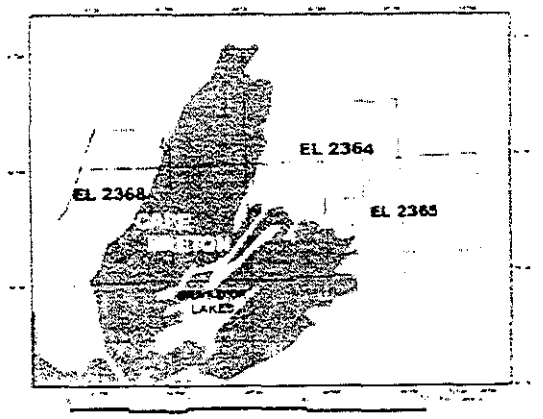
Description of the Southern Gulf of St. Lawrence and Sydney Bight Marine Ecosystems in Relation to Oil and Gas Exploration

Background

The Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) operates under provincial and federal legislation to regulate oil and gas development in Nova Scotia's offshore. Recently, CNSOPB called for and accepted bids for exploration activity on 3 areas off the coast of Cape Breton. Various fishing groups, environmental organizations, and private citizens expressed concern about the potential impacts of the proposed activity.

On October 20, 2000, the CNSOPB received a joint directive from the federal and provincial energy ministers to conduct a Public Review on the effects of potential oil and gas exploration and drilling activities within Exploration Licenses 2364, 2365 and 2368. One license is located off the west coast of Cape Breton and the other two are in the area of Sydney Bight.

Fisheries and Oceans Canada possesses a large amount of scientific information about marine ecosystems and potential impacts of oil & gas exploration activity that is relevant to this review. In order to provide this scientific information to the commissioner, scientists from Fisheries and Oceans Canada in Maritimes, Gulf and Laurentian Regions compiled this information in a series of working papers. This information was presented and reviewed at a meeting under the Maritimes Regional Advisory Process (RAP). This document summarizes the information tabled at that meeting.



Summary

- The marine area of the west coast of Cape Breton and Sydney Bight is biologically and physically complex and dynamic.
- These are two biologically sensitive areas that are closely linked.
- This is a biologically diverse area where sensitive life stages of marine organisms are present throughout the year.
- The Gulf is a shallow, semi-enclosed sea that seasonally is a highly productive seasonal environment. It contains important spawning grounds and nursery areas and is a growth and feeding area during the ice-free period. Many important fish stocks over-winter in the deep water of the Cabot Strait and Sydney Bight area (cod, plaice, hake, witch flounder, adult herring, redfish).
- There is seasonal ice coverage that provides a barrier to migration and a breeding habitat for marine mammals.

- Since the early 1990s an increased proportion of the biomass of many important groundfish species occurs in the eastern southern Gulf.

- The west coast of Cape Breton and Sydney Bight is the main migration pathway between over-wintering grounds outside the Gulf and spawning and feeding grounds in the sGSL for many important commercial fish stocks (cod, plaice, white hake, witch flounder, herring, mackerel, tuna). These migrations occur through a narrow body of water.

- Sydney Bight is a spawning and nursery area for indigenous stocks and those from other areas, e.g. Bras d'Or Lakes. Sydney Bight is home to a diverse array of organisms, which together with the physical attributes of the water and bottom areas, define the structural and functional elements of a marine ecosystem. The system is dynamic.

- The current status of some Sydney Bight (4Vn) fish populations (especially cod) is fragile.

- For these two areas, a lot is known about the commercial stocks but little is known about the non-commercial biota.

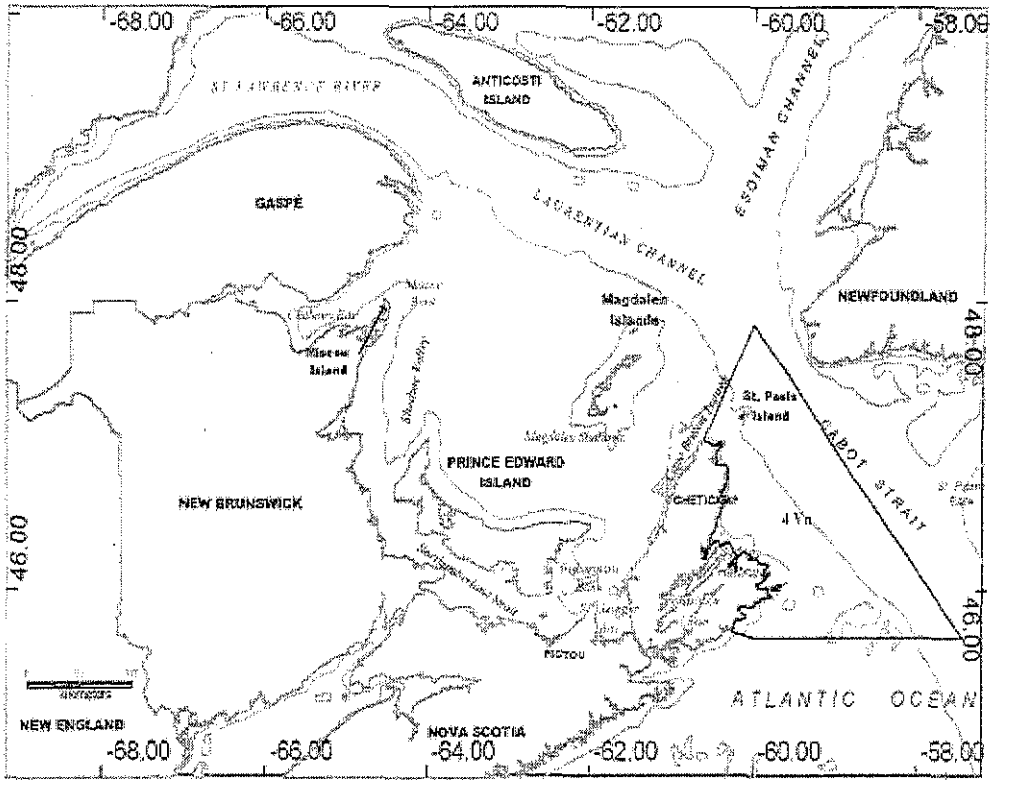
- Any impacts from oil and gas exploration activities will be amplified due to the shallow enclosed nature of the environment and the high biomass and diversity year-round.

Introduction

Canada's Oceans Act promotes an integrated approach to aquatic resource management that applies the precautionary approach. Any evaluation of marine resource extraction needs to be done in this context.

This review focuses on describing the ecosystem components and functions in the two areas of interest. The term "west coast of Cape Breton" will be used to identify that area of the southern Gulf of St. Lawrence (sGSL) in the vicinity of the lease area 2368. Sydney Bight, to be consistent with local usage, refers to an area including the other two leases and is considered to be synonymous with NAFO sub-division 4Vn. As such, it includes part of the Laurentian Channel. The two areas collectively will be referred to as the "area of interest". References to sGSL refer to the larger area of the southern Gulf that is bounded on the north and east by the Laurentian Channel. The ecosystem components and functions of these areas are subject to numerous external forces. For instance, the Sydney Bight is the major approach to the unique ecosystem of the Bras d'Or Lakes.

This review is not an environmental impact assessment. No attempt is made to assess the risks associated with either the potential impacts or the gaps in knowledge. The purpose of the review is to describe those components and functions of the environment in these two areas that could be impacted by the proposed exploration activities.



Environmental Overview

Geology

The bedrock underlying the study area is mostly red and grey sandstones, siltstones, shales, gypsum, limestone, oil shales and coal seams. In some areas there are salt formations directly beneath the seafloor.

The bedrock is covered in most places with glacial and postglacial unconsolidated sediments. The surface sediments along the west coast of Cape Breton are mostly muddy sands or sand and gravel. The distribution of these sediments is modified by the oceanographic currents that transport sediment in a northeasterly direction. The bottom currents are strong enough to erode the seafloor and, in some areas, to produce up to 11m high sand waves.

Physical Oceanography

Regional morphology of the Gulf controls the current patterns at various scales:

On a broad scale, the shallow, enclosed Gulf results in a counterclockwise flow that is modulated, and reversed, by the action of tide and wind. This enclosed shape favors the formation of a northeastward coastal current along the west coast of Cape Breton. This flow, combined with the morphology of the channel and the action of tide, generate a pumping mechanism that brings deeper water, rich in nutrients, to the surface layer.

On a smaller scale, the Cape Breton Trough and Sydney Bight influence the current patterns creating gyres and upwelling. Also places where the currents are impeded, such as at St. Paul Island, bottom erosion and current upwelling can occur.

Wind can be an important determinant of the direction and speed of surface water movement.

There is a surface outflow within Cabot Strait along the Cape Breton coast that is partly counterbalanced by an inflow in the deep Laurentian Channel. There are indications that the outflow at Cabot Strait is linked with the presence of a clockwise gyre in Sydney Bight.

The water column in the Cape Breton Trough is strongly stratified in summer, which isolates cold water (0-2 °C) at the bottom. Surface water temperature in summer is between 16 –18 °C and the thermocline is sharply defined between 20-40m depth. In Sydney Bight, the maximum stratification is deeper in the water column (30-50 m).

Sydney Bight and the west coast of Cape Breton areas have ice present for 60 to 100 days per year on average, from January to the beginning of April. There are some years with little ice coverage and thickness and other years with heavy ice coverage and thickness. The ice properties, duration, concentration, thickness, formation and melting could effect biological processes and movement of fishes and invertebrates. Ice pile-up in the sGSL and seabed disturbance has been observed to a depth of 21 metres.

The presence of some physical oceanographic features suggested by the models, such as the Sydney Bight gyre and upwelling along the west coast of Cape Breton, need to be confirmed through the collection of field data. Detailed nutrient data would be useful to verify the presence of upwelling. Also more information is needed on surface wind waves in the area.

Chemical Oceanography

The main features of the surface distributions of **plant nutrients** (nitrate, phosphate and silicate) on the Magdalen Shelf and Sydney Bight are similar. High concentrations of all three nutrients that occur in winter decrease through the spring into summer. Only for nitrate does the average concentration decrease to near zero levels.

Plankton

Because of timing and resource limitations, no information was available on either **phytoplankton** production, biomass or species composition.

The composition of the **zooplankton** communities of sGSL is distinct from that of other regions within the Gulf. The zooplankton ecology of the sGSL is distinguished by the seasonal succession of the copepod community, by the variety and abundance of larval invertebrates and fishes that are present in summer, and by the predominance of gelatinous predators. The zooplankton community includes species that are found throughout all regions of the Gulf, and a number of forms that are restricted to the sGSL. The latter include a number of warm-temperate species that are rarely found north of the Cape Cod biogeographic boundary.

As is typical of temperate waters, copepods have been found to dominate the community in the sGSL. The composition and size characteristics of the copepod community of the sGSL are quite unlike those of other regions of

the Gulf, being dominated by small coastal species with rapid turnover rates.

The sGSL is characterised by a large seasonal change in planktonic biomass, which increases up to five-fold in summer. From April to September, zooplankton biomass (per unit volume) is much higher in the sGSL than elsewhere in the Gulf or Estuary of St. Lawrence. Much of this biomass is attributable to the great variety of larval and immature forms of fishes and invertebrates which are characteristic of the summer zooplankton community. The sGSL has a different ichthyoplankton community from other regions of the Gulf, and the total number of larval species and the overall abundance are generally higher than in the northern Gulf. The adults of many of the invertebrate species represented as larvae in the plankton are benthic.

The Sydney Bight area supports a diverse copepod community, which is more "oceanic" in character than the community described for western Cape Breton. Populations of large copepods (*Calanus* spp.) typical of the northern Gulf are maintained in the waters off eastern Cape Breton Island by advection in the Nova Scotia Current. Less information is available on the zooplankton communities of this area than on the sGSL.

In general there is little information available on the seasonal and spatial distribution of zooplankton and of zooplankton ecology, particularly in winter. There is limited information on the ecology of the Cape Breton Trough.

Marine Plants

The shallow subtidal areas of western Cape Breton and the Sydney Bight are covered by a diverse algal flora that is dominated in biomass by less than 12 species including *Fucus serratus*, *Chondrus crispus*, *Polysiphonia nigrescens*, *Polysiphonia urcelolata*, *Polysiphonia flexicaulis*, *Ceramium rubrum*, *Furcellaria lumbricalis*, *Cystoclonium purpureum*, *Phyllophora pseudoceranoides*, *Phyllophora truncata*, and *Chorda filum*. The plant community in this part of the zone (<8 m water depth) is stable in a 20 year time frame or more. The canopy is low (< 0.5 m), lacking distinct dense beds of large (>1 m) Laminariales. The plant community in the deeper part of the zone (> 8 m depth) in the Sydney Bight area has been unstable over the last 20 years.

There is insufficient data to reliably estimate the total marine plant habitat below 6 m in both the western and eastern Cape Breton. Also there is a lack of annual and seasonal data that could provide an understanding of the dynamics of marine plant habitats in this area.

No information was available on the distribution of eelgrass in the area of interest. This is a major deficiency due to its importance as habitat and its vulnerability to human activities.

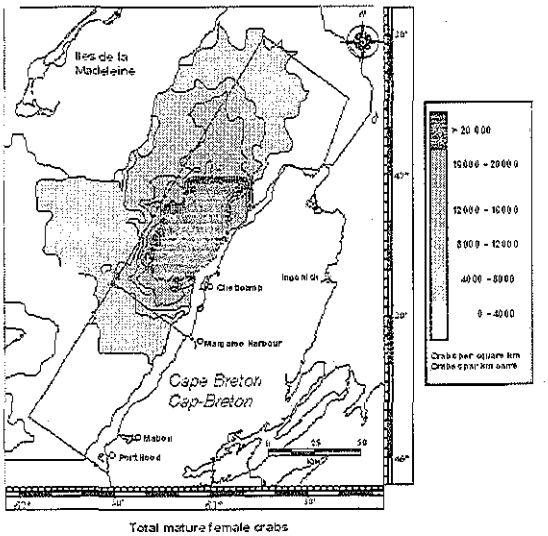
Invertebrates

The west coast of Cape Breton and Sydney Bight are areas of importance for several benthic invertebrates that are commercially fished or have commercial potential. In the area of interest, lobster and snow crab are the target of large and economically important fisheries. Rock crab, sea scallops and sea urchins are targeted by small to moderate fisheries and toad crab, stone crab and shrimp have commercial potential.

Snow crabs inhabit the mid-shore environment. Like the lobster, their life history is well known. The duration of their planktonic phase is 10 to 12 weeks. The area of interest is an important larval settlement area. Once settled, all benthic phases and size groups of snow crabs inhabit the area of interest.

There are concentrated areas of high landings and catch per unit effort (CPUE) in the areas of interest.

Snow crab density contours for the year 2001
Contour de densité de crabe des neiges de 2001



Total mature female crabs
Total des crabes femelles mature

The timing of **lobster** life history events is well known. Lobsters inhabit the inshore environment. They are relatively sedentary and have a larval life span of one to two months. In spring, summer and fall, lobsters are found almost exclusively at depths shallower than 35 m. Lobster movement is well studied but there are gaps regarding late-fall winter movements. The average distance moved by lobsters was about 3 km between tagging in late summer and recovery during the spring fishery, even after two seasons at large.

For the sGSL, on a per unit area basis, the highest landings of lobster have come from the west coast of Cape Breton and the north coast of P.E.I. The production of lobster larvae in sGSL is among the highest per unit of surface area of any region that has been sampled on the East Coast. Long-term lobster production in Sydney Bight is second only to that of southwest Nova Scotia when considering the Atlantic coast of Nova Scotia. Lobster catch rate means (and presumably abundance) are higher in the Sydney Bight area than southeastern Cape Breton.

Similar to lobsters, **scallops** inhabit the inshore area; they are relatively sedentary and have a relatively short larval life. Potential commercial scallop spat settlement sites have been identified along the west coast of Cape Breton, extending down to the mouth of the Northumberland Strait. This species is fished in localized areas in the nearshore of Sydney Bight, with most landings in the southern half of Sydney Bight. Landings for any given port are usually not more than 10 mt.

There are a number of **other invertebrate species** that are either possibly exploitable or currently exploited with a low level of landings in the area of interest. The rock crab fishery is more developed in the Sydney Bight area than any other area of Atlantic Nova Scotia. For toad crab, stone crab and shrimp, July distribution data are available from the trawl survey.

There are no fishery-independent surveys for nearshore species such as lobsters, rock crab and sea scallops. This means that little or no information is available on distributions and movements outside of the commercial fishing period. Also, although seasonal migrations of lobsters are known in general, for the area of

interest their distribution in late fall-winter is not known. In the area of interest, information is lacking on lobster, scallop and snow crab larval distribution and settlement. However, it is known that Sydney Bight is an important area for early larval stages of snow, rock and toad crabs, as well as lobster.

Diadromous Species

Eleven species of diadromous fish occur in the sGSL. Of these, Atlantic salmon, gaspereau (blueback or alewife), striped bass, and smelt, are of particular interest.

The majority of the fisheries occur in coastal, estuarine and freshwater portions of the region.

Of the species that utilize the sGSL for feeding, gaspereau, striped bass and shad utilize the area in the summer and fall but over-winter outside the Gulf. Smelt and tomcod are year-round residents of the sGSL.

The migratory stages move throught the sGSL primarily in the spring (April to July) and fall (Sept. to Oct). In the spring/summer, adult Atlantic salmon spawners, gaspereau, and shad return to the southern Gulf via Cabot Strait. In the fall, gaspereau and shad, both adults and juveniles, and eels exit the sGSL via Cabot Strait. Fall-runs of Atlantic salmon aggregate and pass through the coastal areas prior to entering rivers for spawning. These runs include populations from rivers of the Gulf coast of New Brunswick and P.E.I.

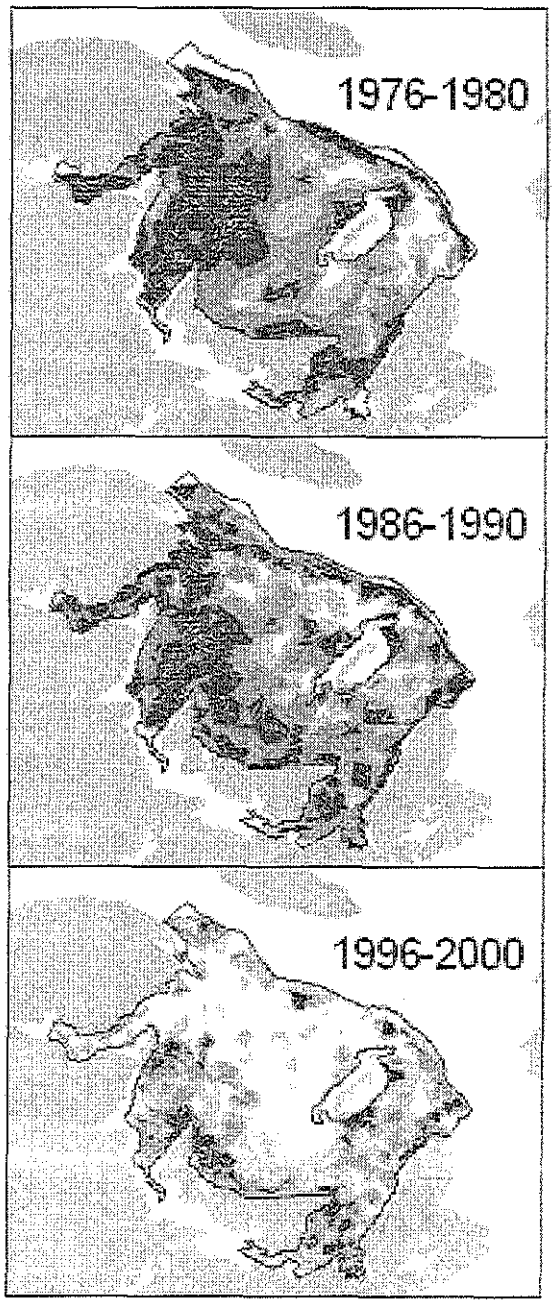
A number of diadromous species as well as marine species migrate into and out of the Bras d'Or Lakes through Sydney Bight. (Nicholls, 1997 describes the fishery in this area in detail.)

Little is known about the movement and feeding of diadromous fish species once they leave the rivers.

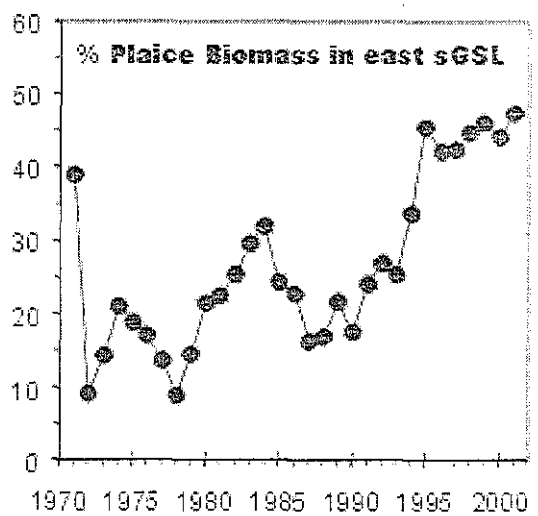
Marine Fishes

(Note: There is a marked difference in the information presented here for the west coast of Cape Breton and Sydney Bight. The data for the west coast of Cape Breton was processed to a greater extent than that from Sydney Bight. Similar information could be extracted from the data available for Sydney Bight.)

The sGSL is the spawning, nursery and feeding area for many important marine fish stocks. For example, the main spawning ground for mackerel in Canadian waters occurs in the sGSL, and about 500,000 tonnes of mackerel move into the Gulf to spawn each year. Estimates of the biomass of mature herring in the sGSL exceed 450,000 tonnes in recent years. Bottom-trawl surveys suggest that average groundfish densities in the sGSL are among the highest in Atlantic Canada. Many of these stocks are currently at depressed levels, but even at these low levels the estimated spawning stock of cod in the sGSL exceeds 85,000 tonnes. Average survey catch rates of American plaice in the sGSL are the highest in the Atlantic Zone.



The eastern region of the sGSL contains spawning habitats for these fishes. Inshore spawning grounds of white hake in the sGSL are now largely restricted to St. Georges Bay and the eastern Northumberland Strait. Spring and fall spawning grounds for herring occur in this area (Magdalen Islands, Fishermen's Bank, Pictou, and smaller spawning grounds along most of the Cape Breton coastline). Spawning grounds for yellowtail and winter flounder occur around the Magdalen Islands and P.E.I. and along the coast of the Northumberland Strait. This area likely also includes spawning grounds for witch flounder.

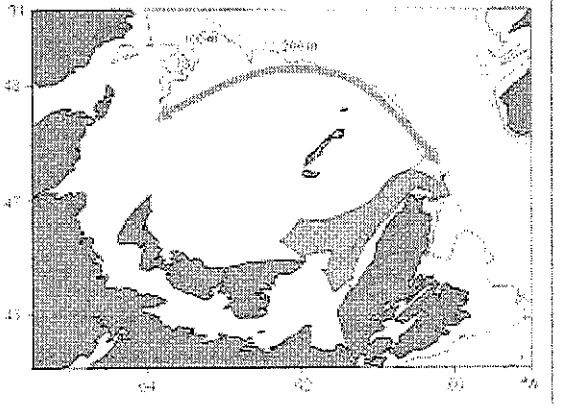


A striking eastward shift in the summer distribution of groundfish has occurred in the sGSL in recent years, making the eastern region of the sGSL an increasingly important feeding ground for these fishes. For example, based on the annual September groundfish survey, the proportion of the biomass of sGSL cod and plaice that occurs in the eastern region doubled between the 1970s and the 1990s. The summer feeding grounds of adult witch flounder in the southern Gulf are now largely restricted to the west coast of Cape Breton. The summer distribution of white hake has also contracted to eastern regions of the Gulf, with high local

densities restricted to St. Georges Bay, the area east of P.E.I. and the Cape Breton Trough.

The west coast of Cape Breton is the main migration pathway for marine fish between spawning and feeding grounds inside the sGSL and over-wintering areas outside of the Gulf. Species using this migration route include mackerel, herring, tuna, cod, plaice, white hake, and witch flounder. Over one million tonnes of mature marine fish may funnel through this narrow corridor each spring and fall.

MIGRATION PATHWAYS



The deeper water of Sydney Bight and Cabot Strait area is a major over-wintering ground for fish stocks from both the sGSL and Sydney Bight. Adult herring and most groundfish stocks, including cod, hake, plaice and witch flounder, aggregate in this area each winter. During that time, there is mixing with stocks of these species that are resident of Sydney Bight in summer.

Sydney Bight (4Vn) is home to a diverse array of organisms which together with the physical attributes of the water and bottom areas define the structural and functional elements of a marine ecosystem. The system is dynamic. It has also been identified as a spawning and nursery area for cod and other species. Sydney Bight is home to a number of fisheries that provide incomes for many coastal communities.

The southern Gulf **cod** migrates between over-wintering grounds in the Cabot Strait and spawning and feeding grounds in the sGSL. Adult cod migrate out of the Gulf between late October and early December and return beginning in mid April, though the return migration may be delayed by the late breakup of winter ice in some years. Most spawning occurs between late April and early July. Though some spawning occurs throughout the sGSL, it appears to be most concentrated in the Shediac Valley area. Eggs and larvae are planktonic and are widely distributed throughout the sGSLf in June and July; egg densities tend to be highest off Miscou Bank in northern New Brunswick. Larval distribution tends to be shifted eastward relative to egg distribution. After spawning, cod disperse throughout the sGSL to feed. An increasing fraction of the population has been distributed in eastern regions of the sGSL during the summer and early fall feeding season in recent years. Juvenile cod tend to be found in shallower waters than larger, older cod during the summer feeding season. Little feeding occurs during winter, when southern Gulf cod are aggregated in warm, deep (200 m) water along the southern slope of the Laurentian Channel in the Sydney Bight.

Cod are fished throughout the Sydney Bight with highest landings along the edge of the Laurentian Channel. Juvenile cod are also found throughout the Sydney Bight. The current status of Sydney Bight fisheries, especially cod, is fragile.

White hake in the sGSL comprise two stock components: one occupying shallow inshore waters in summer and a second occupying deep

water in the Laurentian Channel in summer. Adults of both stock components over-winter in deep water in the Laurentian Channel. The inshore component migrates into the Gulf in May and June and out in November and December. Spawning by the inshore component occurs between June and September, with a peak in mid to late June. The primary spawning areas appear to be St. Georges Bay and the Northumberland Strait. Eggs and larvae are planktonic but their distribution is unknown. Eelgrass beds appear to be important nursery areas for hake. Spawning times and areas are uncertain for the deep-water component, but may be in late winter and early spring in the Laurentian Channel. The distribution of hake in sGSL contracted to the east as the population declined in the early 1990s, and high local densities of hake in summer and fall appear to be now restricted to St. Georges Bay, the area east of P.E.I. and the Cape Breton Trough.

In Sydney Bight White hake is fished along the edge of the Laurentian Channel although there are some landings reported from nearshore in the southern part of the Bight.

The **American plaice** is the most abundant groundfish species in the annual September bottom-trawl survey of the sGSL. Two concentrations of plaice are evident in the surveys, one in western regions (Chaleur Bay, the Shediac Valley and central Magdalen Shallows) and one in the east, between P.E.I. and Cape Breton. In the 1990s, there was a notable shift in the distribution of plaice, with a greater proportion of the sGSL stock occurring off the Cape Breton coast. Some juvenile plaice may over-winter in the sGSL, but larger plaice leave in November-December to over-winter in the Laurentian Channel and Sydney Bight, returning in April-May to spawn. Eggs and larvae are planktonic but their distribution in the southern Gulf is not known.

American plaice is fished for throughout Sydney Bight with heavier effort directed in the two lease areas and along the southern edge of 4Vn.

Juvenile **witch flounder** occur in the deep waters of the Laurentian and Esquiman Channels. Adult witch flounder over-winter in these deep waters but move into shallower waters (100-200 m) to feed in the summer. Biomass of adult witch flounder in western areas of the sGSL declined dramatically in the early 1990s. Their summer feeding grounds in the sGSL have been restricted to the west coast of Cape Breton since then. Witch flounder appear to migrate into this area in May and out of the area in October. Spawning in this area appears to be between April and June, though spawning areas and seasons and the distribution of eggs and larvae are not well known for the Gulf. Witch flounder have a protracted pelagic phase, lasting up to a year.

In the sGSL, **winter flounder** are found mainly along the southern coastline from Chaleur Bay to St Georges Bay, but with concentrations also found around the Magdalen Islands. Winter flounder are typically sedentary, moving seasonally between the inshore and the offshore. Spawning occurs in spring. Fertilized eggs are demersal and adhesive. Winter flounder do not migrate out of the sGSL in winter, instead over-wintering in estuaries and perhaps in mid depths on the Magdalen Shallows.

In the sGSL, **yellowtail flounder** are most prevalent around the Magdalen Islands and off the west and north coasts of PEI. They appear to move into shallow inshore waters to spawn in spring and over-winter at intermediate depths within the sGSL.

Mackerel over-winter in the waters off New England. The sGSL is the main spawning area for the northern stock component of mackerel in the western Atlantic. Mackerel migrate into the sGSL between late May and early July and out in September and October. This migration passes through the Sydney Bight and along the west coast of Cape Breton. Spawning occurs in June and July, followed by a period of feeding throughout the Gulf. Eggs and larvae are planktonic and are widely distributed throughout the sGSL. Egg densities are generally highest in the Shediac Valley area between Miscou and the Magdalen Islands, though peak densities are found further east in some years.

Adult **herring** spawn and feed in the sGSL and over-winter in the Sydney Bight area while juveniles over-winter in coastal areas of the sGSL. Both spring and fall spawning components occur in the sGSL. Spring spawning occurs mostly in April and May, but extends into June. Fall spawning occurs between mid August and mid October. In the eastern region of the sGSL, the most significant spawning grounds are around the Magdalen Islands in spring and in the Fisherman's Bank and Pictou areas in fall. However, some spawning occurs in beds distributed all along the west coast of Cape Breton in both seasons. Eggs are demersal, adhering to the bottom. Eggs hatch in about 30 days in spring and 10 days in fall (when the water is warmer). Larvae are planktonic. In fall, the larval period lasts about 4-5 months.

It is known that the make-up of the herring stocks in the Sydney Bight is very complicated; however, detailed information on this stock was not available. There is a significant herring fishery in the shallower waters of Sydney Bight.

Redfish is also commercially exploited in Sydney Bight. Trawl surveys indicate that overall the Sydney Bight is home to 60+ species of non-commercial finfish species.

The southern Gulf is an important foraging habitat for **Atlantic Bluefin tuna** (13 yrs and older). Judging from fishery distributions, the main feeding grounds in the Gulf are the areas off the northeast coast of P.E.I., between P.E.I. and Cape Breton and the Magdalen Islands. Fishery catches suggest that use of this area by tuna is greatest from August to October.

The distributions of fisheries provide information for legal catch sizes of commercial. However, detailed information on general distributions of marine fish in the sGSL is mostly restricted to September.

Marine Mammals

Information available for this review was limited to that for the sGSL, although some of the same concerns would apply to Sydney Bight.

Four species of seal are common to the Southern Gulf. The Harp and Hooded seals are the only seasonal residents while the Grey and Harbour seals are permanent residents. General knowledge on population abundance, whelping areas, distribution, and diet are available for Harp, Hooded, and Grey seals. Ice cover serves as an essential platform for the reproduction of seals.

There are at least 15 species of whales that occur in or pass through Cabot Strait. The six that are the most abundant regular visitors include Fin, Minke, Humpback and Pilot Whales, White-sided dolphins, and Harbour Porpoise. All are seen regularly. The area is considered particularly important to Pilot

whales, which are also known to be prone to stranding. The Cape Breton Trough is considered to be a key feeding location for whales. The ice cover in the Gulf serves as a barrier to whales using some specific habitats for part of the year.

General knowledge on population abundance, whelping areas, distribution, and diet for Harbour seals is extremely limited. For the area of interest, additional information is needed to properly inventory whale species present, their abundance, diet and seasonal activities.

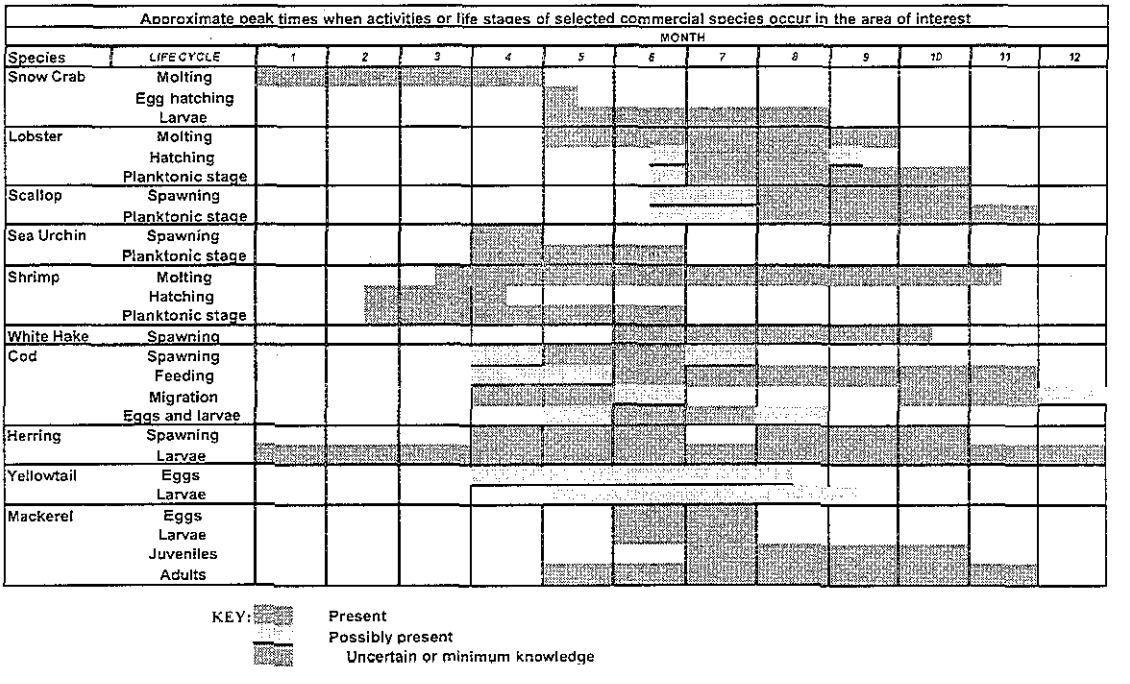
Species at Risk

This issue was not covered in the working papers for the RAP meeting. However the issue was raised and the presence of marine species that are endangered needs to be addressed. Of the marine organisms that are found in the sGSL, the Right whale and Leatherback turtle are listed as endangered and Fin whale, humpback whale, Atlantic cod, and Atlantic wolfish are listed as being of special concern.

Seasonal Use

The species described above spend some or all of their life stages in the area of interest. For many of these species, the spawning period is a particularly sensitive time when their eggs and subsequently their larvae are exposed to natural and human-made perturbations. Precise spawning times and areas are poorly known for some species, particularly the flatfish. Also the seasonal and vertical distribution of eggs and larvae and the over-wintering grounds of some species, e.g. winter and yellowtail flounder, is poorly known.

Because of the diversity of organisms that use the area, it is used almost year-round as a spawning habitat.



The southern Gulf supports a diversified fishery with landings of invertebrates (e.g., lobster, snow crab), groundfish and small and large pelagics. For many groundfish species, fishing activities have focussed on the spring and fall migrations off the west coast of Cape Breton. Important fisheries also occur throughout the summer in the area between P.E.I. and Cape Breton, particularly for plaice and winter flounder. Before closure of the white hake fishery in 1995, this area and St. Georges Bay also supported an important hake fishery throughout the summer. A fishery for yellowtail flounder is concentrated around the Magdalen Islands in spring and to the east throughout the summer. Gillnet herring fisheries occur on the spawning grounds in spring and summer, with highest catches around the Magdalens in spring and east of P.E.I. in fall. Fishing for tuna occurs off the northeast coasts of P.E.I. from July through October, with 43% of the Canadian catch of tuna obtained in the southern Gulf in 2000.

The lobster fishery on the west coast of Cape Breton is opened from May to June. At present the scallop fishery in this area is a fall fishery, in 2001 from October 29 to December 15. The snow crab fishery along this coast is in late summer, from late July to mid-September.

Contaminants

Drilling discharges are a potential source of **heavy metals**. While there are only limited data of questionable quality for concentrations of heavy metals in water for the area of interest, the concentrations are reasonably consistent with model predictions of metal concentrations in coastal waters. Concentrations of metals in the sediments of the Magdalen Shelf are uniformly low, consistent with the sandiness of the sediments on most of the shelf. Finer sediments found in some of the area between P.E.I. and Cape Breton Island may have higher levels but this area has not been sampled.

Little is known about metal concentrations in biota from these areas. However, metal concentrations in biota from some of the inlets and bays in the vicinity of the two lease areas have been studied. None of these studies, exceipt for Sydney Harbour, reported elevated concentrations of heavy metals.

Operational discharges from drilling and associated activities would contain petroleum **hydrocarbons**. There is some information available on baseline concentrations in the area. Concentrations appear to be at background levels. The notable exceptions are the elevated concentrations found in the water, sediments and biota of Sydney Harbour.

The presence of **other organic contaminants** could modify the biological effects of heavy metals and hydrocarbons. Information on the distribution of PCBs in the Gulf is available in the studies following the raising of the sunken barge Irving Whale. Time series data over a period of 25 years available for the organochlorines in the food chain of St. Georges Bay represent a unique data set for the Atlantic Region. Finally extensive data is available on a range of organic contaminants in Sydney Harbour.

There is limited information on contaminant burdens in seals in the sGSL but Harbour seals in the St. Lawrence River estuary have the highest contaminant burdens.

There are insufficient heavy metal, hydrocarbon, and other contaminant data to make a proper

assessment of current contaminant concentrations in the area of interest.

Exploratory Activities and Their Potential Impacts

Seismic Exploration

Seismic shooting kills plankton, including eggs, larvae of many fish and shellfish species, and also some juveniles but only very close to the airguns. Death rates are calculated to be low if plankton is uniformly distributed in the first 50 m of the water column but more severe losses would occur if a particular species was concentrated near the depth of an airgun array. This will be site specific. There may be delayed mortalities.

It may be possible to greatly reduce lethal impacts by selecting a time when plankton populations are more dispersed and larvae are present in much lower concentrations.

There is evidence, based on laboratory studies, that fish and/or marine mammals near an air gun array could suffer permanent hearing loss from exposure to seismic sound. Such loss could have major effects on survival of affected individuals. The range from the airguns at which such sub-lethal effects might occur is unknown.

Herring and shad may be more sensitive than other fish since they have special hearing abilities. Conversely, mackerel, tuna, halibut and other species that lack swim bladders may be less sensitive.

Both fish and whales typically respond to the sound of airgun shooting by avoiding the source. Measured ranges in particular experiments in other areas range from tens of meters to tens of kilometers. Whales and especially Pilot Whales may be particularly sensitive to noise created by seismic activity.

The implications of a seismic survey across a fish or whale migration pathway are unknown. The animals might simply pass through the area of high sound levels but it is possible that their migration would be obstructed. The consequences of such obstruction could be severe. The implications of avoidance reactions from a seismic survey on spawning, calving, feeding or over-wintering animals are equally unknown.

The propagation of sound in the shallow and stratified water around Cape Breton has not been quantitatively estimated. Avoidance reactions and reduced catch rates might be observed at greater distances than in other regions if propagation is enhanced.

Of the various fish species occurring around Cape Breton, data on avoidance are only available from experiments on cod off Norway. The fish catch rate decreased for at least 30 km from the airguns. In other experiments however, some species closely related to cod made much lesser movements. The abundance and catch rates of cod did not return to levels observed prior to the seismic testing over the 5 days of observation following the testing.

In other areas, fisheries catch rates have been depressed by 50% within kilometers or tens of kilometers of seismic shooting in certain cases. Similar effects have been reported for the cod and snow crab fisheries on St. Pierre Bank.

No data are available on avoidance by crustaceans, e.g. lobster and crab. For other finfish, squids, turtles, and whales, some

inference may be drawn from the very limited experimental data on various species.

Of particular relevance in the area of interest is the lack of information on the potential impacts of seismic activities on snow crab, lobster, or other invertebrates. Some details of the information that is lacking for snow crab include:

- acute mortality of eggs, larvae, juveniles, adolescents, and adults, male and female;
- physiological impacts including:
  - structural damage to hearing, digestive and reproductive organs, the respiratory system, digestive tracts and embryos,
  - functional damage to hearing and communicating capacity and the capacity of molting, feeding and hatching;
- inciting abnormal behaviour during mating or molting;
- impacting movement and migration during all life stages, under varying stock status, and in different areas;
- impact on the catch rate of the fishery;

Drill Muds and Cuttings

Several hundred tonnes of drilling muds and cuttings are commonly discharged into the marine environment during the drilling of an exploratory well. These wastes can cause harmful biological effects through several mechanisms including: (a) smothering of benthic organisms, (b) interference of feeding activity by the presence of elevated levels of suspended sediment, (c) toxicity of components such as hydrocarbons and heavy metals, and (d) physical damage. The spatial extent of these effects depends upon numerous factors, including the kind of waste, rates of release, environmental conditions (i.e. depth, tide, currents, etc.) and proximity of the biota. The fate and distribution of these discharges can be modelled. Tainting or perception of tainting of commercial fish species may also be an issue.

A major concern with respect to oil exploration drilling is the size of impact zones around rig sites. Studies have focused on invertebrates associated with soft bottom habitats. Important species such as scallops may be impacted at varying distances from rig sites. Studies of impacts on scallops have combined laboratory and modelling components to make predictions. Similar chronic toxicity/modelling studies should be carried out with other species (e.g. crab, lobster, shrimp, and juvenile flounder) to provide information for reliable assessment of impact prediction. It is also critical that adequate baseline data on the levels of heavy metals and hydrocarbons in sediments and selected biota be undertaken prior to development in the exploratory lease areas.

Accidental Release of Contaminant Hydrocarbons

The risk of spills from a blow-out during exploratory drilling is not significantly higher than that associated with increased vessel traffic. While the probability is low (<1%), in terms of current knowledge, the greatest concern is the release of condensate from a blow-out during drilling operations. The overall impact of a condensate spill would depend on duration, timing and location. While 75% of the spill may evaporate from the sea surface in 24 hours, a large fraction may be water soluble and/or highly toxic. Furthermore, its environmental

persistence following entrainment in sediments may cause chronic effects. The potential for this entrainment is greater in shallow, nearshore environments.

The impacts of contaminant hydrocarbon-induced mortality on early life stages of finfish and invertebrates following spill events remains elusive because of high and variable natural mortality. Nevertheless, there is conclusive evidence for potential lethal and sublethal effects of oil to eggs, larvae and juveniles of various fisheries species.

Contingency plans for oil spill response are required before permits for exploratory drilling may be issued. Research is needed to improve our understanding of natural recovery processes and rates. This knowledge will aid the assessment of the effectiveness and develop new oil spill countermeasures to protect coastal nearshore and/or intertidal environments. These environments are considered among the most productive and ecologically significant marine ecosystems.

Other Issues

The presence of seismic survey vessels and drilling rigs will result in vessels of all types being excluded from a certain area for periods of time ranging from days to weeks.

In the vicinity of the drilling rig, the noise and light regime of the environment will be changed. This will impact fish behaviour. Also, recently the risk of introducing exotic species in ballast water or as fouling organisms on oilrigs has been recognized.

Additional Concerns Related to Production Activity

This review and assessment was limited to petroleum exploration activities. A review of production activities, that are unknown at present, and their potential impacts was not conducted. However it is important to note that there are many aspects of production activity that have potential impacts on the marine ecosystem. Some of these activities are the same as for the exploration phase but are greater in scale. Other activities are unique to the development and production phases. Relative to the exploration phase, these include:

- additional infrastructure, such as more or different platforms in place for a long time;
- new infrastructure, such as pipelines;
- increased vessel traffic for operational support and the possible use of shuttle tankers;
- different formulations of drilling muds;
- additional discharges, such as sewage and biocides;
- loss of access for the duration of the project;
- potential release of produced water; and,
- gas flaring.

Knowledge Gaps

In addition to the specific gaps in knowledge that have already been noted, there are general knowledge gaps that impact our ability to adequately describe marine ecosystems and thereby make comprehensive assessments of the impacts of human activities. These knowledge gaps are not peculiar to this area of interest. With a few exceptions, our knowledge of early life stages of marine organisms, their timing and duration, and trophic linkages is poor. Little is known about the habitat requirements of all life stages and we only have limited knowledge of the spatial distribution and quality of benthic habitat.

Conclusions

The marine area of the west coast of Cape Breton and Sydney Bight is biologically and physically complex and dynamic.

These are two biologically sensitive areas that are closely linked.

This is a biologically diverse area where sensitive life stages of marine organisms are present throughout the year.

The Gulf is a shallow, semi-enclosed sea that is a highly productive seasonal environment. It contains important spawning grounds and nursery areas and is a growth and feeding area during the ice-free period. Many important fish stocks over-winter in the deep water of the Cabot Strait and Sydney Bight area (cod, plaice, hake, witch flounder, adult herring, redfish).

There is seasonal ice coverage that provides a barrier to migration and a breeding habitat for marine mammals.

Since the early 1990s an increased proportion of the biomass of many important groundfish species occurs in the eastern southern Gulf in recent years

The west coast of Cape Breton and Sydney Bight is the main migration pathway between over-wintering grounds outside the Gulf and spawning and feeding grounds in the sGSL for many important commercial fish stocks (cod, plaice, white hake, witch flounder, herring, mackerel, tuna). This migration occurs through a narrow body of water.

Sydney Bight is a spawning and nursery areas for indigenous stocks and those from other areas, e.g. Bras d'Or Lakes. Sydney Bight is home to a diverse array of organisms, which together with the physical attributes of the water and bottom areas, define the structural and functional elements of a marine ecosystem. The system is dynamic.

The current status of some Sydney Bight (4Vn) fish populations (especially cod) is fragile.

For these two areas, a lot is known about the commercial stocks but little is known about the non-commercial biota.

Any impacts from oil and gas exploration activities will be amplified due to the small, shallow, enclosed nature of the environment and the high biomass and diversity year-round.

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This report is available from the:
Maritimes Provinces
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http://www.mar.dfo-mpo.gc.ca/science/rap/internet/index.htm

La version française est disponible à l'adresse ci-dessus.

Correct citation for this publication:

DFO, 2001. Description of the Southern Gulf of St. Lawrence and Sydney Bight Marine Ecosystems in Relation to Oil and Gas Exploration. DFO Maritime Provinces Regional Habitat Status Report 2001/01.