mixing. There is also a strong possibility that, like Cobb Seamount, a Taylor cone caps Bowie Seamount. This has not been observed to date, but a theoretical model is presented in Figure 13. Biologically, this particular suite of flow phenomena is believed to be very important, and may contribute to the highly productive communities that often exist on shallow seamounts.



(a) Plan view



(b) Side view

Figure 13. Schematic representation of ocean circulation at Bowie Seamount (Dower and Fee 1999).

[8] The following discussion on localized ocean circulation around Bowie Seamount was compiled and written by John Dower and Frances Fee (Dower and Fee 1999). See list of references cited in Appendix C)

In addition to localized eddies, the Bowie Seamount Area is subject to regional eddies, known as 'Haida Eddies', which further complicate the ocean chemistry properties around the seamount. These are large (200-300 km diameter), long-lasting (up to three years), anti-cyclonic vortices formed along the continental margin of the Gulf of Alaska, west of the Gwaii Haanas (Queen Charlotte Islands) (Crawford 2001). They generally drift westward or southwest-ward passing through the Bowie Seamount Area (Figure 14). During the winter of 1997/1998 the two ocean features shown in Figure 14 merged to form Haida-1998, a clockwise-rotating eddy that formed off the west coast of Haida Gwaii (Queen Charlotte Islands). It drifted away from the continental margin in the spring of 1998, and was visible in satellite imagery for two years (Crawford and Whitney 1999).

Eddies are characterized by less saline, warmer waters, and increased sea surface height of up to 40 cm above surrounding waters. Figure 14 shows surface height anomalies for Haida-1998[9]. Heights in the core of the Haida-1998 eddy surpassed 40 cm (Cherniawsky *et al.* 2001). While eddies can penetrate to over 1500 m, most baroclinic structure is confined to the upper 300 m (Crawford 2001). The salinity and temperature profiles are similar to those of source waters in the continental margin. Consequently, the eddies carry coastal waters rich in fish, plankton and nutrients such as nitrate and iron (DFO 2001a).

In the Bowie Seamount Area, surface currents in the top meter below the ocean surface were measured for a few days in January 1991. The position of one surface buoy (4B50e) was tracked every few hours using the System Argos satellite, as shown in Figure 15. The buoy's track shows that it drifted about 10 to 15 km a day (or at a speed of 10 to 15 cm/sec), predominantly in a southeast direction. Unfortunately from such limited information, oceanographers are not able to make generalizations about surface currents, their average speed and direction.

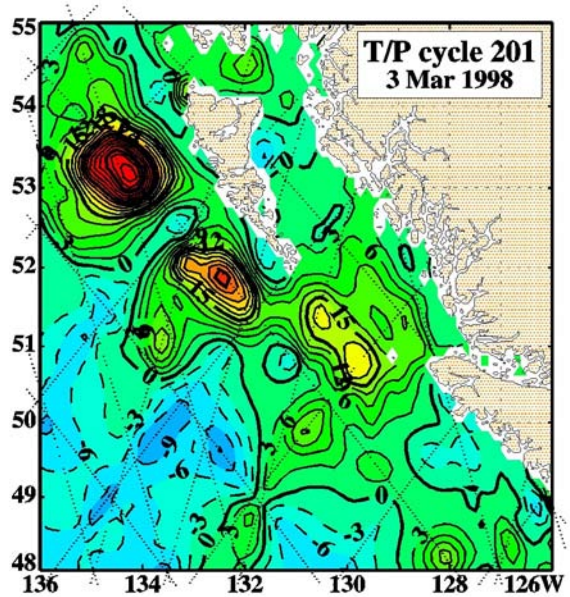


Figure 14. Surface height anomalies (in cm) showing the Haida 1998 eddy passing in the vicinity of the Bowie Seamount Area (Josef Cherniawsky, Institute of Ocean Sciences, DFO).

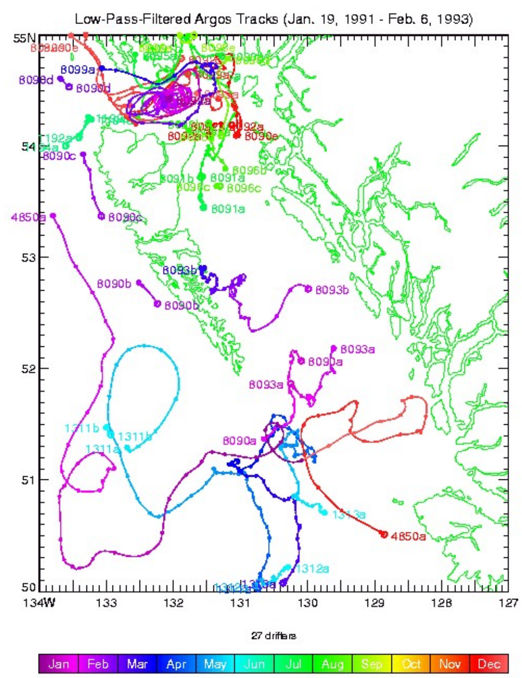


Figure 15. Tracks of Argos ocean drifter buoy west of British Columbia in January 1991 (Crawford 2002).

[9] The image was prepared by Josef Cherniawsky of the Institute of Ocean Sciences, using TOPEX/POSEIDON and ERS-2 satellite altimeter data initially processed by Brian Beckley of Goddard Space Flight Center, USA. Tidal elevations were removed from the data using algorithms and tidal constants developed at the Institute of Ocean Sciences, Fisheries and Oceans Canada (Foreman *et al.* 2000). Elevation contours denote height in centimetres above a four-year average sea surface height determined from TOPEX/POSEIDON and ERS-2 observations. Only observations within a 10-day period centred on March 3, 1998 were used to compute these elevation contours.

2.3.3 Ocean Properties

Limited information has been collected and made available on the oceanographic properties in the Bowie Seamount Area. Sea surface temperature measurements from the weather buoys surrounding the area show monthly average sea surface temperatures ranging from relatively stable values of approximately 7°C in winter to a peak of 15°C in August (Figure 16).

A Line P cruise of the CCGS *J.P. Tully* passed over Bowie Seamount on 23 June 1998 during which oceanographic measurements and observations, including temperature and salinity, were recorded. These measurements were incidental to the intent of the cruise which was to gather seabird data in an 'X'-shaped search pattern centred on the seamount. Therefore, oceanographic data coverage is not complete and the time period of data collection is short. As a result, the data acquired represent only a rough snapshot of conditions in the Bowie Seamount Area at the time, and cannot be interpreted as representing an average condition. Nevertheless, the patterns do seem to show some structure at the position of Bowie Seamount in particular.

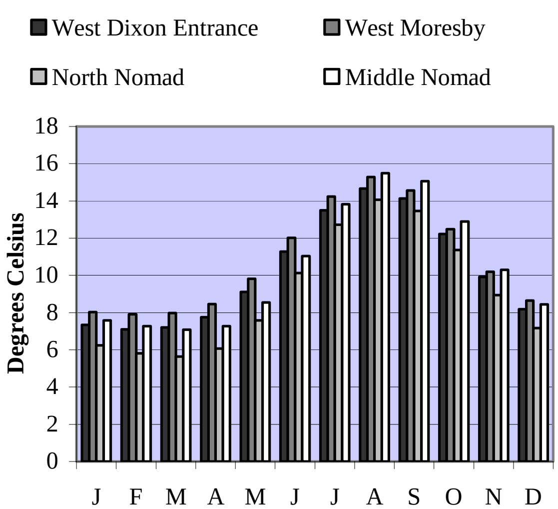


Figure 16. Average monthly sea surface temperature measured from offshore buoys surrounding the Bowie Seamount Area (IOS wave buoy archive).

Temperature, salinity and surface height measurements were contoured by Ron Perkin, Institute of Ocean Sciences for Bowie Seamount as shown in Figure 17. The positions of the peak of the seamount are given by the posted depths of 25 m and 40 m, and the position of the vertical profiles of temperature, salinity and nutrients are marked as "500m CTD cast".

If there were any surface manifestations of the seamount, these would be expected to be in the form of patches of cooler, more saline waters from upwelling or enhanced turbulent mixing generated by waves and currents. These patches would then be soon carried away by the mean current field into the surrounding area. For example, the CTD cast appears to have been in a patch of water with lower temperature, higher salinity and lower chlorophyll that may reflect the influence of Bowie Seamount's summit. However, the ocean is normally somewhat patchy and subject to wind mixing so a more detailed study would have to be made to determine the significance of such features.

Profiles of temperature and salinity (Figure 18) show low vertical gradients to a depth of 30 m, so it seems that, for at least some periods of time, vertical exchange to 30 m was taking place. Also unusual in this profile is the large step in temperature and salinity at 150 m – quite probably a feature generated by the seamount.

Bowie Seamount lies within the so-called High Nutrient - Low Chlorophyll domain within the Gulf of Alaska. Nutrient levels of surface waters in the vicinity of the Bowie Seamount Area have been measured as part of local surveys (Whitney and Welch, 2002) and studies of mesoscale eddy transport (Whitney and Robert, 2002). Nitrate measurements taken in the Bowie Seamount Area during an eddy survey in June 2000 show levels in the 1-5 µM[10] range (Figure 19). In comparison, coastal areas show nitrate levels less than 1 µM and offshore values can be in the 10-15 µM range.

[10] µmol l-1or micro-moles per liter (concentration in seawater).

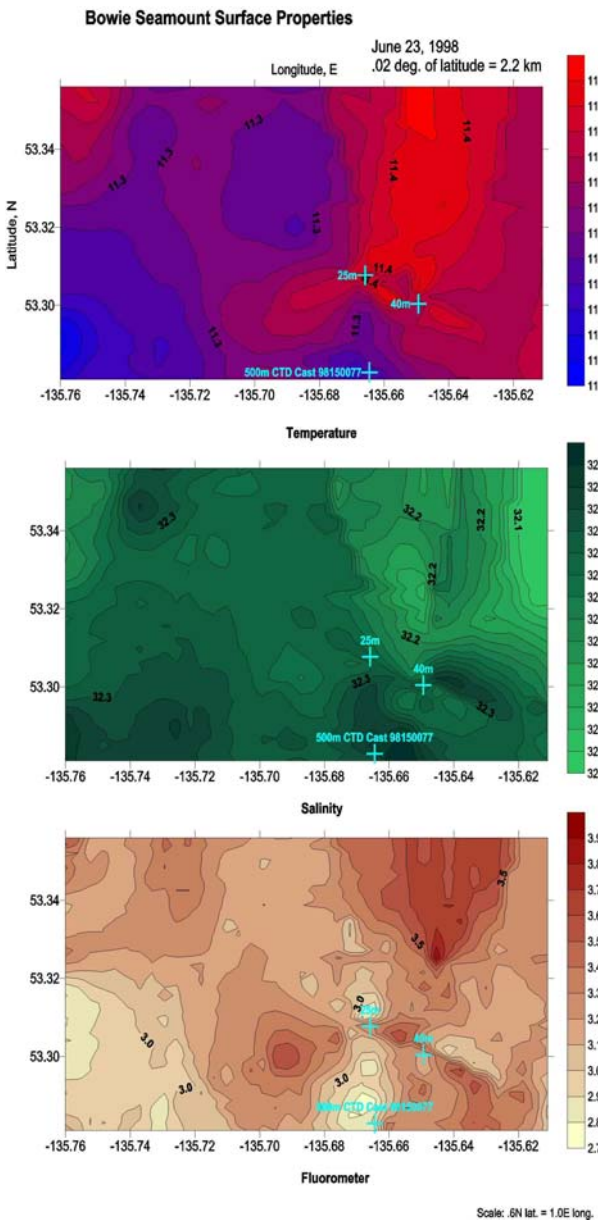


Figure 17. Bowie Seamount Area sea surface oceanographic properties (23 June 1998) (Ron Perkin, Institute of Ocean Sciences, Fisheries and Oceans Canada).

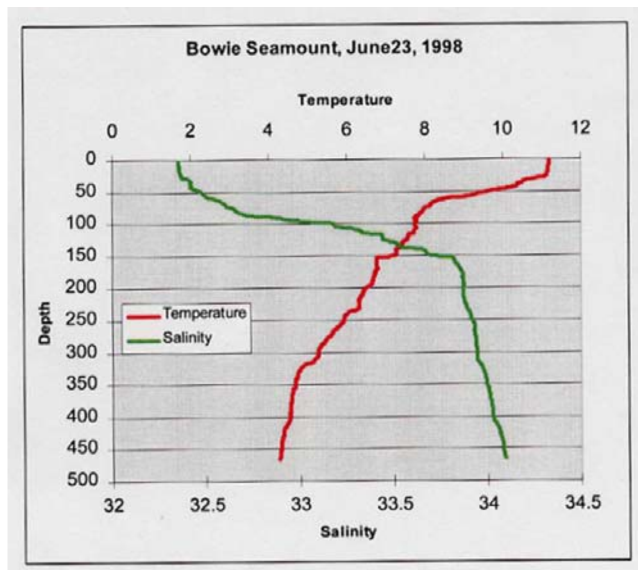


Figure 18. Bowie Seamount Area water column profile data (23 June 1998) (Ron Perkin, Institute of Ocean Sciences, Fisheries and Oceans Canada).

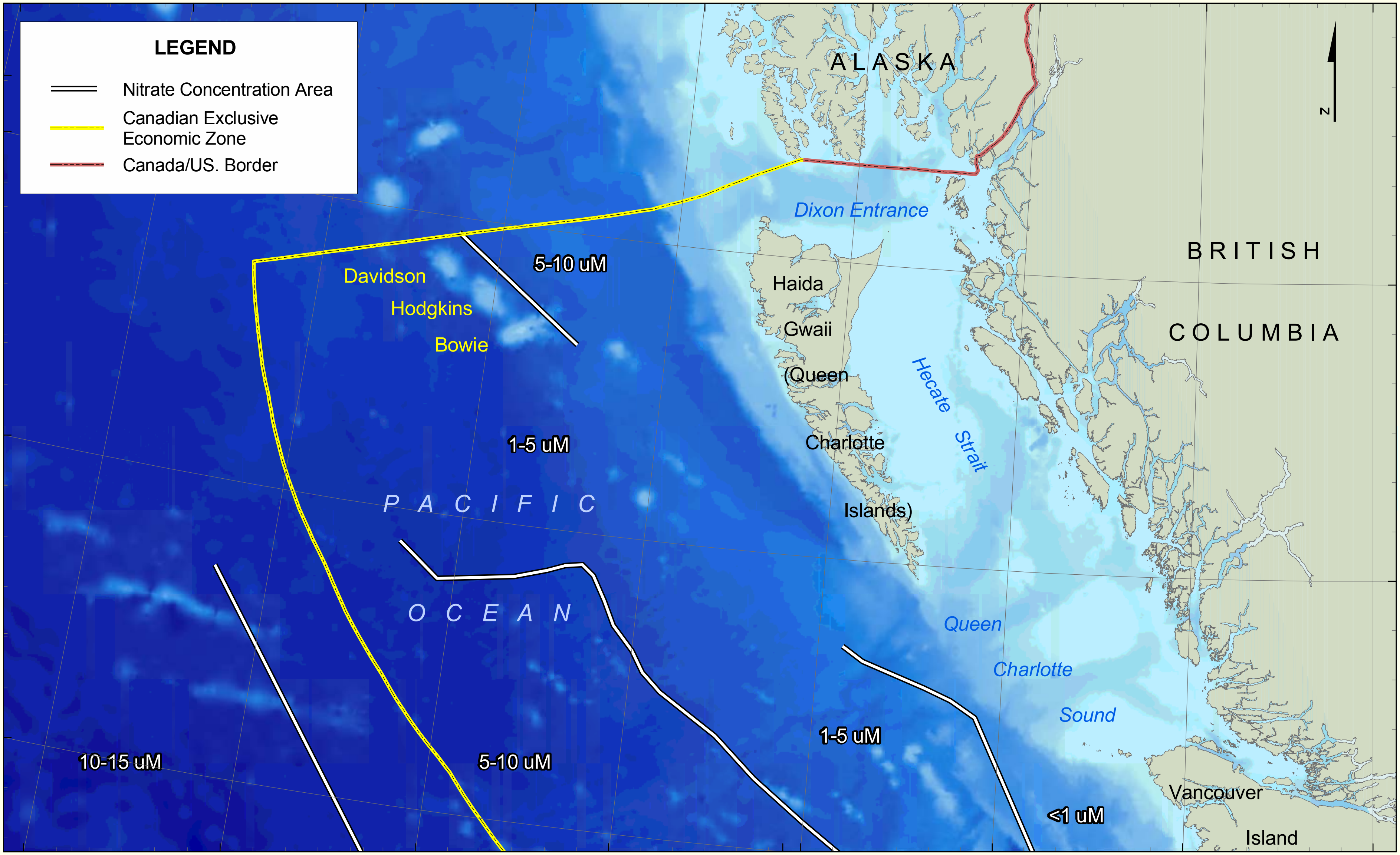
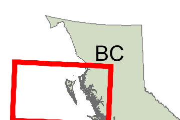


Figure 19.
Concentrations of Nitrate (uM) in Surface Waters in the Vicinity of the Bowie Seamount Area (June 2000)



Area of Detail

0 40 80 120 160
Kilometres

Data Sources: F. Whitney (Fisheries & Oceans Canada);
Bathymetric model created by AXYS with data from National Geophysical Data Center, National Environmental Satellite, Data and Information Service (NESDIS)
Projection: BC Standard Albers

SP378 - Fig. 19

2.4 BIOLOGY

Oceanographic properties, particularly upwelling and turbulent mixing of surface waters, suggest that the Bowie Seamount Area, like other seamounts, supports rich biological communities in otherwise unproductive regions of the sea. Primary productivity is expected to be high through spring and summer since nutrients are never depleted, and micro nutrients such as iron, are readily available from Bowie Seamount's summit (Frank Whitney, Institute of Ocean Sciences, DFO, personal communication). Based on a National Geographic Society (NGS) video survey of Bowie Seamount, the area has been described as relatively rich in terms of high biodiversity and extensive algal coverage of the rock substrate (Austin 1999, Curtsinger 1996). The summit of Bowie Seamount has an interesting ecosystem structure that, despite its shallowness, exhibits the juxtaposition of oceanic species (*e.g.* salps), deep water species such as prowfish and squat lobsters, and intertidal and shallow subtidal coastal species including California mussels and split leaf laminarian kelp (Austin 1999).

There has not been thorough research nor comprehensive monitoring of the flora and fauna of the Bowie Seamount Area ecosystems. However, in this overview report we have painted a crude picture of the marine life at and around the Bowie Seamount, by compiling taxonomic records from several sources, including:

- benthic algae survey, late 1960s (Scagel 1970)
- oceanographic survey, 1969 (Herlinveaux 1971)
- bathymetric survey, 1969 (Scrimger and Bird 1969)
- video imagery, 1995 (Curtsinger 1996; Austin 1999)
- bird observations, 1997, 1998, 2000 (Ken Morgan, Canadian Wildlife Service, Environment Canada, personal communication)
- fisheries reports and logs, 1998 (Yamanaka and Brown 1999; Lynne Yamanaka, Pacific Biological Station, DFO, personal communication)
- mesoscale eddy transport studies, 2000 (Dave Mackas, Institute of Ocean Sciences, DFO, personal communication; Frank Whitney, Institute of Ocean Sciences, DFO, personal communication)

Based on these studies, there are more than 158 plant and animal taxa found on Bowie Seamount and in the surrounding waters (Table 4). The species richness is greatest for fishes (53+ taxa), arthropods (30) and birds (16+). A preliminary listing of all taxa observed in the Bowie Seamount Area is presented in Appendix D. The reader should remember however that in most cases, biological sampling in the Bowie Seamount Area was often incidental to other research and commercial fishing objectives; therefore, this list should not be considered comprehensive.

Table 4. Species richness of biota observed at or near Bowie Seamount (summarized from Appendix D).

Taxonomic group	# of taxa
Algae	
Brown algae	4
Red algae	10
Protozoa	3
Invertebrata	
Porifera (sponges)	1+
Cnidaria (anemones, jellyfish, hydroids)	7+
Annelida (polychaete worms)	2
Bryozoa (moss animals)	1+
Mollusca (snails, octopus, squid, chitons, bivalves)	6
Arthopoda (barnacles, crabs, amphipods, copepods)	30
Echinodermata (sea stars, brittle stars, sea cucumbers)	6
Urochordata	
Larvacea and Thaliacea (salps)	4
Vertebrata	
Chondricthyes (sharks, skates)	7
Osteichthyes (flounders, soles, rockfish, sculpins)	53+
Aves (albatrosses, auklets, puffin, petrel, shearwater)	16+
Mammalia (seals, sealions, dolphins, whales)	8+
TOTAL	**158+**

Notes:
+ Possibly more species observed but unconfirmed

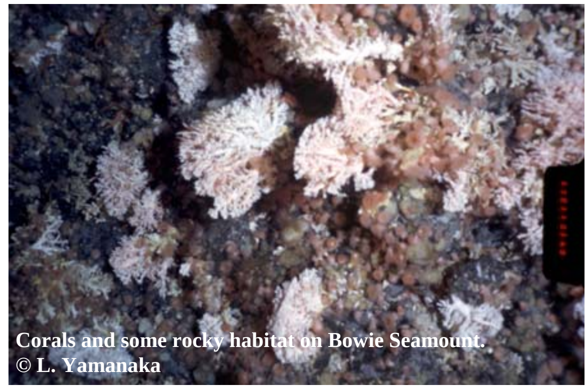
2.4.1 Plankton

In the Bowie Seamount Area, the zooplanton community was sampled in June and September as part of a 2000 study on a large anticyclonic eddy which spent several months (early May to late October) in the area. The samples included 16 taxa of calanoid copepods, one taxon of pteropods, one taxon of cladocerans, three taxa of protozoans, one taxon of amphipods, one taxon of larvaceans, and euphasiid larvae. Pteropods and calanoid copepods were by far the most abundant zooplankton accounting for 57% and 52% respectively, of the total biomass surveyed. The most abundant species were *Pseudocalanus mimus*, *Paracalanus parvus*, *Neocalanus plumchrus* and *Limacina helicina* (Dave Mackas, Institute of Ocean Sciences, DFO, personal communication).

Plankton tow
© L. Yamanaka

2.4.2 Benthos and Benthic Habitat

There is little information that characterizes the benthic habitats of the Bowie Seamount Area aside from some surveys in the late 1960s (Scagel 1970) and the recent examination of the NGS video footage. The NGS video survey showed most upper surfaces of Bowie Seamount are dominated by a red algal turf while the under surfaces of ledges are dominated by a variety of encrusting algae (Austin 1999). Scagel (1970) identified twelve taxa of brown and red algae, several of which were also observed by Austin (1999). Austin (1999) also possibly identified *Polysiphonia* sp., a filamentous red turf. This degree of species richness is typically limited to shallow, moderate current or wave exposure regimes along the British Columbia coast. The taxa recorded at Bowie Seamount are not uncommon in coastal regions, however, the depths at which some taxa were found were greater than those ever recorded.



Corals and some rocky habitat on Bowie Seamount.
© L. Yamanaka

While the Bowie Semaount taxa list derived from the NGS video is by no means comprehensive, it does provide a thumbnail sketch of the incredible species diversity of the benthic areas. The video footage combined with other observations show that the benthic community includes at least nine species of crab including king crab (*Paralithodes camtschatica*), queen crab (*Chionoecetes* sp.), tanner crab (*Chionoecetes* sp.) and the snow crab (*Chionoecetes* sp.). The squat lobster (*Munida quadrispina*) was observed in unusually large numbers given the shallow depth of water at Bowie Seamount (Austin 1999). In addition, numerous species of anemone, sea stars, brittle stars, and barnacles are visible on the flanks of the seamount. Both squid and octopus were also observed.

Close-up of a seastar, anemone, and corals
© L. Yamanaka

2.4.3 Fishes

Based on catch logs and biological samples collected under fishing permits, a few general statements can be made regarding fish populations around Bowie Seamount. A total of 53 fish taxa including rockfish (*Sebastes* spp.), Pacific halibut (*Hippoglossus stenolepis*), sablefish (black cod) (*Anoplopoma fimbria*), sole shark and prowfish (*Zaprora silenus*) have been found in the area (Appendix D). The large number of prowfish observed is surprising as the species is recorded as inhabiting somewhat deeper waters than those found at Bowie.

Prowfish, *Zaprora silenus*, in a rock crevice
© L. Yamanaka

As on several other shallow seamounts in the north Pacific, the fish community at Bowie is dominated by rockfish (21 species in total), the most abundant being harlequin (*Sebastes variegatus*), rougheye (*S. ruberrimus*), yelloweye (*S. ruberrimus*) and widow rockfish (*S. entomelas*). The dominance of rockfish on shallow offshore seamounts is due to the species life history strategy of giving birth to live young instead of laying eggs. This strategy seems to be particularly useful in retaining larvae long enough to settle over a seamount.

Yelloweye Rockfish, *Sebastes rubberrimus*
© L. Yamanaka

During both the first Bowie Seamount survey in 1969 and most recent in 2000, a complete range of age and size of one rockfish species, the widow rockfish, was recorded (Herlinveaux 1971; Yamanaka 2001). This suggests that, at least for this species, a self-supporting population exists on the seamount. In contrast, data gathered via the scientific permits in the 1980s showed the yelloweye rockfish population on Bowie Seamount lacked any fish younger than about fifteen years (Figure 20). Several possibilities could explain these differing results. Some rockfish species, such as the yelloweye, may be dependent on episodic influxes of individuals from the coast, while other species may represent reproductively stable populations around the seamount. The difference in time between the two studies may also indicate a shift in the age structure of Bowie Seamount fish populations.

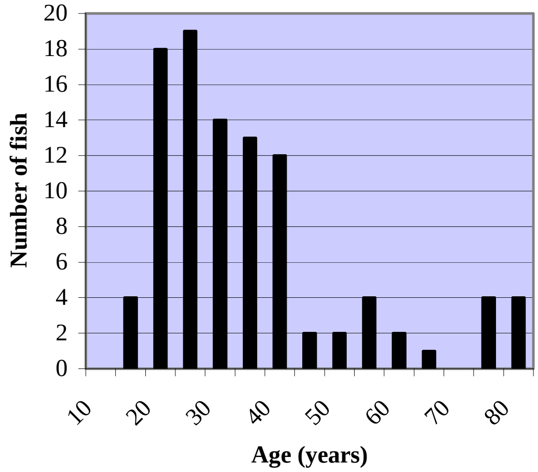
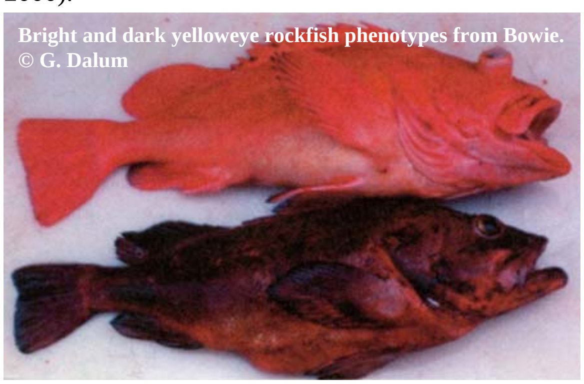


Figure 20. Age structure of Bowie Seamount yelloweye rockfish, August/September 1980.

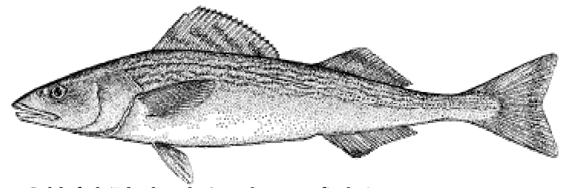
In the Molecular Genetics Lab at the Pacific Biological Station, DFO, researchers have developed the ability to study rockfish (genus *Sebastes*) species at microsatellite DNA loci. This allows them to examine the distribution of genetic variation within and among these species in the coastal waters of British Columbia. Delineation of the genetic structure of species is important for developing conservation plans that appropriately quantify biodiversity and that improve fisheries management, monitoring activities and establishment of refugial areas such as MPAs. The fishes' microsatellite loci are the most sensitive genetic markers available for identifying levels of genetic 'relatedness' throughout the geographic range of a species.

Genetic analyses of 2,520 yelloweye rockfish at 13 microsatellite loci were conducted in 1999-2000 (Yamanaka *et al.* 2000). Twenty-five samples were collected at nine sites from northwestern Vancouver Island (49.50 N 127.5 W) to southeast Alaska (57.18 N 136.07 W) and included Bowie Seamount (53.30 N and 135.60 W). Allelic diversity and observed heterozygosity levels at microsatellite loci were high, indicating that effective population size was large. All samples were drawn from a single panmictic population. Although the genetic data provide evidence of a single 'unit stock' among yelloweye rockfish in this study, the age composition data indicate that demographic factors vary on a much smaller spatial scale. The low level of genetic differentiation among yelloweye rockfish is likely the result of larval dispersal by ocean currents. However, adult yelloweye rockfish reside over specific rocky habitats and move little from these areas. Hence, the combination of biological characteristics (longevity and sedentary behavior) and fishery harvests, have caused detectable changes in yelloweye rockfish population parameters. A general north to south cline of increasing total mortality estimates highlights the influence of fishing on local population structure. Heavily fished populations are characterized by a truncation of the age distribution as older individuals are removed by fishing and not replenished rapidly by adult immigration or population growth.

Research has found that samples of the dark yelloweye rockfish phenotype from Bowie Seamount are not genetically differentiated from samples of the bright phenotype from the same or other sites (Yamanaka *et al.* 2000). This phenotype was previously thought to be a genetically distinct subspecies of yelloweye rockfish (Yamanaka *et al.* 2000).


Bright and dark yelloweye rockfish phenotypes from Bowie.
© G. Dalum

Sablefish is another key species associated with the Bowie Seamount Area. Sablefish are long-lived and slow growing after maturity. Although the commercial fishery targets sablefish in a depth range of 100-1000 m, sablefish occupy depths below 1000 m (DFO 2002e, Haist *et al.* 1999, McFarlane and Beamish 1983a). Juvenile sablefish (age 3+) are known to be highly migratory, travelling as far as the Gulf of Alaska and Bering Strait from Hecate Strait (DFO 2002e). Alaskan sablefish are known to migrate up to 500 nm (Kimura *et al.* 1998). Evidence from parasite studies indicates that the sablefish on Bowie Seamount are discrete from sablefish in coastal areas (Kimura *et al.* 1998, Whitaker and McFarlane 1997, Kabata *et al.* 1988). Age structures of sablefish populations on the seamounts suggest that these populations are not self-sustaining since very few young age-class fish are found on the seamounts.


Sablefish/Blackcod, *Anoplopoma fimbria*
© Fisheries and Oceans Canada

Current hypotheses conflict with regards to Bowie Seamount's role as a biological sink or a source. Some scientists suggest that diversity and populations on the seamount are dependent upon organisms being transported to the seamount from coastal populations (Mark Saunders, Stock Assessment Division, DFO, personal communication). Others suggest that, with sablefish for instance, there is insufficient knowledge on where coastal stocks come from and offshore seamounts could in fact be a source just as readily as a sink (Richard Beamish, DFO, personal communication). For example, some, albeit very few, tagged sablefish from seamounts have been found to return to coastal waters. Further information is required, however, to determine if sablefish spawn on the seamount. (Mark Saunders, Stock Assessment Division, DFO, personal communication).

2.4.4 Seabirds

The Bowie Seamount Area has been identified as a CWS Area of Interest for Migratory Birds and Bowie Seamount itself is a CWS confirmed area of importance to marine and coastal birds (Figure 21 and Canadian Wildlife Service 2003). Nine bird species were observed within 30 km of the Bowie Seamount summit during two different cruises (June 1997 and June 1998): Northern Fulmar (*Fulmarus glacialis*), Sooty Shearwater (*Puffinus griseus*), Murphy's Petrel (*Pterodroma ultima*) (a species that is quite rare to British Columbia waters), Leach's Storm-petrel (*Oceanodroma leucorhoa*), Fork-tailed Storm-petrel (*Oceanodroma furcata*), Long-tailed Jaeger (*Stercorarius longicaudus*), South Polar Skua (*Stercorarius maccormicki*), Rhinoceros Auklet (*Cerorhinca monocerata*) and Ancient Murrelet (*Synthliboramphus antiquus*). Between 30 km and 100 km from the Bowie summit the following species were encountered: Black-footed Albatross (*Phoebastria nigripes*), Northern Fulmar, Sooty Shearwater, Leach's Storm-petrel, Fork-tailed Storm-Petrel, Long-tailed Jaeger, Tufted Puffin (*Fratercula cirrhata*) and Cassin's Auklet (*Ptychoramphus aleuticus*). Other species observed in the Bowie Seamount area include Buller's Shearwater (*Puffinus bulleri*), Glaucous-winged Gulls (*Larus glaucescens*), Black-legged Kittiwake (*Rissa tridactyla)*, Horned Puffin (*Fratercula corniculata*).

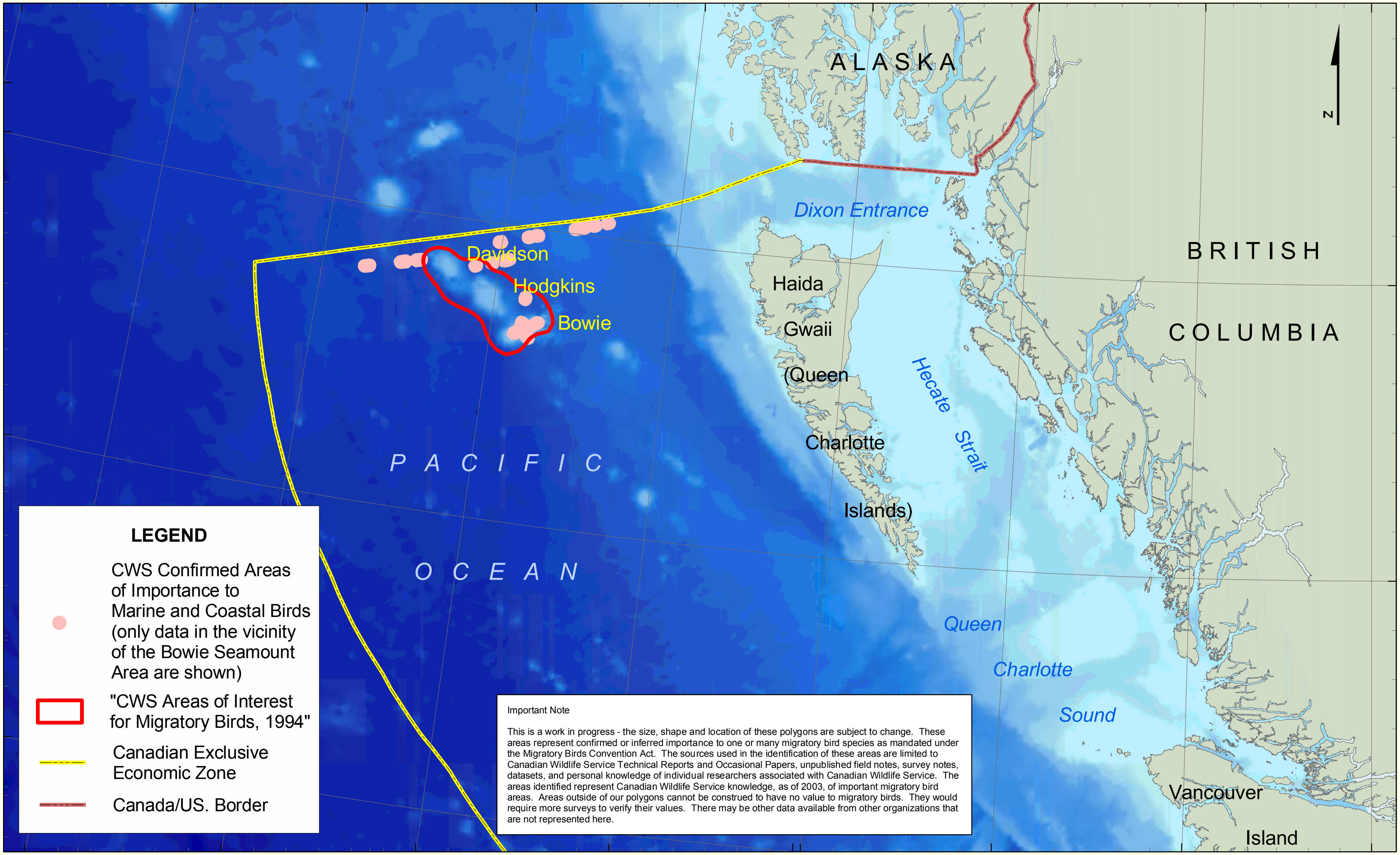
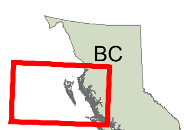


Figure 21.
Areas of Importance to Marine Birds in the Bowie Seamount Area (21 January 2003)



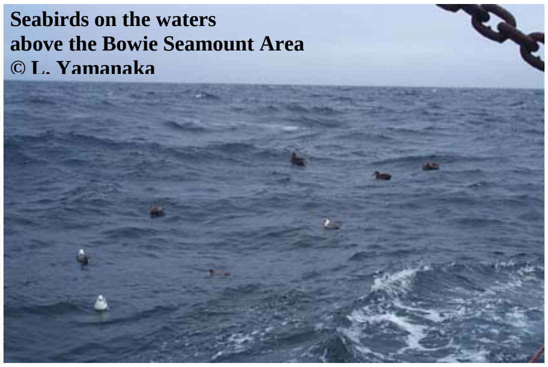
Area of Detail

0 40 80 120 160
Kilometres

Data Sources: Canadian Wildlife Service, 2003;
Bathymetric model created by AXYS with data from
U.S. National Geophysical Data Center, National Environmental Satillite,
Data and Information Service (NESDIS)
Projection: BC Standard Albers

SP378 - Fig. 21

Table 5 shows the seasonal density of bird species in the Bowie Seamount Area. The most commonly observed birds are Fork-tailed Storm Petrel and Leach's Storm Petrel. Most observed species are most abundant in summer, although Black-footed Albatross and Buller's Shearwater predominate in autimn, and Glaucous-winged gull and Black-legged Kittiwake predominate in winter.



Seabirds on the waters above the Bowie Seamount Area © L. Yamanaka

Generally, seabirds have been shown to be more abundant in the vicinity of shallow seamounts. Studies around Cobb Seamount found that observed numbers of several species of seabirds were significantly higher around the seamount than elsewhere in the region (Dower and Fee 1999). However, the small sample size and uneven survey effort at Bowie Seamount are insufficient to determine if the same concentrating effect occurs there.

2.4.5 Mammals

Marine mammals observed in the Bowie Seamount Area include dolphins, seals, Stellar sealions and several species of whales including sperm whales (*Physeter catodon*). Dolphin species recorded at Bowie Seamount include killer whales (*Orcinus orca*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), northern right whale dolphin (*Lissodelphis borealis*) and possibly the striped dolphin (*Stenella coeruleoalba*).

Sea lions at Bowie Seamount © National Geographic Society

Table 5. Average seasonal density of birds in the Bowie Seamount Area.

	Summer		**Autumn**		**Winter**	
	ASD[a] ($\#/km^2$)	**Freq. of Occurrence[b]**	**ASD[a]** ($\#/km^2$)	**Freq. of Occurrence[b]**	**ASD[a]** ($\#/km^2$)	**Freq. of Occurrence[b]**
Black-footed Albatross	0.036	8	0.042	14	0.000	0
Northern Fulmar	0.219	26	0.000	0	0.205	2
Murphy's Petrel	0.019	2	0.000	0	0.000	0
Sooty Shearwater	0.085	15	0.000	0	0.000	0
Buller's Shearwater	0.000	0	0.182	2	0.000	0
Fork-tailed Storm-Petrel	5.479	85	0.000	0	0.067	1
Leach's Storm-Petrel	5.064	132	0.000	0	0.000	0
Long-tailed Jaeger	0.010	3	0.000	0	0.000	0
Glaucous-winged Gull	0.000	0	0.000	0	0.067	1
Black-legged Kittiwake	0.000	0	0.000	0	0.543	8
Ancient Murrelet	0.081	3	0.000	0	0.000	0
Cassin's Auklet	0.103	9	0.000	0	0.000	0
Rhinoceros Auklet	0.133	3	0.000	0	0.000	0
Horned Puffin	0.005	1	0.000	0	0.000	0
Tufted Puffin	0.065	9	0.000	0	0.000	0
Number of transects	**265**		**63**		**25**	

Notes:
[a] Average seasonal density by species based on all transects occurring within a 14,000 km^2 surrounding Bowie, Hodgkins and Davidson seamounts
[b] = number of transects species was observed (not the total number of birds)
Source: Ken Morgan, Canadian Wildlife Service

2.4.6 Trophic relationships

Using an Ecopath model to explore the impact of excessive fishing on key species at Bowie Seamount, Beamish and Neville (In prep.) have mapped out the trophic relationships (Figure 22). The authors describe the Bowie Seamount trophic system as being simpler than the typical coastal ecosystems due to the apparent diminished presence of the small pelagic community on the seamount relative to the number of species at the highest trophic levels (Beamish and Neville In prep.).

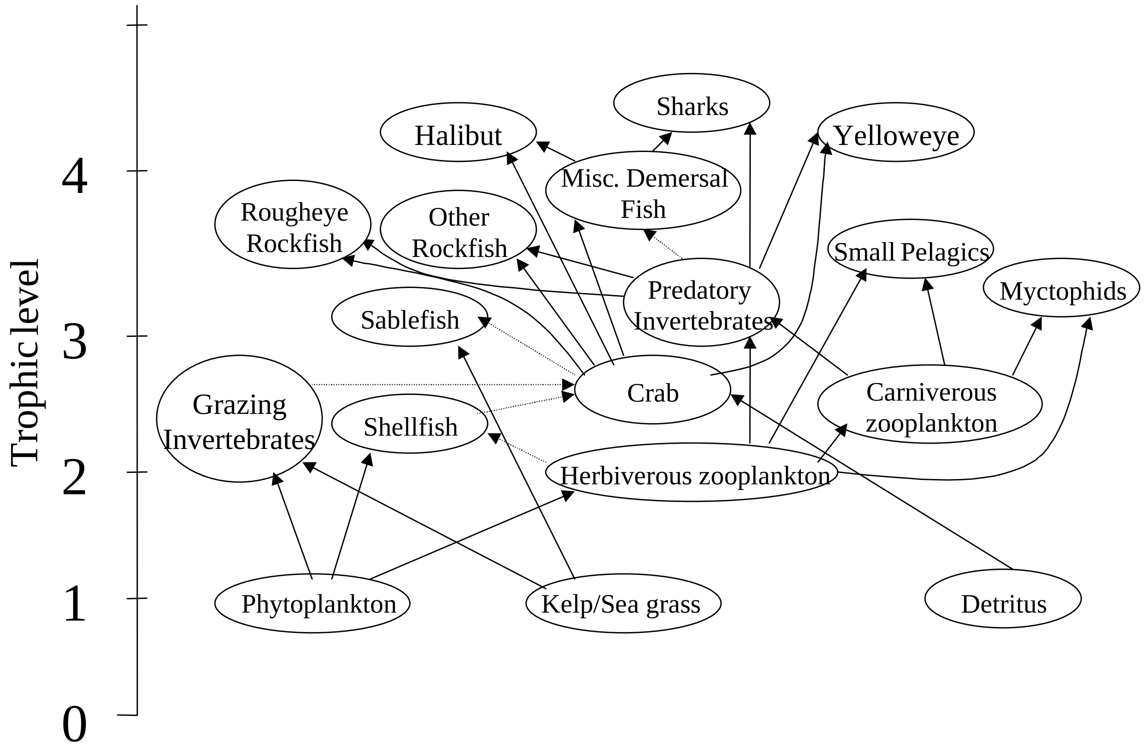


Figure 22. Trophic relationships at Bowie Seamount (Beamish and Neville In prep.)

3.0 SOCIO-ECONOMIC COMPONENTS

In addition to ecological factors, the International Union for the Conservation of Nature (IUCN) considers social, economic and scientific values important criteria for MPA selection (Kelleher and Kenchington 1992). These values apply equally to both coastal and offshore areas (including seamounts such as Bowie, Hodgkins and Davidson) and may include:

- Economic importance – existing or potential contribution to economic value by virtue of its protection *e.g.*, protection of an area for recreation, subsistence, use by traditional inhabitants, appreciation by tourists and others or as a refuge nursery area or source of supply for economically important species;
- Social importance – existing or potential value to the local, national or international communities because of its heritage, historical, cultural, traditional, aesthetic, educational or recreational qualities; or
- Scientific importance – existing or potential value for research, monitoring, or education.

This section summarizes the known human uses including historical and cultural values of the Bowie Seamount Area (Table 6). Where available, information is included on the scale, scope, duration and status of these activities.

Table 6. Chronology of human activities in the Bowie Seamount Area.

Date	Type of Activity
1911-1943?	Whaling
1950s	Estimated start of halibut fisheries
1969	First recorded research trip by R.H. Herlinveaux
1970s	Japanese longline fishing
1979	Exploratory longline set on Bowie Seamount
1980s	Mid-water trawl effort on *Callistratus* and *Arctic Harvester*
1980/81	Experimental rockfish fishing by B. Leaman
1983	Commencement of limited experimental sablefish seamount fishery
1987	Commencement of formalized experimental sablefish seamount fishery, including the collection of biological samples
1987/1988	Sablefish stock identification study
1988	Voluntary Tanker Exclusion Zone established for the Pacific Coast (the Bowie Seamount Area is outside the zone)
1992	Experimental sablefish seamount fishery
1993	Exploratory trawl survey in joint venture by Deep Sea Trawlers Association, Fisheries and Oceans Canada and the B.C. Ministry of Fisheries
1994	G. Dalum fishes Bowie Seamount on a sablefish license from the vessel *Nordic Spirit*, with low success but a significant catch of rougheye rockfish
1995	G. Dalum fishes Bowie Seamount from the vessel *Double Decker*, with a scientific permit for the capture of rockfish
1995	National Geographic Society expedition to Bowie Seamount
1998	Department of National Defense rescue divers performed a combination plane jump and SCUBA dive on Bowie Seamount
1998	Sounding track lines are run for the Canadian Hydrographic Services; a Canadian Wildlife Service observer counted seabirds in the area
1998	Water quality (CTD) sampling by Canadian Hydrographic Service
1998	High-seas salmon research transects near Bowie Seamount by Institute of Ocean Sciences, DFO
1998	Two sets attempted for flying squid, both were unsuccessful
1999	Fish sampling for genetic studies
2000	Multi-disciplinary research biological, oceanographic and geological survey of Bowie Seamount
2000	Multi-beam bathymetry data acquired for Bowie and Hodgkins seamounts by NOAA and CHS
2000	Zooplankton surveys at Bowie Seamount as part of study on a Haida Eddy
2000	Closure of the rockfish scientific permit fishery
2001/02	Conversion of sablefish fishery from scientific permit fishery to limited commercial entry by draw.
2002	First known recreational dive on Bowie Seamount (Brian Fuhr, personal communication)

3.1 RESEARCH AND MONITORING

While scientists have studied seamounts for at least the past 30 years, there remain considerable gaps in the knowledge of these features. Past studies have focused on only a few seamounts, and even fewer studies have looked at very shallow seamounts such as Bowie Seamount (Dower and Fee 1999). Extensive oceanographic and biological research has been conducted on other seamounts in the northeast Pacific Ocean, such as Cobb Seamount. State-of-the-art monitoring equipment, remote-access submarines, and techniques for deep-water diving have allowed researchers from the University of Washington to gather valuable data on the geological, hydrographic and biological aspects of Cobb Seamount for the last two decades.

Conversely, this degree of research activity has not been conducted in the Bowie Seamount Area. However, Bowie Seamount itself is a relatively new research location and avid interest to perform research does exist. One of the principal obstacles to conducting research here is remote access and deep waters (Curtsinger 1996). There is limited availability of suitable vessels and difficulty performing research activities in offshore, open waters. Many research trips are limited to the summer months when wave and weather conditions are more favourable for surface vessels and for divers. Reductions in research funding over the years have also compounded these challenges of undertaking research at Bowie Seamount (John Dower, University of Victoria, personal communication; Jim Cosgrove, Royal British Columbia Museum, personal communication).

One of the first documented research trips to Bowie Seamount took place in 1969 (Scrimger and Bird 1969, Herlinveaux 1971) (Table 7). During this trip, divers explored the seamount summit and recorded photographic images using underwater cameras. These early photographs provided biologists and oceanographers with a first glimpse of the seamount and its diverse marine life.

The next known research trips to Bowie Seamount occurred in the early 1980s. The purpose of these trips was to find new fisheries for the near-shore groundfish fleet (Lynn Yamanaka, Pacific Biological Station, DFO, personal communication). As part of this project, two exploratory trips were undertaken: the first was from 28 August to 12 September 1980 aboard the M.V. *Viking Star* (Carter and Leaman 1981); the second trip was undertaken from 11 – 23 August 1981 aboard the M.V. *Star Wars II* (Carter and Leaman 1982; Bruce Leaman, International Pacific Halibut Commission, personal communication). There was a mid-water trawl effort in the early 1980s at Bowie Seamount on two chartered vessels, the *Callistratus* and the *Arctic Harvester* (Bruce Leaman, International Pacific Halibut Commission, personal communication). However, capture information suggests that the project was minimally successful. The Deep Sea Trawlers Association of British Columbia, in a joint initiative with DFO and the British Columbia Ministry of Agriculture, Fisheries and Food, undertook an exploratory trawl survey of Bowie Seamount in 1993.

Data for sablefish and rockfish stocks, both commercially important, have been collected for the Bowie Seamount Area from as early as 1969. Some of these data have been collected from research trips; others from catch statistics from commercial vessels. A study was conducted at Bowie Seamount and two other seamounts in 1987/1988 for sablefish stock identification using parasites as biological tags (Whitaker and McFarlane 1997). A three-year research project has been underway since 1998 to examine the genetic diversity of rockfish and sablefish found on Bowie Seamount compared to samples of the same species taken from near-shore environments. Section 2.4.3 discusses the results from rockfish genetic analysis. Funding has not yet been received to analyze the sablefish samples taken.

The Pacific Biological Station conducted oceanographic and high-seas salmon sampling near Bowie Seamount in August of 1998 (David Welch, DFO, personal communication). This involved numerous transects running perpendicular to the shore out to the open ocean, just to the north of Bowie Seamount. These transects were designed to collect biological and oceanographic data to assess juvenile salmonid survival and location along the Continental Shelf migratory route.

Table 7. Summary of science and research activities in the Bowie Seamount Area.

Dates	Research Activities
March, August 1969	**CSS *PARIZEAU*, Captain Colin Angus, oceanography, ecology and geology** R. H. Herlinveaux (Pacific Environment Institute, West Vancouver) directed an oceanographic program on and over Bowie Seamount as a cooperative study with the Pacific Defense Research Establishment. Investigations included physical oceanography of water properties and current observations, satellite navigation, biological oceanography of flora and fauna forms on rock samples, observations of fish life through echo sounders, and photographs taken by divers. Herlinveaux stated that Bowie Seamount *"is extremely interesting ecologically because of the large year-round complete population of fish."*
August, September 1980	**M.V. *VIKING STAR*, Captain Emil Sletten, rockfish** Bruce M. Leaman (Pacific Biological Station, DFO, Nanaimo) led an investigation of rockfish resources as part of a joint project with the B.C. Ministry of Environment. Experimental fishing was carried out using longline gear at locations on the west coast of the Queen Charlotte Islands and Bowie Seamount. The catch of commercial species on individual hauls was higher at Bowie Seamount than at inshore locations. Rockfish resources at Bowie Seamount were found to be relatively unexploited, with an accumulation of older, larger fish.
August 1981	**M.V. *STAR WARS II*, Captain John Strand, rockfish** Bruce M. Leaman's group returned to Bowie Seamount to collect biological data on the two prominent rockfish species present: rougheye and yelloweye. Longline and gillnet fishing gear was used to survey the fish in the area. A total of 20 species of fish were caught, half of which were rockfish.
1983 - present	**Commercial fishing vessels, rockfish and sablefish** Since 1983, several commercial fishing vessels that are licensed to catch rockfish or sablefish with hook and line gear in the domestic fishery were permitted to carry out fishing operations at Bowie Seamount. The Scienctific Fishing permits required each vessel to carry a fishery observer, provide video records of their activities, record catches and collect biological samples of the catch. The sablefish fishery converted to a limited commercial entry by draw fishery in 2002 with similar requirements.
February 1987 and September 1988	**Sablefish stock identification study** A total of 120 sablefish were taken from Bowie Seamount as part of a study into identifying sablefish stocks using parasites as biological tags. The results indicated that sablefish inhabiting seamounts are discreet stocks and little movement between seamounts occurs.
May 1993	**M.V.*EASTWARD HO* and M.V. *CALEDONIAN*, rockfish** The Deep Sea Trawlers Association of B.C., in a joint initiative with Fisheries and Oceans Canada and the B.C. Ministry of Agriculture, Fisheries and Food, undertook an exploratory trawl survey of Bowie Seamount. The majority of rockfish caught were harlequin and rougheye.
1998-2001	**CCGS *JOHN P. TULLY*, water properties, phytoplankton and zooplankton associated with a mesoscale eddy** Several oceanographic surveys have been conducted in the vicinity of Bowie Seamount on an opportunistic basis or as part of a mesoscale eddy study. In 2000, an eddy stalled over Bowie, resulting in surveys near the seamount in June and September. These included measurements of water properties (temperature, salinity, oxygen, nutrients) by F. Whitney of Institute of Ocean Sciences (IOS), DFO, phytoplankton (primary productivity, chlorophyll, species) by T. Peterson of University of British Columbia, and zooplankton and larval fishes by D. Mackas of IOS and J. Dower of University of Victoria (undertaken from the CCGS John P. Tully).
July 2000	**NOAA R/V *RAINIER*, CDR Daniel Herlihy, bathymetry** Multibeam bathymetry data for Bowie and Hodgkins seamounts were collected by the Canadian Hydrographic Service (CHS) of Fisheries and Oceans Canada in collaboration with the Hydrographic Surveys Division of the US National Oceanographic and Atmospheric Administration (NOAA). Multibeam surveys of Bowie and Hodgkins seamounts were conducted over a 1046 km^2 (305 square nautical miles) area in depths ranging from 24.3 m to 2835 m. Backscatter data were collected to a depth of 200 m.
July and August 2000	***CCGS JOHN P. TULLY*, oceanography, ecology and geology** Fisheries and Oceans Canada together with Gwaii Haanas National Marine Park Reserve/Haida Heritage Site, University of British Columbia and Environment Canada conducted a multidisciplinary research survey to develop in-situ survey methods for directly estimating inshore rockfish abundance using the two-person submersible *DELTA*. Biological, oceanographic and geological samples were also collected, in conjunction with longline fishing surveys conducted by a chartered longline fishing vessel.

Sources: DFO 2000, DFO 1998a, NOAA 2000, and Dave Mackas, DFO, personal communication.

In 1998, Department of National Defense (DND) rescue divers performed a combination plane jump and SCUBA dive on Bowie Seamount. Photographs and videos of the seamount were taken and the divers were picked up upon surfacing by the Coast Guard vessel CCGS *Narwhal* (Robert Bennett, Canadian Coast Guard, DFO, personal communication; Anthony Ethier, AXYS Technologies Inc., personal communication). In tandem with the DND dive, sounding track lines were run to gather bathymetric data for the Canadian Hydrographic Service (CHS). Based on the bathymetry data, CHS produced a rough digital elevation model of the seamount structure. A Canadian Wildlife Service contractor who was monitoring seabirds in the area was also onboard this trip (Robert Bennett, Canadian Coast Guard, personal communication). On a separate trip in June 1998, Institute of Ocean Sciences researchers on board the CCGS *John P. Tully* took water samples in the vicinity of Bowie Seamount as part of routine sampling procedures conducted by the Institute of Ocean Sciences, DFO.

During 2000, a large anticyclonic eddy (Haida Eddy) was in the vicinity of Bowie Seamount. During that time, zooplankton surveys were conducted near Bowie Seamount as part of a DFO project on the ecology and geochemistry of the eddies (Dave Mackas, Institute of Ocean Sciences, DFO, personal communication).

The National Oceanic and Atmospheric Administration (NOAA), through a collaborative agreement with DFO, acquired more detailed hydrographic and backscatter data of Bowie Seamount using a multibeam system to a depth of 2000 m. The bathymetric data have not yet been processed, although preliminary results are available (NOAA 2000).

In August 2000, the Pacific Biological Station, DFO together with Gwaii Haanas National Marine Park Reserve/Haida Heritage Site (Parks and Heritage Canada), the International Pacific Halibut Commission, commercial ZN fishing industry, the Universities of British Columbia and California (Santa Barbara) and the Canadian Wildlife Service (Environment Canada) conducted a multidisciplinary research cruise to Bowie Seamount and Gwaii Haanas. Primary research included the development of *in situ* survey methods for directly estimating inshore rockfish abundance using the two-person (observer and pilot) submersible DELTA. Sampling of rockfish populations for stock assessment data as well as fish health, characterization of oceanographic conditions, and enumeration of sea bird and mammals were also conducted (DFO 2000, Environmental Science Strategic Research Fund 2000).

Launching the Delta Submersible alongside the CCGS John P Tully. © L. Yamanaka

The development and deployment of a Moored Ecosystem Observatory (MEOS) for marine ecosystem monitoring at MPAs was originally proposed for Bowie Seamount. The project was to involve data gathering from buoys at various locations using satellites to monitor a number of physical and oceanographic parameters. After considering the feasibility and constraints of installing buoys in offshore marine areas, scientists and engineers have determined that the project was not feasible at this time due to the shallow water and extreme surface conditions at Bowie Seamount.

3.2 FISHERIES

The number of vessels involved in fisheries activities around Bowie Seamount and adjacent seamounts has been limited by their open ocean location, distance from shore, and other factors. The likelihood of unpredictable, rough seas requires that fishermen have a vessel of sufficient size and power capacity. The costs to charter these larger vessels in addition to motoring costs (both time and fuel) to reach Bowie Seamount could be prohibitive.

Despite the relatively high biomass and biodiversity, seamounts such as Bowie Seamount can represent delicate and isolated ecosystems making them susceptible to human pressures. In an effort to understand the extent to which even limited fishing activities are affecting fish stocks and other ecosystem components on seamounts and to implement appropriate fishery management measures, fishing on seamounts has generally been managed as experimental fisheries. Collection of biological data is required as part of the fishery.

The Bowie Seamount Area lies in the vicinity of three Pacific Fisheries Management subareas (Figure 23). Bowie, Hodgkins and Davidson seamounts lie in subarea 142-02. Subareas 101-01 and 101-02 are to the north. Fisheries in the Bowie Seamount Area have primarily existed on a limited basis for groundfishes such as rockfish, sablefish and Pacific halibut; and more migratory species such as albacore tuna (*Thunnus analunga*) (DFO 1997; Gerald Dalum, commercial fisherman, personal communication; Bruce Leaman, International Pacific Halibut Commission, personal communication; William Shaw, Pacific Biological Station, DFO, personal communication). Additionally, test fisheries for neon flying squid (*Ommastrephes bartrami*) have included the Bowie Seamount Area (DFO 1998c). Gear types used at the seamounts comprise bottom trawl, jig, longline and traps. The following sections describe the various types of fisheries that are currently occurring at or near Bowie Seamount.

3.2.1 Sablefish Fishery

The commercial fishery for sablefish is one of the most valuable fisheries in western Canada (Beamish and McFarlane 1988). Information collected from the past experimental fishery on the offshore seamounts in 1983-2001 suggested that the offshore seamounts present a viable economic opportunity for sablefish vessels. In 2001 the offshore seamount fishery was subsequently converted to a limited commercial fishery by draw with biological sampling requirements (DFO 2002d). The offshore seamount fishery runs from 1 May to 31 October, permitting one vessel to fish per month in each of two offshore seamount management areas (north and south).

The Bowie Seamount Area lies in the northern offshore seamount management area (DFO, 2002d) and has been fished by the Canadian fleet since 1985 (Murie *et al.* 1996) (Figure 24). Information privacy restricts reporting catch data in years for which there were fewer than three vessels. Therefore, it is difficult to describe annual trends. However, it can be noted that the cumulative catch from 1987-2000 was approximately 1450 t with an average annual catch for the same period of approximately 100 t (Beamish and Neville In prep.). Sablefish catch at Bowie Seamount peaked in 1991 at just over 350 t coincident with a coast-wide peak 395.5 t (Beamish and Neville In prep., Murie *et al.* 1996). This increase in sablefish catch in 1991 corresponded to an increase in the number of vessels fishing, traps deployed and hours soaked.

Since 1990, nine fishing vessels have fished at Bowie Seamount for sablefish, ranging from one vessel per year (1991 and 1997) to five vessels in 1992. In that period, approximately 45 commercial fishing trips have been made to Bowie Seamount, ranging from one trip per year (1990) to eight trips (1991 and 1992). Between 1990 and 2001 there was an average of four trips per year (Archipelago Marine Research 2001, 2000, 1998, 1997). Records of the number of traps set at Bowie Seamount between 1987 and 2001 show that the depths range from 242 m to 1326 m with 85% of traps set between 675 m and 1125 m (Figure 25 and Figure 26). More traps were set between 925 m and 950 m than any other depth interval. The average depth of traps between 1995 and 2000 was approximately 860 m.

Murie *et al.* (1996) examined catch per unit effort (CPUE) (kg/trap) at Bowie and other Pacific seamounts between 1985 and 1993, restricting their analysis to resolved catch weights and 20-70 hr soak times, in order to reduce the influence on CPUE of extremely short or excessively long soaks. CPUE was at a maximum and was significantly greater on Bowie Seamount in 1988 compared to 1989, and decreased considerably in 1993 (Murie *et al.* 1996). The decrease in CPUE and total catch to 1993 suggested that the population of sablefish on Bowie Seamount was not sustainable at current fishing levels (Murie *et al.* 1996).

Though not available for the Bowie Seamount Area, coast-wide stock estimates suggest that British Columbia sablefish decreased in abundance at a rate of 20% per year through 1997, followed by an increase in 1999 (Haist and Hillborn 2000). Stock projections for 2000 to 2002 forecasted an increase in abundance (Haist and Hillborn 2000). However mid-season in the 2001/2002 Integrated Fisheries Management Plan, the coast-wide sablefish fishery was temporarily closed as an interim precautionary measure arising from preliminary results of the 2001 stock assessment survey. The fishery was subsequently reopened at a significantly reduced Total Allowable Catch (TAC) of 2,800 metric tonnes, down from the original 4,500, and a forecasted TAC of 2,450 metric tonnes for the 2002/2003 fishing season (DFO 2002d).

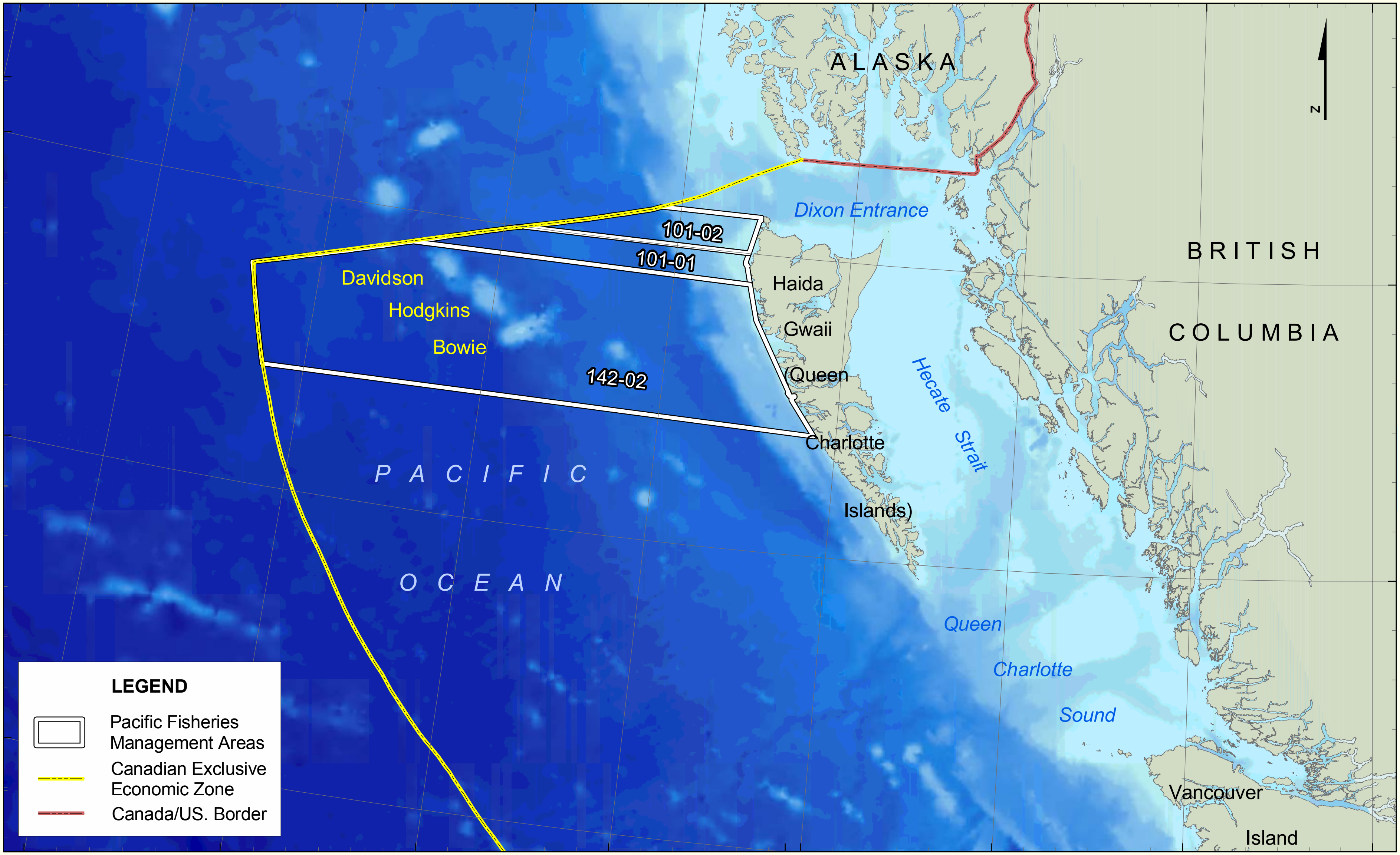
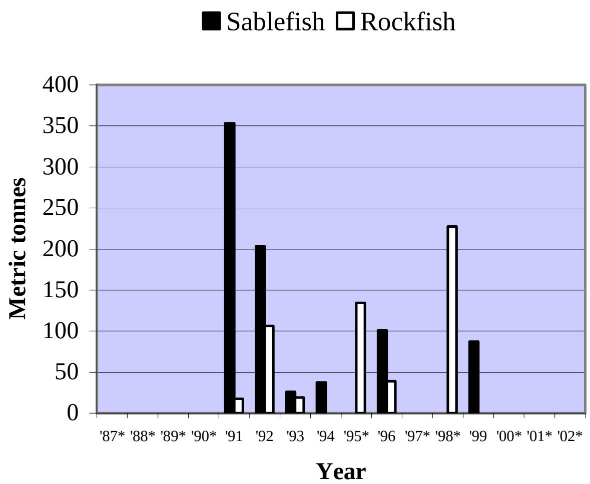


Figure 23.
Pacific Fisheries Management Subareas in the Vicinity of the Bowie Seamount Area

Data Sources: Fisheries & Oceans Canada;
Bathymetric model created by AXYS
with data from National Geophysical Data Center,
National Environmental Satellite, Data and Information Service (NESDIS)
Projection: BC Standard Albers

SP378 - Fig. 23



* For years in which <3 vessels fished for one or both species, data cannot be disclosed, although catch was reported at Bowie Seamount.

Figure 24. Annual catch of sablefish and rockfish at Bowie Seamount (Commercial groundfish database and/or logbooks as reported in Beamish and Neville In prep.).

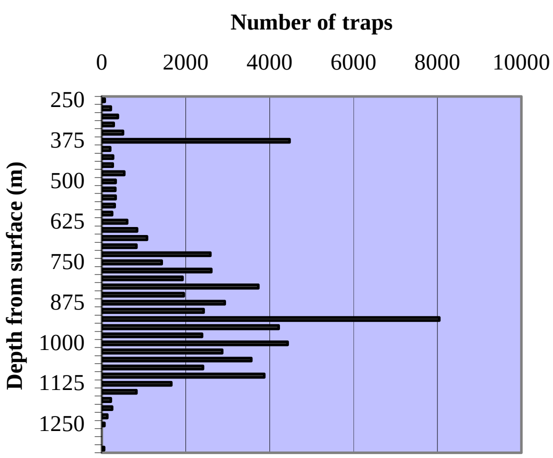


Figure 25. Cumulative number of traps set for sablefish in the Bowie Seamount Area by depth (1995-2001) (DFO Commercial groundfish database).

3.2.2 Rockfish Fishery

Rockfishes were taken incidentally in the sablefish fishery, until 1992 when a directed fishery was permitted on the seamounts and regulated by scientific permit requiring onboard observers. Coincident with the decline of the sablefish fishery, the rockfish fishery expanded focusing exclusively on Bowie Seamount of the three seamounts. The target depth was 200 – 550 m (Gerald Dalum, G.P Dalum Enterprises, personal communication).

A fishery management plan is developed by DFO annually for the Pacific Region rockfish fishery. For the 2002/2003 season (DFO 2002c). The key management objectives were to ensure conservation and protection of the species through application of scientific management principles, to continue implementing measures identified in the Rockfish Conservation Strategy, including reducing rockfish mortality, and to continue with consultations to define Rockfish Protection Areas (DFO 2002c). However, the seamount fishery was not incorporated into the Rockfish Hook and Line Fisheries Management Plan. There is no specific management plan for the seamount rockfish fishery and the scientific permit rockfish fishery for seamounts was closed after the 1999 season (Robert Wright, Hook and Line Coordinator, Fisheries and Oceans Canada). Since 2000 rockfish have not been fished at Bowie Seamount except as bycatch. Fishing for rockfish on a ZN license is not permitted (Robert Wright, Hook and Line Coordinator, Fisheries and Oceans Canada).

As was reported with the sablefish fishery, information privacy restricts reporting catch data in years for which there were fewer than three vessels. Making it difficult to describe annual trends. However, the cumulative catch of rockfish from Bowie Seamount between 1993 and 2000 was 1430 t with an annual average annual catch of approximately 130 t and an annual range of 0.1 t to 440 t (Beamish and Neville In prep.). The total catch of rockfish from Bowie Seamount reached a peak in 1999 (Beamish Neville In prep.).

The rockfish landing data from 1995 to 1998 were examined for species composition. Rougheye rockfish (*Sebastes aleutianus*) comprise the bulk of the catch at Bowie Seamount and have been the targeted species in recent years accounting for as much as 17% of the total Canadian rougheye catch (Beamish and Neville In prep.) (Table 8).

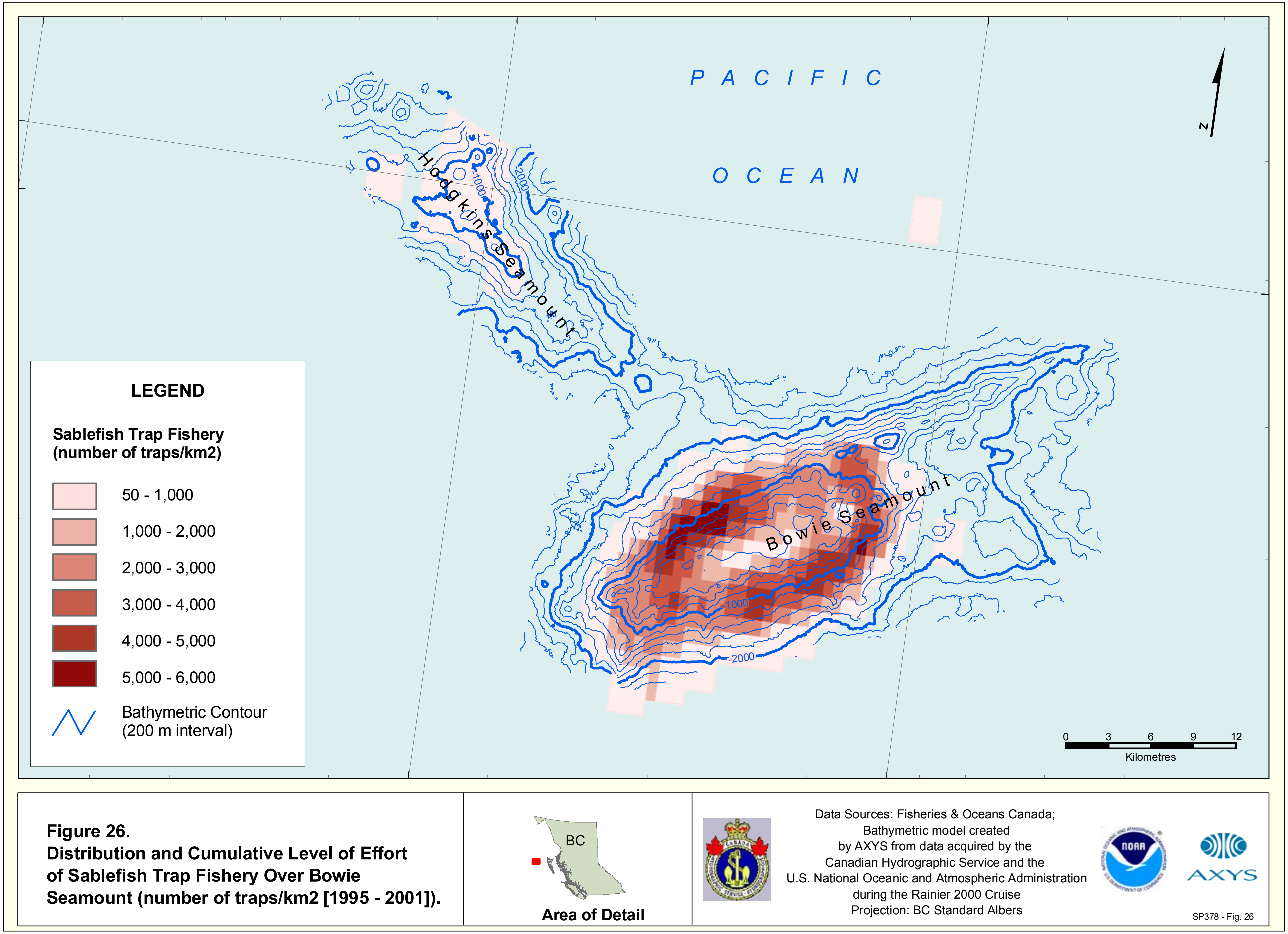


Figure 26.
Distribution and Cumulative Level of Effort of Sablefish Trap Fishery Over Bowie Seamount (number of traps/km2 [1995 - 2001]).

Data Sources: Fisheries & Oceans Canada;
Bathymetric model created
by AXYS from data acquired by the
Canadian Hydrographic Service and the
U.S. National Oceanic and Atmospheric Administration
during the Rainier 2000 Cruise
Projection: BC Standard Albers

SP378 - Fig. 26

Table 8. Rockfish species composition from landing data (1995-1998).

Rockfish species	% of Composition
rougheye rockfish (*S. aleutianus*)	90.50%
yelloweye rockfish (*S. ruberrimus*)	6.27%
redbanded rockfish (*S. babcocki*)	1.16%
slivergray rockfish (*S. brevispinis*)	0.73%
rosethorn rockfish (*S. helvomaculatus*)	0.59%
yellowmouth rockfish (*S. reedi*)	0.28%
widow rockfish (*S. entomelas*)	0.16%
shortraker rockfish (*S. borealis*)	0.14%
shortspine thornyhead (*S. alascanus*)	0.12%
harlequin rockfish (*S. variegatus*)	0.03%
Pacific ocean perch (*S. alutus*)	0.01%

Source: Archipelago Marine Research Ltd.

3.2.3 Pacific Halibut Fishery

Halibut fishing in the Bowie Seamount Area has been conducted since approximately the 1950s, but significant consecutive annual harvests have been rare (Bruce Leaman, Director, International Pacific Halibut Commission, personal communication). Bruce Leaman (International Pacific Halibut Commission) has suggested that during the 1970s, halibut fishing activity was likely very limited. Unfortunately, specific data for Bowie Seamount prior to 1980 cannot be extracted directly from the existing International Pacific Halibut Commission (IPHC) database. Data that are available show that halibut fishing activity has been low to non-existent for the area around Bowie Seamount. Available records from the IPHC database show that between 1984 and 1992 there were only five boat landings of fish caught from Bowie Seamount, for a total weight of just under 139,000 pounds within the context of a 11.75 million pound annual quota for Pacific halibut (DFO 2003). Since 1991 there are no records of commercial halibut landings from Bowie Seamount (Keri Taylor, Archipelago Marine Research Ltd., personal communication; John Davidson, DFO, personal communication).

Halibut fishing techniques include bottom trawls and longline sets. The season dates for the commercial fishery for halibut is set by the International Halibut Commission each year and generally is open from 15 March to 15 November.

3.2.4 Albacore Tuna Fishery

Albacore tuna harvest records show that harvests have occurred within the Canadian 200 nm EEZ since at least 1952 (DFO 1999b). While harvests generally have occurred closer to Haida Gwaii (Queen Charlotte Islands), albacore tuna have been caught at Bowie Seamount particularly when warm water moves north (William Shaw, Pacific Biological Station, DFO, personal communication; Billy de Greef, Pacific Coast Fishing Vessel Owner's Guild, personal communication). At least two boats fished for tuna at Bowie Seamount in September 1980 (Billy de Greef, Pacific Coast Fishing Vessel Owner's Guild, personal communication). Over the years American fishermen have been known to come south from their Alaska salmon fishery and try tuna fishing off Bowie Seamount, although the size of their catches is unknown (Billy de Greef, Pacific Coast Fishing Vessel Owner's Guild, personal communication). Access to the seamount, due to distance from shore, has probably had a significant impact on the annual catch. Nonetheless, albacore tuna could prove to be an important fishery at Bowie in the future if restrictions to the salmon fisheries continue, and if oceanographic conditions (*i.e.*, warmer water temperatures) draw the tuna farther north.

Fishing methods for albacore tuna involve dragging decorative lures near the surface at higher speeds relative to those used for salmon trolling (Hart 1973). The albacore fishery is conducted near the sea surface away from bottom habitat.

3.2.5 Squid Fishery

The potential for a squid fishery throughout B.C. waters and at Bowie Seamount has been explored for many years. Jamieson and Heritage (1986) describe some of the efforts undertaken to determine the feasibility of this fishery in Pacific waters. In 1990 and 1991 there was a coast-wide exploratory squid-jigging program as part of a joint venture fishery between DFO and a Japanese cooperative using commercial Japanese jig vessels (DFO 1998d). Neon flying squid was the dominant species caught in the program. It was found that neon flying squid inhabit waters within Canada’s EEZ and that distribution was linked with specific ocean temperatures, 14°C – 16°C (DFO 1998d). Some of the jigging was performed near but not over Bowie Seamount (William Shaw, Pacific Biological Station, DFO, personal communication). CPUE in the vicinity of Bowie Seamount during different sampling efforts ranged from no catch to greater than 0.30 kg/jig hour (Shaw and Smith 1995).

An official experimental management plan for flying squid was established in 1996 with an allowable catch of 1500 metric tonnes. Catches of neon flying squid at Bowie Seamount were attempted in two sets in the 1998 fishery resulting in very low catches. The fishers were forced closer to the shores of Haida Gwaii (Queen Charlotte Islands) where catch rates increased significantly (William Shaw, Pacific Biological Station, DFO, personal communication).

The fishing procedure for squid involves the use of single hook jig lines that generally are only sent down to about 30 feet. These lines are mechanically jigged back to the surface and returned to a pre-determined depth.

3.2.6 Bycatch

Fishing operations can result in incidental catch of non-target fish species and seabirds, the latter occurs primarily in longline fisheries. Collectively these incidental catches are termed 'bycatch', which is recorded via at-sea observers and/or catch reporting, *i.e.* log book data. Rockfish, sablefish, halibut, and tuna fisheries all have observer and/or catch reporting requirements.

Sablefish fishing is conducted by hook and line or by trap. To reduce incidences of bird bycatch, sablefish vessels fishing by longline are required to use bird avoidance measures and devices, which are outlined in sablefish license conditions. Retention of rockfish while fishing for sablefish is permitted by both hook and line and trap gear up to 40% and 10% of the total catch respectively. The predominant bycatch species in the sablefish fishery is rougheye rockfish comprising almost 50% of the total bycatch between 1990 and 2002 (Table 9). Scorpionfishes also comprise a considerable proportion of by catch. Cumulative bycatch from the sablefish fishery between 1990 and 2002 represents approximately 20% of total catch.

Bycatch from the rockfish fishery at Bowie Seamount is currently being compiled. However, there are reports of Black-footed Albatrosses being caught from the rockfish fishery at Bowie Seamount (Ken Morgan, Canadian Wildlife Service, personal communication, The Honourable Herb Dhaliwal letter to Ms Katherine Cousins, NOAA).

3.2.7 Whaling

Commercial whaling records show that between 1924 and 1927, seven fin whales and one blue whale were caught within approximately 60 km to the northeast of Bowie Seamount (Figure 27). The kill records originate from the Naden Harbour whaling station on Graham Island, Haida Gwaii (Queen Charlotte Islands). This whaling station operated from 1911 to 1941. Commercial whaling records between 1920 and 1924 and between 1927 and 1943 do not include locational information (Linda Nichol, Pacific Biological Station, DFO, personal communication).

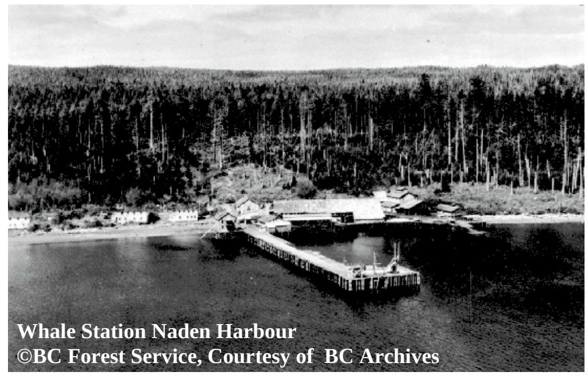


Table 9. Total bycatch (kg) by species from the sablefish fishery in the Bowie Seamount area (1990-2002).

Common Name	Scientific Name	Estimated weight (kg)
	Repiantia	850
Alaskan king crabs	*Paralithodes*	14
Box crabs	*Lopholithodes*	4
Cow sharks	*Hexanchidae*	680
Grenadiers	*Macrouridae*	5076
Octopus	*Octopoda*	2
Pacific halibut	*Hippoglossus stenolepis*	3044
Prowfish	*Zaprora silenus*	4
Redbanded rockfish	*Sebastes babcocki*	448
Rosethorn rockfish	*Sebastes helvomaculatus*	1297
Rougheye rockfish	*Sebastes aleutianus*	81974
Scorpionfishes	*Scorpaenidae*	59030
Shortraker rockfish	*Sebastes borealis*	753
Shortspine thornyhead	*Sebastolobus alascanus*	818
Silvergray rockfish	*Sebastes brevispinis*	167
Skates	*Rajidae*	45
Tiger rockfish	*Sebastes nigrocinctus*	13
True crabs	*Bracyura*	487
Unknown fish	*Unknown fish*	90
Widow rockfish	*Sebastes entomelas*	27
Yelloweye rockfish	*Sebastes ruberrimus*	16036
Yellowmouth rockfish	*Sebastes reedi*	9

Source: DFO Commercial Groundfish Database

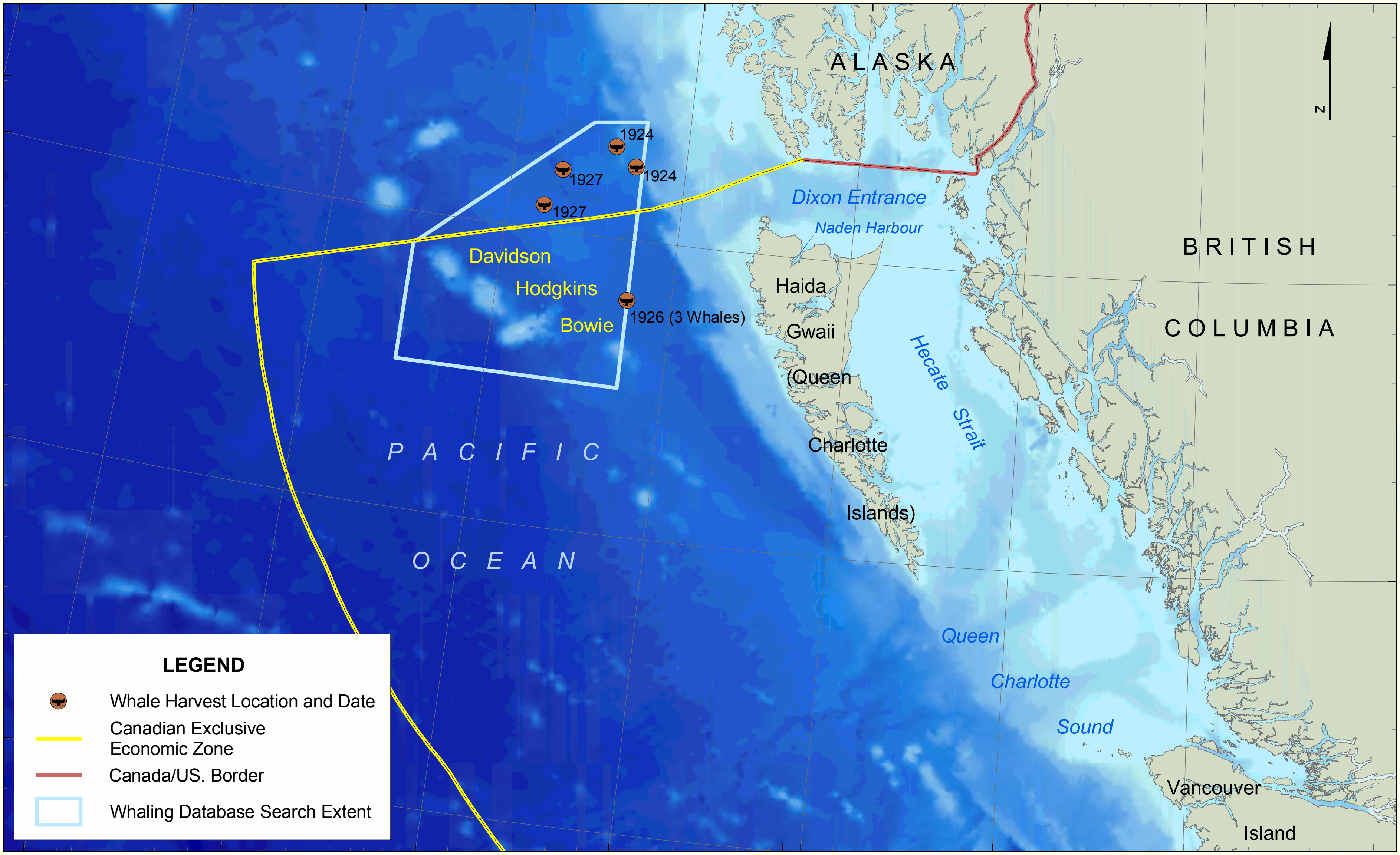
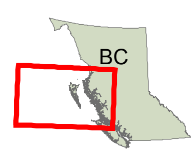


Figure 27.
Whaling Harvests in the Vicinity of the Bowie Seamount Area



Area of Detail

0 40 80 120 160
Kilometres

Data Sources: BC Historical Whaling Database,
DFO; Bathymetric model created by
AXYS with data from National Geophysical Data Center,
National Environmental Satellite, Data and Information Service (NESDIS)
Projection: BC Standard Albers

SP378 - Fig. 27

3.3 OCEAN MINING

Mineral exploration or extraction has not occurred in the Bowie Seamount Area (Ian Jonasson, Mineral Resources Division, Natural Resources Canada, personal communication) and the mineral potential is assessed as being so minimal that a desk study utilizing existing information was deemed to be unnecessary (Natural Resources Canada 2001). There are no proposed mineral tenures in this area (MINFILE 1998); all provincial tenures presently granted in the vicinity of Haida Gwaii (Queen Charlotte Islands) are entirely land-based.

3.4 OFFSHORE HYDROCARBON DEVELOPMENT

Oil and gas resource assessment work was carried out by the Geological Survey of Canada (GSC) on the landward side of Haida Gwaii (Queen Charlotte Islands) in the Queen Charlotte basin. There is currently no interest in examining the Pacific Plate side of Haida Gwaii for similar oil and gas assessment research, and there are no outstanding proposals for future exploration work in the Bowie Seamount Area at this time (Grant Mossop, Geological Survey of Canada, Natural Resources Canada, personal communication). The Bowie Seamount Area is deemed to have no hydrocarbon value (Natural Resources Canada 2001).

Of interest, oil drilling in the Queen Charlotte region dates back to 1949. Further drilling in the 1960s in Hecate Strait revealed non-commercial levels of oil. No drilling has taken place offshore of Haida Gwaii (Queen Charlotte Islands). Concerns over tanker safety and the lack of a regulatory framework for offshore oil and gas activity prompted the federal government to establish a moratorium on offshore oil and gas activity in 1972 (Ron Burleson, British Columbia Ministry of Energy and Mines, personal communication). The most recent provincial moratorium was established in 1982 in the inland marine zone. The moratorium precludes offshore oil and gas exploration and drilling in the Queen Charlotte basin, which includes the seabed beneath Queen Charlotte Sound, Hecate Strait, Dixon Entrance and the eastern part of Graham Island. In 1986, an Independent Federal-Provincial Review Panel reinforced the moratorium pending implementation of 93 recommendations aimed at managing environmental impact. Since 1989, the moratorium has been a policy of both the province and federal government although there is now renewed interest by the province to lift the moratorium.

3.5 MARINE TRANSPORTATION

In the 1970s, the Trans Alaska Pipeline System (TAPS) that runs from Prudhoe Bay to Valdez, Alaska was completed. Since that time, tankers varying in size from 50,000 to 250,000 Dead Weight Tonnes (DWT) have been transporting crude oil from Valdez to west coast ports in the lower 48 US states. On average, one loaded tanker enters the Juan de Fuca Strait every day and another tanker, in ballast, leaves the strait for Alaska (Canadian Coast Guard 1998). Bowie, Hodgkins and Davidson seamounts are located within the TAPS north/south transit route out of Valdez, Alaska (Wayne Fullerton, Canadian Coast Guard, Pacific Region, personal communication).

After several iterations, a Tanker Exclusion Zone (TEZ) off Canada’s west coast was voluntarily adopted in 1988 by the Canadian Coast Guard, the U.S. Coast Guard and the American Institute of Merchant Shipping (AIMS; now the Chamber of Shipping of America) (Figure 28). As an environmental protection and safety measure, tankers are restricted from the TEZ, defined as an area where a disabled tanker may drift ashore in unfavourable weather conditions prior to the arrival of salvage tugs (Canadian Coast Guard 1998).

The summit of Bowie Seamount is 18 to 36 km (10 to 20 nautical miles) west of the Tanker Exclusion Zone, and is, therefore, subject to oil tanker traffic and associated risks. Risk to sensitive coastal resources from oil or hazardous cargo spills caused by groundings or disabled, drifting vessels has been the subject of a West Coast Offshore Vessel Traffic Risk Management project (WCOVTRM) initiated by the Pacific States/British Columbia Oil Spill Task Force (WCOVTRM 2001). The project has compiled information on vessel traffic volume and vessel casualties[11] among other data and completed two risk assessments.

[11] Casualty is defined by WCOVTRM as a vessel which has experienced a collision, grounding, flooding, mechanical/equipment failure or structural failure or otherwise become disabled.

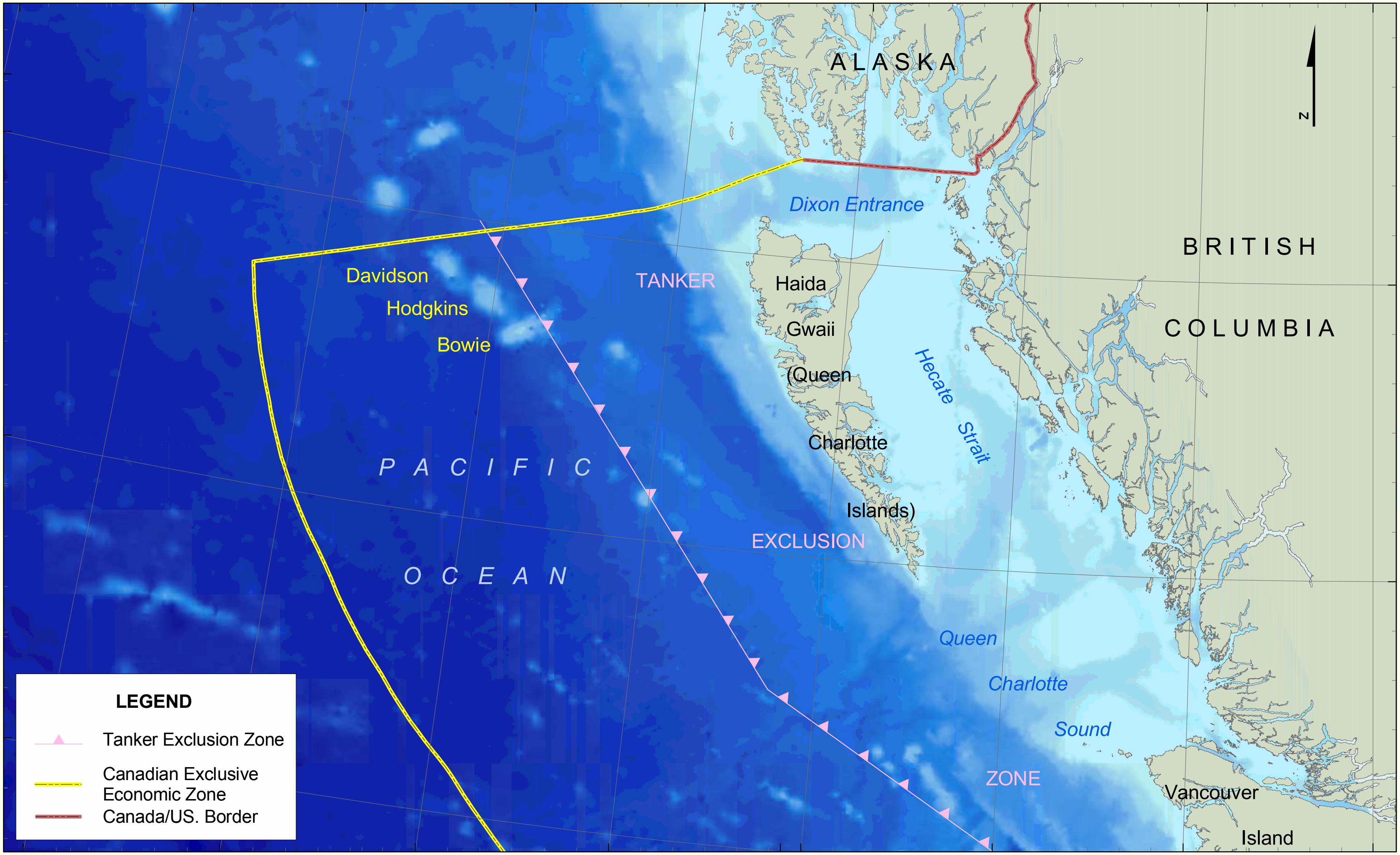
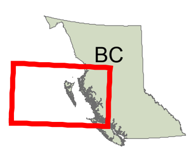
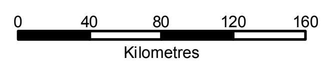


Figure 28.
Pacific Coast Tanker Exclusion Zone





Data Sources: Canadian Coast Guard; Bathymetric model created by AXYS with data from National Geophysical Data Center, National Environmental Satellite, Data and Information Service (NESDIS)
Projection: BC Standard Albers

SP378 - Fig. 28

While the amount of vessel traffic in the vicinity of the Bowie Seamount Area was not estimated for this report[12], some relevant vessel activity information in the Pacific can be gleaned from a WCOVTRM (2001) study. The study noted approximately 12,000 vessels transited the west coast of North America (not including trans-Pacific traffic) in a one- year period between July 1998 and June 1999. According to the study, the best estimate of vessels transiting along the British Columbia coast during this one-year period was 2,527 vessels. Since 1970, the tonnage from west coast vessel traffic has quadrupled contributing to an increase in the number of vessels in the area. Investigations into vessel casualties revealed that between December 1994 and August 1999, there were five vessel casualties within 200 km of the Bowie Seamount summit (Figure 29). Three of these became disabled due to mechanical failure and two suffered on board fire. Of these, the closest vessel was approximately 130 km southeast of Bowie Seamount.

Grounding of an oil tanker typically with draft of 14m is possible on the shallow Bowie Seamount summit, especially under high wave conditions. Tanker companies contacted by the Canadian Coast Guard as part of a study on grounding possibilities have stated that their vessels typically stay at least 18 km (10 nm) from Bowie Seamount, as this is their most efficient route[13]. The companies also stated they are aware of the risks associated with the Bowie Seamount Area (WCOVTRM 2001).

3.6 MARINE SAFETY AND DEFENCE

3.6.1 Coast Guard Activities

The Canadian Coast Guard (CCG) is responsible for servicing Atmospheric Environment Services (AES) weather buoys, one of which is located near Bowie Seamount. Regular maintenance of the buoys occurs on average twice per year. Other servicing tasks include retrieving a buoy if it becomes detached during a storm or collision with a vessel, and then reattaching it to the existing mooring.

It is also within the CCG mandate to respond to any marine emergency in the area. Fierce winter storms have been known to occur in this part of the Pacific Ocean and wave heights can exceed 20 m. In fact, hydrographic charts list Bowie Seamount as a potential hazard to navigation. However, there are generally very few calls for Search and Rescue (SAR) at this location. Over the past six years there has been only one SAR incident in the vicinity of Bowie Seamount (John Palliser, Canadian Coast Guard, Pacific Region, personal communication).

American Coast Guard cutters pass through the offshore waters near Bowie Seamount *en route* to Alaska, although most of this traffic is approximately 75-90 km (40-50 nm) west of Bowie Seamount (William Peterson, United States Coast Guard, personal communication).

3.6.2 Department of National Defence

The Bowie Seamount Area is located within the Maritime Forces Pacific area of responsibility. The Canadian Navy does not conduct, nor does it plan to conduct, research tests or routine drills in the area. Bowie Seamount is not on the normal shipping routes used by Canadian Navy vessels. However, Canadian Navy vessels may on occasion transit the area. In addition, aircraft conducting training or routine surveillance may overfly Bowie Seamount while undertaking exercises in the area known as ‘CYR 106’ extending from the southern tip of Vancouver Island north to the Bowie Seamount Area (Rear-Admiral Ronald Buck, Chief of Maritime Staff, Department of National Defence, personal communication).

[12] A Notice to Shipping for information on vessel movements in the vicinity of Bowie Seamount resulted in no responses (Dale Gueret, Oceans and Community Stewardship, Fisheries and Oceans Canada, personal communication). Mr. Guer*et al*so indicated that the department is awaiting information from the Chamber of Shipping of BC regarding vessel routes in the Bowie Seamount Area.

[13] This information was not acquired as part of the WCOVTRM study, but was provided by Canadian Coast Guard participants in the WCOVTRM study (Jean Cameron, Pacific States/British Columbia Oil Spill Task Force, personal communication).

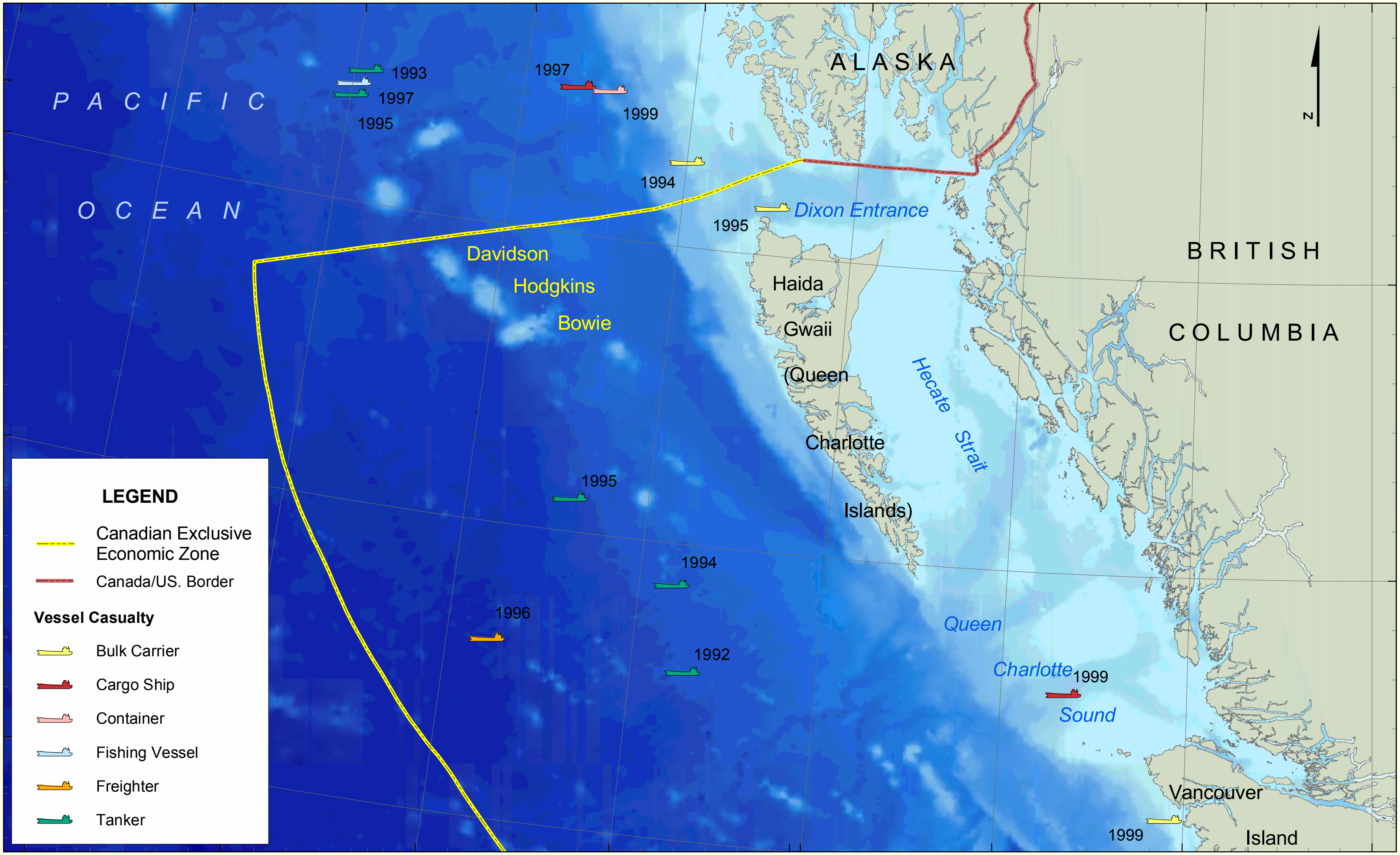
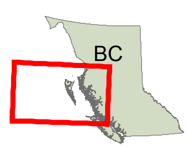


Figure 29.
Vessel Casualties on the Pacific Coast (1992-1999)



Area of Detail

0 40 80 120 160
Kilometres

Data Sources: West Coast Offshore Vessel Traffic Risk Management Report (2001); Bathymetric model created by AXYS with data from National Geophysical Data Center, National Environmental Satellite, Data and Information Service (NESDIS)
Projection: BC Standard Albers

SP378 - Fig. 29

3.7 RECREATION AND TOURISM

Recreational use of the Bowie Seamount Area currently is negligible. While the shallow summit of Bowie Seamount is attractive to divers for its sea life and geological features, most recreational diving is precluded by factors such as distance, cost, safety and logistics. Recreational diving may be feasible for larger groups of experienced divers who have the resources to charter vessels. Bowie Seamount would still be considered a high risk dive due to ocean currents and surges around the seamount (Michael Paris, British Columbia Underwater Archaeological Council, personal communication).

Anecdotal accounts received while conducting research seem to indicate the primary, albeit minor, recreation and tourism interest in the Bowie Seamount Area is currently SCUBA diving. A few reports of planned dives were received, but only one dive was confirmed to have taken place. Brian Fuhr (BC Ministry of Sustainable Resource Management, personal communication), conducted a recreational dive from aboard his sailboat on July 4, 2002. Brian had indicated he had been planning to do the dive for several years, but did not execute it until this time due to concerns regarding the weather conditions in the area.

The submarine tourism industry may have a future interest in Bowie Seamount as an eco-tourism destination. Eco-tourism is a growing industry, and new and relatively undisturbed areas such as Bowie Seamount are in demand (John Whitney, Atlantis Submarines International, personal communication).

3.8 EDUCATION AND OUTREACH

Some educational values are certainly attributed to the Bowie Seamount Area, such as the *National Geographic* article (Curtsinger 1996), although the potential for hands-on education and interpretation is much less than that of near-shore areas. Still, ocean features such as seamounts provide a unique opportunity for research into geological and ecological processes that will have educational benefits for the general public, as well as scientists and students. The same factors that constrain research or diving expeditions are also applicable to educational trips. However as the state of seamount knowledge grows, there may be opportunities to add the Bowie Seamount Area to the educational curriculum of some marine biology or oceanography programs, or to include students on upcoming research trips to study the seamounts.

There may also be educational values attributed to managing the Bowie Seamount Area as an offshore MPA, and to studying the successes and failures of various management approaches. The Bowie Seamount Area, along with the three other west coast pilot projects, provide an opportunity to ‘learn-by-doing’ using an adaptive approach to management that will provide valuable information and experience relevant to the long-term maintenance of a MPA system. In this regard, the education values of Bowie are significant considering the lack of current examples of working offshore MPAs within Canada and internationally.

4.0 TRADITIONAL AND CULTURAL COMPONENTS

The Bowie Seamount Area lies within the traditional territory claimed by the Haida (Russ Jones, Chairman, Haida Fisheries Committee, personal communication). In March 2002, the Haida Nation commenced a court action in which they claim aboriginal title to Haida Gwaii (Queen Charlotte Islands) and the surrounding waters and seabed out to the 200 nm national boundary. Their claim, thus includes the Bowie Seamount Area. The Haida people refer to Bowie Seamount as Sgaan Qintlas, pronounced "Skon Kintlas" and roughly translated to "supernatural, looking outward" (Guujaaw president, Council of the Haida Nation, personal communication).

The Haida Fisheries Committee that conducts research and gathers traditional knowledge on matters concerning the Haida, has not yet examined the values or uses of Bowie Seamount (Russ Jones, Chairman, Haida Fisheries Committee, personal communication). Further consultation between governments is therefore required to determine the significance, if any, of the Bowie Seamount Area to the Haida and to discuss implications of managing the seamount as a MPA. The Haida Nation has expressed an interest in being involved in the evaluation process of the Bowie Seamount Area as a MPA and its subsequent management, should it be designated (Guujaaw, President, Council of Haida Nation, personal communication).

Other than its potential significance to the Haida, there are no other known historical or cultural values associated with Bowie Seamount.

5.0 KNOWLEDGE GAPS AND RECOMMENDATIONS

5.1 ENVIRONMENTAL COMPONENT

There is still much biophysical research that needs to be done on seamounts in general, and Bowie, Hodgkins and Davidson seamounts in particular. Much of the research attention has been focused on Bowie Seamount and comparatively less is known about Hodgkins and Davidson seamounts.

5.1.1 Geology and Physiography

The 2000 R/V *Rainier* survey acquired detailed bathymetry on Bowie and Hodgkins seamounts. However, the coverage was not 100% for either Bowie Seamount or Hodgkins Seamount and did not extend to Davidson Seamount.

Recommendation: Acquire additional bathymetric data to complete the coverage of the Bowie Seamount Area.

While not directly applicable to MPA designation, knowledge of seismicity in the area would contribute to a better understanding of the geological history of the seamounts.

Recommendation: Increase understanding of seismicity in the area.

5.1.2 Physical and Chemical Oceanography

Additional physical oceanographic surveys would be useful in understanding oceanographic features and processes around Bowie, Hodgkins and Davidson seamounts. Of particular importance is determining the potential role of local currents and eddies, the occurrence of significant upwelling and/or the existence of a closed re-circulating current (*i.e.* Taylor cone).

Recommendation: Conduct a detailed physical oceanographic surveys as part of a multi-disciplinary program.

The general ocean chemistry (*e.g.*, temperature and salinity) of the Bowie Seamount Area has been derived from distant weather buoys. More detailed temperature and salinity profiling from vessels for the seamounts would provide a baseline for long-term monitoring.

Recommendation: Conduct temperature and salinity profiling of the seamounts at various times of the year over a number of years.

5.1.3 Biology

While a picture is slowly emerging of the seamount community by piecing together a species list, only a few species have been studied in any detail (*e.g.*, rockfish and sablefish). An understanding of the Bowie Seamount Area ecosystem requires an understanding of a full inventory of species, biomass and ecological interactions, in particular:

- local and regional productivity (*i.e.*, source or sink);
- primary productivity;
- biomass of fish populations;
- timing and periodicity of recruitment and influence of oceanography on recruitment;
- larvae and juvenile fish;
- trophic interactions;
- benthos and bottom habitat classification;
- ecological effects of human uses;
- commercial fish species; and
- birds (*e.g.*, staging area) and marine mammals.

Recommendation: Expand species research including biomass and ecological interactions.

Recommendation: Continue building a comprehensive species list for Bowie, Hodgkins, and Davidson seamounts.

Recommendation: Analyze the DELTA submersible video in conjunction with existing bathymetric backscatter data to identify and extrapolate habitats and biota for the nearsurface region of the Bowie Seamount.

Recommendation: Establish Bowie Seamount as an Ecosystem Research Area (ERA) has been proposed by Beamish and Neville (In prep.). An ERA may allow experimentation that could improve our understanding of the impacts of fishing, shifts in climate and other large-scale changes on the species within the ecosystem. The ERA may also provide the pilot study that could be used to develop other ERAs in the coastal fishing areas. Research at Bowie Seamount would be overseen by a multi-interest review panel that would consider ecosystem studies based on the merit of ideas, rather than a researcher's affiliation. Research efforts in the area would work towards the development of ecosystem-based management practices that could be applied to other area.

5.2 SOCIO-ECONOMIC COMPONENT

Efforts have been made to contact individuals within relevant government, industry and public sectors that may have a potential interest in Bowie Seamount. However, in some instances, information gaps remain. It is recommended that further research and follow-ups be conducted in the areas listed as follows.

5.2.1 Fisheries

Reporting and distributing fisheries data to individuals or organizations outside Fisheries and Oceans Canada is restricted by privacy considerations due to the few number of vessels that fish in the Bowie Seamount Area in a given year. As a result, data have to be reported in an aggregated format or not at all. Thus, neither the annual variability nor the implications of the Bowie Seamount Area on commercial fisheries can be fully communicated.

Recommendation: Pursue agreements with the fishing fleet to release data for the Bowie Seamount Area to enable communication of this data to the public advisory board for their consideration of this important socio-economic data.

Recommendation: Work with scientists and the fishing industry to determine potential partnerships in obtaining data towards filling the gaps addressed in section 5.1.

Recommendation: Estimate the economic contribution of commercial fisheries. The economic contribution of the commercial fisheries could be estimated albeit for aggregated data by multiplying the catch in metric tonnes by a market value for any given year.

In addition, much of the description of fisheries in the Bowie Seamount Area pertains to Bowie Seamount itself and has not been compiled for Hodgkins and Davidson seamounts.

Recommendation: Extend fisheries description to include Hodgkins and Davidson seamounts.

5.2.2 Marine Transportation

While there are estimates of vessel traffic along the BC coast and general proximity to Bowie Seamount, more detailed information may be required to ascertain the implications of the Bowie Seamount Area on shipping activities, particularly if including the Area within the TEZ is warranted.

Recommendation: Compile more detailed information on vessel traffic in the vicinity of the Bowie Seamount Area.

5.3 FIRST NATIONS

There is a lack of information on historical and cultural values of Bowie Seamount Area to the Haida First Nation. As Bowie Seamount falls within the traditional territory claimed by the Haida, it may contain significant values that cannot be uncovered without further consultation with knowledgeable members of the Haida community and anthropologists, or other researchers as appropriate.

Recommendation: Continue consultation with the Haida community.

Recommendation: Conduct anthropological research of historical archives of the Haida to determine any historical traditional connections to the Bowie Seamount Area.

Recommendation: Conduct anthropological field studies in the Bowie Seamount Area to determine potential traditional uses of the area by the Haida. Due to resource limitations, this might best be done in partnership with other research in the area.

5.4 EDUCATION AND OUTREACH

Given the remoteness and extremes of the Bowie Seamount Area, an outreach program could focus on virtually bringing the seamounts to students and the public. Based on the detailed bathymetry recently acquired, a scaled model of the Bowie Seamount Area could be designed and constructed for presentation at schools, Oceans Day events and open houses. In its simplest form, the model would illustrate the size and physical structure of the seamounts. The surface of the model could be enhanced by a textured covering to represent the algal turf on the seamount surface, and miniature marine animals could be affixed to represent the benthos. Pelagic animals, including fish and marine mammals, could be suspended from a plexiglass covering representing the sea surface. A model of the bathysphere used in the 2000 research cruise could also be suspended from the plexiglass covering. Situated on the plexiglass covering could be examples of research and fishing vessels as well as marine birds. It would perhaps be more difficult to include in the model the water circulation typical of seamounts. However, the model could be used as a basis for discussion.

Recommendation: Construct a scaled model of the Bowie Seamount Area.

Researchers should be encouraged to contribute ecological and oceanographic data acquired from the Bowie Seamount Area to the newly-established *Seamounts Online* (http://seamounts.sdsc.edu, March 2002). *Seamounts Online* is intended as a reference site for seamount research primarily by acting as a repository and clearinghouse of ecological information on seamounts. While still in a fledgling stage, the web site has potential to be a valuable educational tool.

Recommendation: Contribute data to *Seamounts Online*.

In the short term, DFO and others could participate in conferences and symposia such as the previously held 2002 International Council for the Exploration of the Sea (ICES) Annual Science Conference on Oceanography and Ecology of Seamounts – Indications of Unique Ecosystems by presenting papers and posters on recent surveys, and the MPA initiative itself.

Recommendation: Participate in seamount and MPA conferences and symposia.

5.5 INFORMATION MANAGEMENT AND DISSEMINATION

A key challenge is gathering information on the Bowie Seamount Area from disparate research initiatives and disseminating them to the scientific and public community. In addition, increasingly, lack of information sharing agreements is restricting the data that can be distributed.

Recommendation: Negotiate data-sharing agreements with, for example, commercial fishers.

Recommendation: Update the Ecosystem Overview periodically with a supplementary Technical Report, as and when substantially new information is made available.

Recommendation: Centrally index and archive existing Ecosystem Overview information including multi-media or large format products such as videos, photographs and maps in a central "Bowie Seamount Area Technical Holdings", for future use by managers, planners, stakeholders and others.

Recommendation: Link the Ecosystem Overview multi-media information to the Bowie Seamount Area webpage for the wider public and others.

Recommendation: Produce and publish new multi-media products such as video ‘fly-throughs’ be produced and published using the existing bathymetric data for Bowie and Hodgkins.

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Appendix A. Glossary of Environmental Terms Related to Bowie Seamount MPA

Term	Definition
µM	µmol l-1or micro-moles per liter (concentration in seawater).
ABYSSAL PLAIN	A flat, almost level area making up the deepest parts of many of the ocean basins.
ADVECTION	The horizontal movement of a mass of fluid.
ALLELES	The specific sequence copy of a DNA marker. Individuals inherit one allele from each parent at each DNA marker (locus).
ALLELCI DIVERSITY	Mean number of alleles observed per locus.
BASALT	A type of tough volcanic rock that makes up most of the ocean's basins, mid-ocean ridges, and plates.
BATHYMETRY	Measurements of the depths of water in oceans or lakes.
BENTHIC	To spend life cycle predominantly attached to or in close association with the sea floor.
BIOMASS	In the oceans, the amount of living matter that exists within a unit volume of water at a specific instant in time.
BLOOM	The period of the most intense growth in biomass of a plant species.
COMMUNITY	A population made up of different interacting species sharing a common location.
CONTINENTAL SHELF	The part of the continental margin presently submerged under the shallow coastal oceans, very flat.
DIURNAL	Cycling once a day.
DOMINANT SPECIES	The species in a community whose individuals outnumber the individuals of all other species present.
EDDY	A unit of motion in a fluid medium running contrary, usually circularly, to the main current.
ENTRAINMENT	With respect to seamounts, the trapping of particles in a closed eddy.
EUPHOTIC ZONE	The upper area of the ocean in which sufficient light penetrates to allow photosynthesis to occur.
FAULT	A fracture in the earth's crust along which movement occurs or has occurred.
FLUSHING TIME	Time interval required for complete replacement of water in an area.
FOOD WEB	A specific pathway along which the chemical energy created in photosynthesis passes to successive trophic levels.
GUYOTS	Flat-topped seamounts.
HETEROZYGOSITY LEVELS	Percentage of individuals carrying two different alleles, as opposed to two copies of the same allele, at a given locus.
HOTSPOTS	The site of a plume of ascending magma.
INTERNAL WAVES	A disturbance that propagates wavelike along the density interface of two water masses.
ISOTHERMAL DOMING	A curve of constant temperature shaped like a dome.
LITHOSPHERE	The outer, solid portion of the earth, composed of rock essentially like that exposed at the surface and generally considered 80 km thick.
MAGMA	Molten rock material within the earth.
MANTLE	The interior of the earth that lies beneath the lithosphere and above the core.
MESOSCALE	10 km – 1000 km (with respect to eddies)
MICROSATELLITE LOCI	Rapidly evolving DNA markers that contain tandemly repeated, short (2-6 nucleotide) sequence motifs.
MORPHOLOGICAL	Dealing with the form and structure of plants and animals.
NUTRIENTS	In the oceans, the dissolved nitrates and phosphates that are the principal building blocks used by plants in photosynthesis.
OCEANIC	Relating to the open sea beyond the continental margin.
PANMICTIC POPULATION	A population with no structure, such that all breeding individuals can interact with one another OR random mating within a breeding population.
PHENOTYPE	The expression of a specific trait based on genetic and environmental influences.

Term	Definition
PHYTOPLANKTON	Plants small enough to be planktonic in the sense of drifting with prevailing ocean currents.
PILLOW LAVA	Rounded pieces of basaltic lava that are created when the lava erupts under water.
PLANKTON	The passively floating or weakly swimming animal and plant life, usually minute.
PLATE TECTONICS	A group of theories concerning the global geology of the earth's crust, proposing that it moves in integral segments.
PROVINCE	A grouping of seamounts.
SEA LEVEL	The average vertical position of the sea surface, measured over an extended period of time.
SEAMOUNT	A mountain or volcanic feature on the deep sea floor, the top of which does not penetrate the sea surface.
SESSIL	The tendency to stay in one place.
SPREADING RIDGE	Region of the seafloor where tectonic plates are spreading apart as new sea floor is being formed.
STRATIFICATION	In the oceans, the arrangement of different water masses in vertical sequences, with density increasing downwards.
SUSPENSION FEEDER	Animal that feeds directly upon suspended particles.
TECTONICS	A study of the building and changing of the earth's crust.
ZOOPLANKTON	Animals small enough to be planktonic in the sense of drifting with prevailing ocean currents.

Appendix B. Summary of International Seamounts and Offshore MPAs

NAME	PROTECTED STATUS	COUNTRY / REGION	LOCATION	DESCRIPTION	KEY ENVIRONMENTAL SIGNIFICANCE	KEY SOCIO-ECONOMIC SIGNIFICANCE
Axial Seamount	N/A, but is the NOAA NeMO Site (New Millenium Observatory)	USA	Approximately 300 miles west of Cannon Beach, Oregon along the Juan de Fuca Ridge.	The seamount rises 700 m above the mean level of the ridge crest and is the most magmatically robust and seismically active site on the Juan de Fuca Ridge.	Hydrothermal vents colonized with biological communities are located near the summit of the seamount, which is shaped like a caldera.	Scientific and research activities are the main human use. Scientific exploration has been conducted with sidescan sonar, towed cameras and submersibles.
Baja Seamounts	N/A	USA	Several seamounts off the coast of California and Mexico in the south Pacific.	No information	Marine life.	Used for recreational diving.
Banco Gorringe	Proposed as a protected area by the World Wildlife Fund.	Portugal	Off the southwest coast of Portugal	The volcanic seamount arise from abyssal plains at almost 5000 m depth n its northern side to peaks at only 20-28 and 33-36 m depth	Serves as a “stepping stone” for the dispersal of benthic fish species from the African continents to Madeira and from Madeira to Azores owing to extensive kelp forests and diverse sessile fauna	Deep sea fishery, mainly in terms of drifting vertical longline fishery
Channel Islands	National Marine Sanctuary	USA	25 miles off the coast of Santa Barbara, California, USA..	Approximately 4300 km^2.	Marine life.	Fishing within the sanctuary is an important part of the livelihood of local communities. The area is also used for scientific research.
Chile Bay	N/A	Antarctica		Two small separate tracts of benthic habitat, one at depth of 50-100 m, the other at depths of 100-200 m.		
Cobb Seamount	N/A	USA	500 km (270 nautical miles) west of Gray's Harbor, Washington in the north east Pacific Ocean.	An ancient volcano that rises from a base of 1500 fathoms (2743 m) to within 18.5 fathoms (34 m) of the surface and comprises an area of 824 km^2 (240 square nautical miles).	Undersea features and processes, productive biological resources.	Scientific and research activities are the main human use.
CoCos Ridge	N/A	Costa Rica				Scientific research to investigate upper plate response to subducting plate morphology; also used for recreational diving.
Cordell Bank Seamount	National Marine Sanctuary	USA	60 miles northwest of San Francisco, California, USA.	1360 km^2 surrounding an offshore seamount.	The Bank rises to within 115 feet of the sea surface with water depths of 6000 feet only a few miles away. Upwelling of nutrient-rich, deep	Human activities are mainly education and research based; fishing occurs within the NMS and research is currently being

NAME	PROTECTED STATUS	COUNTRY / REGION	LOCATION	DESCRIPTION	KEY ENVIRONMENTAL SIGNIFICANCE	KEY SOCIO-ECONOMIC SIGNIFICANCE
					ocean waters stimulates the growth of organisms at all levels of the marine food web. It is a destination feeding ground for many marine mammals and seabirds.	conducted to determine the impacts of various types of gear; recreation includes whale watching and birding.
Cross Seamount	N/A	Hawaii	Southwest of the island of Hawaii.			Fishery management analysis.
East Dallmann Bay Palmer Archipelago	Antarctic Special Protected Area	Antarctica		Benthos rich sea floor down to 200 m depth.		
Easter Seamount Chain	N/A		Undersea linear feature oriented in approximately east-west direction between Rapa Nui and Chilean Trench.	Easter Seamount Chain is a long (~3000 km) linear feature. Its formation has been a mystery to scientists for a long time.	Undersea processes.	Scientific and research activities are the main human use. Scientific investigations include geophysical and geochemical analysis to determine formation.
Eldey Islands	Nature Reserve	Iceland		Offshore islands and the waters within a radius of 2 km.		Scientific research.
Fagatele Bay	National Marine Sanctuary	American Samoa	Southwest shore of Tutuila Island, American Samoa, 14 degrees south of the equator.	0.65 km^2.	Fagatele Bay contains a pristine coral reef area that is an outstanding example of an Indo-Pacific coral reef ecosystem. Containing hundreds of species of fish, corals and other reef denizens, Fagatele Bay also bears the scars of some recent and severe natural disasters.	The NMS is completely contained in the 0.25 square miles of the bay. The land surrounding the bay resides in the hands of the families who have lived near the bay’s slopes for thousands of years and is a traditional fishing area. Diving also occurs.
Fieberling Guyot	N/A	USA	Located off the southern California coast.			Scientific research on physical and biological processes.
Fijian Seamounts	N/A	Fiji	Several seamounts around the Fijian Islands.		Marine life.	Used for recreational diving.
Florida Keys	National Marine Sanctuary	USA	Off the coast of Florida, USA.	Approximately 9500 km^2 surrounding the archipelago formed by the Florida Keys.	Primary marine feature is the extensive coral reefs; also contains mangrove islands and seagrass beds.	Multiple uses occur including fishing and other economic activities; the area has high recreation and research values; also includes shipwrecks, including the wreck of the Spanish treasure ship *Atocha* and the slave ship *Henrietta Marie*.
Flower Garden Banks	National Marine Sanctuary	Gulf of Mexico, USA	Roughly 110 miles south of the Texas-Louisiana border, USA.	145 km^2 area to protect surface expressions of salt domes beneath the sea floor	Presence of brine seeps which harbour unusual species adapted specifically to unusual water conditions. The area also serves as a	Premiere diving destination harbors the northernmost coral reefs in the US; oil and gas activity is also permitted; the site has historical

NAME	PROTECTED STATUS	COUNTRY / REGION	LOCATION	DESCRIPTION	KEY ENVIRONMENTAL SIGNIFICANCE	KEY SOCIO-ECONOMIC SIGNIFICANCE
					regional reservoir of shallow water Caribbean reef fishes and invertebrates.	fishing significance dating back to the 1800s and is a very significant location for research.
Gemini Seamount	N/A	South Pacific	100km south of Anatom Island, Vanuatu.		Well-developed marine life around the summit.	Research of volcanic activity and dredging
Gray's Reef	National Marine Sanctuary	USA	32 kilometers off Sapelo Island, Georgia, USA.	60 km^2.	One of the largest nearshore live-bottom reefs of the southern US; series of rock ledges and sand expanses has produced a complex habitat of caves, burrows, troughs, and overhangs that provide a solid base for sessile invertebrates.	One of the most popular recreational fishing and sport diving destinations along the Georgia coast. During World War II's Battle of the Atlantic, German U-boats sank Allied merchant ships near the reef. Commercial fishing is restricted, as are military, mineral extraction, and ocean dumping activities; little commercial shipping occurs.
Great Australian Bight	Marine Park	Australia	A 20 nautical mile band from the boundary of South Australian to the edge of the Exclusive Economic Zone.	This 17,000 km^2 MPA is the second largest marine park in the word next to Great Barrier Reef.	382,477 ha along the coastline are designated for mammal protection and a further 1,330,952 ha will help conserve the wildlife of the sea floor such as sponges, delicate marine algae and sea fans. It is the first major marine park in any part of the southern ocean that seeks to protect such a large area of the ocean’s sea floor.	The commercial fishing (tuna and lobster) and petroleum industries have an interest in the area.
Gulf of Farallones	National Marine Sanctuary	USA	Along the coast of California north and west of San Francisco, California, USA..	3200 km^2 of nearshore and offshore waters encompassing wetlands, intertidal, pelagic and deep-sea communities.	Largest breeding population of marine mammals and seabirds in the continental US.	Various uses occur including fishing, sailing, diving, surfing and whale watching; the area is located along one of the busiest shipping lanes in the world; contains more than 100 shipwrecks.
Hawaiian Islands	National Marine Sanctuary	USA	Within the 100-fathom isobath in the four-island area of Maui, the north shore of Kauai, the north and south shores of Oahu, and the Kohola coastline off the Big Island.	3550 km^2.	The warm, shallow waters surrounding the main Hawaiian Islands constitute one of the world's most important humpback whale habitats and the only place in the U.S. where humpbacks reproduce.	Remains of World War II shipwrecks; offshore shark temples; site is used for diving, while watching and boating.
Hyeres Seamount	N/A	Atlantic	Atlantic Ocean west of Madeira			Meddy research.

NAME	PROTECTED STATUS	COUNTRY / REGION	LOCATION	DESCRIPTION	KEY ENVIRONMENTAL SIGNIFICANCE	KEY SOCIO-ECONOMIC SIGNIFICANCE
Lo`ihi Seamount	N/A, but is the site of an "Observatory" (University of Hawaii and the US Geological Survey)	Hawaii	About 30 km south of Kilauea, Hawaii.	Undersea volcano previously thought to be an inactive seamount. The seamount rises to 969 m below sea level and generates frequent earthquake swarms, the most intense of which occurred in 1996.	Geological significance as part of a volcanically active chain of undersea and above sea features. May be the next Hawaiian Island.	Important scientific, research and educational values related to the study of volcanic processes including study of hydrothermal vents, bathymetry and seismic activity.
Macquarie Island	UN Biosphere Reserve UN World Heritage Area Marine Park	Australian Antarctic	In sub-Antarctic waters, Macquarie Island lies in the Southern Ocean, some 1500 km SSE of Tasmania, Australia.	An isolated subantarctic island with no permanent residents; except for adjacent islets and seastacks the nearest land is over 600 km away. The island is 34 km long by 5.5 km wide, rising to 433 m above sea level. It is the exposed crest of the Macquarie Ridge.	The existing reserve supports huge concentrations of land-breeding marine wildlife, comprising over 100,000 seals and over 3.5 million seabirds, mainly penguins.	Research and monitoring; current fishing activities.
Monitor	National Marine Sanctuary	USA	16 miles southeast of Cape Hatteras, North Carolina, USA.	Vertical water column in the Atlantic Ocean one mile in diameter extending from the surface to the seabed.	Few significant ecological features.	Contains the wreck of the U.S.S. *Monitor,* the famous Civil War ironclad warship sunk in 1862 in a ferocious storm.
Monowai Seamount	N/A	South Pacific	Kermadec Islands, French Polynesia about 1,500 km northeast of North Island, New Zealand.	A volcanically active seamount. Monowai has erupted at least eight times in the last twenty years.		Has been studied to measure undersea seismic activity around the seamount.
Monterey Bay	National Marine Sanctuary	USA	In the Pacific Ocean, between Cambria California and the Marin headlands, Central California, USA.	7500 km^2 NMS encompassing ocean and seafloor.	Close-to-shore deep-ocean environment; marine life; kelp forest; contains a canyon which is deeper than the Grand Canyon.	High public interest to people of California because of its extraordinary, unspoiled, natural beauty and the diversity of marine life; high recreation and research values; there are also native American relics found here along with the wreckage of 1276 vessels.
Nikko, Kaikata and Suiyo Seamounts	N/A	Japan			Bythograeid crabs	Research
Olympic Coast	National Marine Sanctuary	USA	Extends from Cape Flattery to the mouth of the Copalis River, on Washington's outer coast, USA.	8570 km^2 of marine waters averaging approximately 38 miles seaward, covering much of the continental shelf.	Protecting coastal and marine habitats for one of the most diverse marine mammal faunas in North America; this NMS is a critical link in the Pacific flyway; also contains deep-ocean geothermal vents.	Key area for marine transportation and recreation; the sanctuary boasts a rich mix of cultures and there is a Makah Research and Cultural Centre (archaeological museum) and other coastal First Nations cultural sites.
Patton Seamount	N/A	USA	Gulf of Alaska, USA.		Deepwater crabs.	Research into the habitat ecology of

NAME	PROTECTED STATUS	COUNTRY / REGION	LOCATION	DESCRIPTION	KEY ENVIRONMENTAL SIGNIFICANCE	KEY SOCIO-ECONOMIC SIGNIFICANCE
						deepwater crabs.
Port Foster	N/A	Antarctica		Two small separate tracts of benthic habitat within a sea-filled volcanic caldera, one at depth of 50-150 meters, the other at depths of 100-150 meters		
Red Coral	Nature Reserve	Monaco	Located in Monaco Territorial waters.	1 ha in size.	Red coral.	
Saba	Marine Park	Caribbean	Surrounds Saba Island, Netherlands Antilles.	Includes all of Saba's offshore waters and two offshore seamounts.	Saba is a dormant volcano that rises steeply from the ocean. Depths of a 1000 feet and over are found within half a mile from shore. The MPA protected varied coastal, intertidal and marine life.	Recreation and tourism are important social values with diving being one of the main activities. Education and research programs are also underway.
Sisifo Seamount	N/A	Italy	Aeolian Island Arcm South Tyrrhenian Sea.			Research on geologic framework and volcanic activity.
South Bay Palmer Archipelago		Antarctica		115 ha embayment plus adjacent littoral zone, protecting coastal and sub-littoral benthos to 45 m depth.		
Stellwagen Bank	National Marine Sanctuary	USA	25 miles east of Boston, located in the mouth of Massachusetts Bay in the Gulf of Maine, USA.	2180 km^2.	Coastal and marine systems including a sandbank covered by waters where humpback, fin and northern right whales feed and nurse their young.	Fishing occurs within the NMS.
Surtsey Island	Nature Reserve	Iceland		Offshore islands and the waters within a radius of 2 km.		
Tasmanian Seamounts	Marine Protected Area	Australia	South of Tasmania, Australia.	370 km^2 area encompassing a series of approximately 15 seamounts.	A diverse fauna characterized by a high proportion of species endemic to local seamounts.	Formerly used for commercial trawling; currently used by long-line tuna fishery.
Vesteris Seamount	N/A	North Atlantic	off the southeast coast of Greenland.			Scientific investigation of sedimentation due to oceanic circulation.
Vrangel Island Zapovednik	N/A	Russian Arctic		Offshore island including a 5 km buffer zone around the Nature Reserve on Wrangel Island.		
Western Bransfield Strait	Site of Special Scientific Interest	Antarctica		Benthos rich sea floor area to 200 meters depth, including a small area of adjacent land and foreshore.		

Appendix C. Bowie Seamount Backgrounder Bibliography (Dower and Fee 1999)

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Appendix D. Species Observed in the Bowie Seamount Area

Group	Scientific name	Comments	Source
ALGAE			
Phaeophyta (brown algae)	*Laminaria yezoensis* (Miyabe)	split frond kelp (based on appearance and identification material by Scagel 1970)	Scagel 1970; Austin 1999
	Desmarestia herbacea	large branched leafy seaweed	Scagel 1970
	Desmarestia foliacea		Scagel 1970
	Desmarestia viridis (Muller) Lamouroux		Scagel 1970
Rhodophyta (red algae)	*Antithamnion defectum* (Kylin)		Scagel 1970
	?*Callophyllis sp*	leafy red turf (as above but larger leafy form, based on appearance and identification material by Scagel 1970)	Scagel 1970; Austin 1999
	Callophyllis flabellulata		Scagel 1970
	Cryptopleura		Scagel 1970
	Delesseria decipiens		Scagel 1970
	Fryeella gardneri		Scagel 1970
	Polyneura latissima		Scagel 1970
	?*Polysiphonia sp*	filamentous red turf	Austin 1999
	Polysiphonia pacifica		Scagel 1970
	Ptilota tenuis		Scagel 1970
PROTOZOANS			
	Foraminiferida spp.		Mackas, pers. comm.
	Acantharia spp.		Mackas, pers. comm.
	Radiolaria spp.		Mackas, pers. comm.
INVERTEBRATES			
Porifera (sponge)		unidentified yellow species; other species may well be present but cannot be differentiated from other encrusting forms	Austin 1999
Cnidaria (anemones, jellyfish, hydroids)	Alcyonacea (order)	soft corals	Yamanaka pers. comm.
	Anthopleura xanthogrammica	bright green sea anemone (tentacles look longer and more flexible than one would expect in *A. xanthogrammica*)	Austin 1999
	?Epizoanthus scotinus	colonial tan zoanthid	Austin 1999
	Oblelia of longissima		Scrimger and Bird 1969
	Gorgonacea (order)	gorgonian corals	Yamanaka pers. comm.
	Madreporia (order)	stony corals	Yamanaka pers. comm.
	?*Urticina spp*	based on form but colour not clear	Austin1999
Annelida - Polychaeta (segmented worms)	*Arctone fragilis*	bristleworms	Scrimger and Bird 1969
	?Serpula vermicularis or ?Protura pacifica		Austin 1999
Bryozoa (moss animals)		not identified but expected to be a major component of overhangs and walls	Austin 1999
Mollusca – Gastropoda (snails)	*Limacina helicina*	pteropod (winged snail)	Mackas, pers. comm.

Group	Scientific name	Comments	Source
Mollusca – Cephalopoda (octopus and squid)		octopus	Yamanaka and Brown 1999
		squid	
Mollusca – Polypacophora (chitons)	*Cryptochiton stelleri*	gumboot chiton	Scrimger and Bird 1969
Mollusca - Bivalvia	*Mytilus californianus*	California mussel	Scrimger and Bird 1969
	Saxicava pholadis		Scrimger and Bird 1969
Arthropoda – Crustacea - Brachiopoda	*Podon*	water flea	Mackas, pers. comm.
Arthropoda – Crustacea – Cirripedia (barnacles)	*Balanus nubilus*	giant barnacle	Scrimger and Bird 1969
Arthropoda – Crustacea – Decapoda (crabs and lobsters)	*Chionoeates tanneri*	tanner crab	Yamanaka and Brown 1999
	Chionoecetes sp.	queen crab	Yamanaka and Brown 1999
	Paralithodes camtschatica	king crab	Yamanaka and Brown 1999
	Calappa sp.	box crab	Yamanaka and Brown 1999
	Pilumnus hirtellus	bristly crab	Yamanaka and Brown 1999
	Stenocionops sp.	decorator crab	Yamanaka and Brown 1999
	Libinea emarginata	spider crab	Yamanaka and Brown 1999
	Pugettia gracilis	kelp crab	Yamanaka and Brown 1999
	Chionoecetes sp.	snow crab	Yamanaka and Brown 1999
	Munida quadrispina	squat lobster (unusual to find large numbers at this shallow depth in coastal waters)	Austin 1999
Arthropoda – Crustacea Amphipoda (side swimmers)	*Caprella (C. hennerlyi)*		Scrimger and Bird 1969
	Themisto pacifica		Mackas, pers. comm.
Arthropoda – Crustacea - Copepoda	*Acartia longiremis*		Mackas, pers. comm.
	Calanus marshallae		Mackas, pers. comm.
	Calanus pacificus		Mackas, pers. comm.
	Eucalanus sp.		Mackas, pers. comm.
	Euphausiis eggs		Mackas, pers. comm.
	Euphausiid nauplii		Mackas, pers. comm.
	Metridia pacifica		Mackas, pers. comm.
	Metridia sp.		Mackas, pers. comm.
	Neocalanus cristatus		Mackas, pers. comm.
	Neocalanus flemengeris		Mackas, pers. comm.
	Neocalanus plumchrus		Mackas, pers. comm.
	Oithona atlantica		Mackas, pers. comm.
	Oithona similis		Mackas, pers. comm.
	Paracalanus parvus		
	Pseudocalanus mimus		Mackas, pers. comm.
	Scolecthricella minor		Mackas, pers. comm.
Echinodermata - Asteroidea (sea stars)	*Asteroidea (subclass)*	sea stars	Yamanaka pers. comm.
	Dermasterias imbricata	leather sea star	Austin 1999
	Pycnopodia helianthoides	sunflower sea star: moderately abundant	Austin 1999
	Henricia leviuscula	blood star	

Group	Scientific name	Comments	Source
Echondermata - Ophiuroidea (brittle stars)	*Ophiopholis aculeata*	variegated brittle star	Austin 1999
Echinodermata - Holothuroidea (sea cucumbers)	*Cucumaria quinquesemita*	white sea cucumber?	Scrimger and Bird 1969
UROCHORDATA			
Larvacean	*Oikopleura dioica*		Mackas, pers. comm.
Thaliacean (salps)	*Cyclosalpa sp*		Austin 1999
	?Thalia democratica		Austin 1999
	Thetys vagina	Both solitary and aggregated forms, and particularly abundant	Austin 1999
VERTEBRATES			
Condrichthyes (cartilaginous fish)	*Apristurus brunneus*	brown cat shark	Yamanaka and Brown 1999
	Cetorhinurs maximus	basking shark	Yamanaka and Brown 1999
	Prionace glauca	blue shark	Yamanaka, pers. comm.
	Raja rhina	longnose skate	Yamanaka and Brown 1999; Yamanaka, pers. comm.
	Rajidae (family)	skates	Yamanaka and Brown 1999; Yamanaka, pers. comm.
	Somniosus pacificus	Pacific sleeper shark	Yamanaka and Brown 1999
	Squalus acanthias	spiny dogfish	Yamanaka and Brown 1999
Osteichthyes (bony fish)	*Anarrhichthys ocellatus*	wolf eel	Herlinveaux 1971; Austin 1999; Yamanaka, pers. comm...
	Anarrhichthys ocellatus	wolf eel	Yamanaka and Brown 1999
	Anoplopoma fimbria	sablefish/black cod	Yamanaka and Brown 1999; Yamanaka, pers. comm.
	Antimora microlepis	Pacific flatnose	Yamanaka and Brown 1999
	Atheresthes stomias	turbot	Yamanaka and Brown 1999
	Atheresthes stomias	arrowtooth flounder	Yamanaka, pers. comm.
	Avocettina sp.	snipe eel	Yamanaka and Brown 1999
	Bathophilus flemingi	highfin dragonfish	Yamanaka and Brown 1999
	Bothrocara brunneum	twoline eelpout	Yamanaka and Brown 1999
	Bothrocara remigerum	longsnout eelpout	Yamanaka and Brown 1999
	Bramidae (family)	pomfrets	Yamanaka, pers. comm.
	Careproctus melanurus	blacktail snailfish	Yamanaka and Brown 1999
	Chauliodus macouni	Pacific viperfish	Yamanaka and Brown 1999
	Coryphaenoides acrolepis	roughscale rattail	Yamanaka and Brown 1999
	Coryphaenoides pectorialis	pectoral rattail	Yamanaka and Brown 1999

Group	Scientific name	Comments	Source
	Cottidae (family)	sculpins	Yamanaka, pers. comm.
	Cottus ricei	spoonhead sculpin	Yamanaka, pers. comm.
	Embassichthys bathybius	deepsea sole	Yamanaka and Brown 1999
	Eopsetta jordani	petrale sole	Yamanaka and Brown 1999
	Gadus marcocephalus	Pacific cod	Yamanaka, pers. comm.
	Hemilepidotus hemilepidotus	red Irish lord	Yamanaka, pers. comm.
	Hippoglossus stenolepis	Pacific halibut	Yamanaka and Brown 1999; Yamanaka, pers. comm.
	Icosteus aenigmaticus	ragfish	Yamanaka and Brown 1999
	Lampacyctus ritteri	broadfin lampfish	Yamanaka and Brown 1999
	Lepidopsetta bilineata	rock sole	Yamanaka and Brown 1999
	Micristomua pacificus	Dover sole	Yamanaka and Brown 1999; Yamanaka, pers. comm.
	Scorpaenidae (family)	scorpionfish	Yamanaka, pers. comm.
	Sebastes aleutianus	rougheye rockfish	Yamanaka, pers. comm.
	Sebastes alutus	Pacific ocean perch	Yamanaka, pers. comm.
	Sebastes aurora	aurora rockfish	Yamanaka, pers. comm.
	Sebastes babcocki	redbanded rockfish	Yamanaka, pers. comm.
	Sebastes borealis	shortraker rockfish	Yamanaka, pers. comm.
	Sebastes brevispinis	slivergrat rockfish	Yamanaka, pers. comm.
	Sebastes crameri	darkblotched rockfish	Yamanaka, pers. comm.
	Sebastes diploproa	splitnose rockfish	Yamanaka and Brown 1999
	Sebastes elongatus	greenstriped rockfish	Yamanaka, pers. comm.
	Sebastes entomelas	widow rockfish	Herlinveaux 1971; Austin 1999; Yamanaka, pers. comm.
	Sebastes flavidus	yellowtail rockfish	Yamanaka, pers. comm.
	Sebastes helvomaculatus	rosethorn rockfish	Yamanaka, pers. comm.
	Sebastes maliger	quillback rockfish	Yamanaka, pers. comm.
	Sebastes miniatus	Vermillion rockfish	Yamanaka and Brown 1999
	Sebastes nebulosus	China rockfish	Yamanaka, pers. comm.
	Sebastes nigrocinctus	tiger rockfish	Yamanaka, pers. comm.
	Sebastes paucispinis	bocaccio rockfish	Yamanaka and Brown 1999
	Sebastes pinniger	canary rockfish	Yamanaka and Brown 1999
	Sebastes proriger	redstripe rockfish	Yamanaka, pers. comm.
	Sebastes reedi	yellowmouth rockfish	Yamanaka, pers. comm.
	Sebastes rubberrimus	yelloweye rockfish	Herlinveaux 1971; Austin 1999; Yamanaka, pers. comm.
	Sebastes variegatus	harlequin rockfish	Yamanaka, pers. comm.
	Sebastolobus alascanus	shortspine thornyhead rockfish	Yamanaka and Brown 1999; Yamanaka, pers. comm.
	Sebastolobus altivelis	longspine thornyhead rockfish	Yamanaka and Brown 1999
	Tactostoma macropus	longfin dragonfish	Yamanaka and Brown 1999

Group	**Scientific name**	**Comments**	**Source**
	Theragra chalcogramma	pollock	Yamanaka and Brown 1999
	Zaprora silenus	prowfish (the large numbers of prowfish are surprising as it is recorded as occurring in somewhat deeper water)	Austin 1999; Yamanaka and Brown 1999
Aves (birds)	*Stercorarius maccormicki*	South Polar Skua	Morgan, pers. comm.
	Cerorhinca monocerata	Rhinoceros Auklet	Morgan, pers. comm.
	Phoebastria nigripes	Black-footed Albatross	Yamanaka, pers. comm.; Morgan, pers. comm.
	Fratercula cirrhata	Tufted Puffin	Morgan, pers. comm.
	Fratercula corniculata	Horned Puffin	Morgan, pers. comm.
	Fulmarus glacialis	Northern Fulmar	Morgan, pers. comm.
	Larus glaucescens	Glaucous-winged Gulls	Morgan, pers. comm.
	Oceanodroma furcata	Fork-tailed Storm-petrel	Morgan, pers. comm.
	Oceanodroma leucorhoa	Leach’s Storm-petrel	Morgan, pers. comm.
	Pterodroma ultima	Murphy’s Petrel	Morgan, pers. comm.
	Ptychoramphus aleuticus	Cassin’s Auklet	Morgan, pers. comm.
	Puffinus bulleri	Buller’s Shearwater	Morgan, pers. comm.
	Puffinus griseus	Sooty Shearwater	Morgan, pers. comm.
	Rissa tridactyla	Black-legged Kittiwake	Morgan, pers. comm.
	Stercorarius longicaudis	Long-tailed Jaeger	Morgan, pers. comm.
	Synthliboramphus antiquus	Ancient Murrelet	Morgan, pers. comm.
Mammalia	Pinnipedia	Unidentified seals	
	Pinnipedia	Unidentified sealions	
	Eumetopias jubatas	stellar sea lions	
	Lagenorhynchus obliquidens	Pacific white-sided dolphin	
	Lissodephis borealis	northern right-whale dolphin	
	Orcinus orca	killer whale	
	Physeter catodon	sperm whale	
	Stenealla coeruleoalba	striped dolphin	

? = unconfirmed species observations

Appendix E. Agencies and Organizations Contacted while Conducting Research for "Bowie Seamount Pilot Marine Protected Area: An Ecosystem Overview Report"

At Large
Peter **Hamel**

Atlantis Submarines International
John **Witney**, Vancouver, BC

AXYS Technologies
Anthony **Ethier**, Manager, Field Operations, Sidney, BC
Simon **Skey**, (former) Vice President, Sidney, BC

Bamfield Marine Station
Ann **Stewart**, Public Education Coordinator, Bamfield, BC
Jason **Thompson**, Researcher, Public Education Department, Bamfield, BC

BC Coast Pilots Ltd.
N. **McDougall**, Vancouver, BC

BC Ferries Corporation
Capt. Jamie **Marshall**, Operational Safety Superintendent, Victoria, BC

BC Ministry of Competition, Science and Enterprise
Galen **Greer**, Senior Analyst, Science, Technology and Communications Division, Victoria, BC

BC Ministry of Energy and Mines
Rob **Burleson**, Senior Project Manager, Victoria, BC
Lynne **Ewing** (retired), Victoria, BC
Colin **Magee**, Assistant Director, Petroleum Lands Branch, Victoria, BC

BC Ministry of Sustainable Resource Management
Joe **Truscott**, Coastal Planning Specialist, Victoria, BC
Mark **Zacharias**, (former) Coastal Business Area Manager, Decision Support Services, Victoria, BC

BC Ministry of Water, Land and Air Protection
Doug **Biffard**, Protected Areas Ecologist (Aquatic), BC Parks Conservation Services, Victoria, BC
Stafford **Reid**, Emergency Planning Analyst, Victoria, BC
Marty **Roberts** (retired), Planner, Parks and Ecological Reserves Planning, Victoria, BC

BC Underwater Archaeological Society
Neil **McDaniel**, Underwater film maker, Vancouver, BC
Mike **Paris**, Member, Vancouver, BC

British Columbia Coast Pilots Ltd.
Ed **Storzer**, Vancouver, BC
Alan **Thornett**, Vancouver, BC

Canadian Parks and Wilderness Society
Sabine **Jessen**, Executive Director, Vancouver, BC
Keith **Symington**, (former) Marine Spaces Coordinator, Vancouver, BC

Canadian Petroleum Products Institute
David **Watson**, Marine Issues Manager, Nanaimo, BC

Canadian Sablefish Association
Bob **Fraumeni**, President, Victoria, BC
Rick **Jones**, Director, BC
Erling **Olsen**, Director, BC
Thomas **Tournier**, Director, BC
Bruce **Turris**, Executive Director, New Westminster, BC

Chamber of Shipping of British Columbia
Stephen **Brown**, Vancouver BC
Ron **Cartwright**, (former) President, Vancouver, BC
Claus **Hendriksen**, Treasurer, Vancouver, BC

City of Prince Rupert
Don **Scott**, Prince Rupert, BC
Cyril **Stephens**, Councillor, Prince Rupert, BC

Council of BC Yacht Clubs
Norm **Dyck**, Chairman

Council of Marine Carriers
D. **Chapman**, Vancouver, BC

Council of the Haida Nation
Guujaaw, President, Skidegate Council of Haida Nations, Queen Charlotte City, BC
Terry **Hamilton**, Masset, BC
Russ **Jones**, Coordinator, Haida Fisheries Program, Queen Charlotte City, BC
Gilbert **Parnell**, Vice President, Queen Charlotte City, BC
Kathy **Pearson**, Skidegate Council of Haida Nations, Queen Charlotte City, BC
Ed **Russ**, Skidegate Band Council, Skidegate, BC
Amos **Setso**, Member of the Executive, Queen Charlotte City, BC

Deep Sea Trawlers Association
Ed **Zyblut**, Deep Sea Trawlers Association, Richmond, BC

Department of National Defense
VAdm. Ron **Buck**, (former) Commander, Maritime Forces Pacific, Victoria, BC
Lt. Cdr. **David** Kirby, MARPAC, Victoria, BC
Duane **Freeman**, Formation Environment, Victoria, BC
Lt. Cdr. Bill **Liang**, Maritime Forces Pacific, Victoria, BC
Andrew **Smith**, Victoria, BC
Ulrich **Suesser**, Maritime Forces Pacific, Victoria, BC

Environment Australia
Peter **Taylor**, Canberra, Queensland, Australia

Environment Canada
Michael **Dunn**, Senior Habitat Conservation Coordinator, Canadian Wildlife Service, Delta, BC
Ken **Morgan**, Marine Conservation Biologist, Canadian Wildlife Service, Sidney, BC

Fisheries and Oceans Canada
Angela **Addison**, Library Services, Prince Rupert, BC
Bruce **Adkins**, Shellfish Coordinator, Pacific Biological Station, Nanaimo, BC
Douglas **Alpen**, Assistant Regional Program Specialist, Canadian Coast Guard, Vancouver, B.C.
Doug **Andrie**, Coordinator, Integrated Coastal Zone Management West Vancouver Island, Oceans Directorate, Ucluelet, BC
Elaine **Antilla**, Marine Biologist, Habitat Enhancement Branch, Prince Rupert, BC

Fisheries and Oceans Canada (cont.)
Sam **Baird**, Chief, Oceans Policy, Oceans Sector, Vancouver, BC
Wade **Barney**, Liaison Officer, St. John’s, NF
Randall **Barnhart**, Manager, Aboriginal Fisheries, Operations Branch, Prince Rupert, BC
Richard **Beamish**, Research Scientist, Pacific Biological Station, Nanaimo, BC
Robert **Bennett**, Regional Operations Centre, Canadian Coast Guard, Victoria, BC
Lia **Bijsterveld**, Information Management, Corporate Services, Vancouver, BC
Robin **Brown**, Ocean Science and Productivity, Institute of Ocean Sciences, Sidney, BC
Tom **Brown**, Biologist, Coastal and Marine Habitat, Pacific Biological Station, Nanaimo, BC
Rick **Bryant**, Regional Director, Canadian Coast Guard, Vancouver, BC
Dick **Carson**, Regional Director, Oceans Directorate, Vancouver, BC
Alan **Cass**, Chair, Pacific Scientific Advice Review Committee, Pacific Biological Station, Nanaimo, BC
Mary Jean **Comfort**, National Marine Protected Areas Coordinator, Ottawa, ON
Christiane **Cote**, Communications Advisor, Policy and Communications Branch, Vancouver, BC
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George **Eaton**, Canadian Hydrographic Service, Institute of Ocean Sciences, Sidney, BC
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Wayne **Fullerton**, Canadian Coast Guard, Vancouver, BC
Jean **Gagnon**, Chief Data Manager, Institute of Ocean Sciences, Sidney, BC
Ann **Gargett**, Ocean Science and Productivity, Institute of Ocean Sciences, Sidney, BC
Jim **Gower**, Research Scientist, Institute of Ocean Sciences, Sidney, BC
Dale **Gueret**, A/Area Chief, Oceans and Community Stewardship, Prince Rupert, BC
Sue **Hahn**, Regional Coordinator, Groundfish Enforcement, Vancouver, BC
Ken **Halcro**, Canadian Hydrographic Service, Institute of Oceans Sciences, Sidney, BC
Rob **Hare**, Canadian Hydrographic Service, Institute of Ocean Sciences, Sidney, BC
Fern **Hietkamp**, Coordinator, Integrated Coastal Zone Management, Oceans Directorate, Vancouver, BC
Marilyn **Joyce**, Advisor, Resource Manager Groundfish, Vancouver, BC
Ron **Kadowaki**, Stock Assessment, Pacific Biological Station, Nanaimo, BC
Tiina **Kurvits**, (former) National Marine Protected Areas Coordinator, Ottawa, ON
Lisa **Lacko**, Biologist, Groundfish Section, Pacific Biological Station, Nanaimo, BC
Ed **Lochbaum**, Coordinator, Marine Mammals, Nanaimo, BC
John **Lubar**, Area Director, North Coast, Operations Branch, Prince Rupert, BC
Sean **MacConnachie**, Oceans Project Coordinator, Georgia Basin, Oceans Directorate, Nanaimo, BC
Paul **Macgillivray**, Regional Director, Fisheries Management Branch, Vancouver, BC
Dave **Mackas**, Head, Plankton Productivity, Institute of Oceans Sciences, Sidney, BC
Colin **Masson**, A/Area Director, Oceans Directorate, Nanaimo, BC
Gordon **May**, Program Specialist, Marine Communications and Traffic Services, Vancouver, BC
Gordon **Miller**, Librarian, Pacific Biological Station, Nanaimo, BC
Kristi **Miller**-Saunders, Aquaculture, Pacific Biological Station, Nanaimo, BC
Yvette **Myers**, Director of Marine Programs, Vancouver, BC
Chrys **Neville**, Research Biologist, Science Branch, Pacific Biological Station, Nanaimo, BC
Linda **Nichol**, Pacific Biological Station, Nanaimo, BC
Marc **Pakenham**, Oceans Act Implementation Officer, Victoria, BC
John **Palliser**, Superintendent, Marine Search and Rescue, Canadian Coast Guard, Victoria, BC
Ron **Perkin**, Ocean Data Management, State of the Ocean, Institute of Ocean Sciences, Sidney, BC
Ted **Perry**, Director, Stock Assessment Division, Science Branch, Pacific Biological Station, Nanaimo, BC
Paul **Preston**, Oceans Act Implementation Officer, Nanaimo, BC
Dave **Prince**, Managers, Nautical Publications, Sidney, BC

Fisheries and Oceans Canada (cont.)
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Diana **Trager**, Hook and Line Coordinator, Groundfish Management Unit, Vancouver, BC
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Frank **Whitney**, Program Coordinator, Water Properties, Institute of Ocean Sciences, Sidney, BC
Ruth **Withler**, Head, Molecular Genetics, Pacific Biological Station, Nanaimo, BC
Robert **Wright**, A/Hook and Line Coordinator, Fisheries Management, Pacific Biological Station, Nanaimo, BC
Malcolm **Wyeth**, Research Biologist, Groundfish Section, Pacific Biological Station, Nanaimo, BC
Lynne **Yamanaka**, Research Biologist, Stock Assessment, Pacific Biological Station, Nanaimo, BC

Fraser River Port Authority
S. **Davis**, New Westminster, BC

G.P. Dalum Enterprises Ltd.
Gerald **Dalum**, Fisherman, Cranbrook, BC
John **Vogelarr**, Fisherman, Sidney, BC

Geographical Names Board of Canada
Sheila **Acheson**, Secretary of the Advisory Committee on Names of Undersea and Maritime Features, Ottawa, ON

Georgia Strait Alliance
Howard **Breen**, (former) Habitat Campaign Director, Nanaimo, BC

Groundfish Hook and Line Advisory Committee
Henry **Heggelund**, Rockfish fisher, Sooke, BC
Terry **Henshaw**, Fisher/advisor, Delta, BC

Haida Fisheries Committee
Charlie **Bellas**, Haiida Gwaii, BC
Pat **Fairweather**, Fisheries Technician, Haida Gwaii, BC
Gary **Russ**, Chairman, Haida Gwaii, BC

Industry Canada
John **Beveridge**, Environmental Affairs Advisor, Vancouver, BC

International Pacific Halibut Commission
Tracee **Greernaert**, Biologist, Seattle, WA
Bruce **Leaman**, Director, Seattle, WA

Living Oceans Society
Jennifer **Lash**, Executive Director, Sointula, BC

Marine Ecology Station
Bill **Austin**, Sidney, BC

National Oceanic and Atmospheric Administration
Edward **Baker**, Supervisory Oceanographer, Pacific Marine Environmental Laboratory, Seattle, WA

Natural Resources Canada
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Old Massett Village Council
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Steve **Samuels**, Old Massett Band Council, Old Massett, BC

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Pacific Coast Marine Review
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Ed **Monteiro**, Chair PACMAR

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R. **Plecas**

Seaspan International Ltd.
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Simon Fraser University
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Skeena Queen Charlotte Regional District
Joan Ann **Allen**, Director, Port Clements, BC
Paddy **Greene**, Director, Prince Rupert, BC
Barry **Pages**, Director, Masset, BC

The Chamber of Shipping of America
Joe **Cox**, President, Washington, DC

Transport Canada
Goride **Mann**, Senior Marine Surveyor, Vancouver, BC

Underwater Council of BC
Tom **Beasley**, President, Vancouver, BC
Roy **Mulder**, Vice President

University of British Columbia
Richard **Chase**, Professor, Department of Earth & Ocean Sicences, Vancouver, BC
Steve **Martell**, Researcher, Fisheries Centre, Vancouver, BC

University of Connecticut at Avery Point
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University of Minnesota
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University of Quebec at Montreal
Kim **Juniper**, Professor, Biological Sciences, GEOTOP, Montreal, PQ

University of Toronto
Steven **Scott**, Professor, Department of Geology, Toronto, ON

University of Utah
Robert **Harris**, Research Assistant Professor, Department of Geology and Geophysics, Salt Lake City, UT

University of Victoria
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University of Washington
John R. **Delaney**, Professor, School of Oceanography, Seattle, WA
Bruce **Howe**, Principal Oceanographer, Applied Physics Lab, Seattle, WA
Russ E. **McDuff**, Professor, School of Oceanography, Seattle, WA

US Coast Guard
RAdm. Paul **Blayney**, Commander, 13^{th} Coast Guard District, Seattle, WA
Commander Bill **Devereux**, Chief, Aids to Navigation and Waterways Management Branch, 13th Coast Guard District, Seattle WA
Captain William **Peterson**, Commanding Officer and Chief of Search and Rescue, Port Angeles, WA
Lieutenant Patricia **Springer**, Marine Transportation Systems, Pacific Area, Berkley, California
Lieutenant Commander Jane **Wong**, Compliance and Investigations Branch, Seattle, WA

Western Marine Community
J. **Nichol**

Woods Hole Oceanographic Institution
Margaret K. **Tivey**, Associate Scientist, Marine Chemistry and Geochemistry, Woods Hole, MA

World Wildlife Fund Canada
Lynn **Lee**, Biologist, Tlell, BC
Michele **Patterson**, Marine Program Director, Pacific Region, Prince Rupert, BC

Xanatos Holdings
B. **English**, Port Moody, BC