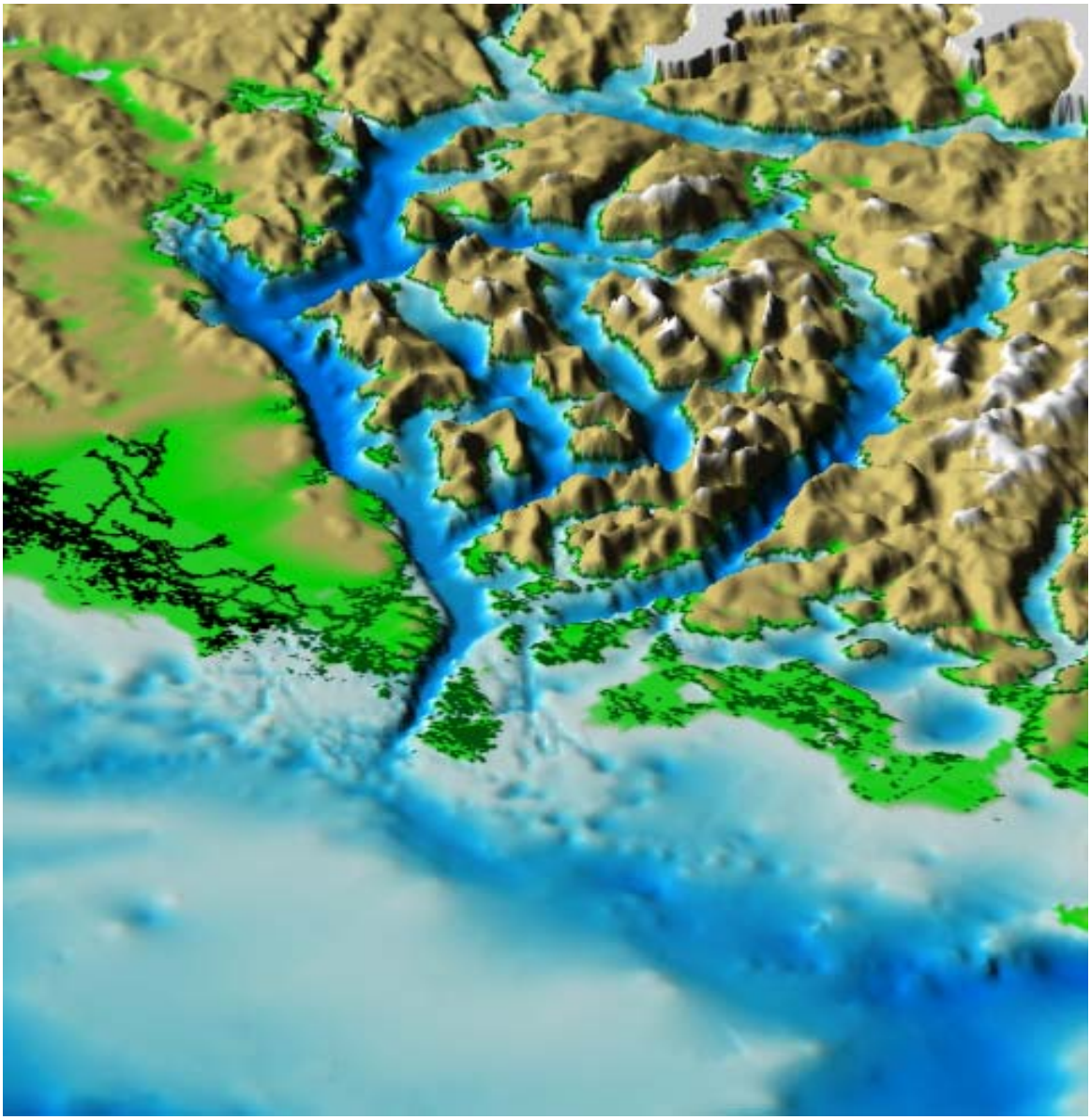
MarineBasicNuuk

The Nuuk Marine Monitoring Program



Sampling manual for the field program

MarineBasicNuuk
2008
3rd edition
By: Søren Rysgaard, Morten Frederiksen, Ditte Marie Mikkelsen, Thomas Juul-Pedersen, Kristine Arendt, Dorte Krause-Jensen, Martin Blicher & Mikael Sejr.

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3900 Nuuk
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Front cover illustration

BATHYMETRY IN THE GODTHÅB FJORD ENTRANCE.

Introduction

A long-term monitoring program, NuukBasic, monitors the area around Nuuk, West Greenland. NuukBasic aims at an increased understanding of low-arctic ecosystems and consists of five components – BioBasic, ClimateBasic, MarineBasic, GeoBasic and GlacioBasic. The program supplements a similar program in the high Arctic, ZackenbergBasic, which has been running in North East Greenland for a decade.

MarineBasicNuuk is carried out by “Center of Marine Ecology and Climate Effects” at Greenland Institute of Natural Resources. The program is funded by the Danish Environmental Protection Agency and the Greenland Institute of Natural Resources. The objective of the program is to establish long-term data series of key parameters in the marine environment. The program will contribute to an increased understanding of the coupling between physical parameters (i.e. temperature, currents, precipitation) and biological processes (i.e. primary production, grazing, food web composition). The program was initiated in August 2005.

MarineBasicNuuk consists of pelagic sampling at “hovedstationen” (64°07’N, 51°53’W) in Godthåbsfjorden, benthic sampling in Kobbefjord (64°9.9’N, 51°28’W), investigations of benthic flora and fauna, sea ice monitoring as well as two annual oceanographic sections. In addition, monitoring of a) fish, crab and shrimp larvae and b) marine mammals and seabirds are carried out. Additional studies will supplement the program; these components will vary from year to year.

This manual describes the sampling procedures of the regular sampling as well as the additional studies in 2008. Laboratory analyses are briefly outlined - an exhaustive description can be found in the MarineBasicNuuk Laboratory Manual (in Danish).

Dates and times are in GMT
Geographic positions are in WGS-84 DD MM.MM (degrees, minutes, decimal minutes)Date format for files are YYYY_MM_DD

1. Regular sampling

1.1 Pelagic sampling

1.1.1 Light, temperature, salinity, nutrients (NO_3^-, PO_4^{3-} & SiO_4), pH, DIC, total alkalinity, primary production, plankton composition and chlorophyll *a*:

Position: "Hovedstationen", 64°07'N, 51°53'W – depth c. 350 m.

Sampling outline: - Profile obtained with SBE19plus.
- Water samples obtained with Niskin water sampler - 1, 5, 10, 15, 20, 30, 40, 50, 100, 150, 250 and 300 m water depth.
- Triplicate hauls with 20-µm plankton net and 45-µm WP2 plankton net.

Temporal resolution: c. monthly

Procedure:

Temperature, light, salinity, turbidity, fluorescence: Ensure that the SBE19plus is calibrated for use in the area. Leave the device suspended in surface water for minimum 5 minutes before profile measurement (0-300 m).

Primary production: Triplicate (120ml) water samples from 5 , 10 , 20 , 30 and 40 m are filled onto Winkler bottles and added 200µl $H^{14}CO_3^-$. 2 bottles are incubated under *in situ* light conditions and 1 bottle in dark for 2 hours at the *in situ* depth. The incubation is stopped by adding 100 µl 5 % $ZnCl_2$. The content of each bottle is GF/C filtered (max 0.3 bar). The filters are transferred to scintillation vials and 100 µl 1 M HCL added onto the filters. The vials are frozen. Analysis is done by adding scintillation cocktail (UltimaGold+) and measuring the samples on a PerkinElmer Scintillation Counter.

DIC/alkalinity: 120 ml from the surface water (1m) and primary production depths are stored in Winkler bottles (transferred with overflow) and preserved with $HgCl_2$ (saturated solution) to a final concentration of 0.02%. Samples are stored at 4°C and analyzed on a coulometer.

Nutrients: Four GF/C filtered water samples (c. 10 ml) from each sampling depth are frozen (-18°C) for later nutrient analysis. Phosphate and silicate are measured using standard spectrophotometric methods, while NO_x (nitrate+nitrite) is measured by vanadium chloride reduction.

Chlorophyll *a*
Samples for chlorophyll *a* determination are GF/C filtered (max 0.3 bar) and the filter is placed in 10 ml 96% ethanol. Samples are stored frozen (-18°C) until analysis on a Turner TD-700 Fluorometer.

Planktonic composition:
300 ml from each sampling depth is saved in an amber glass bottle and preserved with lugol to a final concentration of 1%.
Algae – Triplicate vertical hauls are taken from 60m to surface with a 20-µm net and preserved with lugol to a final concentration of 1% in amber glass bottles.
Zooplankton – Triplicate vertical hauls are taken from 100m to surface with a 45-µm modified WP-2 net and preserved with borax-buffered formalin (final conc. 4 %) in 300-ml polyethylene container with double lid.
Plankton samples are analyzed at the Arctic Agency in Poland.

Equipment: SBE19plus
Niskin water sampler and weight messenger
11 Plastic bottles (5 litre, screw-cap)
Funnel
11 gas tight glass vials (Winkler type) for DIC/alkalinity
15 gas tight glass vials (Winkler type) for primary production
Primary production: Winkler holder, robe and float
11 amber glass bottles (300-ml) for plankton composition
Plankton net (20-µm) and weight
100 ml amber glass bottles for phytoplankton and DOM
WP2-net (and weight), propeller and 1 cod end
Polyethylene containers with double lid
Filtering equipment
5 % $HgCl_2$ (saturated)
5 % $ZnCl_2$
Borax-buffered formalin
Lugol
$H^{14}CO_3^-$

1.1.2. Vertical sinking flux of total matter, organic matter, carbonate, chlorophyll *a*, carbon and nitrogen.

Position: "Hovedstationen", 64°07'N, 51°53'W – depth c. 350 m.

Sampling outline: Double sediment traps are filled with GF/C filtered water (adjusted to 40psu). The traps are lowered to 60 and 65 m and left for c. 2 hours. After recovery, the sediment traps are collected, closed with a lid and brought back to the lab.

Temporal resolution: c. monthly

Procedure:

One sediment trap is left at 4°C for 24 hours and the sedimented material is preserved with lugol to a final concentration of 1 %.
One sediment trap is GF/C filtered (max 0.3 bar) for fluorometric determination of chlorophyll *a* concentration.
Two sediment traps are GF/C filtered on pre-combusted pre-weighed filters, and dried at 60°C for 24 hours. Zooplankton "swimmers" are removed from filters prior to drying. The filters are weighed and stored in a desiccator until analysis of $CaCO_3$, PON, POC and TC.

Total carbon (TC) is determined on an elemental analyzer. POC and PON content is obtained by analysis of decalcified samples - decalcification is achieved by H_2SO_3 treatment and heating to 80°C. The $CaCO_3$ content is calculated as TC – POC. Stable isotopic composition of the decalcified samples is analyzed on a mass spectrometer.

Equipment: Sediment traps with lids, floater and rope, NaCl, GF/C filtered seawater and filtering equipment.

1.2 Sediment

1.2.1 Oxygen, dissolved inorganic carbon (DIC) and nutrient exchange between water column and sediment.

Geographic position: Kobbefjord. “Mudder”, 64°9.9’N, 51°28’W - depth 120 m.

Sampling outline: 6-7 sediment cores are collected (minimum 10 cm sediment) with a kajak sampler. 25 litres of bottom water is collected with a Niskin water sampler.

Temporal resolution: Two times per year (winter and summer).

Procedure: Cores are placed in an incubator at *in situ* temperature. Each core is aerated and equipped with a 3-cm Teflon-coated stirring magnet placed 5 cm above the sediment surface (60 rpm.) and *in situ* bottom water. The cores are left over night.

Initial nutrient samples are taken with a plastic syringe (NO_3^-, NH_4^+, PO_4^{3-} & SiO_4 and an extra) and frozen (-18°) for later analysis. Initial O_2 and DIC samples are taken with a glass syringe, and transferred to exetainer vials - oxygen samples are added Winkler reagents I+II, while DIC samples are added 50 µl $HgCl_2$ (saturated 5% solution). Remember to measure water column height in the cores.
Incubation is started by sealing the cores. Incubate for approximately 24 hours. Sediment cores are processed (as described below) at 7-8 different times during the 24 hour incubation period, documenting linear concentration changes.
Incubation of each core is ended by carefully removing a floating lid from the core and taking samples for oxygen, DIC and nutrients as described above. Three cores are kept for profiling (see section 1.2.2).

Equipment:

Kajak sediment sampler	20-ml glass syringe
Niskin water sampler + weight messenger	Filter holder (Swinex)
1 25-l water bottle	25 GF/C filters ø 25 mm
10 kajak tubes + stoppers	250 plastic test tubes (10 ml)
10 teflon-coated magnets + positioners	50 Exetainers for DIC and O_2
Incubator + stirrer	Winkler reagents I+II
Aquatic pump	10-ml beakers for titration
Rubber stoppers + floating lid	Small stir bars for titration
Tubing	Microburette
Airstone	Phosphorous acid 85%
Tweezers	Pipettes + tips
100-ml plastic syringe	Starch

1.2.2 Vertical sediment oxygen profiles.

Geographic position: Kobbefjord. “Mudder”, 64°9.9’N, 51°28’W - depth 120 m.

Sampling outline: Three of the cores described in section 1.2.1 are used for measurement of oxygen profiles.

Temporal resolution: Two times per year (winter and summer).

Procedure: Clarke-type microelectrodes with internal reference and guard cathode, measuring diameter <10 µm and a 90% response time <1 s are used for measuring the distribution of oxygen in the upper sediment layers. The electrode is positioned by a motorized micromanipulator connected to an A/D converter, which transmits the signal to a PC. Profiles are measured at a resolution of 200-500 µm steps in the dark.

Three profiles in each of the three sediment cores are measured during stirring (air-flow over 2 cm water cover of sediment) at *in situ* temperature and oxygen conditions.

One sediment core is used for determination of porosity and density.

Equipment: Oxygen electrode mounting system and electrodes

1.2.3 Carbon burial in the sediment.

Geographic position: Kobbefjord. “Mudder”, 64°9.9’N, 51°28’W - depth 120 m.

Sampling outline: One undisturbed sediment core (at least 20 cm long) is collected with a kajak sediment sampler. The core is sliced for further analysis.

Temporal resolution: C. every five years

Procedure: Aspirate the water overlying the sediment (except for a 1-mm film of water) and store the cores at *in situ* temperature.

Section the sediment cores into 1-cm slices, transfer the slices to separate plastic bags (zip-lock type) and freeze (-18°C) for later analysis of Pb-210, Cs-137 and C and N. (NOTE: avoid contact with silver).

Equipment: Core sectioning system
Kajak sediment sampler and tubes
Zip-lock bags

1.3 Sections – measurements of salinity, temperature, fluorescence etc.

1.3.1 Length section from Fyllas Bank to the bottom of Godthåbsfjorden.

Geographic position:

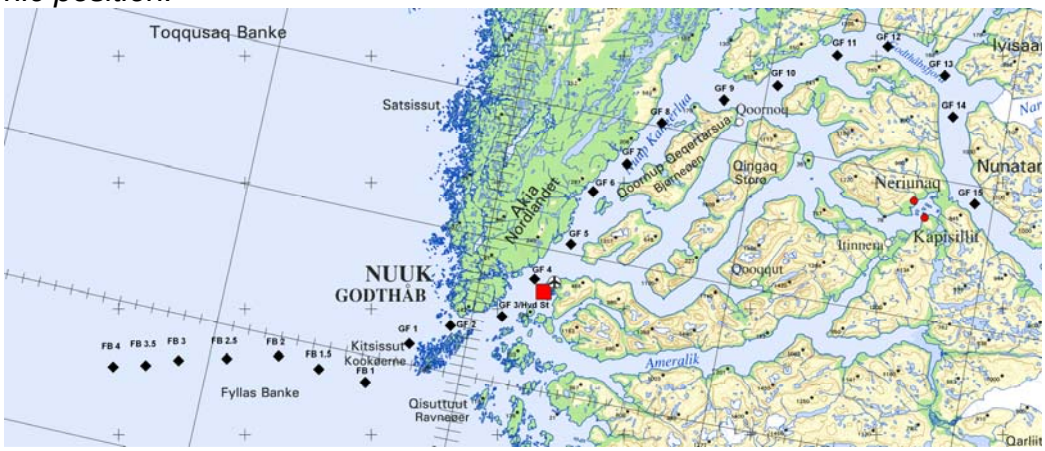


Figure 1: Length section

Station ID number	DEPTH (m)	LATITUDE	LONGITUDE
FB 4	956	63°53	53°22
FB 3.5	220	63°53.9	53°14.7
FB 3	72	63°55	53°07
FB 2.5	63	63°56.4	52°55.9
FB 2	47	63°58	52°44
FB 1.5	102	63°56.6	52°26.9
FB 1	273	63°57	52°22
GF 1	330	64°03.2	52°10.9
GF 2	391	64°04.8	52°04.2
GF 3/ Hovedstationen	350	64°07	51°53
GF 4	400	64°11.5	51°46.8
GF 5	357	64°16	51°40
GF 6	630	64°22	51°37.4
GF 7	626	64°25.5	51°30.6
GF 8	624	64°30.5	51°24.0
GF 9	602	64°34.0	51°10.0
GF 10	579	64°36.6	50°57.5
GF 11	552	64°41.0	50°44.4
GF 12	531	64°42.9	50°32.8
GF 13	476	64°40.8	50°17.3
GF 14	453	64°36.8	50°13.5

Sampling outline: SBE19plus profiles are obtained at up to 22 stations on a length section from the outer bank to the fjord bottom. Water samples for salinity and chlorophyll *a* calibration are obtained. Triplicate bongo hauls are obtained at four stations (section 2.3).

Temporal resolution: Annually (in May)

Equipment: SBE19plus, Portasol bottles, chl *a* filtering equipment

1.3.2 Additional scientific studies on length section 2008

Geographic position: See section 1.3.1

Sampling outline: Water samples for DIC/TA are obtained at 1 m at all sampling stations.

Temporal resolution: Annually (in May)

1.3.3 Transverse transect

Geographic position:

Figure 2: transect across Godthåbsfjorden

ID #	DEPTH (m)	LATITUDE	LONGITUDE
GFTT01	80	64°10,769' N	51°45,477' W
GFTT02	270	64°10,868' N	51°46,789' W
GFTT03	250	64°11,013' N	51°47,806' W
GFTT04	217	64°11,191' N	51°48,693' W
GFTT05	80	64°11,349' N	51°49,374' W
GFTT06	45	64°11,445' N	51°50,172' W

Sampling outline: SBE19plus profiles are obtained at six stations along section.

Temporal resolution: Annually

Equipment: SBE19plus

1.4 Sea ice monitoring

1.4.1 Satellite data

Geographic position: The entire fjord system

Sampling outline: Satellite images of Godthåbsfjorden are obtained (in collaboration with Leif Toudal, DMI)

Temporal resolution: Daily / twice daily

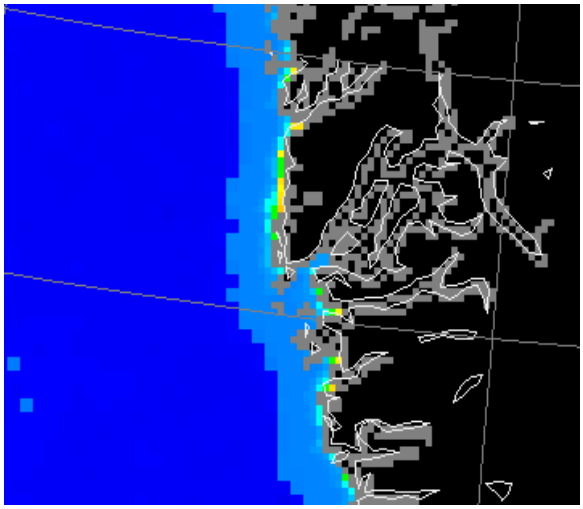
MarineBasicNuuk obtains two types of satellite images:

1. TERRA og AQUA-MODIS (Visible og Infrared images). Resolution: 250-1000m. Daily. Cannot see through clouds
2. AQUA AMSR-E (Microwaveradiometer/mikrobølgeradiometer). Resolution: 3-6 km. Twice daily.

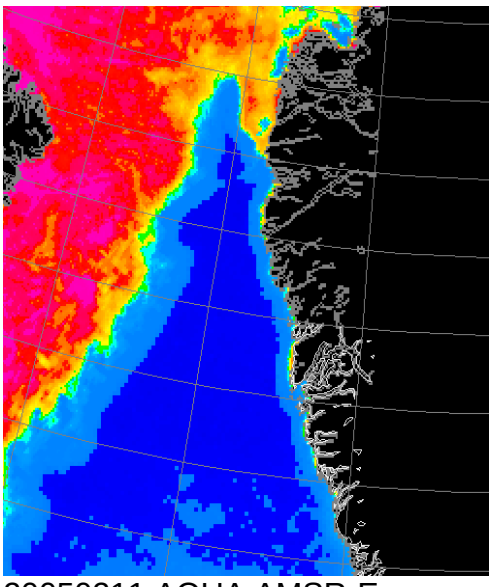
Examples:

20050227 MODIS

20050702 MODIS



20051011 AQUA AMSR-E



20050211 AQUA AMSR-E

1.4.2 Digital camera

Geographic position: Greenland Institute of Natural Resources

Sampling outline: A digital camera has been placed overlooking Nuuk Fjord. The camera points towards North, and acquires an image every three hours. Images are downloaded every two weeks.

Temporal resolution: Every three hours

Examples:

Figure 3: view of the Godthåbsfjord

1.5 Benthic fauna and flora

1.5.1 Composition and distribution of indicator species – benthic fauna.

Geographic positions: N 64º 07.651' W51º 38.587', 50-60 m depth

Temporal Resolution: Annually (in May)

Sampling outline: The following is collected by dredge and frozen until analysis:

	Gonads	Condition	Growth
C. islandica	30 ind. > 60 mm	30 ind. 40-60 mm	50 ind. 35-45 mm
S. droebachiensis	30 ind. > 50 mm	30 ind. 40-50 mm	

Procedure:

C. islandica:

1. Shell height, total wet weight (including shell) is noted
2. Dissect soft parts into gonad, adductor muscle and "rest"
3. Measure wet weight of shell, gonad, muscle and "rest"
4. Dry at 60°C for 24 hours. Record dry weights for gonad, muscle, "rest" and shell
5. Burn at 550 °C for 12 hours. Record weights again for gonad, muscle and "rest". Calculate ash free dry weights.
6. Determine age for appropriate size group by counting increments in the hinge region

S. droebachiensis

1. Measure shell diameter and total wet weight
2. Dissect animal into gonads, shell and "rest" and determine wet weight
3. Determine dry weight for test and gonads dry weight and Ash free dry weight.
4. Dry at 60°C for 24 hours and burn at 550°C for 12 hours

Equipment: KC dredge, caliper, buckets and plastic bags

1.5.3 Measurement of annual growth of *Laminaria longicruris*

Geographic positions:
Kobbefjord – protected bay: 5-10 m depth, c. position 64° 08 408' N, 51° 35 158' E
Kobbefjord – exposed site: 5-10 m depth, c. position 64° 07 908' N, 51° 35 074' E

Sampling outline: 10-20 *Laminaria longicruris (*because *Saccharina latissima* is absent*)* with blades >1 m long are collected and their growth is determined

Procedure:

(1) Laminaria plants (10-20) are collected with a KC plant rake.

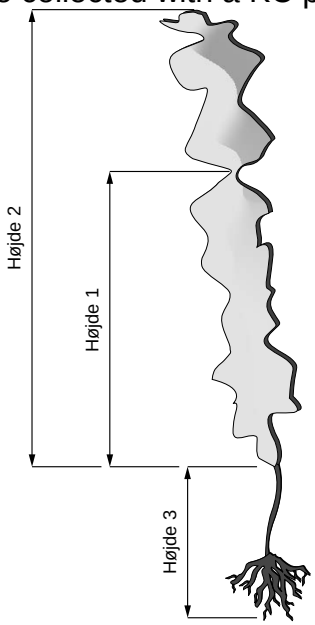


Figure 4: schematic presentation of L. longicruris

(2) Plant length (cf. Fig 4) is determined using a tape measure to the nearest 5 mm. “Height 1” is the length from blade base to the first marked constriction. “Height 2” is the total blade length, and “Height 3” is the length of the stipe plus the haptera.

(3) Weigh the wet weight of (a) the blade section corresponding to “Height 1” and (b) the blade section corresponding to “Height 2 minus Height 1” and (c) the stipe plus the haptera.

(4) Roll up the “Height 1” and freeze entire blade (-18°C) in separate plastic bags until later analysis of dry matter and carbon and nitrogen content.
- Alternatively cut a 5 cm cross section of the fresh blade (Height 1) at ¼ of the blade length, at the middle of the blade, and at 3/4 of the blade length. Pool the three 5-cm cross sections, weigh them and freeze them until later analysis of dry matter and carbon and nitrogen content. (As the edge of the blade is wavy, cross sections of 5 cm width in the central blade become broader and fan-shaped towards the edges). Throw the remaining blade.

(5) Drying procedure: In case the entire blade was frozen: unroll it and cut 5 cm cross sections as described above Pool the three 5-cm cross sections and dry them as well as the rest of the blade to constant weight in an oven at 60°C. Weigh the dry weight of (a) the 3 cross sections of the blade and (b) the rest of the blade. Their sum gives the dry weight of “Height 1”
- In case only the cross sections were frozen: Dry them to constant weight in an oven at 60°C. Determine the dry weight. Calculate the dryweight/wetweight ratio and assess dry weight of “Height 1” by multiplying the wet weight of Height 1 with the dryweight/wetweight ratio.

(6) Pulverise/grind the pooled 3 cross sections of the blade and analyse the C and N content using an elemental analyser.

Equipment: KC plant rake, plastic bags, tape measure, scales.

1.6 Monitoring of colony-breeding seabirds in the vicinity of Nuuk.

The overall objective of the seabird monitoring program in association with MarineBasic is to monitor long-term changes in seabird breeding numbers in relation to changes in both biological and non-biological parameters. The seabird monitoring programme includes a high diversity of species with a variety of life strategies, such as foraging strategy, foraging distances, vulnerability to predators etc. which may all response differently to long-term changes. The relative importance of different prey species (fish larvae, zooplankton and fish) will furthermore differ significantly within the seabird species included in the programme.

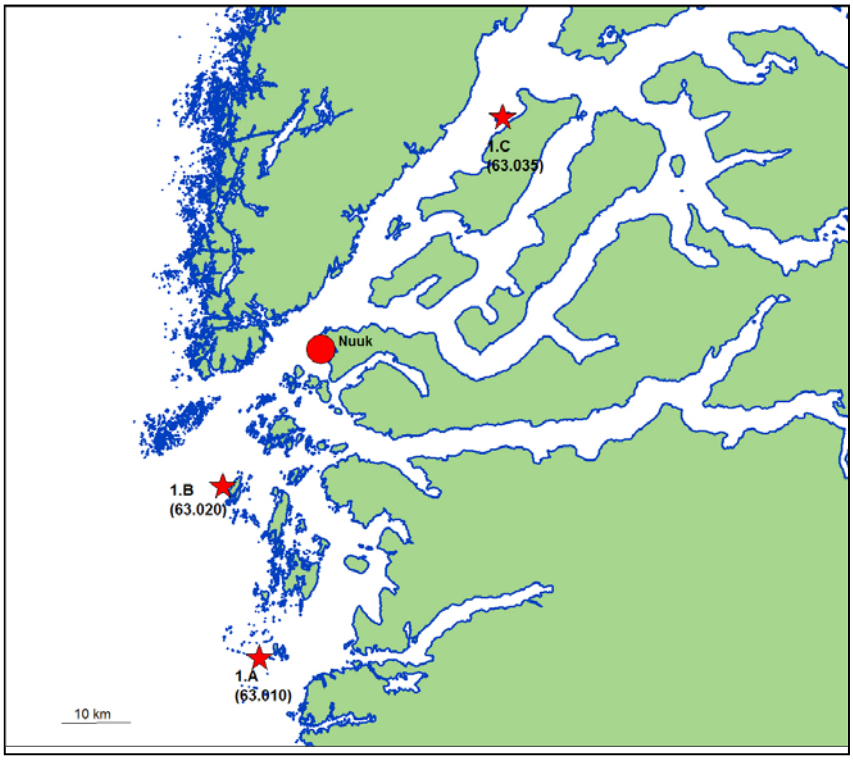


Figure 5: Seabird monitoring sites.

1.6A Brünnich's guillemots at Nunngarussut

Geographic position: 63° 45' N; 51° 43' W, (seabird database no. 63.010)

Sampling outline: Direct count from boat of breeding birds on the north facing steep cliffs.

Temporal resolution: Annually – one full day in the field during the early chick-rearing period (15-25 July).

The objective is to monitor the long-term population changes of a deep-diving, fish-eating seabird, the Brünnich's guillemot (*Uria lomvia*).

Equipment: Binoculars, handheld GPS, maps, notebook, "click-counter"

1.6B Atlantic puffin at Qissuttuut (ravneøerne)

Geographic position: 63° 58' N; 51° 54' W, (seabird database no. 63.020)

Sampling outline: Counts of the nest cavities at Ravneøerne during late chick-rearing or post-fledging (primo-medio August) on land. The count is conducted as a "total count" by walking amongst the nest holes in the colony. Active nest cavities from the current year are defined by the amount of excreta at the entrance of the nest hole.

Temporal resolution: If time permits, one full day (primo-medio August) every year.

The objective is to monitor the long-term population changes of a medium-depth-diving, fish-eating seabird, the puffin (*Fratercula arctica*).

Equipment: Binoculars, handheld GPS, maps, notebook, "click-counter"

1.6C Surface feeding seabirds at Qeqertannguit

Geographic position: 64° 30' N; 51° 19' W, (seabird database no. 63.035)

Temporal resolution: One annual count – three full days.

Sampling outline: Direct counts from boat of kittiwake and Iceland gull is recommended whereas lesser- and great black-backed and glaucous gull should be counting using a combination of sea and land-based counts. The remaining breeding species on Qeqertannguit is easiest counted from land.
The counts should be conducted during late incubating period (ult. June) and three full days is needed in the field to cover all species (not including black guillemot).

The objective is to monitor the long-term population changes of surface feeding seabird species in Godthåbfjorden. Qeqertannguit hold the largest diversity of breeding seabirds in Nuuk District. All breeding seabird species on Qeqertannguit could in principle be included in the monitoring programme but kittiwake (*Rissa tridactyla*), Iceland gull (*Larus glaucoides*), Arctic tern (*Sterna paradisaea*) and lesser black-backed gull (*L. fuscus*) should be given a high priority. Great black-backed gull (*L. marinus*), glaucous gull (*L. hyperboreus*) is also very relevant to include in the monitoring programme whereas black guillemot (*Cepphus grylle*) – a benthic feeding alcid is logistic difficult to work with and only occasionally counts should be conducted. Other species, such as Arctic skua (*Stercorarius parasiticus*) and red-breasted merganser (*Mergus serrator*), breed in low numbers at the island but should be included as these are easy to record.

Equipment: Binoculars, handheld GPS, maps, notebook, "click-counter", spotting scope.

1.7 Monitoring of marine mammals

1.7.1 Humpback whales

Geographic position: Nuuk: 64° 11’ 10,19” N, 51° 43’57,07 W

Sampling outline: Observations of marine mammals is performed in periods of 20 minutes. The time between blows, as well as the position and angle of the diving whale (measured by theodolite) is noted.

Equipment: Theodolite

1.8 Monitoring of juvenile fish egg and larvae

Geographic position: Positions FB3.5, FB2.5, GF3 and GF10 on the length transect (see section 1.3.1)
Sampling at the marin station (GF3) throughout the year.

Sampling outline: Triplicate hauls are obtained with a bongonet (0.35 and 0.5 mm), fitted with a flowmeter and scanmar depth sensor. Samples are preserved in formalin for later taxanomic analysis.

Sampling performed in order to better understand the dynamics between the inshore and offshore larval distribution as well as the seasonal dynamics. Main focus is on cod (*Gadus morhua*), Greenland halibut (*Reinhardtius hippoglossoides*) and capelin (*Mallotus villosus*).

Temporal resolution: Annually (in May)

Equipment: bongo net, Scanmar depth sensor, Flowmeter, Airtight containers, formalin