Regional definition

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

Boundaries of the regions

The marine waters of Greenland holds by far most of the international aspects in GIWA, whereas land and river issues are of minor or no importance. Greenland holds three GIWA regions: Arctic (1), East Greenland Shelf (15), and West Greenland Shelf (16) (Figure 1). It was agreed among task team experts to assess Greenland waters in these three predefined regions in order to maintain the comparability with the other UNEP/GIWA regions and to use the GIWA methods. However, there are major differences between ecosystems from south to north within regions 15 and 16 due to differences in physical characteristics, species compositions, and community structures on both the East and West Greenland Shelf.

Physical characteristics

Geography (location, geology, climate)

Geographically, Greenland is part of the North American continent, geopolitically, a part of Europe. Greenland is the biggest island in the world. It stretches from Nunap Isua (Kap Farvel) in the south at 59°46’ N lat to Odaap Qeqertaa (Odak Island) at 83°40’ N lat (Figure 1). Odaap Qeqertaa lies only 700 km from the North Pole, and Kap Farvel, 2 600 km further south, is at the same latitude as Oslo in southern Norway (180 km south of Anchorage, Alaska, USA). The ice-free parts alone have a topography dominated by alpine areas and cover an area of 2 175 600 km².

85% of Greenland is covered by a continuous, slightly convex ice cap, which is the world’s second-largest ice sheet. In a borehole drilled in the central part of the ice cap, the drill reached the bedrock in a depth of 3 030 m. The remaining 15% of the island is a narrow stretch of land between the ice cap and the sea, where flora and fauna exists and the people live – mainly in the coastal areas, with access to open water.

The coast around Greenland is dominated by bedrock shorelines with many skerries and several archipelagos. Very large differences in depths can be found within a short distance in the coastal zone. Some of the world’s largest fjord complexes are found in East Greenland, e.g. Kejser Franz Josephs Fjord and Scoresby Sund, leading out north of the Denmark Strait. In several places the icecap reaches the coast as glaciers at the heads of fjords; so called icefjords. Deep fjords often continue as deep channels outside the coastal line, dividing the offshore banks.

Greenland is located in the Arctic. That means that the average temperature in July does not exceed 10°C, that there is permafrost in most regions, so only the top layers of soil thaw in the summer, and there are no forests. In southwest, however, there is generally no permafrost and at a few locations close to the inland ice the average temperature in July may exceed 10°C. The country can be divided from south to north into sub-arctic, low-Arctic and high-Arctic climate zones. The mean summer temperatures on both the west and the east coast differ by only a few degrees from south to north, despite a distance of more than 2 600 km. The reason for this is the vast iceshield on the one hand, and the summer midnight sun in north Greenland on the other. Conversely, winter darkness and the absence of warm sea currents from North and East Greenland mean that the temperature during the winter
period differs considerably from north to south, average temperatures in February 1961-1990: -30.9°C in the north and -3.9°C in the south (see www.dmi.dk).

The highest temperature officially recorded in Greenland since 1958 is 25.5°C. It was recorded near the “ice cap” in Kangerlussuaq (West Greenland) in July 1990. In Greenland, frost can occur in principle in all the months of the year except deep inside the large fjords in southern and western Greenland during the summer months. The “frostfree” period in southern Greenland varies from 60 to 115 days per year.

The coldest place in Greenland is naturally on the ice cap, where the temperature can fall to below -70°C. Temperatures in Greenland have shown a slightly increasing trend for the last 125 years, although, on a

Figure 1  Boundaries of the Arctic Greenland, East Greenland Shelf and West Greenland Shelf regions.
shorter time scale, temperatures have generally fallen since the 1940s (Anon, 2003a, Figure 2.10). This has been most marked on the west coast, where a temperature rise trend has only been seen over the last few years. On the east coast, however, there has been an increasing trend since the 1970s.

Recorded precipitation in Greenland decreases with rising latitude and from the coast to the inland area. In the south and particularly in the southeastern region, precipitation is significant with average annual precipitation ranging from 800 to 2 500 mm along the coasts. Further inland, towards the ice cap, considerably less precipitation is recorded.

In the northern regions of Greenland there is very little precipitation, from around 250 mm down to 125 mm per year. In the northeastern most coastal areas there are ‘arctic deserts’, i.e. areas that are almost free of snow in winter, and where evaporation in summertime can exceed precipitation.

Not surprisingly, snow is very common in Greenland. In principle, in the coastal region it can snow anytime during the year without snow cover necessarily forming. The winter snow depth is greatest in southern Greenland, averaging from one to more than two metres in all the winter months and sometimes reaching up to six meters.

The prevailing patterns of wind direction, especially in winter, transport air masses from industrialised areas to the Arctic. The cold Arctic climate seems to create a sink for pollutant compounds (certain heavy metals and persistent organic pollutants), resulting in a so-called bio-accumulation in higher animals (fish, sea birds, marine mammals), causing concern for human health of Greenlanders consuming these animals.

**The Greenland ice cap, icebergs, and sea ice**

The Greenland ice cap (1.7 million km²) holds 9 % of the world’s freshwater. The Greenland ice cap produces about 300 km³ of icebergs per year. About 10 % of Greenland’s icebergs stem from one particularly active glacier near the town Ilulissat (‘Icebergs’ in Greenlandic) in Disko Bay. This glacier (Sermeq Kujalleq) – is the most prolific glacier in the Northern Hemisphere and produces 22 million tonnes of ice each day (Chisholm and Parfit, 2002).

The extensive sea ice is one of the most characteristic and most important features of the Arctic Ocean, North Greenland and adjacent waters. Sea ice plays a decisive role for marine productivity and life in Arctic Greenland (e.g., Rysgaard et al., 2003; Born et al., 2003; Wiig et al., 2003; Heide-Jørgensen and Laidre, 2004). In the white stretch of frozen Arctic Sea, there exist many winter refugia or “microhabitats” for air-breathing marine animals. Several species seek access to open water leads and productive foraging opportunities for many months of the year. The refugia range widely in size, from a few hundred meters to many kilometres of vast open water. They remain ice-free during even the coldest period of winter and are generally surrounded by solid sea ice. Often these areas are annual recurrent ‘polynyas’ (the Russian word for ‘open water area surrounded by ice’), variable shore leads and cracks, or tidal- and/or wind-driven openings in the consolidated pack ice. What defines these microhabitats is that they occur predictably in the same locations year after year, independent of how they are generated and maintained. This geographical and temporal predictability permits numerous Arctic sea birds and marine mammals to utilise open water during winter, when survival in the Arctic sea ice is most critical. Many of these open water habitats demonstrate conspicuous levels of production, generally due to large-scale upwelling events along the ice edge driven by the absence of ice providing early availability of light for photosynthesis. This widely attracts sea birds and marine mammals that seek to benefit from zooplankton production and associated fish abundance in these areas (Heide-Jørgensen and Laidre, 2004).

Species that utilise open water winter refugia include Arctic cetaceans, pinnipeds, sea birds and polar bears and their winter behavioural preferences are specific to requirements for survival and reproductive success (Heide-Jørgensen and Laidre, 2004). One of the largest winter refugia is the North Water Polynya (NOW) found during winter in Smith Sound and the northernmost Baffin Bay (Figure 2). NOW is utilised during winter and spring by approximately 13 000 belugas or white whales (Delphinapterus leucas) (who undertake a northbound migration to this locality from Lancaster Sound in the fall), thousands of narwhals (Monodon monoceros), and 30 million little auks (Alle alle) feeding in the area prior to the breeding season. Alternate and smaller open water localities of great importance are situated over shallow banks, such as Store Hellefiske Bank in West Greenland, containing vast benthic resources utilised by species such as king eiders (Somateria spectabilis) and common eiders (Somateria mollissima) and walrus (Odobenus rosmarus) with limited diving abilities. Hundred of thousands of thick billed murrens (Uria lomvia) from Canada, Greenland and Svalbard over winter in smaller regions along the productive coastal open water area in West Greenland.

**Oceanography**

Comprehensive descriptions of the physical oceanography of the Greenland waters have been given by Buch (1990), Valeur et al. (1996), Buch et al. (2004), and Rudels et al. (2002).
East Greenland
The surface layer in the eastern part of the Greenland Sea is dominated by the northward flowing Norwegian Atlantic Current, an extension of the North Atlantic Current. Waters from the Arctic Basin are transported southward through the Fram Strait along the east coast of Greenland to the Greenland Sea (Figure 3). The East Greenland Current flows over the Greenland shelf. During spring and early summer it carries large amounts of pack ice along with it.

The East Greenland Current flows southward along the coast of East Greenland and rounds Cape Farewell. A branch of the North Atlantic Current, known as the Irminger Current, turns westward along the west coast of Iceland. Part of the current turns further towards Greenland, where it flow southward parallel to the East Greenland Current down to Cape Farewell, where it joins the East Greenland Current (Figure 3), and flows up the west coast, securing largely open water in the harbours of Southwest and West Greenland.

Southwest and West Greenland
The water masses flowing northward along the West Greenland coast originate partly from the cold East Greenland Current, and partly from the warmer Irminger Current. These two water masses mix intensely. The hydrographic conditions along West Greenland depend greatly on the relative strengths of these two currents. The West Greenland Current, which flows over the Greenland shelf, continues northward until it reaches a latitude of about 65-66° N in the Davis Strait. At this point, a part of it turns westward and unites with the south flowing Baffin Current along the Canadian east coast, and a part continues northward in Baffin Bay.

North Greenland
Baffin Bay receives polar water from the Arctic Ocean through the Nares Strait and the Canadian Archipelago. This polar water flows southward along the eastern Canadian coast. Baffin Bay is covered by ice during winter, and in very cold winters, the ice can cover the whole Davis Strait. In summer the ice breaks up and drifts south along Canada’s east coast.

Climate-oceanography-sea ice
The oceanographic and sea ice conditions around Greenland are linked to climate variability and the changes in the distributions of atmospheric pressures on the northern hemisphere (e.g. Buch et al., 2001, 2004; Serreze et al., 2000; Johannessen et al., 2002; Macdonald et al., 2003). For example the winter (December-March) North Atlantic Oscillation Index (NAO-index) tends to be positively correlated with next years winter sea
ice concentrations in West Greenland, but negatively correlated with next years sea ice concentrations in Northeast Greenland (Stern and Heide-Jørgensen, 2003). The last decades warming of the northern hemisphere has given reduced summer ice cover and increased open-water periods in East Greenland, however, at the same time regional lower temperatures, increased ice cover, and reduced open-water periods has been observed in West Greenland (e.g. Stern and Heide-Jørgensen, 2003).

**Marine ecosystems**

Basic information on biological diversity and marine ecosystems in Greenland has been given in Jensen (1999) and Born and Bøcher (2001). Specific research and reviews of potential environmental impacts and status of species and their habitats have recently been given in reports and scientific papers e.g. Heide-Jørgensen and Johnsen (1998), Riget et al. (2000), Buch et al. (2001), Petersen et al. (2001), Glahder et al. (2003), Mosbech et al. (1996, 1998), Mosbech (2002), Pedersen (2003), Møller et al. (2003), Born et al. (2003), Wiig et al. (2003), Buch et al. (2004), Rysgaard et al. (2003), Hansen et al. (2003), Heide-Jørgensen and Laidre, 2004).

**Primary production**

The annual pelagic primary production in the low arctic south Greenland waters averages 40-80 g C/m of sea surface. Annual productions as high as 605 g C/m have been registered. This is more than in most boreal and tropical waters, but still compares poorly with annual productions of 5.5 kg C/m near Antarctica and over 3.5 kg C/m off the Peruvian coast. Sea ice, ocean currents, light, nutrients, temperature, and grazing by herbivores are primary factors determining the distribution of marine productivity and animal life. Areas, in which water masses are vertically mixed, with a continuous supply of nutrients to the surface, are especially productive. One example is the front area between polar and Atlantic water masses that predominates off the southeast coast of Greenland. Another is the mixed water mass on the banks off West Greenland, where the surface layers are well supplied with nutrients throughout the summer (Figure 4).

The annual cycle in primary production in the seas of Greenland is normally initiated in May reaching peak biomasses in June. Large diatoms dominate the spring bloom, but depending on the nutrient availability, the flagellate Phaeocystis may also contribute. After the spring bloom where silicate or nitrate is depleted from the surface layer, the phytoplankton biomass is low and dominated by autotrophic flagellates < 10 µm.

Obviously there are significant regional differences in the timing and composition of the spring bloom within the northern North Atlantic.

While the surface community in the open water is nutrient depleted in the late summer, the continuous supply of nutrients from the melt water at the marginal ice zone can support a high phytoplankton biomass. Thus blooms can be observed at the ice edges throughout the season while it is more episodic in the open water.

To understand the carbon drawdown, it is essential to have a good description of the structure and succession of the zooplankton of the area. The zooplankton influences the carbon dynamics in several ways; by vertical migration, through grazing activity and by acting as accelerators of sedimentation of organic matter through production of faecal material. During the last decade, the views on high latitude pelagic food web structure have changed.

**Pelagic food web**

The present knowledge of pelagic food chain structure in high latitude ecosystems is primarily based on sampling with coarse nets (>200 µm) ignoring the smaller components of the food web. However, use of nets with smaller mesh size has documented that the smaller copepod species can contribute significantly to standing stock of the grazer community, especially after the oldest Calanus stages have
left the surface layer. During the recent cruises in connection to the Danish Global Change Program in the Greenland Sea, a pronounced shift in the copepod community was observed from June to August; in June *Calanus* dominated while the small copepod species and developmental stages of *Calanus* took over in August. It is important to keep in mind that the *Calanus* species have a 2-4 year life cycle while the smaller species likely go through 2-3 generations per year. So the turnover of the copepod community and grazing rates in August is much higher than in June.

Knowledge of the role of the microbial food web in the Arctic has been limited because the microbial loop in cold water ecosystems has been considered less important than at lower latitudes. However, recent comprehensive investigations in Disko Bay, West Greenland, have documented that bacterioplankton and unicellular zooplankton also play a prominent role in the food web of Arctic ecosystems (Hansen et al., 2003).

**Young Sund**

Since 1994 there has been an extensive research activity in the high Arctic fjord Young Sund (74°N) on the northeast coast of Greenland (Rysgaard et al., 2003). In the Young Sund estuary, sea ice algae, primarily diatoms, were heterogeneously distributed in the sea ice both vertically and horizontally. Annual ice algal production at the sea ice-water interface in Young Sund may be highly variable and regulated by the thickness of snow cover. Primary production was <0.01 g C/m during 1998-1999. Compared to other coastal fast ice areas in the literature this rate seems low but comparable to measurements further out in the Greenland Sea. The low biomass and productivity in Young Sund was caused by a combination of poor light conditions due to snow cover and freshwater drainage from melt ponds and river discharge removing and/or inhibiting the algae at the sea ice-water interface through physical disturbance and exposure to freshwater. Thus, seen on an annual scale, the primary production of sea ice algae in Young Sund was <1% of the pelagic primary production.

In Young Sund the phytoplankton community was dominated by diatoms in the surface samples as well as in the subsurface bloom succeeding the spring bloom. Pelagic primary production was limited by light during sea ice cover. After break-up of the sea ice, silicate initially limited primary production in the surface water due to a well established pycnocline, and maximum photosynthesis occurred in a subsurface layer at 15-20 m depth. In August, production was displaced to deeper water layers presumably due to nitrogen limitation. The carbon budget describing the fate of the annual pelagic primary production revealed that the pelagic production was tightly coupled to the grazer community since total consumption by the grazer community. The classical food web dominated this northeastern Greenlandic fjord and it was estimated that copepods account for >80% of the grazing pressure upon phytoplankton (Rysgaard et al., 1999). Based on this study and other values of annual pelagic primary production and sea ice cover found in the literature, annual pelagic primary production in the Arctic was found to increase with the length of the open water light period (Figure 5). Rysgaard et al. (2003) proposed future increase in the annual pelagic primary production, secondary production, and hence food production for higher trophic level animals in a wide range of Arctic marine areas, as a consequence of reduction and thinning of sea ice cover due to global warming. The reduction in sea ice may be a benefit to some marine mammals e.g. Atlantic walruses (Born et al., 2003), but probably not for others e.g. polar bears (*Ursus maritimus*) (Wiig et al., 2003).

![Figure 5](a) Annual pelagic primary production versus length of productive open water period. b) Geographical location of investigations. Further details are given by Rysgaard et al. (1999)
Due to physical differences and because different species have different ranges of temperature and habitat tolerance there are differences in species composition and community structure of the marine ecosystems from south to north along East and West Greenland. Water temperatures and sea ice distributions play a decisive role in determining the distribution of fish, sea birds and marine mammals. For example the distribution of a fish species is limited not only by the temperatures at which the species can survive, but especially by the narrow temperature interval in which reproduction is successful. Accordingly, the geographical range of Greenlandic fish species is primarily determined by the distribution of cold water of polar origin and warmer water of Atlantic origin.

**Southwest and southeast Greenland**

With respect to commercial fisheries resources, the marine ecosystems of Southwest and Southeast Greenland waters are the most productive in Greenland and the best investigated ones. They are intermediate between the cold polar water masses of the Arctic region and the temperate water masses of the Atlantic Ocean and they are characterised by relatively few dominant species (e.g. Jensen, 1939; Hansen, 1949; Rätz, 1999; Pedersen and Zeller, 2001). Ocean currents that transport water from the polar and temperate regions affect the marine productivity in the Greenland shelf areas, and changes in the North Atlantic circulation system therefore have major impact on the distribution of species and fisheries yield (Rätz, 1999; Rätz et al., 1999 Pedersen and Rice, 2002; Pedersen et al., 2002, 2003; Wieland and Hovgaard, 2002; Buch et al., 2004). The relative strengths of the warm vs. cold water currents contribute to the definition of the habitat of the flora and fauna.

**Fish**

Since the beginning of the 20th century, cod (*Gadus morhua*) has been the most important commercial fish species in Greenland waters, with annual catches peaking at levels between 400,000 and 500,000 tonnes in the 1960s (Mattox, 1973; Horsted, 2000). Until the introduction of the 200 mile EEZ in 1977, most of the catch was taken by foreign vessels. During the late 1960s, the annual catches of cod and other commercially important fish species - mainly taken as by-catch in the cod fishery, e.g., redfish (*Sebastes marinus*), Atlantic halibut (*Hippoglossus hippoglossus*) and wolffish (Atlantic wolffish, *Anarhichas lupus*, and spotted wolffish, *A. minor*) declined drastically (Figure 6).

After 1970 the catches of cod and redfish showed fluctuations at much lower levels compared to the 1960s (Figure 6). Except for a temporary improvement of the cod fishery during 1988-1990, the catches of cod, redfish, Atlantic halibut and wolffish showed decreasing trends towards the present very low levels (Rätz, 1999; Buch et al., 2004). During the same period, however, catches (inshore and offshore combined) of two other important species, Greenland halibut (*Reinhardtius hippoglossoides*) and northern shrimp (*Pandalus borealis*) increased and annual catches are presently about 25,000 tonnes and 100,000 tonnes, respectively.

**Other living resources**

In addition to the fisheries yields from mainly the West Greenland, but also the East Greenland large marine ecosystem, one has to add the hunting (and consumption) of more than 100,000 seals, several hundred whales and several hundred-thousand seabirds per year on average (e.g. Mosbeck et al., 1998; Greenland Institute of Natural Resources, 2000; Namminersorullitik Oqartussat, 2002). The seal hunt targets primarily ringed seals (*Phoca hispida*) and harp seals (*Phoca groenlandica*), but also other species including the walrus (*Odobenus rosmarus*).
The whale hunt is mainly on fin whales (Balaenoptera physalus), minke whale (B. acutorostrata), beluga (Delphinapterus leucas), narwhal (Monodon monoceros) and occasionally others. The seabird hunt is primarily on Brünnich’s guillemot / thick-billed murre (Uria lomvia), king eider (Somateria spectabilis), common eider (S. mollissima), little auk (Alle alle) and kittiwake (Rissa tridactyla). Polar bear (Ursus maritimus) is hunted and a total of about 170 animals are killed in Greenland per year with approximately an equal number in West- and East Greenland (Namminersornerullikut Oqartussat, 2002).

**Transboundary aspects**

The marine animal resources, e.g. fish, sea birds and sea mammals, generally have an extensive distribution area, involving the waters of several nations. This means that fishery, hunting and other influences on one part of a population will eventually affect the rest of it, within as well as outside of Greenland waters. International cooperation on management and protection of marine species and resources is thus imperative if sustainable yields and protections of endangered species are to be attained. Accordingly, Greenland is member of several international organisations that advise a sustainable use of Greenland’s marine resources, e.g. North Atlantic Fisheries Organisation (NAFO), International Council for the Explorations of the Sea (ICES), North East Atlantic Fishery Commission (NEAFC), North Atlantic Salmon Conservation Organisation (NASCO), Joint Commission for the Conservation and Management of Narwhal and Beluga (JCNB), North Atlantic Marine Mammal Conservation Organisation (NAMMCO), and International Whaling Commission (IWC).

Greenland’s membership of e.g. ICES and IWC is through Denmark and Greenland has an active Greenlandic representation/participation. Greenland is a self-governing part of the Kingdom of Denmark. In 1979 the Home Rule Act transferred the mandate of legislation to the Greenland Parliament in all areas defined to be issues of self-government. Hence, regulations issued in Denmark or international conventions ratified by her are not automatically in force also in Greenland.

In 1991, the eight Arctic countries – Canada, Denmark, Finland, Iceland, Norway, Sweden, Russia, and the United States – initiated the Arctic Environmental Protection Strategy. Under this framework, the countries pledged to work together on issues of common concern. Recognising the importance of the environment to the indigenous communities of the Arctic, the countries at that time included three indigenous organisations in their cooperative programs. In 1996, the eight Arctic countries created the Arctic Council, incorporating the Arctic Environmental Protection Strategy and expanding it to include sustainable development issues. They have also included three more indigenous organisations for a total of six permanent participants. One of the programs created under the Arctic Environmental Protection Strategy and continued under the Arctic Council is the Arctic Monitoring and Assessment Programme (AMAP). AMAP was designed to address environmental contaminants and related topics, such as climate change and ozone depletion, including their impacts on human health (AMAP, 2002). In 2000, the Arctic Council approved the Arctic Climate Impact Assessment, overseen by AMAP; its sister working group on Conservation of Arctic Flora and Fauna (CAFF), and the International Arctic Science Committee. According to AMAP (2002), this impact assessment will deliver a report to the Arctic Council in 2004.

Greenland has responded to threats to the freshwater systems and the fauna and flora these habitats support by establishing protected areas and designating important wetland areas under the Convention on Wetlands of International Importance (Ramsar) (Figure 7; Egevang and Boertmann, 2001).

The objective of the UNESCO Convention concerning World Heritage is to help protecting irreplaceable expressions of former cultures and of natural landscapes of great importance and beauty. The foundations for two international conventions were laid in the mid-1960s and later,
in 1972, merged into one, the UNESCO World Heritage Convention. The five Nordic countries, among others, ratified the convention between 1977 and 1995. As Greenland is not a sovereign state, in these matters Greenlandic interests are upheld through the Danish government.

After a request by the Danish Ministry of the Environment in 1988, the Greenland government has selected natural heritage areas and cultural monuments in Greenland for inclusion in the UNESCO World Heritage List (Mikkelsen and Ingerslev, 2002). This work was properly organised in 1995 when cooperation was established between the Greenland Department of Culture, Education and Ecclesiastical Affairs, the Department of Health, Environment and Research, the Greenland National Museum and Archives, and the Greenland Institute of Natural Resources. The Greenland National Museum selected culturally significant historical objects and the Institute of Natural Resources pointed out areas of special interest for the natural environment. Subsequently, these proposals comprised sites of both natural and cultural history.

The icefjord of Ilulissat/Jakobshavn, West Greenland, which covers an area of 796 km² are being evaluated to become the first UNESCO World Heritage area in the Arctic (Mikkelsen and Ingerslev, 2002). The result of this evaluation will be announced in 2004. The icefjord contains the Jakobshavn Glacier, which is a floating, calving ice cap glacier. The glacier is presently located about 40 km east of the town of Ilulissat. Because of the relatively easy access to the glacier from the settlements in the immediate vicinity, the fjord and glacier are well known. The glacier is particularly famous for its high speed of 1 m/h and its production of calving ice which amounts to about 30 km³/year. This is more than any other glacier and comprises about 10% of the entire production of calving ice from the Greenland ice cap (Mikkelsen and Ingerslev, 2002).

**Socio-economic characteristics**

**Political structure**

Greenland has been a colony of Denmark since 1728, and obtained home rule in 1979, so it is at present a semi-independent province of Denmark. The Home Rule Government consists of a directly elected parliament (the Landsting), comprising 31 members. A general election is held every four years. The Landsting elects a government (the Landsstyre), which is responsible for the central administration under the Prime Minister (the Landsstyreformand). The members of the government head the various ministries. As Greenland is part of the Kingdom of Denmark, some fields of responsibility remain under the Danish state, including the Constitution, the right to vote, eligibility for election of justice, the concept of citizenship, inspection and enforcing of jurisdiction in territorial waters, as well as all foreign policy and monetary affairs.

The Home Rule Government is responsible for all other administrative areas, including transport and communication, and the environment and nature. The rights to Mineral and Petroleum are shared between the Danish Government and the Greenland Home Rule. Greenland is not a member of the EU, but has an OCT scheme (Overseas Countries and Territories) that ensures the country open access to the European market for its fish products.

**Population**

The population of Greenland was 56,542 in 2002 of which ~88% were born in Greenland, which is the official proxy measure for Greenlandic (Inuit) ethnicity (Anon, 2003b). Most of the remainder of the population (~12%) comes from Denmark. The population pyramid for the indigenous population is relatively broad based until the age group 30-34. Around 1970, a very high fertility rates decreased rapidly which, in combination with relatively few women of childbearing age, resulted in small birth cohorts (Figure 8). After the dramatic decrease, the size of the birth cohorts increased steadily from 1974 to 1995 but is now once more on the decrease (Bjerregaard, 2003).

![Figure 8](image-url)  
*Figure 8* Population pyramid for Greenland, 2001.  
(Source: Greenland Statistics, AMAP, 2003)
East Greenland is inhabited by only about 3,600 people. West Greenland is inhabited by the majority of the Greenland population, about 53,000 people, and the Greenland fishing industry and all major cities including the capital Nuuk are situated in West Greenland. In the capital, Nuuk, lives 13,500 people. 80% of the population lives in coastal towns and settlements in Southwest Greenland and the Disko Bay, where also most of the commercial fishing takes place and the fish processing plants are located. Outside this area subsistence hunting and fishing are predominant occupations. The fishery in East Greenland is performed by offshore fishing vessels, both Greenlandic and foreign vessels, whereas the local and coastal fishery is small, but of cultural and sociological importance.

**Culture**
The Danish/Norwegian colonisation of West Greenland started in 1721, and what today is termed the traditional Greenlandic culture is a mixture of Inuit and European culture. The traditional occupation of the Greenlanders until the early 20th century was the hunting of marine mammals (seal, whales, and walrus). During the 20th century hunting was increasingly substituted by fishing, first from small dinghies but later from large sea-going vessels using the most modern equipment. The Greenlandic culture today is still very much centred around traditional Greenlandic food (kalaalimernit), which is understood as the meat and organs of marine mammals and fish often eaten raw, frozen or dried. Seal meat, for instance, is usually ascribed several positive physical as well as cultural qualities, and asking a person whether he or she likes seal meat is equivalent to asking whether he or she considers himself/herself to be a true Greenlander (Bjerregaard, 2003).

Traditional sealing and whaling still plays an important role in the life of people especially in Northwest, North, and East Greenland although it is not the dominant industry in economic terms. Leisure time hunting and fishing is a very common activity.

The consumption of marine mammals, fish and sea birds is high, but the young and the population in towns eat considerably less than the elderly and the population in the villages. Seal is the most often consumed traditional food item followed by fish. On average, 20% of the Greenlanders eat seal 4 times a week or more often while 17% eat fish similarly often. Traditional food is valued higher than imported food; the highest preference is given to mattak (whale skin), dried cod, guillermot, and blackberries. Almost all value traditional food as important for health and less than one percent (in 1993-94) restricted their consumption of marine mammals or fish because of fear of contaminants (Bjerregaard, 2003).

**Lifestyle**
A sedentary lifestyle is becoming increasingly common among the Greenlanders. In the villages, only 7% are self-reported sedentary while this increased to 23% among the well-educated residents of the capital, Nuuk. Overweight is an increasing problem among the Greenlanders; 35% and 33% of men and women, respectively, are overweight (BMI 25.0-29.9) and 16% and 22% are obese (BMI => 30) (Bjerregaard, 2003).

The consumption of alcohol and tobacco has increased considerably during the last 30-40 years but is now stagnant (Bjerregaard, 2003). The impact of alcohol on social and family life is marked. Among those born after 1960, more than 50% state that they experienced alcohol related problems in their parental home.

According to import statistics, the average consumption of cigarettes increased from 5 cigarettes per day in 1955-59 to 9 in 1990-94. Recent population surveys estimate the proportion of cigarette smokers to be 70-80% among both men and women compared with 40% in Denmark, but the proportions of heavy smokers are similar in the two countries. Young people start smoking very early, often well before the age of 15, and the lowest smoking prevalence is found among the elderly.

**Economy**
In 1998 gross national income (GNP) was more than 7.5 billion Dkr, corresponding to 134,000 Dkr per capita. (Dkr = Danish Crowns; 1 Euro equals approximately 7.4 Dkr) (Anon., 2003b). Principal income for the Home Rule Government comes from a block grant from the Danish state, which constitutes about 2/3 of the Greenland economy. The remaining 1/3 is overwhelmingly based on fishery and its products. In addition, the Home Rule Government and the municipalities have revenue from personal and corporate taxes, indirect taxes, and licences. In addition, Greenland receives payment from the EU for access by EU fishermen to Greenland’s fishing waters.

**Exports**
In 2001, 87% of Greenland’s exports of 2.251 million Dkr consisted of fish products, 60% of which were shrimps (Anon., 2003b). The export value of fish products is heavily dependent on the prices on the world market. Although there was a considerably larger production of shrimps in 2001 than ever, falling prices on the world market considerably reduced the export value.

**Imports**
Apart from fish and hunting products, only few goods are produced in Greenland. Imports therefore include almost all goods used in
households, business and institutions. In 2001 imports amounted to 2,466 million Dkr.

Industry
Fishing is the main industry, and it is estimated that about 2,500 people are directly employed by it. In addition, around 3,000 people work in the fisheries industry and derivative occupations. Hunting is of direct or indirect significance for about twenty percent of the population, and is the principal occupation Northern and Eastern Greenland. Sheep and reindeer are raised in South Greenland. For many years it was expected that tourism and the extraction of raw materials eventually would become leading industries, supplementing fishing as major sources of income. So far, however, the expectations have not been met.

The fisheries in Greenland are characterised by three main sectors with distinct differences between large-scale offshore, intermediate and small-scale inshore activities. This is not only due to structural and economic patterns, but also caused by political relations of importance for the development process. The large-scale sector is dominated by a capital rationale, with concentration and centralisation through large-scale projects and economy of scale as the fundamental mechanisms, giving access to resources otherwise inaccessible, and the major contributor to the national economy. The intermediate sector of the regional fisheries is partly based on capital rationality, partly on a life form which has become a backbone of many of the larger settlements, but also present in many smaller settlements. This sector is important for the regional economies. The small-scale sector, relying on small boats, dog-sledges and skidoos, is vital for the small settlements, and consequently constituting the backbone of the cultural heritage, and important for the direct and indirect political attempts to maintain reasonable living conditions for the smaller places. At the same time its contribution to the maintenance of the informal and subsistence sector is certainly not negligible (Rasmussen, 1998c; Caulfield, 1997; Marquardt and Caulfield, 1995).

Fishing and hunting
Northern shrimp (Pandalus borealis) constitute the most important commercial export. The annual catches of around 100,000 tonnes contribute more than 1 billion Dkr to the Greenland economy. However, this contribution is depending on e.g. the world marked prize for shrimp products.

Cod (Gadus morhua) previously played a central role in the development of the economy, but the cod landings have fallen to <2,000 tonnes and cod fishing in Greenland today is of very low economic importance compared to former periods.

Greenland halibut (Reinhardtius hippoglossoides) on the other hand, has in the last 2 decades become important to the economy of the country. The yearly catch of more than 20,000 tonnes comes first and foremost from the northwesterly districts.

Redfish, catfish, Atlantic halibut, salmon and char are of minor economical importance, however, important to the local socio-economy in towns of Southwest Greenland.

A number of marine mammals are essential for the survival of the traditional hunting communities. The most important of these are the five species of seal which are found in the waters around Greenland. The most common is the ringed seal, and the Greenlanders still harvest around 80,000 of these every year whereas they also harvest 80,000 of all the other species put together. A number of walruses and whales are also caught (see Assessment, Unsustainable exploitation of fish and other living resources). Considerable sums are involved in the lively trade in meat which is only used locally. The only commercial use of the seals comes from the sale of skins to the Great Greenland tannery in Qaqortoq (Julianehåb). The Home Rule Government provides generous subsidies to the sealers because of the difficulty in selling the skins on the world market. Polar bear hunting and the sale of polar bear skin are socio-economical important locally in West and East Greenland.

The rich bird life around the coasts has also played a role in the life of the Greenlanders. In addition to a number of different types of gulls and ducks, of which the most important is the common eider, uses have also been found for a number of colony birds, not least Brünnich’s guillemot, known commonly as the polar guillemot.

The fishing and marine mammal hunting in Greenland is founded on resource assessments and quotas given by international advisory organisations and committees on fishery and marine mammal management (NAFO, ICES, NASCO, NEAFC, JCCM, NAMMCO, and IWC) of which Greenland is a member. The Greenland Institute of Natural Resources is responsible for providing scientific advice on the level of sustainable exploitation of the living resource to the Greenland Government, including long-term protection of the environment and biodiversity. As of today, the scientific advice to the Greenland Government of sustainable use of the renewable resources is entirely based on single-species assessments given for one year. However, for northern shrimp (the most important commercial fishery) an analytical assessment framework using a stochastic version of a surplus-production model that included an explicit term for predation by cod was applied for the first time in 2002.
Today cooperation between Greenland and EU is dominated by fisheries agreements. Within these agreements EU pays Greenland for rights to fish parts of the quotas of the Greenland fish stocks. However, from 2007 Greenland and EU are expected to make a wider partnership agreement.

The Greenland Government regulates the utilisation of renewable resources by quotas, license’s and technical measures (e.g. mesh sizes or closed seasons) (Namminersornerullutik Oqartussat, 2002; www.nanoq.gl). To enforce the decided regulations and laws on fishing and hunting, Greenland has established the “Greenland Fishing License Control” (GFLK) and “Greenland Hunting Patrol” (Jagtbetjentordningene).

Farming and land use
Geographically, Greenland’s agriculture is placed in the south. It consists mainly of sheep farming, and 25 000-30 000 lambs are produced each year. There are also two farms with domesticated reindeer. The number of sheep has remained relatively stable since 1990, whereas the number of domesticated reindeer has more than halved. The area farmed has increased by 85% since 1990 due to cultivation of heath lands for hay cutting.

There is no forestry in Greenland apart from four experimental plantations with conifers, with a total area of 100 ha.

In Greenland there are no roads connecting towns. Therefore all traffic between towns and settlements is either by ship, boat, dog-sledge (seasonally), snowscooter (seasonally) or by fixed-wing aircraft or helicopter. In the towns most goods are transported by car. The main gateways to Greenland are the international airports (former American military bases) in Narsarsuaq (South Greenland) and Kangerlussuaq (West Greenland). From here traffic to all Greenland destinations is being distributed – either by small airplanes or by helicopters. The two towns in East Greenland are accessible by air from Iceland.

Almost all goods transport, both to and within Greenland, is by sea. A small proportion, mainly mail and perishable goods, is transported by air. Only the areas from Paamiut (Frederikshåb) to Sisimiut (Holsteinsborg) on the west coast is open water all year round, and therefore accessible by boat. South of Paamiut (Frederikshåb) drift ice from the east coast can cause trouble for fisheries and transportation in the summer months. North of Sisimiut (Holsteinsborg), ice conditions limit navigation during winter. On the east coast ice may cause troubles year round, as the east coast can only be navigated for a few months in the summer.

Conclusion
The GIWA regions of Greenland, Arctic (1), East Greenland Shelf (15), and West Greenland Shelf (16), cover huge areas, but they are sparsely populated. The development of modern Greenland has been based on fishing and hunting natural resources. Besides the importance of transfers from Denmark, the society of Greenland, including the local economies, depends on living resources from the sea, and more than 90% and Greenland’s total export value stems from fish products. Likewise, the social and physical health of Greenlanders, notably those living in the more isolated areas, depends to a high degree on the collection and consumption of traditional food.