XIX-59 Newfoundland-Labrador Shelf: LME #9

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The Newfoundland-Labrador Shelf LME extends some distance off the eastern coast of Canada, encompassing the areas of the Labrador Current and the Grand Banks. It has an area of about 896,000 km^2, of which 0.44% is protected, and contains 14 major estuaries (Sea Around Us 2007). The seabed of the shelf is structurally complex. As in some other LMEs, overexploitation is the principal driver of changes within this LME, although fluctuations in the ocean climate have also been implicated. The ability to explain the dynamics of this LME is severely limited by the lack of time series of data on living components of the system, except for a few species of fishes and seals. A description of the changing conditions of the fish and fisheries of this LME is given in Rice (2002).

I. Productivity

The Newfoundland-Labrador Shelf LME is considered a Class II, moderately productive ecosystem (150-300 $gCm^{-2}yr^{-1}$). For productivity information, see the GLOBEC Working Group Summary of the Newfoundland and Labrador Shelves (1993). Harsh environmental conditions, extensive and persistent sea ice, extreme cold anomalies, changes in distribution of the area occupied by a Cold Intermediate Layer water mass (CIL), as well as overfishing, have all contributed to fish population collapses (see Fish and Fisheries module) in the 1990s. The crab and shrimp that have increased the most are the favoured prey of cod and other major predators that have collapsed. The new population densities that have appeared may have redistributed energy flows in ways that have made it difficult to return to earlier system configurations. There have been several local studies on plankton dynamics (see Prasad & Haedrich 1993). There was a continuous plankton recorder transect through this area in the 1950s to the early 1970s.

Oceanic fronts (Belkin et al. 2009) (Figure XIX-59.1): The Labrador Shelf-Slope Front (LSSF) extends along the shelf break and upper slope. The Labrador Mid-Shelf Front (LMSF) recently identified from satellite data runs inshore of the LSSF, parallel to Labrador. Farther downstream, the LMSF hugs Newfoundland and merges with the LSSF south of Newfoundland, near 45°N and 55°W. The Flemish Cap, a shallow bank that supports important fisheries, is surrounded by the Flemish Cap Front (FCF) that isolates on-bank waters from direct contact with off-bank oceanic waters. The FCF can be considered an offshore branch of the LSSF. The main branch of the LSSF continues south via Flemish Pass between the Grand Banks of Newfoundland and Flemish Cap.

Newfoundland Labrador Shelf SST (Belkin 2009) (Figure XIX-59.2):
Linear SST trend since 1957: 0.77°C.
Linear SST trend since 1982: 1.04°C.
The thermal history of the Newfoundland-Labrador Shelf LME is different from that of the adjacent Scotian Shelf LME. There was no cold spell in the 1960s. Instead, long-term steady warming has been observed since 1957, punctuated by strong interannual variability with a magnitude of ~1°C. This warming has accelerated since the mid-1990s. Since the near-all-time minimum of 4.6°C in 1991, the SST has risen to 6.4°C in 2006, a 1.8°C increase in just 15 years. Despite a single large reversal in 2000-2002, this increase was one of the fastest regional warming events of the last 25 years.

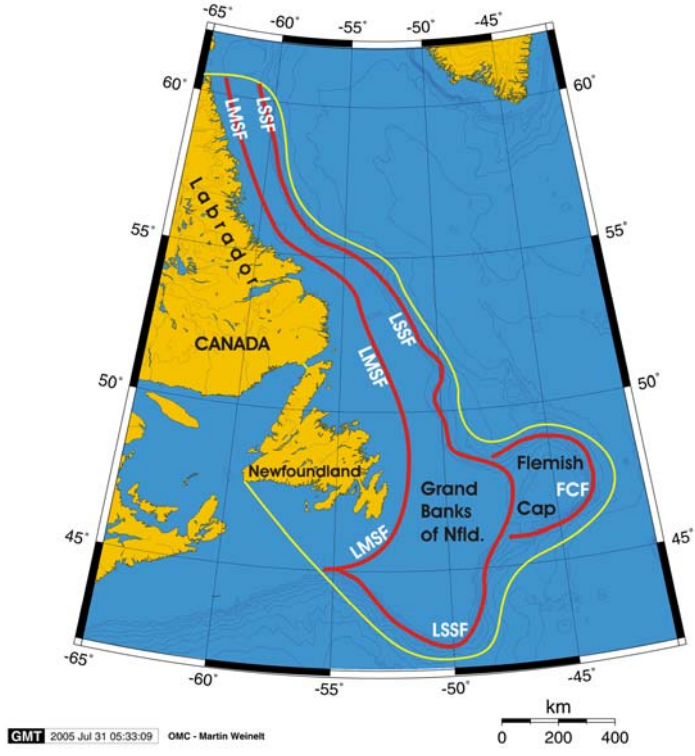

Figure XIX-59.1. Fronts of the Newfoundland-Labrador Shelf LME. FCF, Flemish Cap Front; LMSF, Labrador Mid-Shelf Front; LSSF, Labrador Shelf-Slope Front. Yellow line, LME boundary. After Belkin *et al.* (2009).

The minima of 1972, 1985 and 1991 may have been associated with large-scale cold, fresh anomalies called "Great Salinity Anomalies" or GSAs (Dickson et al., 1988; Belkin et al., 1998; Belkin, 2004). These anomalies form in the Arctic Ocean; enter the northern North Atlantic either via Fram Strait or through the straits of the Canadian Archipelago; and propagate around the Subarctic Gyre, where they profoundly affect regional ecosystems. The GSAs could also form in the Labrador Sea (Belkin et al., 1998; Belkin, 2004).

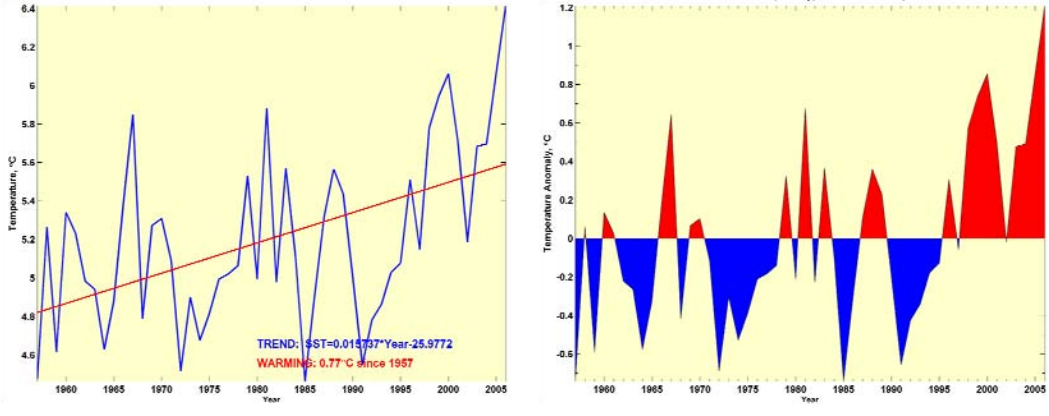

Figure XIX-59.2. Newfoundland-Labrador Shelf LME annual mean SST (left) and SST anomalies (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

Newfoundland-Labrador Shelf LME Chlorophyll and Primary Productivity

This LME is a Class II, moderately productive ecosystem (150-300 $gCm^{-2}yr^{-1}$) (Figure XIX-59.3).

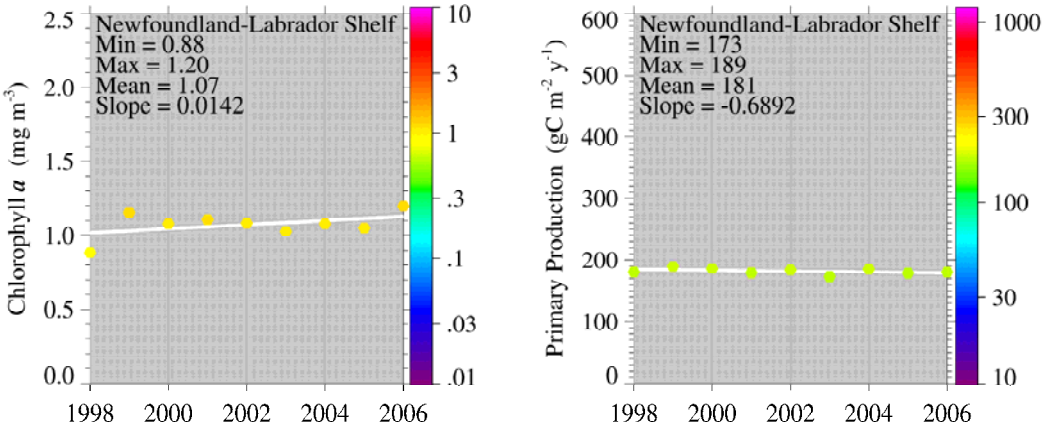

Figure XIX-59.3. Newfoundland-Labrador Shelf LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006, from satellite ocean colour imagery. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

Commercially exploited fish species in this LME include cod, haddock, salmon (see salmon stock assessment for 1997), American plaice, redfish, yellowtail and halibut. Also harvested are lobster, shrimp and crab. Historic records of catches of Atlantic cod can be reconstructed back to 1677 (see Forsey & Lear 1987, for a time series of cod catches). For a stock by stock assessment and recommendation, see Canada's Department of Fisheries and Oceans website.

Total reported landings, dominated by cod until the 1990s, exceeded 1 million tonnes from 1967 to 1970, but declined to 525,000 tonnes in 2004 (Figure XIX-59.4).

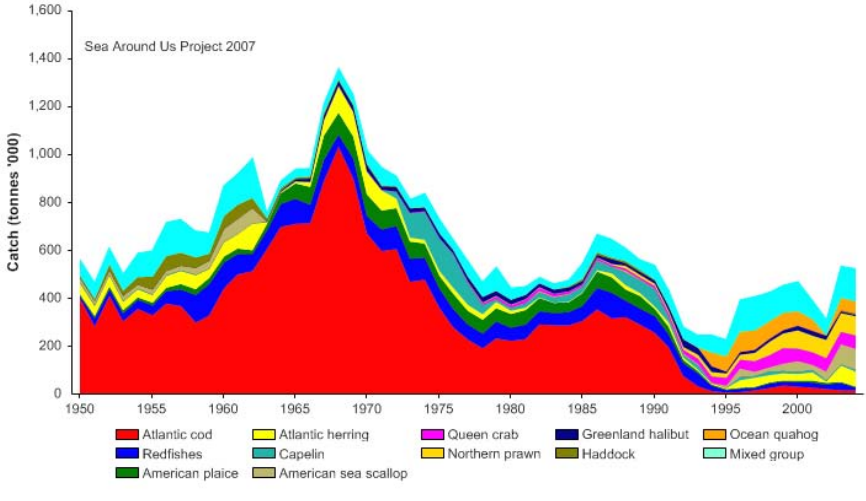

Figure XIX-59.4. Total reported landings in the Newfoundland-Labrador Shelf LME by species (Sea Around Us 2007).

The cod landings, in particular, declined from a historic high of over 1 million tonnes in 1968 to 16,000 tonnes in 2004 with landings of less than 10,000 tonnes recorded in 1995 and 1996. With the collapse of the cod stock, landings in more recent times are dominated by invertebrates (crabs, prawns and scallops) and herring (Figure XIX-59.4). The reported landings of the LME were valued at over US$1.2 billion (in 2000 US dollars) in the late 1960s, most of which was attributed to cod landings, while in recent years similarly high values are produced by its invertebrate landings (Figure XIX-59.5).

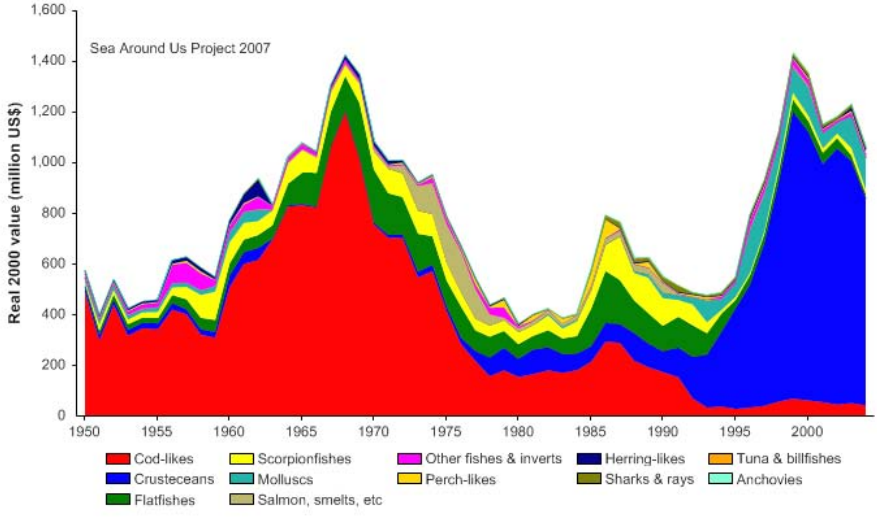

Figure XIX-59.5. Value of reported landings in the Newfoundland-Labrador Shelf LME by commercial groups (Sea Around Us 2007).

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in the LME reached 60% of the observed primary production in the mid 1960s, but has declined in recent year (Figure XIX-59.6). The peak level achieved in the 1960s is likely a result of the high level of accumulated biomass of cod stocks being exploited, not due to the exploitation of annual surplus production.

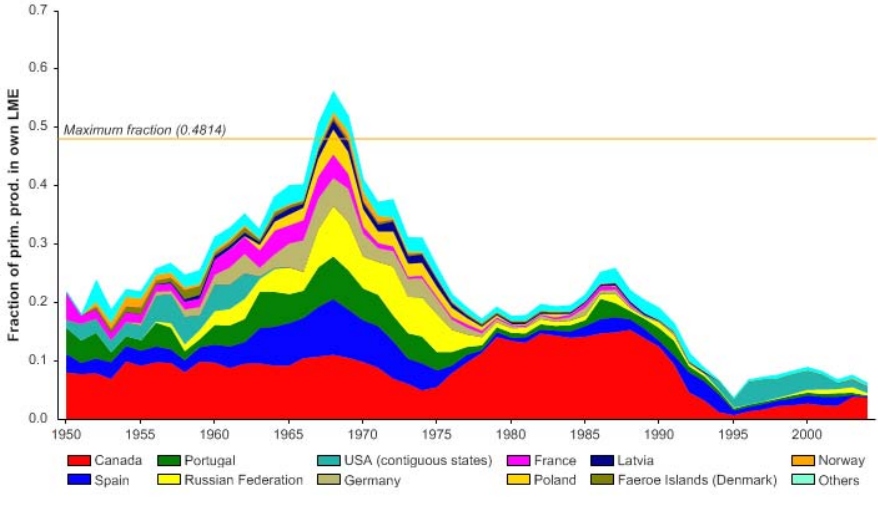

Figure XIX-59.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Newfoundland-Labrador Shelf LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

Since the late 1970s Canada accounts for the largest share of the ecological footprint in this LME, although in the 1960s, a number of European countries also had a large share.

The mean trophic level of the reported landings (i.e., the MTI; Pauly & Watson 2005) remained high until the 1990s, when the cod stock began to collapse (Figure XIX-59.7, top), a clear case of 'fishing down' the food web in the LME (Pauly *et al*. 1998, 2001). The FiB index shows a similar trend (Figure XIX-59.7, bottom), indicating that the reported landings did not compensate for the decline in the MTI over that period. However, these landings do not account for the discarded bycatch from the shrimp fishery, which now accounts for half of the value of the landings (Figure XIX-59.5).

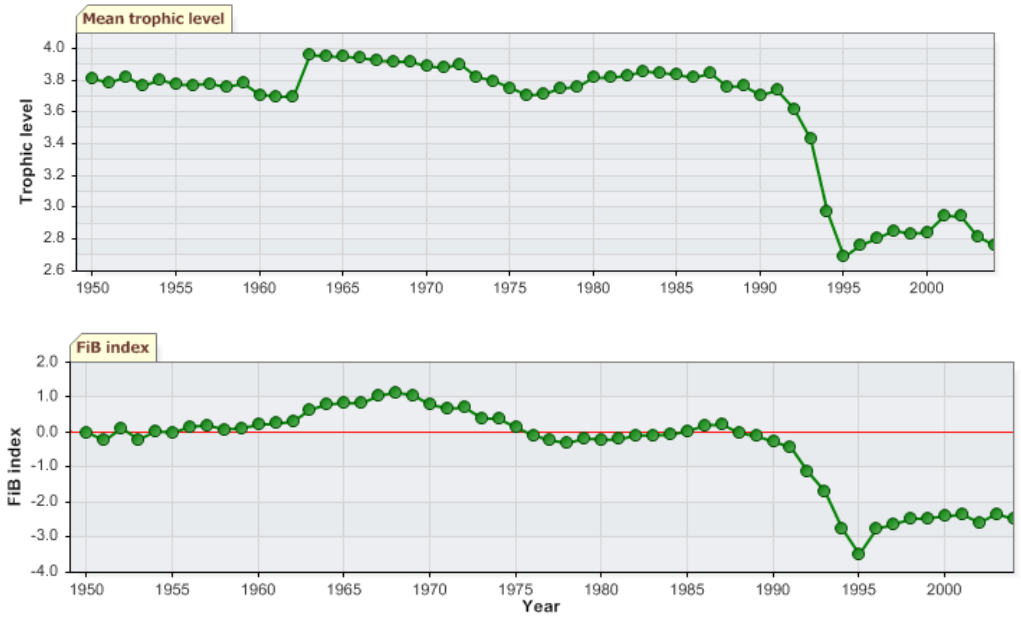

Figure XIX-59.7 Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Newfoundland-Labrador Shelf LME (Sea Around Us 2007)

The Stock-Catch Status Plots show that over 60% of commercially exploited stocks in the LME have collapsed, with another 20% overexploited (Figure XIX-59.8, top). Over 50% of the reported landings biomass is now supplied by fully exploited stocks (Figure XIX-59.8, bottom).

Instability, variability and overexploitation have characterised the entire history of fisheries off the coast of Newfoundland and Labrador. Over time, the LME has shown major changes, which have been greater in recent decades than in any other period in history. There was a rapid expansion of distant water fleets during the late 1950s, as well as an intensification of fishing effort. This affected the major fish stocks of the shelf (Murawski *et al*. 1997; Rice, 2002). Overfishing of cod, haddock, redfish and major flatfish in the 1960s and 1970s led to fisheries collapses. There were also declines in the abundance of broadhead wolffish and thorny skate. These collapses led to a fishing moratorium for cod in 1992 (Walters & Maguire 1996), and the eventual closure of the fishery a decade later. At the same time, other fisheries (notably for crab and shrimp, formerly prey of cod) experienced record high yields.

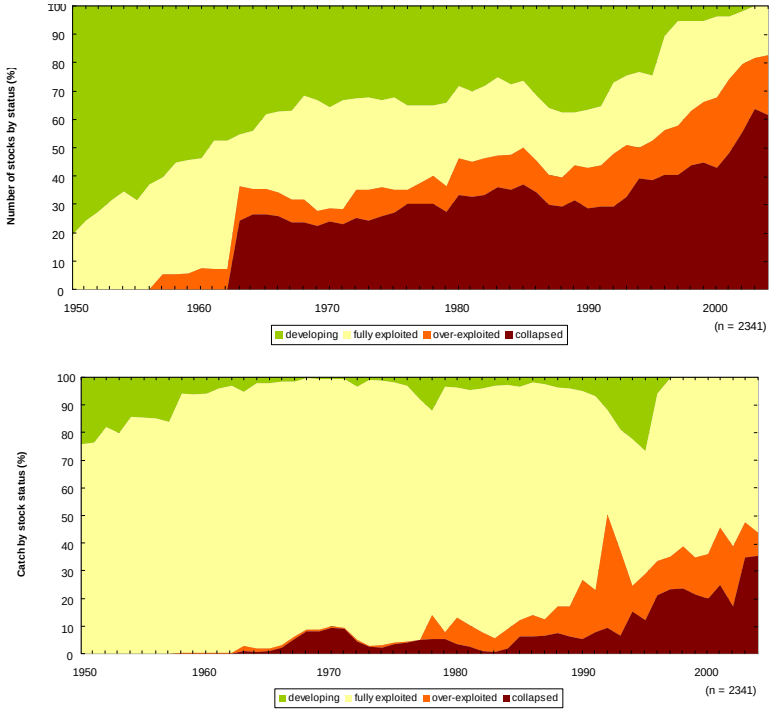

Figure XIX-59.8. Stock-Catch Status Plots for the Newfoundland-Labrador Shelf LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number of 'stocks', i.e., individual landings time series, only include taxonomic entities at species, genus or family level, i.e., higher and pooled groups have been excluded (see Pauly *et al.*, this volume, for definitions).

III. Pollution and Ecosystem Health

Given the low population density of Newfoundland, pollution from land-based sources is mostly limited to urban coastal areas. However, there is an increasing threat to the region from the oil and gas industry's exploitation of the Hibernia, Terra Nova, White Rose, and the Hebron Complex oil reserves, for example. The Canadian Wildlife Federation (CWF) reported three spills in November of 2004 at the Terra Nova oil field off the coast of Newfoundland and Labrador, the first spill releasing 170,000 litres into the ocean. Additionally, CWF asserts that deliberate dumping, the primary source of oil pollution in Atlantic Canada, is a chronic problem that is both illegal and preventable (2004). The Economic Research and Analysis Division of the Government of Canada (2007) reports that oil production in the province is expected to increase by 30%, that prices will remain high, and more exploratory drilling will likely occur in 2008 and 2009.

There have been *Oikopleura* blooms in this LME. The International Cod and Climate Change Programme studies the response of different cod populations to climate changes in various parts of the cod's North Atlantic range. Canada is a key participant in the Scientific Committee on Ocean Research (www.jhu.edu/~scor/) and the International Council for Exploration of the Sea (www.ices.dk).

IV. Socioeconomic Conditions

The Grand Banks of Newfoundland and Labrador have been fished since the 1400s, with fleets arriving annually from several of Europe's fishing nations. The banks and coastal

areas, being rich and productive, formed the basis for human settlement. The Atlantic cod fishery was the base of the economy. About 30,000 people have been adversely affected by the collapse of the cod fishery and its associated economy. However, the value of the annual fisheries catch is approaching that of the cod fishery, with recent increases in the crab and shrimp landings (Rice 2002). Hamilton and Butler (2001) caution that the cod to crustaceans transition, while roughly an even exchange for the Newfoundland economy, should not be taken for a new stable state. They point out that shrimp size has been decreasing, depressing catch value and raising uncertainty about the stock's future. Gear has been changed to prevent the female snow crab from being caught, but the biomass of snow crab declined in 1999 and 2000. Greenland halibut, are slow-growing, long-lived deepwater fish that cannot support intensive exploitation and are thought to be on the verge of collapse (Hamilton and Butler 2001).

Newfoundland's population has been declining and no longer compensates for outmigration. If this trend continues, it will be difficult for the province to provide services to those who remain. Department of Finance Canada (2004) points to high economic growth rates because of the development of offshore oil and gas projects--growth that helps the Government of Newfoundland and Labrador to provide essential public services in the face of a high provincial debt burden and the declining population in the region (www.fin.gc.ca). The Minister of Natural Resources, Gary Lunn, addressed the Newfoundland Offshore Industry Association on 19 June 2007 and urged increased oil and gas investment in the Newfoundland and Labrador province. He cites 2,800 people directly employed by the oil and gas projects and another 14,000 employed in support industries and businesses—8% if all the people employed in Newfoundland and Labrador. Tim Appenzeller (2004) in "The End of Cheap Oil," quotes Thomas Ahlbrandt, the geologist who led the USGS 2000 study asserting 50% more world oil remaining than feared, as saying "Oil and gas are limited; my personal feeling is, we have a concern in the next couple of decades."

Hamilton and Butler point out that Rural Newfoundland hosts a strong informal economy (Felt and Sinclair 1992) including country foods such as moose meat or fish and local firewood cut for heating. Barter or cash-based exchanges of goods and services such as home-building and vehicle maintenance are common.

V. Governance

Canada and France (the islands of St. Pierre and Miquelon) share jurisdiction of this LME. The establishment by Canada of a 200-mile EEZ in 1977 effectively excluded foreign fleets from most of the Grand Banks. The Government of Canada has guaranteed that Newfoundland and Labrador will receive 100 percent of royalties from its offshore oil and gas production, some offset benefits per the Atlantic Accord, and some protection from reductions in revenues.

Single species quota management continues. The Fisheries Resource Conservation Council (FRCC) was created in 1993 with a mandate to contribute to a more comprehensive approach to the management of the Atlantic fisheries on a sustainable basis, to integrate stock assessments at the ecosystem level and recommend to the Minister and industry appropriate action to ensure sustainable fisheries. While there is a stated desire to change to an ecosystem level approach, there are no explicit objectives within fisheries management plans for the ecosystem. This ambiguity in management objectives underscores the need for the many single function management agencies to be integrated. See the West Greenland Shelf LME for further information on the International Commission for the Northwest Atlantic Fisheries.

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