Ocean Management of Queen Charlotte Basin, British Columbia, Canada

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Abstract

Queen Charlotte Basin is known to the world for two conflicting characteristics: 1) a world-heritage site for its unique cultural heritage and biological ecosystem, and 2) its resource wealth in fisheries, potential hydrocarbons, wind power, and precious and industrial minerals. The Canadian federal government's consideration of lifting the moratorium on hydrocarbon exploration in Queen Charlotte Basin, and the proposal to develop marine wind farms, have heightened the need for geoscience information for informed decision-making. The exploration and development of oil and gas, wind farms and placer and aggregate mining will inevitably be in conflict with fisheries and will occur in an area that is subject to significant geohazards and the greatest seismicity in Canada. Of particular concern is the need to determine areas that need to be restricted to resource development and areas that should become full marine protected areas. Consequently, habitat characterization for ocean management for these competing resource industries, and the protection of unique habitats, are critical for the future ecological and economic health of the region. To provide the habitat and geoscientific knowledge necessary for effective decision-making on these competing resource-management issues, a broad approach, including using ocean mapping technology, is presented.

Résumé

Le bassin de la Reine-Charlotte est mondialement connu en raison de deux caractéristiques conflictuelles: 1) le fait qu'il s'agit d'un site de patrimoine mondial en raison de son patrimoine culturel et de son écosystème biologique uniques, et 2) la richesse de ses ressources de pêche, son potentiel en hydrocarbures, en énergie éolienne et en minéraux précieux et industriels. Les considérations du gouvernement fédéral du Canada de lever le moratoire sur l'exploration des hydrocarbures dans le bassin de la Reine-Charlotte, ainsi que la proposition de mettre en place des parcs éoliens marins ont causé une augmentation de la demande d'information géoscientifique en vue de prise de décisions éclairées. L'exploration et le développement dans les secteurs de l'huile et du gaz, des parcs éoliens et des travaux miniers de placers et d'agrégats vont inévitablement entrer en conflit avec les pêches et vont avoir lieu dans une région qui est sujette à d'importants géorisques et à la plus forte sismicité au Canada. Le besoin de déterminer les zones où le développement des ressources doit être restreint et celles qui devraient devenir des zones marines entièrement protégées est une préoc-

cupation particulièrement importante. Par conséquent, la caractérisation des habitats en vue de la gestion océanique de ces secteurs qui se disputent la ressource et la protection des habitats uniques sont cruciaux pour la santé écologique et économique future de la région. Afin d'acquérir les connaissances géoscientifiques et sur les habitats nécessaires à une prise de décision éclairée sur les questions de gestion des ressources disputées, une approche globale, comprenant l'utilisation de la technologie cartographique des océans, est présentée.

INTRODUCTION

The Canadian federal government's consideration of lifting the moratorium on hydrocarbon exploration in Queen Charlotte Basin, off the northwest coast of British Columbia (Figure 1), and the proposal to develop marine-based wind farms, have heightened the need for geoscience information for informed decision-making. These new initiatives will inevitably be in conflict with traditional and new fisheries. They will occur in an area subject to the strongest seismicity in Canada and which also contains globally significant ecological habitat, *e.g.*, sponge reefs (Conway *et al.*, 1991, 2005; Kruatter *et al.*, 2001). Consequently, habitat characterization for ocean management of competing resource industries and the protection of globally unique habitats (*via* Marine Protected Areas) is critical for the future ecological health of the region. To do this, significant geohazards need to be mapped and assessed and areas of unique and critical habitat should be identified prior to the opening of the basin to exploitation.

The objective of this paper is to discuss the criteria and outline the general methods that will provide the habitat and geoscientific knowledge necessary for effective decision-making on competing resource management issues (oil and gas, wind farms, fisheries, aggregate production) and the environment in Queen Charlotte Basin.

REGIONAL SETTING

Queen Charlotte Basin is a semi-enclosed basin between mainland British Columbia (BC) and the Queen Charlotte Islands. The basin is connected to the northeast Pacific through Dixon Entrance in the north and Queen Charlotte Sound in the south (Figure 1). Water depths vary between the shallow waters of Dogfish Bank (15-30 m) to greater than 400 m in the troughs. Three canyons enter Queen Charlotte Sound; the largest of these, Moresby Trough (Figure 1), extends about 270 km northeastward to the eastern side of central Hecate Strait. Mid-shelf banks exist from 40 to 110 m water depth; these are isolated by the deep-water troughs and form the other significant physiographic elements on the shelf.

Tectonic Setting

Tectonism gave rise to the existence and location of the Queen Charlotte Islands. The Pacific Plate slides northward and slightly into North America at an average rate of 50-60 mm a^{-1} along the Queen Charlotte Fault (Riddihough, 1982; Rohr *et al.*, 2000). At the junction of the two plates (Figure 1), this motion has been accompanied by frequent earthquakes that vary in intensity along the fault, although the overall pattern has been stable since records have been kept (Bird, 1997). Along with numerous small events, four large earthquakes have occurred this century, with the largest (magnitude 8.1) occurring adjacent to the northwestern edge of the continental shelf off Graham Island in 1949 (Figure 1), and the most recent on February 17, 2001 (magnitude 6.1). This active plate boundary defines the shape and physiography of the Pacific margin of the Queen Charlotte Islands. The western continental shelf is narrow, extending offshore less than 5 km in the south and up to 30 km at 54°N to the shelf edge, at about 200 m water depth (Figure 1).

Surficial Geology

The present morphology of the Queen Charlotte Islands and surrounding seabed (Queen Charlotte Basin) is a product of glaciation, tectonism, sea level change and a dynamic oceanography over the late Quaternary period (approximately the last 30,000 years). A regional sea level regression in western Hecate Strait and Dixon Entrance of the northern Pacific margin of Canada began soon after the late Wisconsin glacial maximum and continued throughout deglaciation. Relative sea level had reached a maximum lowering of greater that 150 m below present levels after 13,000 C^{14} years BP (corrected dates) in western Hecate Strait and remained low until approximately 12,400 C^{14} years BP (Josenhans *et al.*, 1997; Barrie and Conway, 1999). Eustatic sea level rise, coupled with collapse of a glacioisostatic forebulge resulted in relative sea level rise (Clague, 1983; Luternauer *et al.*, 1989a). Sea level reached the present position on the Queen Charlotte Islands by about 9100 C^{14} years BP and then rose to a maximum of 13 to 16 m above present sea level by 8900 C^{14} years BP, returning to the present level by 2000 C^{14} years BP (Clague *et al.*, 1982; Clague, 1983; Josenhans *et al.*, 1995, 1997; Fedje and Josenhans, 2000). Relative sea level change has been influenced by isostatic crustal depression and rebound, the raising and lowering of eustatic sea level, and local tectonic crustal adjustments (Hetherington *et al.*, 2004; Hetherington and Barrie, 2004).

Distribution of glacial ice on the continental shelf surrounding the Queen Charlotte Islands is inferred from seismostratigraphic investigations which suggest ice-contact sediments (tills), up to 50 m thick, occur to the shelf edge within the cross-shelf troughs (Josenhans *et al.*, 1995) and Dixon Entrance (Barrie and Conway, 1999). Extensive glacimarine mud, up to 20 m thick, overlies thin, ice-proximal sediments, or more usually a till, over most of Queen Charlotte Basin in water depths generally greater than 200 m (Luternauer *et al.*, 1989b; Barrie *et al.*, 1991; Barrie and Conway, 1999). The unit is interpreted to have been ice-distal, deposited by iceberg rafting and from floating sea ice (Barrie and Conway, 2002a). Overlying the glacimarine mud in the troughs is a thin sandy mud unit that represents a lag formed over a period of several hundred years when sea level was lower than at present (Luternauer *et al.*, 1989b; Barrie *et al.*, 1991; Barrie and Conway, 1999). Finally, during the Holocene, sedimentation has resulted in up to 40 m of olive, clay-rich mud in the troughs and a thin (usual-

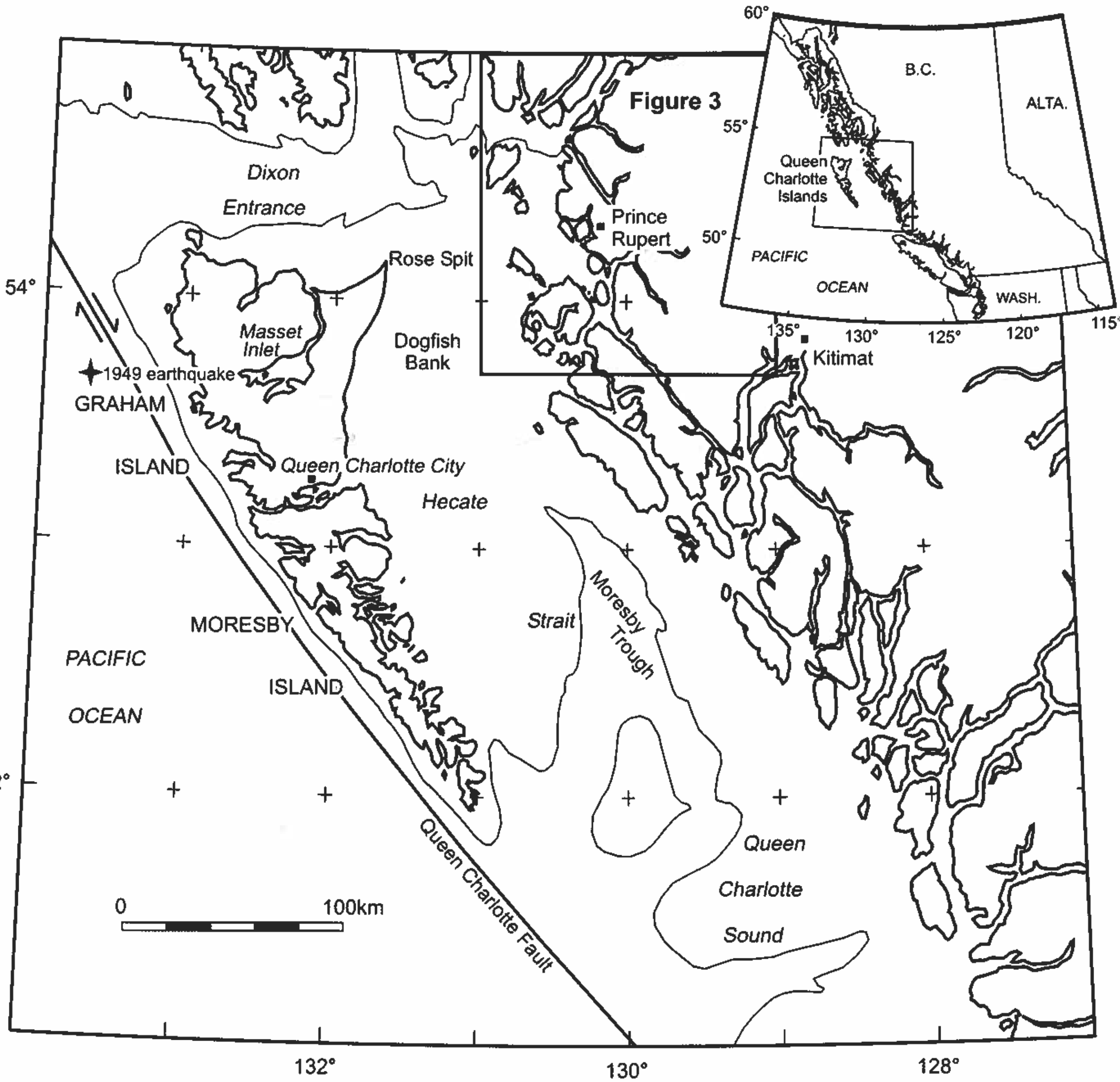

Figure 1. *Queen Charlotte Basin. The 200 m contour and the location of Figure 3 are shown.*

ly less than 10 m) sand and gravel unit on the bank tops deposited as the coast migrated during sea level rise. Most terrestrially-derived material is trapped in the deep inshore fjords and channels bordering the shelf (Luternauer and Murray, 1983).

Oceanography

Water circulation on the central and northern British Columbia continental shelf is dominated by semi-diurnal tidal streams that are continually modified by wind and meltwater runoff (Thomson, 1981; Crawford *et al.*, 1995). Tides flood into the basin from the southeast through Queen Charlotte Sound and southward from Dixon Entrance (Thomson, 1981). Tidal ranges are between 3.0 and 4.5 m, with the maximum tides in excess of 7.0 m occurring near Prince Rupert and Queen Charlotte City (Figure 1). Tidal streams in Hecate Strait are rectilinear which results from restrictions imposed by bathymetry (Figure 2; Crawford *et al.*, 1988). Near-bottom tidal current velocities characteristically are between 0.15 and 0.25 m s^{-1}.

Annual average significant wave height for Hecate Strait is 1.8 m and 4.0 m for Queen Charlotte Sound, with a maximum observed wave height of 14.3 m (Eid *et al.*, 1993). The dominant wave direction in Hecate Strait is south to southwest although strong southeast wind, and onshore refraction in shallower coastal waters, cause frequent southeast waves on Dogfish Bank.

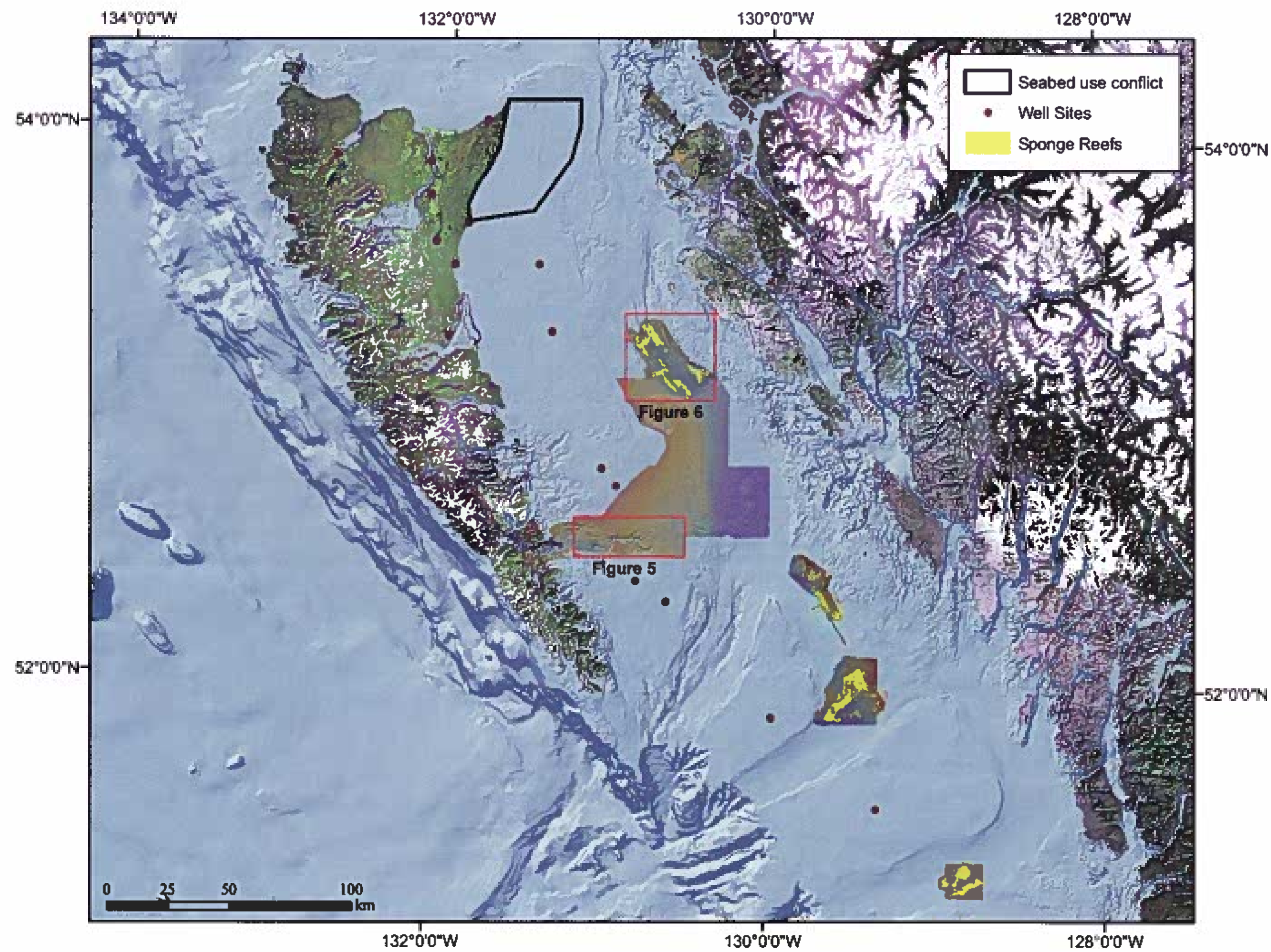

Figure 2. *Map of Queen Charlotte Basin showing multibeam swath bathymetry collected up until September 2005 in the central basin area (oil and gas and trawl fisheries interest) and in the area of the four sponge reef complexes. The other unmapped region of conflict (crab fisheries and wind farms) and the locations of Figures 5 and 6 are shown.*

The Hecate Strait and Queen Charlotte Sound region are near the northern extent of the Coastal Upwelling Domain along the North American margin (Thomson *et al.*, 1989; Thomson and Ware, 1996). Prevailing winds are from the southeast in winter, creating strong downwelling conditions, and change to northwesterly in summer (Hannah *et al.*, 1991) which results in weak upwelling. Flow at depth is counter to wind direction with bottom currents through shelf canyons being generally onshore in summer (Crawford *et al.*, 1985; Hannah *et al.*, 1991). The relaxation of downwelling, tidal mixing (which increases nutrient supply (Perry *et al.*, 1983)), and estuarine entrainment of nutrients into the euphotic zone are likely the major stimulants to biological production in this region.

ISSUES

Oil and Gas

Exploration for oil and gas within Queen Charlotte Basin began in 1958 with seismic surveys culminating in a number of wells being drilled in the late 1960s, including eight in Hecate Strait and Queen Charlotte Sound (Figure 2). In 1969, the British Columbia provincial government imposed a moratorium on offshore exploration drilling. In 1972, the Canadian federal government imposed a moratorium on crude oil tanker traffic though the basin and all oil and gas activities; the province followed by imposing a similar moratorium in 1981. The Geological Survey of Canada reviewed the potential of the basin for oil and gas, based on more recently-developed basin models, and concluded that significant potential of a large hydrocarbon find exists within the basin (Hannigan *et al.*, 2001). Following this, the provincial government asked the government of Canada to consider lifting the federal moratorium on oil and gas activities for the British Columbia offshore region. Two scientific reviews followed, one by the provincial government and one by the federal government. Both found no inherent or fundamental inadequacy of science or technology to justify the retention of the moratorium. Both reviews recommended that scientific gaps need to be addressed before development of an oil and gas industry in Queen Charlotte Basin. One of the key recommendations arising from the federal government review for the

Government of Canada (www.rsc.ca/BC_offshore/reportpageEN.html) was that concerted action be taken to determine the areas that should be protected in Queen Charlotte Basin.

Fisheries

An extensive and diverse commercial and sport fishery exists within Queen Charlotte Basin for six species of salmon, rockfish, dogfish, lingcod, flatfish, skates and crab. Over 40 species are landed in the hook-and-line fishery and up to 70 species in the commercial trawl fishery. Beginning in 1996, a program of 100% observer coverage was implemented for the British Columbia offshore groundfish bottom-trawl fishery, along with vessel quotas for individual species and fishing areas. Most of the groundfish-fishing effort occurs in specific areas along the slopes of banks or troughs. The rockfish fishery occurs primarily in areas of significant rock outcrops within the basin and the primary crab fishery occurs on the shallow waters of Dogfish Bank and the bays of northeastern Graham Island (Figure 1). In addition to these fisheries, deeper water trap fisheries for black cod and a shrimp-trawl fishery exist. Inshore fisheries for herring, and invertebrate species, including clams, sea urchins and sea cucumbers, are also present within the waters of the basin.

Wind Farms

A proposal has been submitted to the government of Canada to establish a wind farm 1 to 35 km off northeastern Graham Island in the shallow waters (<30 m) of Dogfish Bank (Figure 2), the largest proposed wind power project in Canada. As much as 700 megawatts of power generation, produced from up to 350 turbines of the 2-megawatt type, could be produced and input into the British Columbia power grid serving markets as far away as California. Such a farm would cover an area of 500 km^2 using turbines that sit 60 to 80 m above the seabed with a rotor diameter of 70 to 80 m. At present there are no environmental regulations specific to offshore wind power in Canada. However, an environmental assessment may benefit from the latest practices in Europe, where offshore wind power is under active development.

Marine Minerals

More that 6.3×10^6 DMT (Dry Metric Tonnes) of sand and gravel aggregate has been mined from the nearshore waters of the basin near Prince Rupert since 1956. This aggregate production was undertaken from 17 Provincial lease blocks (Figure 3) starting in 1956 and ending in 1997. Most of the production was undertaken at one site where a tombolo (Metlakatla; Figure 3) was completely removed (Good *et al.*, this volume). This production was largely unregulated and no environmental monitoring was undertaken. Construction aggregate is currently trucked in from the interior of the mainland, or obtained by small, local blasting and crushing operations. For any broad-scale project within the basin, such as oil and gas production platforms, aggregate supplied by either of these options would be costly and logistically problematic, especially relative to barge transport of locally-dredged material.

In addition, both gold and titanium (ilmenite) placer mineral potential exists in the region and exploration has only been halted due to lack of marine mining legislation (Barrie *et al.*, 1988; Barrie, 1994). Two deposit types have been defined for the region: 1) modern and relict gold/titanium beach deposits, and 2) reworked relict titaniferous shelf deposits (Barrie, 1991; Barrie and Emory-Moore, 1994).

Sponge Reefs

In 1988, large reefs built by hexactinellid sponges were discovered in Hecate Strait and Queen Charlotte Sound (Figure 2) in water depths of 165-240 m (Conway *et al.*, 1991). The Hexactinosida, unlike other Hexactinellid sponges, produce a relatively strong and durable siliceous skeleton by fusing body spicules with a secondary coating of silica that results in an elaborate rigid framework skeleton. It is this rigid skeleton that allows three species of Hexactinosidan sponges to construct the modern reefs (Conway *et al.*, 1991, 2001; Kruatter *et al.*, 2001). The extensive reefs (area of coverage ~1000^2 km) consisting of bioherms (mounds) and biostromes (beds) baffle and trap suspended sediment near the heads of troughs which reach from open ocean into the continental-shelf environment of this region. It is here, where upwelling of

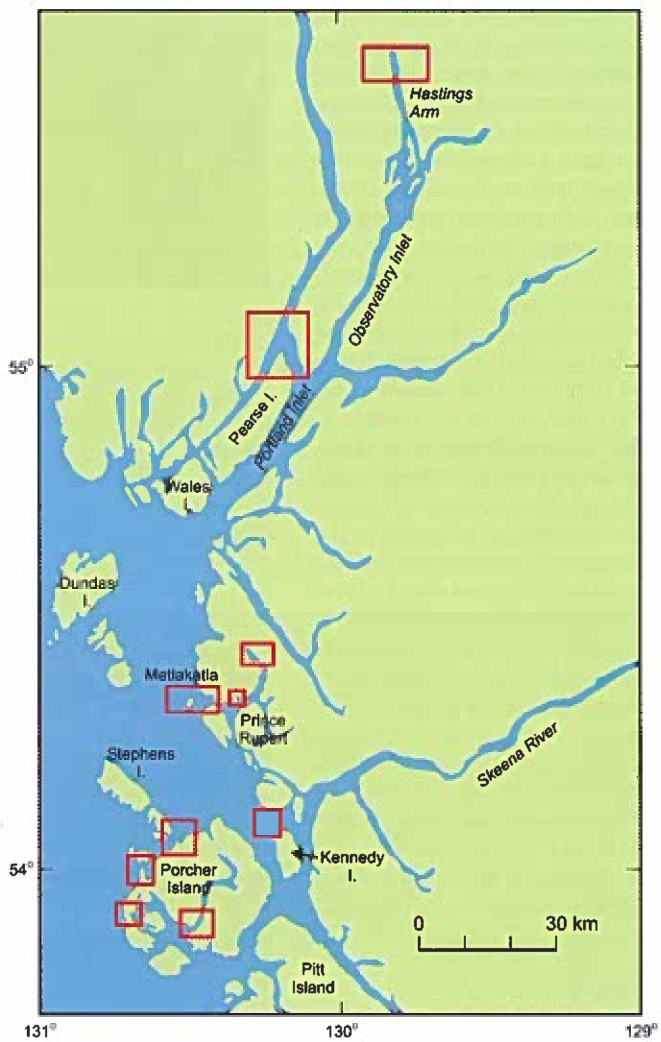

Figure 3. *Lease holdings for marine aggregate mining between 1956 and 1997 in the Prince Rupert region.*

nutrient rich waters supply the reefs with silica and particulate materials upon which they grow (Whitney *et al.*, 2005). Coring of sponge bioherms and radiocarbon dating of contained carbonate shells indicate that reefs began growing by about 9000 C^{14} years BP (Conway *et al.*, 1991). The living surface of the reefs can be completely covered by sponges up to 1.5 m in height, and frequently sponges form large clusters many square metres in area.

Geohazards

Queen Charlotte Basin falls within the most seismically active zone in Canada and where several seafloor hazards are a direct result of this elevated seismicity and active faulting. Changes in sediment supply through sea level changes during the Holocene resulted in the rapid formation of large deltas, drowned wave-cut terraces, and spit platforms (Barrie and Conway, 2002b). These features are composed of thick deposits of unconsolidated sediment that have significant slopes; slope instability and tsunami generation is a considerable threat. The rapid transgression also overstepped fetch-protected paleolacustrine and estuarine environments that contained sediments with very different physical properties. Interstitial gas, both thermogenic and biogenic, have been identified in the basin shelf sediments (Barrie and Bornhold, 1989; Barrie *et al.*, 1991) and will be of concern to hydrocarbon drilling or to the placement of spudded platforms for wind turbines. The presence of gas is often apparent on the seabed by the presence of pockmarks, seafloor craters tens of metres wide and several metres deep, formed by the removal of sediment as fluid (commonly gas) escapes into the water column (Hovland and Judd, 1988). Migrating sedimentary bedforms occur in many areas of the basin. These bedforms range in size from ripples to large sand ridges (Barrie and Bornhold, 1989); the latter size will be a geohazard issue for seabed engineering systems such as pipelines and wind farm platforms.

Coastal Erosion

The northeast shores of the Queen Charlotte Islands are dynamic with an extensive coastal plain prograding 0.3–0.5 m per year on the north coast, while the entire 120 km of the east coast is actively eroding (Figure 4) at 1.0–3.0 m per year (Barrie and Conway, 1996). Most of the sediment released by the east coast erosion is transported to a prograding spit platform (Rose Spit; Figure 1) that extends 10 km off the northeastern corner of Graham Island (Figure 1; Barrie and Conway, 2002b). Sea level rise during El Niño–Southern Oscillation (ENSO) events have resulted in erosion of

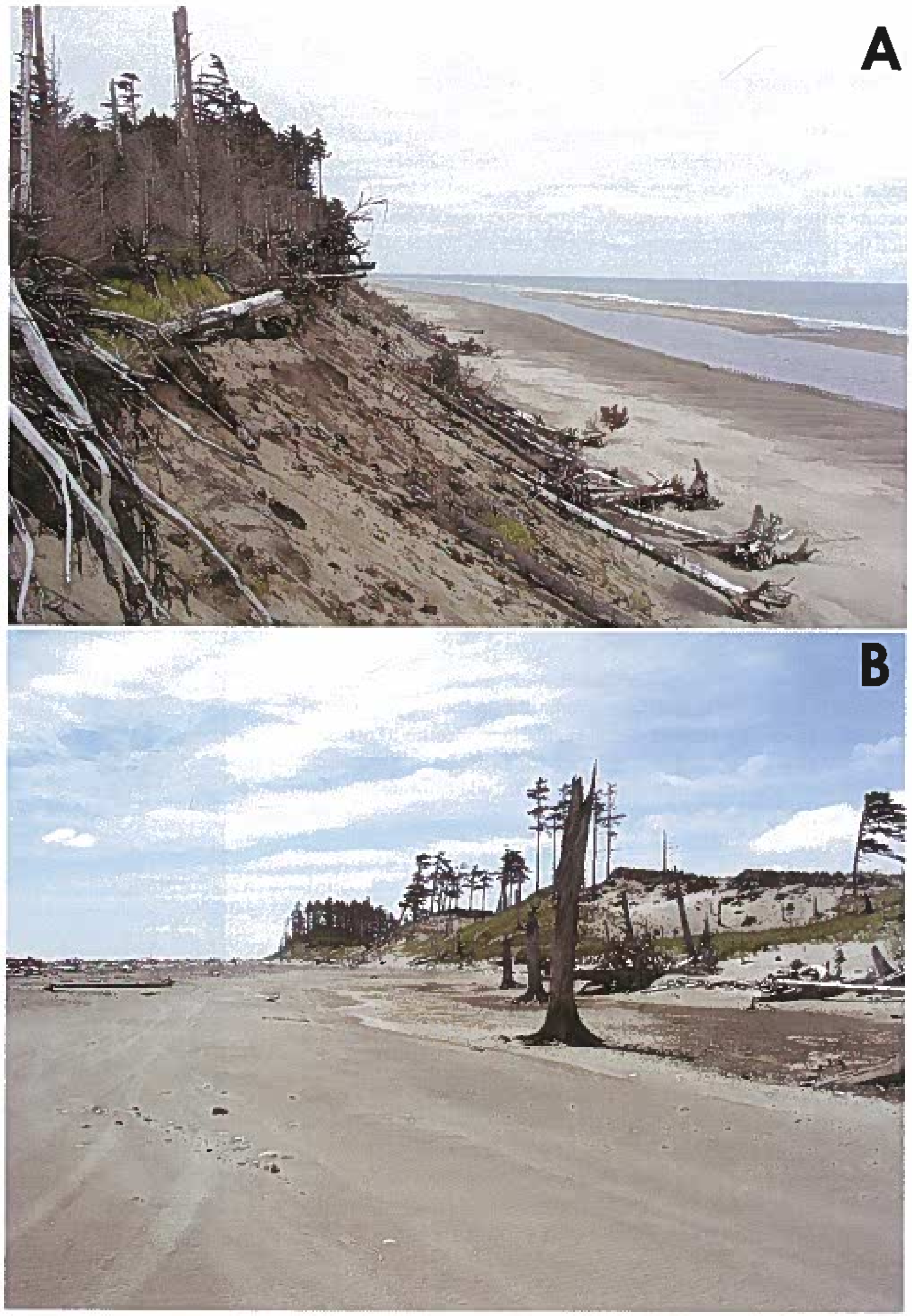

Figure 4. *Photographs of the eroding coast of northeastern Graham Island, showing a northerly migrating shore attached bar (A) and backshore dunes (B) that form part of the littoral sediment transport system.*

greater than 12 m (Barrie and Conway, 2002b). The eastern sandy shoreline is maintained by strong northward littoral transport driven by nearshsore currents and strong winds that deliver sediment from bluff erosion to multi-barred and dune-backed beaches (Walker and Barrie, 2006). Alongshore transport continues northward to Rose Spit and, during southeast storms, westward around the spit to accrete on low gradient North Beach (Amos *et al.*, 1995).

RESEARCH PROGRAM

The request by the British Columbia government to lift the moratorium in an area of extreme beauty, major fisheries, and where thirty years have passed since any significant integrated research has taken place, requires a research strategy that considers all the issues and provides the best science for decision-making. A program was established by the Geological Survey of Canada to collect and collate the geoscientific knowledge necessary for decision-making on competing resource management issues in Queen Charlotte Basin. This ocean management strategy requires an interactive Geographic Information System (GIS) digital database, using national standards, from which maps at any scale can be produced for surficial geology, geohazards and habitat.

Surficial geological maps provide an understanding of the morphology, sediment type and physical properties of the sediment making up the seafloor of the basin. An understanding of the Quaternary history is key to an understanding of the geomorphic features present, such as iceberg scours and drowned coastal features. The life history of critical habitats, like the sponge reefs, can be better understood once the Quaternary chronological development is known. Similarly, knowledge of geohazards, including slope stability, active faults, shallow gas, boulder fields, and the distribution and movement of large sedimentary bedforms, is derived from an understanding of the seafloor geology and the tectonic environment. The last component is habitat maps; these are derived from seabed morphology, surficial geology, sediment distribution, seabed features, and benthic ecology. Though these are considered separate maps, it is the ability to analyze these aspects geospatially using GIS that enables iterative interpretations to be made. Inter-relationships between benthic fauna, deep–bottom-feeding seabirds and geology, for example, can be queried independently and in combination. It is from these associations that a better understanding of the total ecosystem can be made and ultimately managed.

The critical base to all these maps is the acquisition of multibeam sonar bathymetry and backscatter. Multibeam technology, when integrated with data from other survey tools, can generate powerful imagery and it is upon this base that other physical and biological datasets can be laid and compared. A contiguous coverage of multibeam sonar bathymetry can provide a visual picture or roadmap into development of the basin to its present morphology. This is particularly important in areas of resource and environmental conflict. Consequently, it is the development of a seabed-mapping strategy using multibeam sonar that will provide the maximum geoscientific information to address the issues raised in a timely manner.

Preliminary Results

The size of the basin is such that total coverage by multibeam sonar bathymetry surveys would take decades, particularly considering the storms in the basin for up to eight months of the year. The first requirement is to identify the areas of maximum conflict between the primary renewable and non-renewable resource interests (fisheries, oil and gas, wind power, marine mining) and map these relative to what is known of critical habitats and geohazards. In most cases, habitat information does not exist and will be a primary output of the program. For Queen Charlotte Basin, two large areas of conflict and one unique and critical habitat are identified: 1) in central Hecate Strait a significant groundfishery exists in the area of highest oil and gas interest; 2) on northern Dogfish Bank the largest Canadian crab fishery could be in conflict with wind power and potential marine mining, adjacent to an actively eroding shoreline; and 3) in the eastern basin sponge reef complexes occur in areas of active fisheries (Figure 2).

The multibeam sonar mapping program initially has been focused on the central Hecate Strait conflict area and the sponge reefs. The initial multibeam sonar survey for central Hecate Strait clearly shows the morphological and geological complexity of the basin (Figure 5). In an area of only 700 km^2, a range of geohazards,

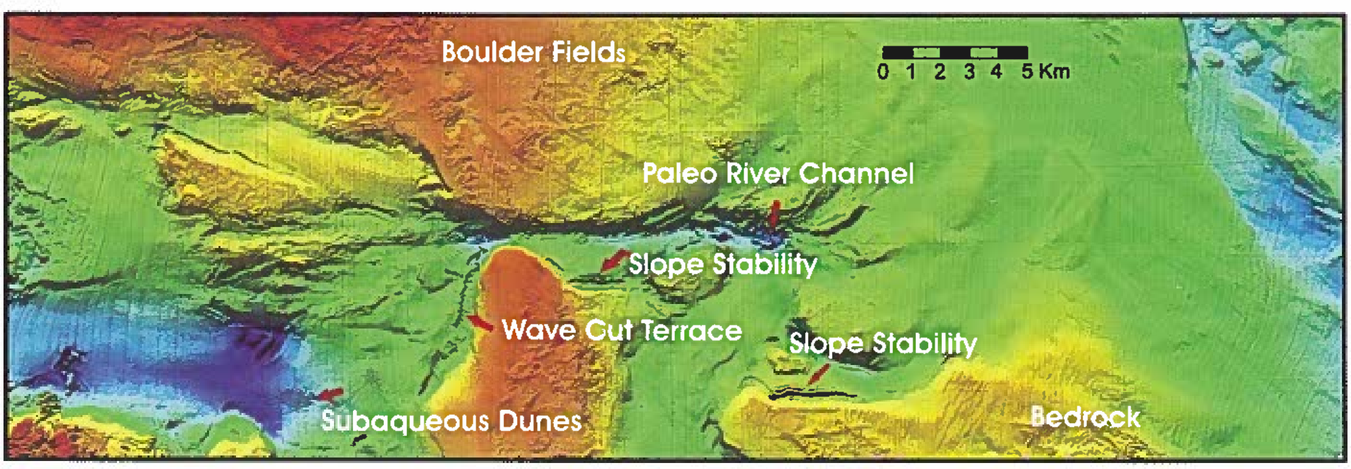

Figure 5. *Multibeam bathymetric image from central Hecate Strait illustrating the diversity of bottom morphology and geohazards in a small area (700 km^2) of Queen Charlotte Basin.*

including steep unconsolidated slopes (wave-cut terraces and drowned river valley), downslope creep, pockmarks and large sedimentary bedforms are apparent (Figure 5). In addition, a variety of habitats, from bedrock to boulder fields to flat sand plains, demonstrate the rapid shift from rockfish to groundfish habitats. As this area likely would be the region for hydrocarbon exploration drilling, there are issues regarding the location of wellheads in relation to the seabed geohazards and the local fishery habitats.

Multibeam sonar imagery of the sponge reefs reveals the setting, form and organization of four reef complexes (Figure 2) in Queen Charlotte Basin (Conway *et al.*, 2005). The skeleton framework of sponges and clay-rich sediment results in a distinctive pattern of low-intensity backscatter compared to the more reflective glacial sediments which the reefs colonize (Figure 6). The pattern of reef growth is in the dominant direction of near-bottom, tidally-driven currents that are bathymetrically constrained (Conway *et al.*, 2005).

DISCUSSION

The Canada Oceans Act of 1996 provides the legislative framework for development and implementation of a national strategy for ocean management, including the establishment of Marine Protected Areas. The Oceans Act is founded on three principles, sustainable development, integrated management and the precautionary approach. For example, under the Oceans Act, Fisheries and Oceans Canada has designated the four sponge reef complexes as non-trawling areas and has made them a candidate for Marine Protected Area status. With the new multibeam and backscatter imagery (Figure 2), the full extent of the complexes can be mapped in high resolution enabling definition of the boundaries (Figure 6) that will both protect the reefal habitat and provide for efficient seabed use planning as defined under the Oceans Act.

Through the Oceans Act, Canada is also developing regional-scale plans for integrated ocean management. As part of this, an ecosystem approach to management has recently been adopted by Fisheries and Oceans Canada to provide more comprehensive advice to fishery managers. To initiate this for Queen Charlotte Basin, the "Hecate Strait Ecosystem Project" (http:// www-sci.pac.dfo-mpo.gc.ca/sa-hecate/default.htm) is underway to understand the spatial and temporal distribution of key marine populations and their habitat by integrating data from bottom-trawl surveys, commercial fisheries, physical oceanographic datasets, surficial geology and high-resolution multibeam bathymetry. Areas of

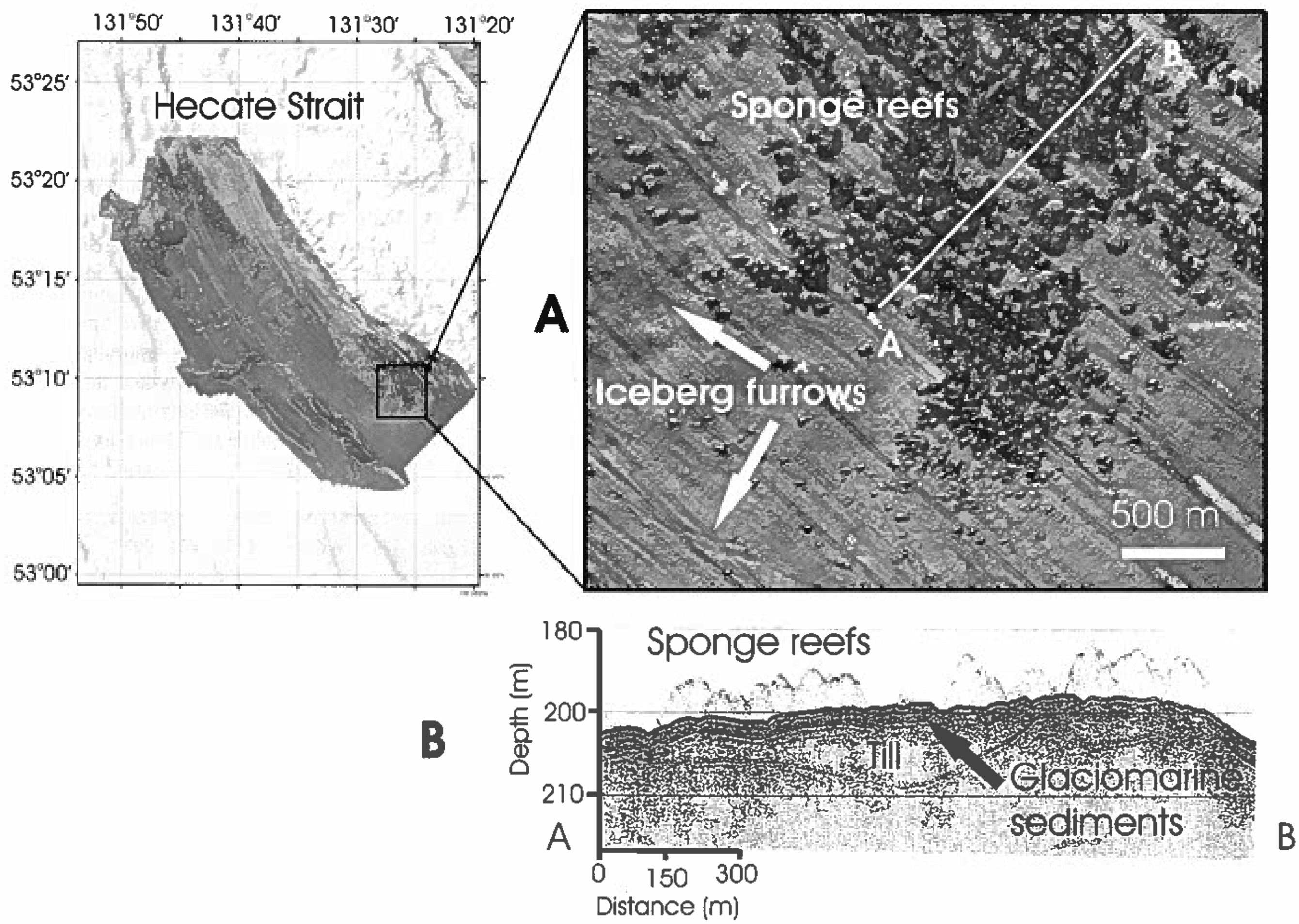

Figure 6. *Sponge reefs are located in all three major shelf troughs. (A) Multibeam bathymetry draped with backscatter has been very effective in reef detection and mapping. (B) Huntec profile shows the morphology and thickness of the sponge reef unit and the underlying glacial substrate upon which the reefs are founded.*

significant fishing were overlaid on surficial geological data to determine if any relationship exists between fishing in areas of sands and gravels as opposed to areas dominated by thin sediments over bedrock or glacial till. Initial results suggest that there is a good association of different groups of groundfish species and surficial geology/sediment type (Sinclair *et al.*, 2005). While overall surficial geological units were strongly associated with the location of fishing and the spatial distributions of individual species, oceanographic conditions were more strongly associated with the distribution of total fish density (Sinclair *et al.*, 2005).

SUMMARY

A decision to lift the moratorium on hydrocarbon exploration and develop wind farms requires geoscience knowledge for ocean management for Queen Charlotte Basin. This paper outlines an integrated project approach that will combine the highest quality marine geophysical, sedimentological, biological and oceanographic research expertise to undertake integrated ocean management and advance marine science beyond a single discipline approach. A key result of this will be habitat maps in formats appropriate to meet the needs of internal and external policy specialists.

With the developments in multibeam mapping technology, in concert with traditional geoscience survey techniques, there is now the capability to image the seafloor in high resolution. The contiguous coverage of multibeam sonar bathymetry and backscatter provides a visual picture or roadmap into development of Queen Charlotte Basin.

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