14 Appendix D, Methods and Documentation

14.1 Introduction

In the Chapters 6, 7 and 8 the methods and data used in the Atlas project have been described. However, some technical details and data documentation was not included in these chapters and is presented here. Appendix D should thus be seen as supplementary to the descriptions in Chapters 6, 7 and 8.

This chapter contains the detailed settings used for calculating the sensitivity index values with the Greenland Oil Spill Sensitivity Application (Chapter 14.2); a description of the data and methods used in the geomorphological coast classification (Chapter 14.3); a description of the data and methods used to assess abundance values for the biological occurrences for each area (Chapter 14.4); and a description of the data and method used to assess Assigned Values for the archaeological sites for each shoreline area (Chapter 14.5).

14.2 The parameters of the Greenland Oil Spill Sensitivity Application

Below is a list of the parameter settings in the Greenland Oil Spill Sensitivity Application for the index calculations in this Atlas.

Assigned Values to shoreline and offshore areas:

Score per Community	10
Special Status Area Score (Ramsar Sites)	5
Resource (Human) Use, range*	0-5
Archaeological sites, range	0-5
Animal Relative Abundance, range	0-5

*Range from 0 (no importance) to 5 (extreme importance)

Shoreline Exposure Class Modifier for shoreline ice cover:
For Maximum Open Water Periods less than 8 weeks the exposure modifier is –1.

Shoreline ORI modifiers
A few modifications to the basic classification of the ORI value (see Chapter 6) are made to account for shoreline slope, and to account for a few geomorphological coast types considered to have longer residence times. However the maximum ORI value is limited to 5.

ORI slope modifiers

Steep	-1
Flat	+1

ORI shore type modifiers

Archipelagos	+1
Pocket beach	+1
Barrier beach	+1
Delta	+1

Offshore ORI
Offshore Oil Residence Index values have been defined for the offshore areas to approximately correspond to the shoreline ORI values. However, the offshore ORI have been defined for each of the four seasons. In the Davis Strait the presence of the dynamic pack ice with floes and ice edges will act to restrict oil movement and thus significantly increase the potential oil exposure time. The Offshore ORI values have been defined with values increasing from 3 to 5 for the open water period (period with less than 5/10th of ice) decreasing from more than 90% to less than 50% of the season.

Offshore ORI values (ORI for offshore areas)	
0-50% of season with open water	5
51-90% of season with open water	4
91-100% of season with open water	3

Weighing factors	
Resource (Human) Use	2
Species occurrences	1.75
Special Status Areas (Ramsar Sites)	1.5
Oil Residence Index	1.5

Application Constants:	
Biological Resource Constant (shoreline)	22
Biological Resource Constant (offshore)	50
Maximum ORI value	5

With these settings the average contributions (PI-values) to the final sensitivity values for the shoreline areas are: biological occurrences 49%, resource (human) use 20%, oil residence index 14%, archaeological sites 12%, communities 4% and special status areas (Ramsar sites) 1%. However, this is a simplification since the oil residence index value is a factor in the calculation of the PI-value for biological occurrences, and thus has a higher relative contribution to the final sensitivity value.

14.3 Geomorphological Information

The geomorphology of the West Greenland coasts between 62° N and 68° N has been classified according to shore type, sediment type, slope, and exposure. The total shoreline length between 62° N and 68° N is c. 19,000 km. However, the inner fjords, with the exception of Godthåb Fjord, have not been included in this investigation. This reduces the total length of shoreline investigated to c. 15,000 km (Figure 14.1).

14.3.1 Methods

The classification is based on air photo interpretation of stereo images using a stereoscope. The images used were mainly in scale 1:150,000 (taken in 1985). When necessary, the images were supplemented with air photos in a scale of c. 1:40,000 (taken in the period 1959 - 1968). In total, 800 images were used for the classification. Furthermore, topographic maps (scale 1:250,000), geological maps (scale 1:500,000) and charts (scale 1:1,000,000) have been used for the classification.

The division of the shoreline into shore type segments is based on the geomorphology of the coast. A shore type is a repeatable category of coastal geomorphology that indirectly indicates the coastal sediment type. Seventeen different shore types have been used for the classification (Table 14.1). However, in the Atlas the seventeen shore types have been reduced to twelve shore types for simplicity (Table 7.1). This has been done by lumping shore types with erosional cliffs together with the corresponding shore types without erosional cliffs.

A lower segment length of app. 2 km was applied. Therefore, shore types with a shore parallel extent less than app. 2 km were not been categorised separately, but were included in the neighbouring segments.

For each segment the shore type (Table 14.1), the sediment type (Table 14.2), the slope (Table 14.3) and the exposure (Table 14.4) was classified.

Generally, the segments were drawn as lines coincident with the shoreline. However, during the classification, archipelagos were classified as polygons with varying area and form and including a varying number of islands. On the final maps, each island within the archipelago shore type polygons was reclassified as individual line segments (encircling each island) with its own attributes (shore type, sediment type, slope and exposure).

Small islands (perimeter < 6 km), which were not part of an archipelago, were not classified separately as segments, but were attached to the nearest segment and therefore given to the attributes of this segment.

Landscape elements of special geomorphological interest (e.g. cuspate forelands and beach pillars) and morphological indications of littoral sediment transport direction (e.g. displacement of river outlets and lee side erosion at groynes) have been classified where possible. Table 14.5 was used for classification of landscape elements of special interest, while Table 14.6 was used for classification of sediment transport direction.

14.3.2 Statistics

The total number of segments identified is 12,961. Of these, 1,285 segments (5,491 km) are on the mainland coast, 493 segments (3,067 km) are on bigger islands (perimeter > 6 km) and 11,183 segments (5,564 km) are on smaller islands (perimeter < 6 km).

The distribution of segments on shore type, sediment type, slope and exposure categories respectively are given in Tables 14.7-10. In terms of shore line length, the ‘Rocky coast’ is the dominant shore type (59.9%), ‘Rock’ is the dominant substrate (87.9%), ‘Inclined’ is the dominant slope (81.6%) and ‘Semi-protected’ is the dominant exposure type (51.1%). The majority of the coasts within the ‘Archipelago’ shore type are rocky coasts. Together the

Archipelago' and 'Rocky coast' shore types by length constitute 92.3% of the total investigated shoreline..

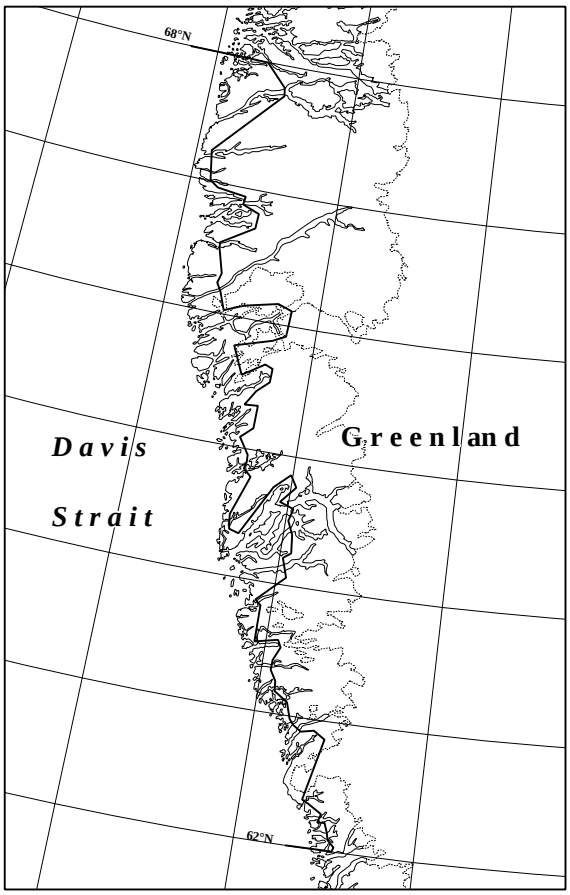


Figure 14.1. The study area in West Greenland. The black line delimit the coastal zone

Table 14.1. Classification of shore types in West Greenland between 62° N and 68° N.
Shores developed in solid rock

Shore type no.	Shore type	Segment-type	Characteristics
1	Rocky coast	Line	- Coast developed on bedrock of varying morphology, elevation and gradient. - Narrow beach with coarse sediment consisting of boulders, cobbles and pebbles might occur. - The occurrence of abraded inter-tidal platforms is indicated by the gradient (Table 14.3).
2	Rocky coast with erosional cliff	Line	- As shore type 1, but with steep or vertical erosional cliff.
3	Archipelago	Polygon	- Several smaller islands, normally developed in solid rock. - Rocky coasts and pocket beaches might occur, but have only been classified individually if the perimeter of the island exceeded 6 kilometres
4	Glacier coast	Line	- Occurrence of a glacier in the intertidal zone.

Shores developed in sediments of glacial, alluvial or colluvial origin

Shore type no.	Shore type	Segment type	Characteristics
5	Moraine	Line	**-** Shore developed on unconsolidated glacial sediments. - Narrow beach with coarse sediment consisting of boulders, cobbles and pebbles might occur. - The occurrence of abraded intertidal platforms is indicated by the gradient (Table 3).
6	Moraine with erosional cliff	Line	- As shore type 5, but with steep or vertical erosional cliff.
7	Alluvial fan	Line	**-** Shore developed in alluvial fan. - Narrow beach with sediment consisting of boulders, cobbles, pebbles, gravel and sand might occur. - The occurrence of intertidal platforms is indicated by the gradient (Table 14.3).
8	Alluvial fan with erosional cliff	Line	- As shore type 7, but with steep or vertical erosional cliff.
9	Talus	Line	**-** Shore developed in talus (colluvial fan) of varying gradient. - Narrow beach with coarse sediment consisting of boulders, cobbles and pebbles might occur.
10	Talus with erosional cliff	Line	- As shore type 9, but with steep or vertical erosional cliff.

Shores developed in marine sediments

Shore type no.	Shore type	Segment-type	Characteristics
11	Beach	Line	- Long, linear depositional beaches of well-sorted sand, gravel, pebbles, cobbles or boulders. - Beach ridge plains often occur landwards the beach.
12	Beach ridge plain with erosional cliff	Line	Coastal cliff cut in beach ridge plain. - Narrow beach with well sorted sediment consisting of boulders, cobbles, pebbles, granules or sand might occur.
13	Barrier beach	Line	- Coastal environment consisting of coastal barriers and lagoons with beaches, dunes, salt marsh and tidal flats. - Spits often occur near tidal inlets. - Wash-over fans might occur on barriers. - Beaches consisting of well-sorted sand, gravel, pebbles or cobbles. - Tidal flats consisting of mud.
14	Salt marsh and/or tidal flat	Line	- Wide salt marshes with or without salt marsh cliff and/or wide intertidal flats. - Consisting of relatively fine sediments (mud, sand, silt and clay).
15	Pocket beach	Line	- Beach developed in the inner part of an embayment in solid rock. - No larger rivers run into the embayment. - Beaches normally consist of well-sorted sediments consisting of sand, gravel, pebble or cobbles.

Shores developed in deltaic sediments

Shore type no.	Shore type	Segment-type	Characteristics
16	Delta	Line	- Low gradient intertidal platform developed by fluvial sediments in front of a river valley. - Braided river channels often occur within the inter-tidal zone. - Sediment normally fine grained ranging from clay to fine sand.

Others

Shore type no.	Shore type	Segment-type	Characteristics
17	Not classified	Line	**-** The shore has not been classified due to lack of air photo information (cloud cover, shadow, etc.)

Table 14.2. Sediment classification for West Greenland coasts between 62° N and 68° N.

Substrate class	Substrate, general	Substrate, specific	Shore description
1	Ice	Ice	Glacial ice within the intertidal zone
2	Rock	Rock	Bedrock within the intertidal zone
3	Rock and sediment	Rock and coarse sediment	A combination of bedrock and coarse sediment including boulders, cobbles and pebbles, either as veneers over the bedrock or as small pocket beaches interspersed with bedrock.
4		Rock and fine sediment	A combination of bedrock and fine sediment including mud, sand or mixtures of sand and boulders, cobbles or pebbles. Sediments most likely to occur as small pocket beaches interspersed with bedrock.
5	Sediment	Coarse sediment	Boulders, cobbles and pebbles. Collectively referred to as 'gravel'. Includes 'shingle-type' beaches.
6		Fine sediment	Mud, sand and combinations of sand and gravel.

Table 14.3. Slope classification for West Greenland coasts between 62° N and 68° N.

Slope class	Slope
1	Steep
2	Inclined
3	Flat

Table 14.4. Exposure classification for West Greenland coasts between 62° N and 68° N.

Exposure class	Exposure
1	Protected
2	Semi-protected
3	Semi-exposed
4	Exposed

Table 14.5. Classification of coastal landscape elements of special geomorphological significance in West Greenland between 62° N and 68° N.

Element no.	Element type
1	Cuspate foreland
2	Tombolo
3	Beach pillar
4	Contemporary basin (isolation basin with sill just below present sea-level)
5	Beach ridge plain
6	Larger beach ridge
7	Larger barrier coast system
8	Terminal or lateral moraines protruding into the coastal zone
9	Others

14.4 Biological Information

14.4.1 Introduction

This section describes the different species/species groups included in the biological part of Atlas, and it gives an overview of the different sources to the biological information. Moreover, a description of the rationale behind the selection of seabird breeding colonies and behind the calculation of the relative abundance of seabirds in each shoreline area.

14.4.2 Marine mammals

Harbour seal

This seal species occur within the area throughout the year. All the presented information is retrieved from Teilmann & Dietz (1994) and Lisborg & Teilmann (1999), supplemented with more general information from Mosbech et al. (1998).

Bearded seal

Bearded seals are widespread in the West Greenland waters during winter. However, only in small numbers, except for an area on Store Hellefiskebanke, where concentrations have been observed. Only information from this area is included in this Atlas.
The information derive from aerial NERI-AE surveys (unpublished) in the years 1995, 1996 and 1997, supplemented with data from the spring 1998 (Heide-Jørgensen et al. 1999) and data from spring 1981 (MacLaren & Davis 1983). All the data are from March to May. Hunting statistics indicate that bearded seals are present in largest numbers from November to May, and may occur in few numbers throughout the year all over the area covered by this Atlas (Mosbech et al. 1998).

Hooded seal

Hooded seals occur throughout the offshore marine areas of the area covered by this Atlas most numerous in period March to October. However, only the occurrence of whelping hooded seals is included. All information on the hooded seal whelping area is retrieved from Kapel (1998). The seals whelp from mid-March, and the pups stay in the whelping area well into April. The locations of the whelping patches are highly dynamic and dependent of the ice conditions both within the single whelping season and between years. The designated area include all the areas where whelping hooded seals have been recorded in 1976 – 1978, 1984 and 1997 according to Kapel (1998).

Walrus

Walrus are winter visitors to the area and occur from February to May. The presented information is retrieved from Born et al. (1994), Heide-Jørgensen et al. (1999) and from our NERI-AE surveys (unpublished). More general information is derived from Boertmann et al. (1998).

Baleen whales

This group comprise three species: Fin whale and minke whale, both summer visitors to the area, and both hunted under regulation by International Whaling Commission. The presented data on these two species are from NERI-AE surveys (Mosbech et al. 1998, unpublished data) and from the Greenland catch statistics (Witting 2000). The third species is the bowhead whale, which is a winter visitor the area. The presented information is retrieved from Reeves & Heide-Jørgensen (1996), Boertmann et al. (1998) and Heide-Jørgensen et al. (1999). The observations are from the period March to May and from the years 1981-1992, 1996, 1997 and 1998. The data may be representative for the winter as well (Dec. to Feb.) (see Reeves & Heide-Jørgensen 1996). The bowhead whale area is divided in two: one where the occurrence is more frequent and one where it is less frequent. Last

mentioned contains all observation from the region 62° N - 69° N made during the above mentioned surveys.

White whale (Beluga)
The white whale is a winter visitor to the area , and the presented data are compiled from following sources: Heide-Jørgensen et al. (1993), Heide-Jørgensen & Reeves (1996) and Heide-Jørgensen et al. (1999). These data represents observation in March and April in the years 1981, 1982, 1990, 1991, 1993, 1995 and 1998. The whales are present in the area from November to late May, somewhat dependent of the ice conditions (Boertmann et al 1998). The depicted white whale area contains all observation from the region 62° N - 69° N made during the above mentioned surveys.

14.4.3 Seabirds

The seabird species have been assembled in some seabird groups:

- Alcids, comprising Brünnich's guillemot (Thick-billed murre), common guillemot, razorbill, black guillemot, Atlantic puffin and little auk (dovekie);
- Seaducks breeding, comprising common eider;
- Seaducks, comprising common eider (non breeding occurrence), king eider, harlequin duck and red-breasted merganser;
- Gulls, comprising Iceland gull, glaucous gull, great black-backed gull, kittiwake and Arctic tern;
- Cormorants, comprising only great cormorant;
- Tubenoses comprising northern fulmar and great shearwater.

Breeding seabirds
The selection of seabird breeding colonies included in this Atlas derive from NERI's database of seabird breeding colonies covering entire Greenland (see Boertmann et al. 1996). The selection is based upon the geographical range between 62° N and 68° N and on the best available surveys, as many colonies have been surveyed several times. However, the most recent surveys are not necessarily the best, as for example aircraft based surveys are inferior to boat based surveys.

All numbers of birds are expressed in individuals, as many species can only be monitored as such. Numbers expressed in pairs or nests are transformed to individuals (No. of pair/nest x 2)

Species criteria for selection
The criteria for inclusion of colonies is listed in Table 14.6.

Table. 14.6. Criteria for inclusion of seabird colonies (all fjords included).

Species	Criteria	No. of colonies meeting the criterion	No. of colonies included because other species meet their criterion (mixed colonies)
Single species			
Northern fulmar:	all colonies	3	-
Great cormorant	all colonies	34	-
Common eider:	colonies with ≥ 5 indvs	31	42
Iceland gull:	colonies with ≥ 500 indvs	10	32
Glaucous gull:	colonies with≥ 500 indvs	1	44
Unsp. glaucous/Iceland gull:	colonies with ≥ 500 indvs	1	3
Black-legged kittiwake:	colonies with ≥ 50 indvs	38	7
Arctic tern:	colonies with ≥ 30 indvs	23	7
Common guillemot:	all colonies	5	-
Brünnich's guillemot (thick-billed murre):	all colonies	5	-
Razorbill:	colonies with ≥ 5 indvs	61	12
Black guillemot:	colonies with ≥ 250 indvs	5	88
Little auk (dovekie):	all colonies	1	-
Atlantic puffin:	all colonies	17	-
Species combinations in mixed colonies (not meeting single species criteria)			
Razorbill and common Eider	all colonies	1	-
Razorbill and black-legged kittiwake	all colonies	0	-
Common eider and Arctic tern	all colonies	1	-

Taking into account that most colonies have a mixed species assemblage the total number of colonies (with different geographical location) selected is 158. All fjords are included in this calculation.

Comments to the criteria

The criteria take into account the sensitivity to oil spill of the bird species both on individual level and on population level. These sensitivities are dependent on the behaviour and ecology of the birds but also the distance to neighbouring colonies, which is a measure of the ability to recolonize a colony. Moreover they take into account the status of the breeding population within the region, whether they are decreasing, increasing or stable, and finally their international conservation status.

Breeding sites for northern fulmar south of Disko Bugt are very few, and only one located to the south of the sensitivity mapping region is fairly large and apparently stable. Those within the region are small and either declining or seem be have been established recently.

Great cormorant colonies are mainly found within the fjords. The Greenland cormorant population is small and most likely isolated from other populations in the North Atlantic. The breeding population is widely dispersed, mainly from the northern part of the sensitivity mapping region northwards to Upernavik District. The population seem to increase and disperse southwards.

The breeding population of common eider in West Greenland has decreased seriously for a century, and within the sensitivity mapping region there are no large and dense colonies to day. Large breeding population are mainly found dispersed in extensive archipelagos. To exclude sites with a few scattered nesting eiders the criteria for inclusion is ≥ 5.

Iceland gull, glaucous gull (incl. unsp. Iceland/glaucous gull) are widespread breeders in West Greenland and within the Atlas region. As gulls are only moderately sensitive to oil spills only the largest colonies are included. A few large colonies situated very high on cliffs (>500 m asl) and inland are excluded.

Black-legged kittiwake. Breeds exclusively in colonies usually on the lower part of steep cliff faces, and is widespread in entire West Greenland. Colony size range from very few to tens of thousands, and the population are probably more or less stable, although some regional variation seen occur. Colonies less than 50 pairs are excluded as they tend to be less stable over time.

Arctic terns breed usually in dense colonies on low islands. The population in West Greenland are generally decreasing. A characteristic feature is that colonies in large areas are in certain years (with adverse weather in spring) abandoned. Small colonies less than 30 pairs are excluded. terns are moderately sensitive to oil spills, but the colony situated on low islands are very sensitive to disturbance e.g. from oil spill response activities.

All members of the family auks (alcids), that is common guillemot, Brünnich's guillemot, razorbill, black guillemot, little auk and Atlantic puffin, are very sensitive to oil spills. This is caused by their behaviour, and also by their very low population turnover. Protection of their breeding sites therefore have high priority. Moreover is the breeding population of Brünnich's guillemot in West Greenland seriously decreasing due to a very high hunting pressure, and the very few breeding sites within the sensitivity mapping region is therefore all included. Common guillemots breeds in few numbers only in colonies of Brünnich's guillemot, and all are included.

Razorbill breeds in small colonies (max. a few hundred pairs) scattered throughout the sensitivity mapping region (and West Greenland). The colonies are difficult to monitor, because the nests are concealed, and the presence of a few birds at a site may sometimes only be conspecting birds, not breeding there. Sites with less than 5 birds are therefore excluded.

The black guillemot is the most widespread and numerous alcid within the region, where colony size range from a few pairs to some hundred. The colonies are often very loose and difficult to deliminate, and all in all only very large colonies with more than 250 pairs are included.

There is only one site with little auks within the Atlas region, why it is included.
The population of Atlantic puffing is small in West Greenland, the largest colonies hold up to 1000 pairs. It was moreover decreasing until hunting and egging was prohibited in 1960. The population seems to be slowly increasing now. All colonies are included.

In each shoreline area the numbers of breeding seabirds for each of the species groups are added to calculate the input (relative abundance) to the sensitivity calculation:

Alcids:

Black guillemot:	1-100	1
	101-200	2

	201-500	3
	501-1000	4
	>1001	5
Razorbill	1-20	1
	21-50	2
	51-100	3
	101-200	4
	>201	5
Puffin	1-5	1
	6-10	2
	11-20	3
	21-50	4
	>51	5
Brünnich's guillemot	1-10	1
	11-50	2
	51-100	3
	101-200	5
	>201	5

A colony/shoreline area which otherwise only will reach a relative abundance of 3 or less, is added one point if three or more alcid species are present.

Seaducks

Common eider	1-50	1
	51-100	2
	101-200	3
	201-500	4
	>501	5

Gulls

Iceland Gull	1-200	1
Glaucous	201-400	2
Great black-backed	401-1000	3
	1001-2000	4
	>2001	5
Kittiwake	1-100	1
	101-1000	2
	1001-2000	3
	2001-10.000	4
	<10.001	5
Arctic tern	1-50	1
	51-200	2
	201-1000	3
	1001-2000	4
	>2001	5

If a colony/shoreline area with four or more gull species (not terns) only reach a relative abundance of 2 are added one point.

Tubenoses

Northern fulmar	1-200	1
	201-1000	2
	1001-2000	3
	2001-10.000	4
	>10.001	5

Cormorants

Great cormorant	1-20	1

21-50	2
51-100	3
101-200	4
>201	5

The information regarding offshore occurrence of seabirds have been retrieved from Brown (1986), Boertmann (1995), Mosbech et al. (1996, 1998), Durinck & Falk 1996, Boertmann & Mosbech (1997), Mosbech & Johnson (1999) and is supplemented with unpublished information from NERI.

Included are seaducks and cormorants. Alcids are omitted, and only related to offshore areas, as they are not dependent of the coast for resting, as seaducks and cormorants are. Gulls are also included, however, only very large aggregations. Gulls are omnipresent in the region, and their occurrence is highly variable, unpredictable and dependent of ice conditions and food availability. The information has been manually imported into the Access database structure.

The index values for non-breeding shoreline seabirds are:
Seaducks:

common eider:
1-200: 1
201-500: 2
501-2000: 3
2001-5000: 4
>5000: 5

harlequin duck:
1-20: 1
21-100: 2
101-250: 3
251-400: 4
>400: 5

red-breasted merganser:
>200: 5

long-tailed duck:
300-500: 3
>501-1000: 4
>1000: 5

14.4.4 Fish, shellfish and fisheries

Capelin, lumpsucker and Arctic char
The information on capelin, lumpsucker and Arctic char derive from an interview survey in West Greenland carried out in summer 1999 (Nielsen et al. 2000). The data mainly reflect areas where the resources are utilised, however the data is also used as an indicator of the presence of the species. Moreover is information from Petersen (1982, 1983a,b,c,d) and more general information from Mosbech et al. (1998) included.

It should be noted that the 1999 interview survey include no data on capelin in the area between 62° 15′ N and 63° 50′ N (northern Paamiut municipality to central Nuuk municipality).

The data collected in 1999 were commented on and augmented by pers. comm. with hunters and fishermen in most settlement and towns between Paamiut and Sisimiut in spring 2000.

Greenland halibut

GINR has supplied the data regarding Greenland halibut fishery (GINR 1999b). The 1998 data are distributed between trawl catches and longline catches, and each single catch is referred to a geographical position. More general information are from Mosbech et al. (1998). According to GINR the off-shore fishery grounds are fairly stable in time. This is caused by the fact that the area off Nuuk is the only site where the bottom between 1000 and 2000 meters are widespread and level, so extensive fishery can take place. Moreover is trawl fishing not allowed north of 64°30' N. In earlier years before 1996, Japanese fishing vessels participated in the fishery. They aimed often at smaller Greenland halibut than fishing vessels from Greenland and European countries, and they were taken in a larger area and more to the east and north east than the present day fishery. Today the fishery takes mainly place adjacent to the midline between Canada and Greenland. However, occasional fishery sometimes is carried out more to the east, but this area is generally avoided by the fishermen due to soft bottom and the possibility of getting stuck.

Snow crab
GINR provided the information, which is unpublished (GINR 1999a). The data set covers the reported catches in the years 1995 to 1998. The data are not complete; e.g. the large and very recently developed fishery in Paamiut is not included in the GINR data. As the snow crab fishery in West Greenland is of a new date (since mid 1990ies), and still in development, many new fishing grounds may be encountered in the future.

Scallop
GINR has supplied the data regarding scallop fishery (GINR 1999c). The data are distributed between the years 1991 to 1999 and each single catch is referred to a geographical position. More general information derives from Mosbech et al. (1998). According to GINR, these areas are fairly stable in time. However, new fishing grounds may turn up and some may be overexploited, why commercial fishing may be given up.

Resource use
Data are extracted from our interview survey (Nielsen et al. 2000) regarding fishery for capelin, lumpsucker and Arctic char. From the large unpublished material collected by Petersen (1992, 1993a,b,c,d) more information of human use of living resources is derived mainly on fishery (capelin, lumpsucker, Arctic char, cod (mainly pound net fishing in fjord areas), halibut, wolffish (mainly spotted), redfish, snow crab and scallop) and hunting (seabirds mainly guillemots and eiders) seals and whales. Data on the location of fin- and minke whales hunting sites were provided by GINR (Witting 2000). Finally are unpublished material from NERI included.

It has been impossible to get complete information on hunting campsites, summer campsites and vacation huts. The information available was an overview of vacation huts in Nuuk municipality provided by Ministry of Environment and Nature (Greenland Home Rule) and our own observations.

A preliminary Atlas with all the human use data compiled was presented to hunters and fishermen in settlements and towns between Paamiut and Sisimiut in spring 2000, and new and supplementary information was included during these session.

14.4.5 References

GINR 1999a. Unpublished information on snow crab fishery.
GINR 1999b. Unpublished information on Greenland halibut fishery.
GINR 1999c. Unpublished information on scallop fishery.
NERI. Unpublished information on seabird and marine mammal abundance and distribution in the Davis Strait.

Ministry of Environment and Nature, Greenland Home Rule. Unpublished information on vacaction huts in the Nuuk area.
Personal communications with local fishermen and hunters in spring 2000.

Boertmann, D. 1995, Havfugletællinger i Davisstrædet i sommeren 1977. En foreløbig bearbejdning. - Grønlands Miljøundersøgelser, 24 pp.
Boertmann, D. & A. Mosbech. 1997. Breeding distribution and abundance of the great cormorant Phalacrocorax carbo carbo in Greenland. - Polar Research 16: 93-100.
Boertmann, D., Mosbech, A., Falk, K. & K. Kampp 1996. Seabird colonies in western Greenland. - NERI Technical Report 170: 148 pp.
Boertmann, D., Mosbech, A. & P. Johansen 1998. A review of biological resources in West Greenland sensitive to oil spills during winter. - NERI Technical report No. 246: 72 pp.
Born, E.W., Heide-Jørgensen, M.P. & R.A. Davis 1994. The Atlantic walrus (Odebenus rosmarus rosmarus) in West Greenland. - Meddr Grønland, Biosc. 40: 33 pp.
Brown, R.G.B. 1986. Revised Atlas of Eastern Canadian Seabirds. 1 Shipboard Surveys. - Canadian Wildlife Service: 111 pp.
Durinck, J. & K. Falk 1996. The distribution and abundance of seabirds off south-western Greenland in autumn and winter 1988-1989. - Polar Research 15 (1): 23-42.
Heide-Jørgensen, M.P. & R.R. Reeves 1996. Evidence of a decline in beluga, Delphinapterus leucas, abundance off West Greenland. - ICES J. mar. Sci. 53: 61-72.
Heide-Jørgensen, M.P., Lassen, H., Teilmann, J. & R.A. Davis 1993. An index of the relative abundance of wintering belugas, Delphinapterus leucas, and narhvals, Monodon monoceros, off West Greenland. - Can. J. Fish. Aquat. Sci. 50: 2323-2335.
Heide-Jørgensen, M.P., Acquarone, M. & F.R. Merkel 1999. Flytællinger af fugle og havpattedyr i Vestgrønland 1998. – Tekniske rapport nr. 24, Pinngortitaleriffik,Grønlands Naturinstitut. 66 pp.
Kapel, F.O. 1998. The Davis Strait hooded seal breeding patch. - Unpubl. manuscript, 10 pp.
Lisborg, T.D. & J. Teilmann 1999. Spættet sæl in Kangerlussuaq/Søndre Strømfjord. – Teknisk Rapport nr. 23, Pinngortitaleriffik, Grønlands Naturinstitut.
McLaren, P.L. & R.A. Davis 1983. Distribution of wintering marine mammals off West Greenland and in southern Baffin Bay and northern Davis Strait, March 1982. - LGL Ltd. Toronto: 92 pp.
Mosbech, A. & S. Johnson 1999. Late winter distribution and abundance of sea-associated birds in Southwest Greenland, Davis Strait and southern Baffin Bay. - Polar Research 18: 1-17.
Mosbech, A., Dietz, R., Boertmann, D. & P. Johansen 1996. Oil exploration in the Fylla Area. - NERI Technical Report 156, 90 pp.
Mosbech, A., Boertmann, D., Nymand, J., Riget, F. & M. Acquarone 1998. The marine environment in Southwest Greenland. Biological resources, resource use and sensitivity to oil spill. - NERI Technical Report 236: 202 pp.
National Forest and Nature Agency 1996. Danish report 1996 on the Ramsar convention. Denmark & Greenland. – Ministry of Environment and Energy, 105 pp + apps.
Nielsen, S.S., Mosbech, A. & J. Hinkler 2000, Fiskeriressourver på det lave vand i Vestgrønland. – Arbejdsrapport fra DMU Nr. 118.
Petersen, H.C. 1992 (unpublished). Registrering af levende ressourcer samt bevaringsværdig natur. Hefte 3. Nuup Kommunea.
Petersen, H.C. 1993a (unpublished). Registrering af levende ressourcer og naturværdier i Grønland. Hefte 4. Paamiut Kommune og Ivittut Kommune.
Petersen, H.C. 1993b (unpublished). Registrering af levende ressourcer og naturværdier i Grønland. Hefte 6. Maniitsoq Kommune.
Petersen, H.C. 1993c (unpublished). Registrering af levende ressourcer og naturværdier i Grønland. Hefte 7. Sisimiut Kommuniat.
Petersen, H.C. 1993c (unpublished). Registrering af levende ressourcer og naturværdier i Grønland. Hefte 8. Kangaatsiaq Kommune.
Reeves, R.R. & M.P. Heide-Jørgensen 1996. Recent status of bowhead whales, Balaena mysticetus, in the wintering grounds off West Greenland. - Polar Research 15: 115-125.

Teilmann, J. & R. Dietz 1998. Status of the harbour porpoise in Greenland. - Polar Biology 19: 211-220.
Witting, L. 2000. Seasonal and geographical distribution of catches of minke and finwhales in West Greenland 1988-99. – Unpublished manuscript to the International Whaling Commission.

14.5 Archaeological and Historic Information

14.5.1 Prehistoric and historic man in Greenland

Based on our present knowledge, Greenland seems to have been inhabited almost continuously since 4500 BP. Evidence of the various prehistoric cultures and settlements, and the use of resources are found almost all along the coasts of Greenland. Around 1500 archaeological sites have been recorded close to the coast between 62º N and 68º N – app. 700 km in direct line. In the present context 'sites' are defined as any evidence of prehistoric and historic man's activities that are protected by the Greenland Conservation Act.

The multiple Inuit migrations into Greenland seem to have taken place via Ellesmere Island and Smith Sound to the Thule (Avanersuaq) area. About 1000 AD, Icelandic farmers settled in South Greenland and with Hans Egede's establishment of the mission Håbets Koloni in 1771 (the predecessor of present day Nuuk), the founding stone for the development of modern Greenland was laid.

The environment along the mapped coastline is highly diverse. These varying conditions provide very different possibilities for human settlement and patterns of use depending on the particular groups, traditions and cultural preconditions.

While the outer coastal areas and the mouth of the large productive fjords provided the survival basis of the early Inuit hunting societies, the relatively mild (in terms of climate) and fertile areas along the fjords in south Greenland were the prerequisite for the existence of Norse farms during several centuries. The Thule-people migrated from Canada into Greenland around AD 1300 and constitute the direct ancestors of the present day Inuit of Greenland. The earliest Thule-people, who were primarily whale hunters, were far more mobile than the earlier Inuit inhabitants of Greenland. Soon after their arrival to Greenland their activities encompassed all of Greenlands west coast and the majority of the east coast. The complex settlement-patterns of the Thule-people, the historic Inuit and their predecessors are reflected in the archaeological record and their distribution can be seen on the shoreline sensitivity maps.

14.5.2 Included information

All known prehistoric and historic sites are included in the Atlas's database. However, in order to protect the sites, only the most basic information's are given.

In case of a marine oil spill threatening the coast further information on the sites are available through contact with either the Greenland National Museum or the Greenland Secretariat, at the Danish National Museum.

The Conservation Act

All human made relic's more than 100 years old are protected according to Landstingslov nr. 5/1980 af 16 oktober 1980 om fredning af jordfaste fortidsminder og bygninger (The Conservation

Act). The Greenland National Museum & Archives manage the legislation and is responsible for recording the sites concerned.

14.5.3 Description of the data

History
Since 1981 the Greenland National Museum & Archives has been responsible for recording and protecting prehistoric sites. Prior to 1981, this was the responsibility of the Danish National Museum, which holds information on prehistoric sites gathered over more than a 100 years. These extensive materials form the basis of a database of prehistoric and historic sites that is presently under construction in Copenhagen. The database will be complete early in 2001 after which all information will be repatriated to Greenland, where the Greenland National Museum & Archives will become responsible for updating the database as known sites are re-visited and new sites found.

The oldest reports of prehistoric sites are from the 18th Century, when the Danish colonialists and various missionaries entered Greenland. The early missionaries were pre-occupied with the faith of the Norsemen and searched out the ruins of their farms. Through the 19th Century vast amounts of material on the Norse settlement history was reported to Copenhagen. Interest in the history of Greenland's indigenous people only arose after about 1900 AD. Systematic archaeological investigations of Inuit prehistory have only been conducted since the 1930'ies.

The basic information
Far from all the sites reported have been investigated by professionals, and the information on these sites are often few. Such sites are included in the present database if sufficient data on their geographical position are available. Until the middle of the 20th Century, archaeologists based a large part of their records of archaeological sites on information derived from local informants and, given the limited resources available to archaeological research in Greenland, a limited number of these sites have subsequently been inspected by archaeologist. The quality of the information in the present Atlas is off course influenced by this restriction.

The data quality
Most of the information derived from secondary sources (i.e. local informants) is to be considered deficient. Basic information on the number and nature of features found at a given site, on their proximity to the coastline, and their state of preservation are often not reported. These defects/deficiencies are of crucial importance in assessing sensitivity values of the sites. The data foundation with respect to sites recorded in more recent times, mainly after 1981, usually contains the necessary information, however, only few of the sites have been subject to actual archaeological investigations. The degree of sensitivity attributed to each site is therefore based on an estimate. The principles behind these estimates are reviewed in the section 'Ranking the prehistoric and historic sites'.

Geographical coverage
Beside the geographical features, a number of other factors must be considered when evaluating the settlement patterns. Each of the sub-areas (municipalities) concerned are commented upon in the following:

Narsaq municipality forms the central part of the Norse 'Østerbygd' and has been subject to extensive archaeological investigations for more than 100 years. The latest surveys in the area were carried out in the 1990'ies. (This municipality is outside the area covered by the Atlas).
Paamiut municipality. The local Museum conducted systematic surveys of the entire area in 1990. The material from the area must be considered representative of the area even though new sites are expected to appear in the coming years.

Nuuk municipality. The southern part of the area - from Frederikshåb Isblink to the entrance of Buksefjorden - are largely uncovered by archaeological surveys. The majority of the information on the area are based on secondary sources. Extensive surveying and excavations has been conducted in the vast landscapes surrounding the fjords of Nuuk form the central part of the Norse 'Vesterbygd' over the last 50 years.
Maniitsoq municipality. Sporadic investigations have been conducted in a few selected areas. From historic sources it is known that the area was densely settled, at least during the last 300 years. In recent years archaeological surveys have confirmed the historical sources, however, materials from the surveys have not been reported and do not form part of the present database.
Sisimiut municipality is characterised by a strong emphasis on the Paleo-eskimo sites. The archaeological coverage of the municipality is therefore not representative as information on Neo-eskimo sites are often limited.
Kangaatsiaq municipality is archaeologically the least known area in Greenland. The majority of the information available is derived from secondary sources.

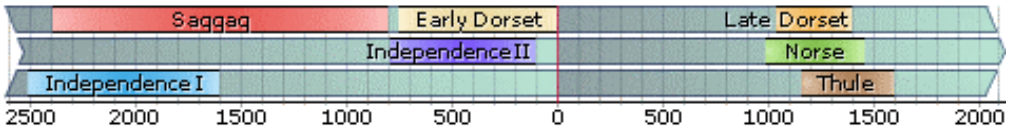
Key to the classification and terms used in the database

Identification:

Idnr.	ID to the individual records in the Greenland Conservation Database
Fmnr.	Each archaeological site recorded in the Greenland Conservation database is assigned a Conservation-number. All man made relics dated prior to 1900 AD are covered by the Conservation Act. When information on new finds are received a new Conservation-number is assigned and registered in the Greenland Conservation Database.

Dating:

Culture-historical periods	In the Greenland Conservation Database each site is described in terms of from which culture-historical periods the individual features originate and were used.
Inuit	The designation of each of the Inuit culture-historical periods and the time span they cover can be seen from the scheme presented below. Reference is made to the lowest possible level in the culture-historical hierarchy.



The Paleo-eskimo period includes the period from the earliest cultural remains in Greenland to 'late Dorset'. The concept 'Neo-eskimo' covers the period from the beginning of 'Thule' to AD 1900.

Norsemen	From Erik the Red's land taking to the collapse of the Norse society - approx. AD 985 - 1350.
Whalers	Sites of European origin dating between AD 1350 - 1721.

The Colonial period	AD 1721 - 1900.
Recent	All sites younger than 1900 AD. If features of recent origin are found on the archaeological sites they are recorded in the Greenland Conservation database, even though they are not covered by the Preservation legislation. Features of European and Inuit origin are not separated.

Site types: The designations shown in the table below are used in the Greenland Conservation Database. Further information on the individual features are recorded when known:

Settlement,
- summer
- winter
- other season
- assembling camp

Camp for capelin-fishery
Sea-hunting camp
Musk-ox hunting camp
Base camp
Overnight camp
Caribou hunting camp
Camp for arctic char fishing
Gravesite or graveyard
Hunting system
Cache
Mineral utilisation,
- pit or exposed mineral
- mine

Cairn

Norse farm
Isolated Norse building
Isolated Norse structure

Town
Village
Expedition base camp
Hunting station
Fishery station
Sheep farm
Trading post
Mission station
Wintering camp
Recent camp site
Train-oil production

Other
Indeterminable structure

14.5.4 Ranking the archaeological and historic sites

General assessment
The majority of the coastal Inuit settlements are established close to the sea, usually immediately above the high tide mark. Therefore the sites are extremely vulnerable in case of a marine oil spill. They can be considered;

- directly vulnerable, due to the decrease in the sites scientific value, i.e. the high probability of a decrease in the organic preservation conditions and the disruption of the possibility of conducting scientific analyses (among others Carbon 14 datings).
- indirectly vulnerable, because contingency activities are likely to result in considerable physical damages on ruins and soil layers containing the various relics of the past.

The majority of the recorded sites are difficult to discern, even for professionals. The vulnerability assessment is therefore to be considered consultative. In case of an oil spill it is therefore a prerequisite that archaeological expertise is involved in both the planning of the alert, as well as in the practical execution of the plans.

Criteria used in assessing sensitivity values
The sensitivity to oil spills of archaeological interests are expressed on a scale from 1 to 3 for each site:

1 - Sites unlikely to be directly or indirectly vulnerable to marine oil spills. In total 375 sites.

2 - Sites that are either directly or indirectly vulnerable to marine oil spills. In total 883 sites.

3 - Sites of significant importance, directly or indirectly vulnerable to marine oil spills, and demanding special measures taken in case of an oil spill. In total 96 sites.

#1 includes sites that are located more than 20 meters above sea level or are located inland. This group also includes sites of minimal historical or scientific importance, due to bad state of preservation.
#2 includes all sites close to the coastline that are presumed to represent value either as a historical source, as a recreational site, or is of special historical significance.
#3 comply with the criterions of #2 and is of special value, mainly from a scientific point of view. The evaluation leading to a site being included in # 3 is often a direct result of archaeological investigations having been performed at the site or historical information that can directly be tied to the site. Furthermore, sites of special importance to local people or the broader public are placed within this group.

The Assigned Value for archaeological sites for each shoreline area has been calculated by assigning a value to each site based on the three sensitivity categories above (0 to #1, 3 to #2 and 5 to #3), and add up the values for the sites on each of the 279 shoreline areas. These scores have then been used to set the Assigned Values within the range from 0 to 5 for each shoreline area based on the following:

Scores below 1	0
Scores from 1 to 9	1
Scores from 10 to 25	3
Scores above 25	5