

TECHNICAL REPORT

TUNU-I EXPEDITION

The Fish Fauna of the NE Greenland Fjord Systems

Danmarkshavn (77°N) - Eskimonæs (74°N)
2-16 October 2003

Jørgen Schou Christiansen
(Editor)



R/V "Jan Mayen" in Danmarkshavn



NORDIC ARCTIC
RESEARCH
PROGRAMME

25 November 2003

Foreword

In October 2002, we had a brief opportunity to survey the marine fish fauna in two selected fjords - i.e. Dove Bugt (77° N) and Godthåb Golf (74° N) - in NE Greenland (Haug et al. 2002). Given the warming trends reported for the Arctic region in recent years, studies of the fish fauna in the fjords and coastal waters of East Greenland pose an unprecedented challenge to Arctic marine biological research. Hence, the "TUNU-Programme" was coined and the ice-strengthened R/V "Jan Mayen" at the University of Tromsø constituted the operational base for the "TUNU-I Expedition".

The term "TUNU" is not another scientific acronym but the Inuit word for "the land at the back" or - in the modern Greenlandic language - East Greenland. The term "Expedition" is used instead of the more prosaic "cruise" since we wish to underline that little or no marine investigations have been conducted in these pristine areas. The Roman numeral marks that this is the first of more planned expeditions.

The TUNU-I Expedition 2003 was a success and included students and scientists mainly from the Nordic countries - Norway, Denmark, Iceland, and Greenland – but also colleagues from Italy and Russia. Although forthcoming TUNU-Expeditions intend to hold the same core of participants there will be room for other colleagues interested in polar marine biology. Importantly, one or two places are reserved for students and scientists from Greenland.

The TUNU-Expeditions form an ideal framework for network-building amongst Nordic and international students and scientist. To continue and complete the programme, we will have to rely on funding from e.g. Nordic research agencies.

Acknowledgements

We thank Namminersornerullutik Oqartussat – Grønlands Hjemmestyre (website: <http://dk.nanoq.gl/enhed.asp?page=enhed&objno=522>), Pinngortitaleriffik - Grønlands Naturinstitut (website: <http://www.natur.gl/>), Dansk Polarcenter (website: <http://www.dpc.dk/>), the crews in Danmarkshavn (e-mail: danmarkshavn@eikmail.com) and Daneborg (e-mail: sirius@web-sat.com), Kort- og Matrikelstyrelsen (website: <http://www.kms.dk/>), Adm. Head of Research Vessels Jon Einar Hansen, and the crew onboard the R/V "Jan Mayen" (website: <http://www.nfh.uit.no/>) for their contribution. Part of the TUNU-I Expedition was kindly supported by NARP - project no.: 56-003 (website: <http://thule.oulu.fi/narp/>).

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Participants and other parties are kindly requested to adhere to the following two guidelines:

- 1) Any communication, publication or any other use of material derived or obtained from the TUNU-I Expedition should be acknowledged:

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- 2) Any use of photographs included in this report should be acknowledged:

*Henrik Schurmann, Eidos Wildlife
(homepage: <http://www.eidoswildlife.com/>)*

Thank you

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Fig. 1. NE Greenland. Area and key stations covered by the TUNU-I Expedition, 2-16 October 2003 (cf. Appendix B1).

1. Introduction

Recent reports demonstrate a marked raise in both air and sea surface temperatures in the Northern Hemisphere and a concomitant decrease in the perennial ice cover of the Arctic Ocean (Comiso 2003, Sturm et al. 2003). The warming trend during the last three decades is evident in Eurasia and North America whereas the climatic situation in Greenland seems more complicated with insignificant changes to the SW and a warming to the N and NE. This corroborates observations from September 2002 along the NE coast of Greenland, where the concentration of sea ice was about 30% lower than the average value for that time of the year (Sturm et al. 2003).

The terrestrial and freshwater environments of NE Greenland have been quite well investigated mainly by Danish scientists and utilised by Norwegian and Danish trappers since the early 1900. This is in marked contrast to the marine ecosystem - and in particular the fish fauna of the fjord systems - which is practically unknown. The sparse knowledge of the fjord and inshore fishes derives mostly from analyses of stomach contents from seals, birds, and the anadromous Arctic charr *Salvelinus alpinus*. A notable exception dates back to "Danmark-Ekspeditionen" (1906-1908) during which an impressive work was carried out by Fritz Johansen in the Dove Bugt area (Johansen 1912). In modern times the Young Sound area (~74°N) – with Zackenberg and Daneborg as the logistical sites – has become a centre for marine research in NE Greenland (e.g. Rysgaard et al. 2003). Still, investigations have focused little on the marine fish fauna.

In the light of the current climatic changes - higher temperatures, less sea ice, and an increase in freshwater discharges into the fjords may have adverse effects on the physiological performance, thermal behaviour (Christiansen et al. 1997), and eventually the distribution range of fishes – fishes which are evolutionary adapted to Arctic conditions (Clarke 2003). Thus, the initiation of the TUNU-Programme is both timely and represents the first attempt to survey the NE Greenland fish fauna on a large scale.

2. Objectives

The following three main points make up the scientific framework of the TUNU-Programme:

1. Conduct a zoogeographical mapping and quantify the marine fish fauna at selected sites along the NE Greenland coast, i.e.:
 - between 77° N (Danmarkshavn) and 70° N (Scoresby Sund) and
 - from the innermost part of the fjords to the continental slope.
2. Gather basic hydrographical data – e.g. depth profiles of temperature, salinity, and density – at the same sites.
3. Revisit and repeat investigations at key stations to obtain data on possible inter-annual changes in fish composition and hydrographical regimes.

The TUNU-Programme is interdisciplinary in the sense that the zoogeographical mapping of fishes is closely linked to genetical, physiological, and hydrographical studies – and multidisciplinary in the sense that a part of the scientific activities is allocated studies of seal physiology and ecology and, in forthcoming expeditions, also benthos (alternatively plankton) communities.

Areas covered by completed (*Fig. 1*) and forthcoming TUNU-Expeditions are given below. Note the overlap in latitudes between expeditions – cf. Objectives, point 3.

TUNU-I (2003)	Danmarkshavn (77° N) – Eskimonæs (74° N)
TUNU-II	Brede Fjord (75° 30' N) – Kong Oscar Fjord (72° N)
TUNU-III	Eskimonæs (74° N) – Scoresby Sund (70° N)
TUNU-IV	Danmarkshavn – Scoresby Sund (key stations)

We attempt to conduct each expedition within a two-week period between medio September and medio October.

3. Participants

The scientists

The names, affiliations and e-mail addresses of the scientific participants are given in Appendix A.



Fig. 2. The participants in front of the bridge. From starboard to port side: John F. Steffensen, Olav K. Nordgård, Kim Præbel, Jørgen Trantum-Jensen, Aili L. Labansen, Jørn Madsen, Guido di Prisco, Donatella de Pascale, Laura Ghigliotti, Trond Thangstad, Oleg V. Karamushko, Snæbjørn Pálsson, Bjørnar Seim, Svein-Erik Fevolden, Henrik Schurmann, and Jørgen S. Christiansen. *Photo: Rune Kismul.*



Fig. 3. A view from the bridge.

The crew

John Almestad (captain), Inge Berg (first mate), Arne Vik (chief engineer), Steven Andresen, Hilbert Eriksen, Bjørnar Karlsen, Rune Kismul, Oddmund Kopperstad, Bjørn Ivar Manin, Geir Bjarne Nygård, and Geir Sørensen.

Unfortunately, we did not manage to gather the crew for a group photo. See also Appendix E.



Fig. 4. "Stirred - not shaken". Bjørnar Karlsen at work.

4. Day by day – a fragmented diary

- Thu. 2 October. Departure Tromsø at 23.10 h (CET).
- Fri. 3 October. Crossing. Permit to kill 20 hooded seals in Greenland waters outside the National Park came via e-mail from Grønlands Hjemmestyre. E-mail correspondence with Danmarkshavn regarding the ice situation.
- Sat. 4 October. Crossing. Rough weather and heavy sea. Little activity.



Fig. 5. "Shaken - not stirred". Crossing the Greenland Sea.

- Sun. 5 October. Offshore. Nice and calm weather. In the open drift ice. First ordinary TUNU-stations and sealing - 11 hooded seals killed (incl. one shot and lost). Many seals (>100) observed on ice floes. Station #884 rich in Poriferas (~12.5 kg ball-shaped specimens, a few preserved in formaldehyde).
- Mon. 6 October. Offshore. Nice and calm weather, some ice bergs. Station E of Store Koldeway (i.e. #1281 from 2002) cancelled due to difficult ice conditions. Ice map ordered from DMI.DK via NCFS (Jon Einar Hansen). Entering the largest National Park in the world (> 1 million km²). Heading for Danmarkshavn S of Store Koldeway via Storbælt. Stations and sealing - 1 hooded seal shot. Station #886 rich in Crinoids (two species) and other Echinoderms, *Sclerocangon* and Amphipods (preserved in formaldehyde).

- Tue. 7 October. Danmarkshavn. Calm weather and light snow. Large thin ice floes. Visit to Danmarkshavn Station - and Danmarks Minde - in the afternoon. Coffee and cakes. Ice map from DMI arrived via fax. Revisited stations from 2002 (i.e. #1287 and #1289). Many juvenile *Arctogadus* and *Boreogadus* at station #887 (cf. # 1287). Oviferous *Sclerocangon*. Observations of ringed seals in water. First Van Veen grab-shots.
- Wed. 8 October. Bessel Fjord. Nice and calm weather. Sunny. No ice in the outer part. New thin ice in the innermost part near Soranerbræen. Sill between stations #890 and #891. Clean trawl catches of mostly large *Arctogadus* and some *Boreogadus*. NB: Mixture of juvenile and sexually mature *Arctogadus* (running males and ripe females). Three musk-oxen observed. Sealing: 1 ringed seal killed. Several ringed seals observed in water. Van Veen grab-shots. Diving team established: *Bjørnar Seim, Trond Thangstad, and Geir Bjarne Nygård*. Bjørnar Seim dived (~27 m) close to the shore at station #890.
- Thu. 9 October. Brede Fjord. Passing Hochstetter Forland and Shannon Sund. Heavy porridge ice in the Shannon Sund S. Many larger ice bergs and disturbed bottom. No conditions for bottom trawling. Gale from NW in Ardencaple Fjord, otherwise nice and sunny. Heading for Brede Fjord. Lookout for "Pitteraq"! Stations within the sill. Final Van Veen grab-shots.



Fig. 6. The entrance to the majestic Brede Fjord. The landscape is dominated by the Caledonian orogeny formed 400-350 MYR ago.

- Fri. 10 October. Ardencaple Fjord. Nice and calm weather. Sunny. A few ice bergs, otherwise open waters. Stations, inshore and offshore. Surprisingly few sea birds inshore. Contact with R/V "Lance".
- Sat. 11 October. Tyrolerfjord. Nice and calm weather. Sunny. Bjørnar Seim dived in Rudi Bugt. Several rutting musk-oxen observed near Kap Ehrenberg. No apparent conditions for bottom trawling in Tyrolerfjorden NW and Rudi Bugt. NB: Station #895 with large catches of *Arctogadus* near Zackenberg. Visit to Daneborg in the afternoon – the grave of Eli Knudsen (1913-1943) and the Headquarters of

Slædepatrulien Sirius. Coffee and cakes. Signing of firearm documents (Bjørnar Seim and Jørgen T. Jensen). "JM" lying still overnight.

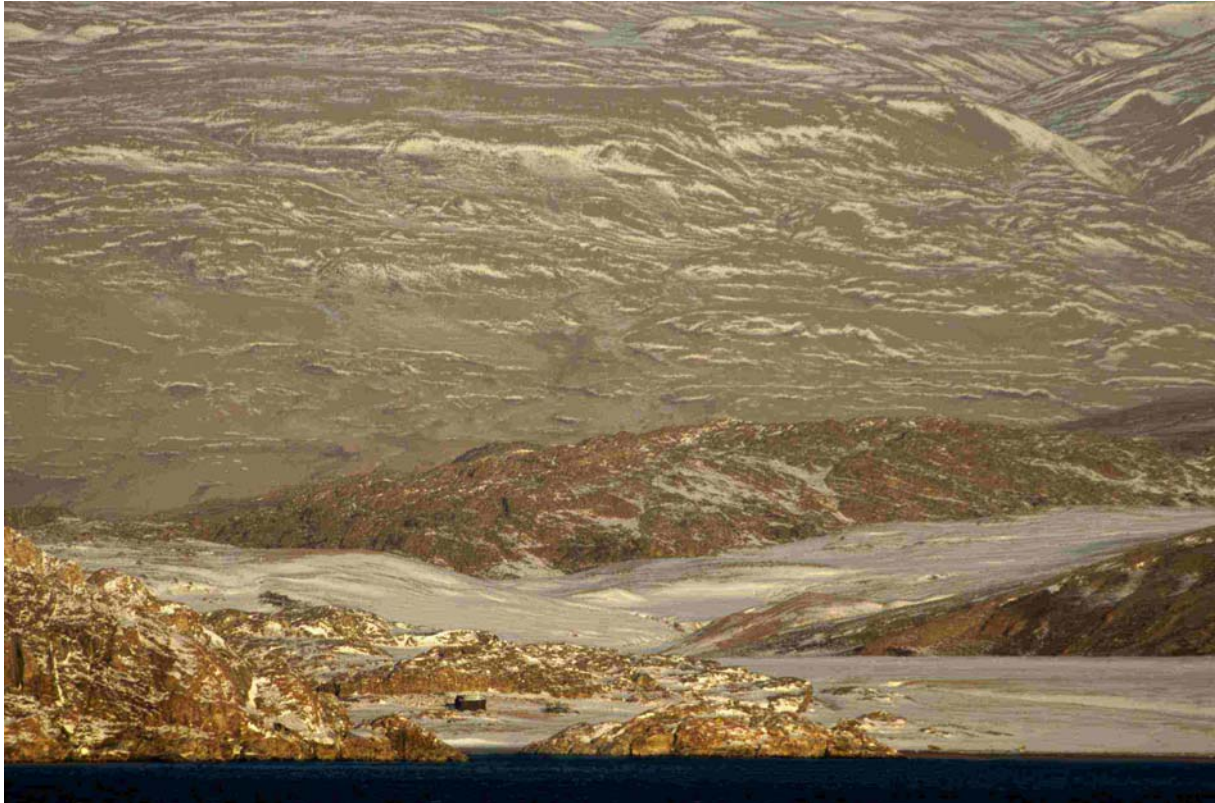


Fig. 7. The ruins of Eskimonæs. Originally a scientific station established by Lauge Koch (1931), then destroyed by Nazi-Germany (1943) – cf. Eli Knudsen. A hut is still in function.

- Sun. 12 October. Clavering Ø S and Copeland Fjord. Nice and calm weather. Sunny. Some ice floes otherwise open waters. Bjørnar Seim dived near Eskimonæs. Stations from 2002 revisited (i.e. #1291 and #1293). No trawling conditions in Copeland Fjord near Revet. One trawl station - live fish bound for "Polaria" and experiments in Tromsø.
- Mon. 13 October. Heading for the drift ice. One bearded seal was taken for a hooded seal and killed by accident. Further sealing cancelled – sorry. Heading for Jan Mayen Island. Last ordinary TUNU-station, i.e. station #901 in the middle of a field of corals (stay away!).
- Tue. 14 October. Jan Mayen Island. Two bottom trawl hauls. Many very large specimens (~ 3.6 kg individuals) of *Lycodes sp.* (Station #902).
- Wed. 15 October. Heading for Tromsø. Exceptionally calm weather. Informal gathering in the evening.
- Thu. 16 October. Arrival Tromsø at 19.15 h (CET). Transport of live fish and other animals to "Polaria".

5. Stations

An overview of the stations covered by the TUNU-I Expedition is shown in *Fig. 1* and further details are given in Appendix B. The fjords and coastal waters of NE Greenland are poorly mapped with regard to bathymetry and bottom topography. Bottoms at depths less than 100 m - e.g. the distance from Haystack via Shannon Sund to Ardencaple Fjord - and in front of the glaciers were often disturbed by ice bergs and, therefore, inaccessible to bottom trawls. Consequently, stations were chosen from bottom topography, and suitable trawl distances were often searched before the actual trawling could take place.

Most acoustic registrations were seen at or close to the bottom. The fine meshed bottom trawl (*Campelen Super 1800/96 NOFI*) was used as the major gear for catching of bottom dwelling fishes and also smaller invertebrates such as krill and amphipods. The Tucker trawl was used for catching of fish larvae and other zooplankton within the upper 100 m of the water column. All bottom trawl stations included a CTD depth survey – i.e. Conductivity ("salinity"), Temperature, and Density (*Sea Bird*) – to compare the trawl catches with the hydrographical profiles. In addition, a temperature sensor (*Scan-Mar*) was mounted on the top line of the trawl in order to register near-bottom temperatures.

An average of two to three stations were conducted each day and a total of 19 bottom trawls (stations #883 – # 901), 6 Tucker trawls (stations #247 – #252), 21 CTD's (stations #813 – # 833), and 3 Van Veen grab-shots (stations #011 – #013) were taken in Greenland waters. Trawling affected a calculated bottom area equivalent to about 1.90 km² in total, and 1.36 km² within the National Park proper (Appendix B).

6. Summaries of scientific activities

The diversity of marine fishes

Oleg V. Karamushko, Jørgen S. Christiansen, and Svein-Erik Fevolden

Data on the diversity of marine fishes in the fjords and coastal waters of NE Greenland were collected. On each station, the species composition and the number and biomass for each species were measured. Altogether, 33 species belonging to 13 families were recorded (Appendix C). The most species rich families were the Zoarcidae (8 species), Liparidae (6 species) and Cottidae (5 species), whereas the most frequent species were *Liparis fabricii* Krøyer, 1847, polar cod¹ *Boreogadus saida* (Lepechin, 1774), and ice cod *Arctogadus glacialis* (Peters, 1874).

¹In the scientific literature, both "polar cod" and "Arctic cod" is used as the trivial name for *Boreogadus saida*. "Arctic cod" has even been used for the *Gadus morhua* in the NE Atlantic. To avoid confusion, we suggest the trivial names "polar cod" for *B. saida* and "ice cod" for *Arctogadus glacialis*.

About 70% of the fish species analysed were "arctic" or "mainly arctic" according to common zoogeographical classification. The total number and biomass of fishes varied between 36 - 10780 specimens and 3 - 194 kg for a standardised one-hour trawl haul. On most stations (excluding those in deeper water), *Boreogadus saida* and *Arctogadus glacialis* were the absolute dominant species (up to 95% by number and biomass). Juvenile *Arctogadus* were also found in the Dove Bugt stations, and it is, therefore, noteworthy that Johansen (1912) does not mention *Arctogadus* in his review.

The *Boreogadus* were encountered at both negative and positive temperatures whereas the *Arctogadus* were most abundant at negative temperatures in the innermost parts of the fjords. Furthermore, there was a clear latitudinal cline with the *Arctogadus* being most abundant at higher latitudes compared to that of *Boreogadus*. Consequently, the fish fauna – and in particular the two cod species - constitutes a most important part of the NE Greenland marine ecosystem and ecosystem modelling ignoring this fact seems futile.



Fig. 8. A portrait of two of the most prominent members of the NE Greenland marine ecosystem. The polar cod *Boreogadus saida* (left) and the ice cod *Arctogadus glacialis*. Note the diagnostic difference in eye diameter.

The distribution of the Greenland halibut *Reinhardtius hippoglossoides*

Trond Thangstad

The Norwegian Institute of Marine Research participated to learn more about the population biology and ecology of Greenland halibut in the NW Atlantic, specifically with regard to possible migration and exchange with populations in the NE regions of the Atlantic Ocean. To this end, we sampled trawl-caught Greenland halibut, measured length and round weight, recorded sex, maturation stage and gonad weight, and collected otoliths for age reading, stomach contents, and muscle tissue samples for DNA analysis.

Results in 2003 were very poor, with a total catch of only 4 individuals (compared to 25 in 2002), two of which were caught near Jan Mayen, and did not form a part of the regular survey. The first two specimens, an immature male 35 cm in length and an immature female 55 cm in length, were caught offshore Greenland at depths of 500-1000 m (stations #884 and #901). A possible explanation for the absence even of juveniles inshore may be the below-zero bottom temperatures that were encountered at nearly all the trawl stations. Presumably one needs to concentrate trawling for Greenland halibut in offshore areas, and at depths below 1000 m where temperatures may reach above 0-1°C.

Phylogeny and population genetics

Svein-Erik Fevolden and Snæbjörn Pálsson

The aims of the genetic studies were:

- to do a population genetic comparison between *Boreogadus saida* (polar cod) in NE Greenland and other regions of its distribution, e.g. W Greenland, Jan Mayen, Svalbard, the eastern North Atlantic, and the Bering Strait.
- to compare genetically *Arctogadus glacialis* (ice cod) from NE Greenland and W Greenland.
- to look for potential genetic structuring of both *B. saida* and *A. glacialis* on a smaller geographic scale, e.g. among fjords in NE Greenland and along gradients in depth and latitude.
- to sample tissue for phylogenetic studies from a variety of species belonging to the families Liparidae, Zoarchidae, and the genus *Lycodes*.

Genetic variation will be studied by scoring polymorphic nuclear DNA (microsatellites and the single copied nuclear locus coding for pantophysin) (Pogson and Fevolden 2003) and by sequencing mtDNA.

The sampling of material was very successful (see other sections of the report) and several hundred samples for genetic studies were either preserved in ethanol or frozen.

Cytogenetics

Laura Ghigliotti

At present only few data are available on the cytogenetic features of arctic fishes, and most of them concern species widely distributed in cold-temperate waters. In this framework I focused on species that show a distribution range limited to cold arctic waters. The main goal onboard was to prepare chromosome suspensions suitable for both conventional cytogenetics (chromosome staining and chromosome banding) and molecular biology (fluorescent *in situ* hybridization).

During the cruise I had the opportunity to collect samples from two species belonging to the family Gadidae: *Arctogadus glacialis* and *Boreogadus saida*. All the specimens were kept in an aquarium for 24-48 hours and then they were injected with a colchicine solution. Head kidney tissue was dissected out some hours after the colchicine injection; it was pre-treated in a hypotonic solution and fixed in a methanol/acetic acid (3:1) solution. The suspensions, ready to be used for slides preparation, were stored at 4° C. In order to extract nucleic acids (DNA and RNA) some other tissue samples from *A. glacialis* and *B. saida* (muscle and testis) were taken and fixed either in EtOH 70% or RNA-later.

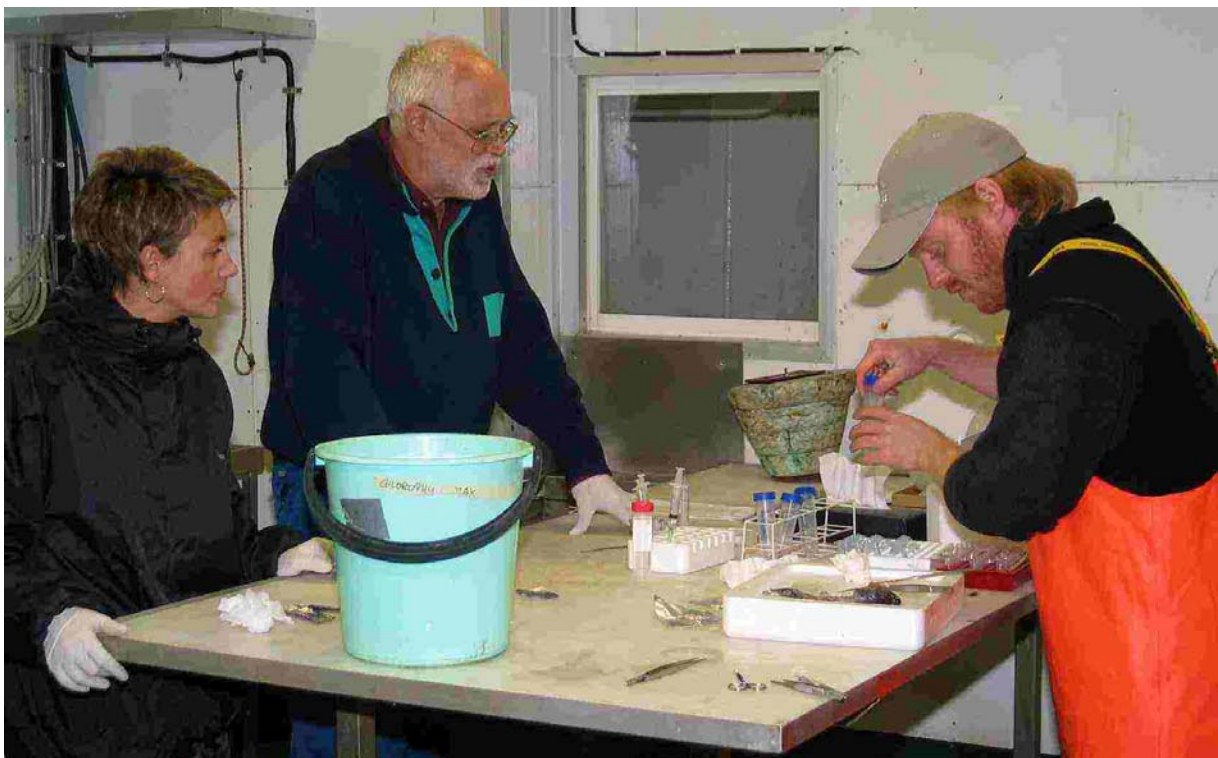


Fig. 9. Tissue sampling. From left: Donatella de Pascale, Guido di Prisco, and Kim Præbel.

Cold adaptations in Arctic fishes – effects of scaling and habitat

Kim Præbel and Jørgen S. Christiansen

Fishes subjected to low temperatures often display a higher serum osmolality compared to those which live in more temperate waters (Christiansen et al. 1995). This has been interpreted as an adaptation to sub-zero temperatures or even as a stress related response. Tissues of fishes - mainly from *Boreogadus saida* and *Arctogadus glacialis* - were sampled to study how serum osmolality and antifreezes – i.e. AF(G)Ps - correlate with scaling and habitat. Thus, different sizes of both species were collected from “warm” and “cold” stations (Appendix B), respectively. Serum was sampled for analyses of osmolality, ionic composition, and thermal hysteresis whereas gill tissues from the same animals were sampled for analysis of Na⁺/K⁺ ATPase activity of the ionic pump.

In addition, blood was sampled from three families (6 species) for various haematological analyses – this was done in collaboration with Guido di Prisco (see below). Other activities included sampling of capelin (*Mallotus villosus*) to support a population genetic study of this species on a large geographical scale (Røed et al. 2003).

Oxygen transport in Arctic fishes

Guido di Prisco and Donatella de Pascale

Together with the team at the Institute of Protein Biochemistry, CNR, Naples, Italy, we have initiated a detailed investigation on the oxygen-transport systems of Arctic fishes, in comparison with the knowledge gathered on Antarctic species. In fact, organisms living in both Polar Regions are exposed to strong constraints, however the northern and southern polar oceans have very different characteristics and the climatic features of the Antarctic waters are more extreme than those of the Arctic. We are investigating the evolutionary adaptation of a vital feature, such as the respiratory system, in polar fishes. The oxygen carrier hemoglobin (Hb), being a direct link between the exterior and body requirements, has experienced a major evolutionary pressure to adapt and modify its features at molecular/functional levels. Our studies on the evolutionary history of Hb are focused on the structure, function and phylogeny of the protein (e.g. di Prisco and Giardina 2000).

Arctogadus glacialis (ice cod), *Boreogadus saida* (polar cod), *Gadus morhua* (Atlantic cod) and *Anarhichas minor* (spotted wolffish) are among the Arctic fish species investigated. They display higher Hb multiplicity (three components) than most Antarctic species.

Our results suggest that the Hb multiplicity and structure/function is correlated with the distinct life style of Arctic vs. Antarctic fishes. Furthermore, they clearly indicate that Arctic and Antarctic species have

followed distinct pathways of evolution. Thanks to the cooperation with colleagues at the Norwegian College of Fishery Science, Tromsø (JS Christiansen and S-E Fevolden), DdP collected specimens during a cruise between Svalbard and Greenland onboard the R/V "Jan Mayen" (autumn 2002). Following this collaboration, we collected more specimens also of additional fish species (blood, liver, spleen, and white muscle). Another theme of our research is focused on the study on new psychrotrophic and psychrotolerant bacterial strain. Thus, we had the opportunity to collect sediments in three different stations along the coast of NE Greenland.



Fig. 10. A clean catch of polar cod *Boreogadus saida*.

Fishes from NE Greenland – are they metabolically cold adapted?

John Fleng Steffensen

In the early 1900 Ege and Krogh (1914) and Krogh (1916) suggested that cold water ectotherms were likely to have a higher metabolic rate than temperate animals when corrected for the differences in environmental temperature. This was later supported by several experiments carried out among others by Scholander et al. (1953) on marine Arctic organisms and Wohlschlag (1960) on Antarctic fishes. In 1960 Wohlschlag described the phenomenon as "Metabolic Cold Adaptation".

In 1974 Høleton, however, challenged the concept of Metabolic Cold Adaptation. He argued that the high rates of standard metabolic rate of polar fishes hitherto measured simply could be ascribed to the methodology and for measuring on stressed and active animals. In 1994

Bushnell et al. and Steffensen et al. (1993) found no proof of elevated metabolic rates of 4 species of teleosts from NW Greenland. Their studies were based on an improved method for measuring standard metabolic rates (Steffensen 1989). In addition Drud et al. (2001) found no elevated standard metabolic rate of the exclusive high Arctic species *Arctogadus glacialis*, compared to temperate fishes. With the above in mind, and in combination with some unpublished results from several species of teleosts from McMurdo Sound in Antarctica, Steffensen concluded in 2002 that metabolic cold adaptation is an artefact.

Earlier experiments have primarily been based on measuring oxygen consumption with polarographic oxygen electrodes that can measure the oxygen content of water. The use of such electrodes at low or even negative temperatures is problematic, however. Among the problems are that the response time is extended considerably and the output signal decrease at lower temperatures. In addition polarographic oxygen electrodes require stirring immediately in front of the electrode due oxygen consumption of the electrode itself. The above problems make it hard or even impossible to measure oxygen consumption of small fish (< 50 gram).

Recently, however, a new method to determine water oxygen content without most of the previous problems has become available. The method is based on an instrument sending light with a certain wavelength through a fibre optic cable once per second. The tip (< 50 µm) of the cable is coated with a flourophor that reacts with the oxygen content of the water and hence change colour. The reflected lights wavelength (phase shift) and amplitude is determined by the instrument and the oxygen content calculated. Among the major benefits are fast response time, even at low temperatures, and no oxygen consumption of the "probe" itself. The aim of the present study was to determine oxygen consumption of juvenile fish (< 20 gram) from NE Greenland to investigate whether these show any sign of metabolic cold adaptation. See Steffensen (2002) and references therein for further information.

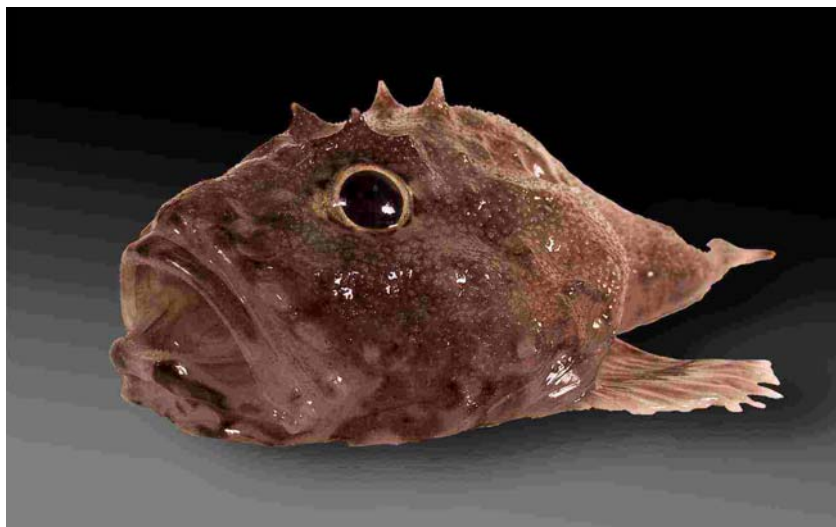


Fig. 11. The bottom dwelling *Cottonculus sadko*.



Fig. 12. Hooded seals *Cystophora cristata* in the drift ice.

Studies on bone mineralization correlated with blubber mass in seals

Jørgen Tranum-Jensen

Initial observations on museum specimens showed that some seal bones are surprisingly heavy mineralized with a mechanical strength much in excess of the biomechanical requirements. This led us to hypothesize that seals may adjust their buoyancy by up- and down regulation of bone mineralization parallel to their blubber mass, possibly following the seasonal variations of the latter. To test the hypothesis we decided to sample bones from different seal species at different periods over the year. Because the blubber of small seals constitutes a higher fraction of the body mass than of bigger seals –blubber thickness equal- the material must be large enough to allow size-grouping within each species. The hypothesised mechanism will expectedly be most easily demonstrated in fully grown adults, where the parameters of bone growth are not confounded by the general growth of the animal.

During three previous cruises with R/V "Jan Mayen" we have collected material from hooded seal (*Cystophora cristata*) in February, July and October, harp seal (*Pagophilus groenlandicus*) in February and ringed seal (*Phoca hispida*) in October. Additional sampling of *P. groenlandicus* has been done on the Newfoundland banks in January. The weight, length, circumference (at level of the shoulder girdle and the maximum abdominal circumference), blubber thickness, and the collective weight of blubber and skin is recorded for each animal, and the age of the animals

is determined by counting of dentin layers in the canines of the lower jaw. We collect systematically from each animal both humerus bones, EDTA-plasma, blubber and liver. The bones are subjected to determination of mass density of the whole, hydrated bone in; mass density of whole, dry bone; X-ray imaging, and histological examination of the bone structure after decalcification. The blood plasma samples are collected for determination of parameters for bone metabolism, e.g. osteocalcin, and relevant hormones. Blubber is sampled for later identification of putative signal molecules/hormones (directly or from m-RNA), and liver is sampled for determination of glycogen as an indicator of time lapsed since last meal, which is relevant for the interpretation of certain hormone levels, e.g. leptin.

Additionally, we have determined the relative contribution of skin, blubber, muscle, viscera, bones and blood to the buoyancy balance (relative to sea water) of three harp seals and one hooded seal with lungs empty of air. These analyses established that the seasonal variations in blubber mass can be fully compensated by adjustments of bone mass density within the range of mass densities observed.

The results may be of considerable medical interest if it is confirmed that seals possess a mechanism for up-regulation of bone mass, independent of the stimulus deriving from the mechanical load. Identification of this putative mechanism may serve as basis for treatment of osteoporosis in man.

Sampling in October is of special interest, because the North Atlantic seals then have about their maximum blubber mass. On the cruise October 2003 we had obtained licence from the Greenlandic authorities to take out 20 hooded, 20 harp, and 20 ringed seals. We were lucky to get 11 hooded seals, of which 8 were fully or near fully grown adults. Regrettably we collected no harp seals and only 3 ringed seals (one fully grown), due to the absence of ice in the fjords south of Dove Bugt. Accidentally, one bearded seal was taken for a hooded seal because of poor sight and shot in the drift ice off the coast. The studies are conducted by Jørgen Tranum-Jensen, Department of Medical Anatomy, The Panum Institute, University of Copenhagen. The sampling of this year was assisted by Jørn Madsen, Eidos Wildlife, and Aili Labansen

Isotopes in seal bone

Archaeological studies of Norse settlements in Greenland include analysis of isotopes in animal and human bone. The relative abundance of different nitrogen and carbon isotopes are clues to food choice of the specimen under study; e.g. whether it is feeding on terrestrial or marine species and its place in the food chain. During the few hundred years of settlement human diet changed from relying on terrestrial sources (livestock and grains) to depend on marine fish and mammals as the climate deteriorated. However, marine mammals - and seals in particular - turn out to be very variable in the relative abundance of isotopes, much more than expected from studies of their feeding behaviour. A possible cause

for this variation could be an error in the way tissues are sampled. If different parts of seal bone show different turn-over rates (see above) the isotope content may represent both a long term mean and a short term pulse that needs to be separated. If this is the case, it may be possible to do fine scale ecological studies of the marine ecosystem using seal bone.



Fig. 13. Oddmund Kopperstad fetches a killed ringed seal from the ice.

Observations on seals and other sea mammals

Jørn Madsen, Aili Labansen, and Jørgen Tranum-Jensen

Observations were not done systematically, as we had to leave the observation posts on the bridge to get the samples from the seals. Still, the overall distribution of seals shows a clear pattern. Seals were only seen on or near ice floes. As the ice had not yet formed in the fjords, only a few ringed seals were seen within the National Park of NE Greenland (all near ice fragments from glaciers). In the drift ice along the coast seals were common:

1. Offshore Haystack, from ca. $10^{\circ}38'$ W and towards the inner limits of the drift ice (depth 500 m or less): hundreds of hooded seals and tens of ringed seals. At one spot around 250 hooded seals (adult females and males and immatures) were seen within an area of approximately 2 km^2 .
2. In the bottom of Bessel Fjord near Soranerbræen: 6 ringed seals.
3. At the mouth of Bessel Fjord: 1 ringed seal.

4. In the inner part of Tyrolerfjord: 1 ringed seal.
5. Offshore Bontekoe Ø from the inner limit of the drift ice to the outer limit (ca. 17°30' W): tens of bearded seals and ringed seals (mostly near the western limit) and hundreds of hooded seals evenly dispersed.
6. WNW of Jan Mayen at 71° 08' N, 10° 28' W: 1 specimen of the rare sei whale (*Balaenoptera borealis*).



Fig. 14. "Dr. Tranums fornemmelse for sæl." Dr. Tranums sense of seal.

Feeding ecology of ringed seal

Aili Lage Labansen

For my master thesis I will mainly look at stomach contents of ringed seal from different areas in Svalbard. A similar study has been done in Svalbard in the early eighties but no one has made a study of the feeding ecology of ringed seals in the National Park of NE Greenland. A nice supplement to my samples from Svalbard would be novel knowledge from NE Greenland in addition to the samples collected from the area between Svalbard and Greenland from earlier cruises with the R/V "Jan Mayen".

Besides my own project, I recorded weight, length, circumference, sex, weight of skin with blubber and sampling of stomachs and jaws for age determination from the hooded seals. In addition blubber and tissue samples from all animals were collected for fatty acids spectrum analysis - a method used for long term determination of their diet. Furthermore, skin samples were collected for DNA analysis in connection with the ringed

seal project at the Norwegian Polar Institute, of which my master thesis is a part of.

Hydrography

Jørgen S. Christiansen

Four stations – i.e. two in Danmarkshavn (77° N) and two at Clavering Ø (74° N) – were visited both in October 2002 and during the TUNU-I Expedition. In each geographical area, we had the opportunity to bottom trawl at a relatively shallow (~ 240 m) and deep (~ 420 m) station. Near-bottom temperatures were registered by a *ScanMar* sensor (Chap. 5).

From this, admittedly, rough and preliminary data set it appears that the bottom temperature has increased at the deep water stations in both areas, whereas there is no consistent trend in bottom temperatures taken at the stations in shallower waters. Thus, *Fig. 15* simply illustrates the importance and possible application of multi-year registrations at selected key sites in NE Greenland – cf. Objectives, point 3.

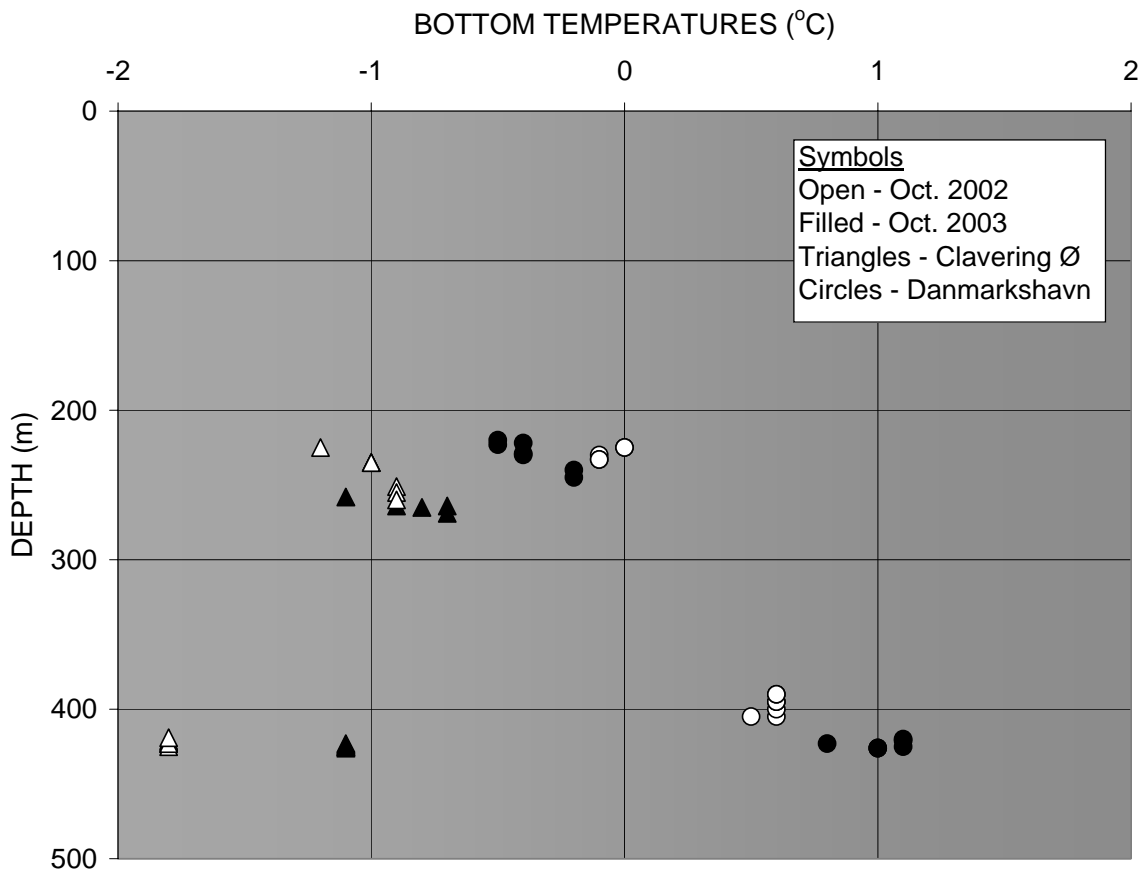


Fig. 15. An exemplified comparison of bottom temperatures measured in two consecutive years in Danmarkshavn (77° N) and at Clavering Ø (74° N). See legend and text above for further details.

Photographic documentation

Henrik Schurmann

The aim of my participation was to make a photographic documentation of the various animals encountered, and prepare the photos so they can be used as illustrations in books, other publications, and for teaching purposes.

I took photos of various fish species, including the polar cod and ice cod. Pictures of invertebrates – especially various amphipods – were also made. The photos were made with digital cameras. The use of tripods was impossible due to vibrations on board the ship. Consequently, a powerful light source was needed to ensure a shutter speed fast enough to hand-hold the camera. The objects were illuminated both by 500 Watts halogen lamps and flashes.

For future photographic documentation the following should be considered. The use of an aquarium would create more naturally looking photos of the animals. Especially the fins of fishes and the extremities of crustaceans appear more natural, when the animal is submerged, even *post mortem*. A better flash setup would also make the light softer and probably improve the quality of the pictures. Many of the photos taken on the TUNU-I Expedition can be seen on the website:

www.eidoswildlife.com

The photos are protected by copyright laws but the participants are free to use the photos on the CD (prepared onboard) for personal use. I thank DFA (Dansk Foto Agentur), who lent me a *Nikon D100* and two lenses, and Canon Denmark, who lent me a *Powershot G3 Camera*.

7. Sampling of biological material for other parties

In addition to own research activities, biological material was also sampled for other parties upon request. They include:

- Nicoletta Ademollo (Silvano Focardi), University of Genova. Samples of fish muscle and liver for studies of pollutants.
- Stig Falk-Petersen, Norwegian Polar Institute, Tromsø. Samples of krill for studies of reproduction.
- Tore Haug, Institute of Marine Research, Tromsø Branch. Basic biological data and stomach contents of hooded seal.
- Jan Heinemeier, Institute of Astronomy and Physics, University of Aarhus. Samples of seal bones for studies of isotopes.
- Bjørn Kraft, Norwegian Polar Institute, Tromsø, Norway. Samples of skin from ringed seal for DNA-analyses.

- Janne Søreide, University of Tromsø, Norwegian College of Fishery Science. Samples of zooplankton, fish muscles for stable isotope analysis, and seal blubber and muscle for analysis of fatty acid profiles.
- Bruno Tota, Stazione Anton Dorn, Naples. Hearths from *Arctogadus glacialis* and *Boreogadus saida*. The samples will be used in a comparative study of heart muscle development of polar (cold) fishes.

Please note that "other parties" are kindly requested also to adhere to the points outlined in the NOTA BENE section, page 3.

8. Scientific communication

At present, there are no plans to publish the scientific outcome of the TUNU-Programme in a book or a special volume of a scientific journal. Original publications will appear in relevant journals during the coming years at the convenience of the authors.

We plan, however, to hold a work-shop in Tromsø after the TUNU-III Expedition has been conducted. This will give us the opportunity to summarise scientific results and pinpoint the key stations for the TUNU-IV Expedition, which intends to cover the whole area from Danmarkshavn to Scoresby Sund – cf. Objectives, point 3. Furthermore, we wish to establish a website, once the TUNU-Programme has been properly funded.

All station logs – incl. CTD data – are stored electronically and can be provided upon a substantiated request.

9. References

General works

Born, E.W. and Böcher, J. (Eds.). 2001. The Ecology of Greenland. Atuakkiorfik, Nuuk.

Nielsen, J.G. and Bertelsen, E. 1992. Fisk i grønlandske farvande. Atuakkiorfik, Nuuk.

Topografisk Atlas Grønland. 2000. Det Kongelige Danske Geografiske Selskab og Kort- og Matrikelstyrelsen. C.A. Reitzels Forlag.

Cited

Christiansen, J.S., Chernitsky, A.G., and Karamushko, O.V. 1995. An Arctic teleost fish with a noticeably high body fluid osmolality – a note on the navaga, *Eleginus navaga*, from the White Sea. Polar Biology 15: 303-306.

- Christiansen, J.S., Schurmann, H., and Karamushko, L.I. 1997. Thermal behaviour of polar fish: a brief review and suggestions for research. *Cybiurn* 21: 353-362.
- Clarke, A. 2003. Costs and consequences of evolutionary temperature adaptation. *Trends in Ecology and Evolution* 18: 573-581.
- Comiso, J.C. 2003. Warming trends in the Arctic from clear sky satellite observations. *Journal of Climate* 16: 3498-3510.
- di Prisco, G. and Giardina, B. 2000. Molecular aspects of temperature adaptation. In G. di Prisco, B. Giardina, and R.E. Weber (eds). *Hemoglobin function in vertebrates. Molecular adaptation in extreme and temperate environments*. Springer-Verlag Italia, Milano. 1-21.
- Haug, T., Arndt, C., Berendtsen, H., Christiansen, J.S., Fevolden, S-E., and Trandum-Jensen, J. 2002. Fellestokt til fjorder, kontinentalsokkel og drivis øst av Grønland i sept./okt. 2002. Toktrapport, Fiskeriforskning, N-9291 Tromsø, Norway.
- Johansen, F. 1912. The fishes of the Denmark Expedition. *Meddelelser om Grønland XII*: 633-675.
- Pogson, G.H. and Fevolden, S-E. 2003. Natural selection and the genetic differentiation of coastal and Arctic populations of the Atlantic cod in northern Norway: a test involving nucleotide sequence variation at the pantophysin (*PanI*) locus. *Molecular Ecology* 12: 63-74.
- Rysgaard S., Vang T, Stjernholm, M., Rasmussen, B., Windelin, A., and Kielsholm, S. 2003. Physical conditions, carbon transport, and climate change impacts in a Northeast Greenland fjord. *Arctic, Antarctic, and Alpine Research* 35: 301-312.
- Røed, K, Fevolden, S-E., Christiansen, J.S., and Midthjell, L. 2003. Isolation and characterization of DNA microsatellites for capelin *Mallotus villosus* population genetic studies. *Marine Ecology Progress Series* 262: 299-303.
- Steffensen, J.F. 2002. Metabolic cold adaptation of polar fish based on measurements of aerobic oxygen consumption: fact or artefact? *Artefact! Comparative Biochemistry and Physiology* 132: 789-795.
- Sturm, M, Perovich, D.K., and Serreze, M.C. 2003. Meltdown in the North. *Scientific American* 289 (October): 42-49.

Appendix A: Scientific participants

	NAME	ADDRESS	E-MAIL	CITIZENSHIP	FIELD OF RESEARCH
	<i>Marine Fish</i>				
1	Christiansen, Jørgen S. (JSC)	UiTø-NFH	joergenc@nfh.uit.no	Danish	Head of TUNU-I, Biodiversity, Physiology
2	Fevolden, Sven-Erik (SEF)	UiTø-NFH	sveinf@nfh.uit.no	Norwegian	Biodiversity, Genetics
3	Præbel, Kim (KP)	UiTø-NFH	kimp@nfh.uit.no	Danish	PhD-student, Physiology and CTD´s
4	Nordgård, Olav K. (OKN)	UiTø-NFH	olavn@nfh.uit.no	Norwegian	Research Tech., Trawls and Live Fish
5	Karamushko, Oleg V. (OVK)	MMBI	karamushko_o@mmbi.info	Russian	Biodiversity
6	Steffensen, John Fleng (JFS)	KU1	JFSteffensen@zi.ku.dk	Danish	Physiology
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8	de Pascale, Donatella (DdP)	CNR-IBP	depascal@dafne.ibpe.na.cnr.it	Italian	Physiology, Biochemistry
9	di Prisco, Guido (GdP)	CNR-IBP	diprisco@dafne.ibpe.na.cnr.it	Italian	Physiology, Biochemistry
10	Pállsson, Snæbjørn (SP)	UoI	snaebj@hi.is	Icelandic	Genetics
11	Thangstad, Trond (TT)	IMR	trond@imr.no	Norwegian	Greenland halibut
	<i>Arctic Seals</i>				
12	Tranum-Jensen, Jørgen (JTJ)	KU2	J.Tranum@mai.ku.dk	Danish	Medical Doctor, Physiology
13	Madsen, Jørn (JM)	KU2	charlotte.munksgaard@get2net.dk	Danish	Physiology
14	Labansen, Aili Lage (ALL)	UiTø-NFH	ailli@nuna.gl	Greenlandic	MSc-student, Feeding Ecology
15	Seim, Bjørnar (BS)	UiTø-NFH	bjornars@nfh.uit.no	Norwegian	Research Tech., Firearms and Diving
	<i>Other activities</i>				
16	Schurmann, Henrik (HS)	Eidos Wildlife	schurmann@mail.dk , website: http://www.eidoswildlife.com/	Danish	Photos and Films

UiTø-NFH: University of Tromsø, Norwegian College of Fishery Science, Norway. *MMBI*: Murmansk Marine Biological Institute, Russia.
KU1: University of Copenhagen, Marine Biological Laboratory, Helsingør, Denmark. *UoG*: University of Genova, Italy. *CNR-IBP*: National Research Council - Institute of Protein Biochemistry, Napoli, Italy. *UoI*: University of Iceland, Reykjavík, Iceland. *IMR*: Institute of Marine Research, Norway. *KU2*: University of Copenhagen, Panum Institute, København, Denmark.

Appendix B1: Stations (cf. Fig. 1) - Positions and other details

BOTTOM TRAWL

NO	DATE	TIME (CET)	STATION #	POSITION	ECCO-DEPTH (M)	BT.HAUL (MIN)	BT.HEIGHT (M)	BT.WIDTH (M)	TEMPERATURE (°C, SCANMAR)	MISCELLANEOUS
1	0510	11.50	883: Offshore Haystack	75° 42N, 10° 22W	1133-1215	30	3.9-5.5	-	-0.4 to -0.2	
2	0510	17.15	884: Offshore Haystack	75° 24N, 11° 45W	501-508	20	4.1-5.4	46-49	0.8 to 1.1	
3	0610	09.25	885: Offshore Haystack	75° 42N, 16° 30W	150-197	20	3.1-4.2	49-53	-1.4 to -1.2	
4	0610	15.40	886: Kap Alf Trolle	75° 48N, 18° 18W	328-341	20	4.2-5.8	46-50	0.5 to 1.1	
5	0710	11.10	887: Stormbugt – Danmarkshavn	76° 43N, 19° 19W	220-245	30	-	48-50	-0.5 to -0.2	#1287 (2002)
6	0710	21.30	888: Dove Bugt – Berg Fjord	76° 27N, 19° 35W	420-426	30	4.1-6.0	48-50	0.8 to 1.1	#1289 (2002)
7	0810	14.50	889: Bessel Fjord – Soranerbræen	75° 58N, 21° 44W	192-233	20	4.0-4.2	48-51	-1.3 to -1.1	
8	0810	17.30	890: Bessel Fjord	75° 58N, 21° 07W	376-386	10	3.9-4.9	48-50	-1.7 to -1.6	
9	0810	21.45	891: Bessel Fjord – Kap Beurmann	76° 02N, 19° 34W	492-503	20	4.0-5.8	48-50	1.0 to 1.1	
10	0910	17.55	892: Brede Fjord	75° 32N, 21° 34W	567-575	20	4.0-5.6	47-50	0.0	
11	1010	09.35	893: Ardencaple Fjord – Kap Rink	75° 05N, 19° 48W	298-316	20	4.2-5.5	48-49	0.8 to 0.9	
12	1010	14.35	894: Hochstetterbugten	74° 40N, 17° 13W	276-281	20	4.1-4.4	49	-0.1 to 0.3	
13	1110	14.35	895: Tyrolerfjord – Lerbugt	74° 27N, 21° 11W	322-333	20	4.0-5.3	46-51	-1.7	
14	1210	10.20	896: Gael Hamke Bugt – Kap Mary	74° 05N, 20° 12W	258-269	20	4.5	48-51	-1.1 to -0.7	#1293 (2002)
15	1210	13.45	897: Godthåb Golf – Eskimonæs	74° 04N, 21° 25W	423-425	20	4.0-5.2	48-50	-1.1	#1291 (2002)
16	1210	17.15	898: Copeland Fjord – Grantapynt	74° 17N, 22° 00W	121-124	20	3.8-4.5	60-63	-1.5 to -1.3	
17	1210	19.45	899: Copeland Fjord – Kap Oetker	74° 14N, 22° 01W	128-136	20	3.6-5.0	60-63	-1.4 to -1.3	Live <i>Arctogadus</i> to Tromsø. No CTD.
18	1310	18.10	900: Offshore Bontekoe Ø	73° 04N, 16° 31W	500-509	30	4.1-5.2	47-50	0.8 to 0.9	
19	1310	21.25	901: Offshore Bontekoe Ø	73° 05N, 16° 22W	975-993	20	3.9-4.6	46-47	-0.6 to -0.4	Corals

Appendix B1: continued

CTD

NO	DATE	TIME (CET)	STATION #	MEASURED DEPTH (M)	ECCO-DEPTH (M)	CORR. BT.STATION #	MISCELLANEOUS
1	0510	11.35	813	1070	1120	883	
2	0510	17.00	814	495	529	884	
3	0610	09.10	815	145	160	885	
4	0610	15.30	816	287	307	886	
5	0710	10.30	817	202	216	887	#1287 (2002)
6	0710	20.45	818	380	405	888	#1289 (2002)
7	0810	13.45	819	60	77	889	
8	0810	17.00	820	376	386	890	
9	0810	21.15	821	500	520	891	
10	0910	17.15	822	530	549	892	
11	1010	09.00	823	320	343	893	
12	1010	14.10	824	260	294	894	
13	1110	10.45	825	108	117	No bottom trawl	Tyrolerfjord NW
14	1110	12.45	826	120	139	No bottom trawl	Rudi Bugt
15	1110	14.15	827	324	342	895	
16	1210	09.45	828	218	230	896	#1293 (2002)
17	1210	12.50	829	398	423	897	#1291 (2002)
18	1210	16.30	830	53	62	No bottom trawl	Copeland Fjord N
19	1210	17.00	831	96	102	898	
20	1310	17.30	832	460	494	900	
21	1310	19.35	833	1006	1023	901	

TUCKER

NO	DATE	TIME (CET)	STATION #	MEASURED DEPTH (M)	ECCO-DEPTH (M)	CORR. BT.STATION #	MISCELLANEOUS
1	0610	09.25	247	100	160	885	
2	0710	09.30	248	100	216	887	#1287 (2002)
3	0710	23.40	249	100	422	888	#1289 (2002)
4	0810	15.30	250	100	192	889	
5	0910	19.15	251	100	549	892	
6	1110	13.15	252	100	152	No bottom trawl	Rudi Bugt

VAN VEEN

STATION #	DATE	TIME (CET)	CORR. BT.STATION #
011	0710	23.00	888, Dove Bugt – Berg Fjord
012	0810	13.20	889, Bessel Fjord - Soranerbræen
013	0910	19.50	892, Brede Fjord

Appendix B2: Stations (cf. Fig. 1) - Area affected by bottom trawling

Gear: *Campelen Super 1800/96 NOFI*

Trawl speed	3 nm (~ 5556 m) per h
Width of trawl	46 - 63 m
Heights of trawl and <i>ScanMar</i> temperature sensor	3.1 – 6.0 m
Time of trawl hauls	10 – 30 min

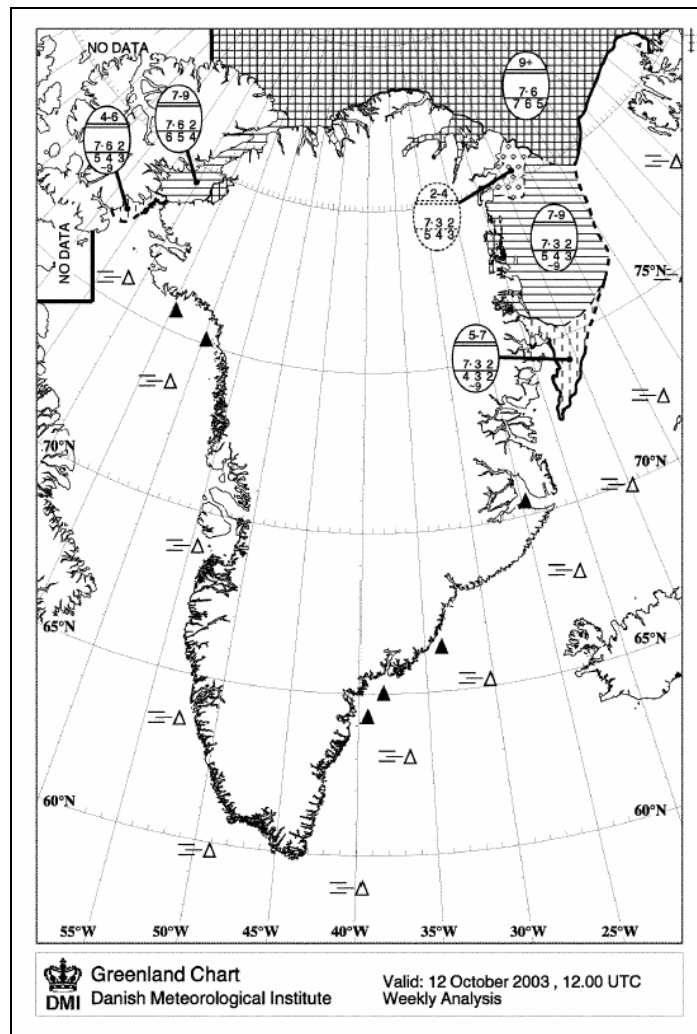
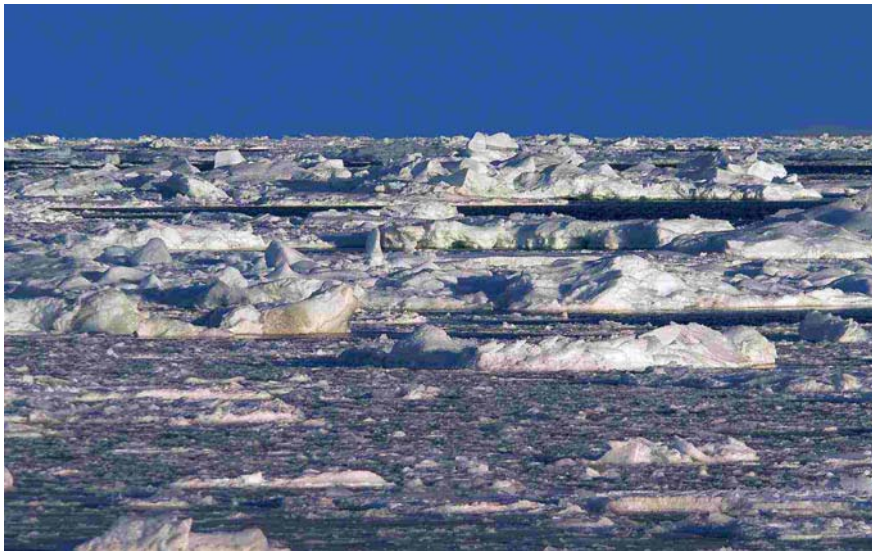
Station (#)	Haul time (min)	Trawl width, minimum (m)	Trawl width, maximum (m)	Minimum (m ²)	Maximum (m ²)	Average (m ²)	Average (km ²)	Average within the National Park (km ²)
883	30	49	51	136122	141678	138900	0.1389	-
884	20	46	49	85192	90748	87970	0.0880	-
885	20	49	53	90748	98156	94452	0.0945	-
886	20	46	50	85192	92600	88896	0.0889	0.0889
887	30	48	50	133344	138900	136122	0.1361	0.1361
888	30	48	50	133344	138900	136122	0.1361	0.1361
889	20	48	51	88896	94452	91674	0.0917	0.0917
890	10	48	50	44448	46300	45374	0.0454	0.0454
891	20	48	50	88896	92600	90748	0.0907	0.0907
892	20	47	50	87044	92600	89822	0.0898	0.0898
893	20	48	49	88896	90748	89822	0.0898	0.0898
894	20	49	49	90748	90748	90748	0.0907	0.0907
895	20	46	51	85192	94452	89822	0.0898	0.0898
896	20	48	51	88896	94452	91674	0.0917	0.0917
897	20	48	50	88896	92600	90748	0.0907	0.0907
898	20	60	63	111120	116676	113898	0.1139	0.1139
899	20	60	63	111120	116676	113898	0.1139	0.1139
900	30	47	50	130566	138900	134733	0.1347	-
901	20	46	47	85192	87044	86118	0.0861	-
TOTAL				1853852	1949230	1901541	1.90	1.36

Appendix C: Fish species encountered in NE Greenland waters

SPECIES AND STATIONS	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	900	901
<i>Raja radiata</i> Donovan, 1808				+								+					+	
<i>Raja hyperborea</i> Collet, 1879										+								
<i>Mallotus villosus villosus</i> (Müller, 1776)		+																
<i>Arctogadus glacialis</i> (Peters, 1874)		++	+	++	+	++	+++	++	+	++	+	+	++	+	+	++	+	
<i>Boreogadus saida</i> (Lepechin, 1774)		+++	++	+++	++	++	+++	+	++	+	+++	++	++	+++	++	++	+++	
<i>Gaidropsarus argentatus</i> (Reinhardt, 1837)	+																+	+
<i>Sebastes mentella</i> Travin, 1951																	+	
<i>Arctiellus atlanticus atlanticus</i> Jordan et Evermann, 1898		+	+	+	+	+					+	+	+	+	+		+	
<i>Gymnocanthus tricuspis</i> (Reinhardt, 1831)																+		
<i>Icelus bicornis</i> (Reinhardt, 1840)			+	+												+		
<i>Myoxocephalus scorpius scorpius</i> (Linnaeus, 1758)								+										
<i>Triglops pingeli</i> Reinhardt, 1831		+	+	+	++	+			+	+	+	+	+	+	+	+	+++	
<i>Cottunculus sadko</i> Esipov, 1937									+			+					+	
<i>Cottunculus subspinosus</i> Jensen, 1902																		+
<i>Leptagonus decagonus</i> (Scheider, 1801)												+		+			+	
<i>Eumicrotremus spinosus</i> (Fabricius, 1776)					+	+												
<i>Careproctus micropus</i> (Gunther, 1887)																		+
<i>Careproctus reinhardtii</i> (Krøyer, 1862)	+			+		+					+	+	+	+	+	+	+	+
<i>Liparis fabricii</i> Krøyer, 1847	+	+	+	++	+	++	+	+	+	++	+	+	+	+	+	+	++	
<i>Liparis gibbus</i> Bean, 1881						+												
<i>Paraliparis bathybius</i> (Collett, 1879)																		+
<i>Rhodichthys regina</i> Collett, 1879																		+
<i>Lycenchelys kolthoffi</i> Jensen, 1903		+															+	
<i>Lycodes eudipleurostictus</i> Jensen, 1901																	+	+
<i>Lycodes pallidus pallidus</i> Collet, 1878					+			+		+		+	+	+	+	+		+
<i>Lycodes polaris</i> (Sabine, 1824)		+			+		+						+					
<i>Lycodes squamiventer</i> Jensen, 1902	+																	
<i>Lycodes reticulatus</i> Reinhardt, 1835		+			+	+				+	+	+					+	
<i>Lycodes rossii</i> Malmgren, 1864		+						+	+	+	+							
<i>Lycodes seminudus</i> Reinhardt, 1837							+						+	+	+	+		
<i>Leptoclinus maculatus maculatus</i> (Fries, 1837)												+	+	+	+			
<i>Hippoglossoides platessoides limandoides</i> (Bloch, 1787)		+				+			+			+		+	+		+	
<i>Reinhardtius hippoglossoides hippoglossoides</i> (Walbaum, 1792)		+																+
Number of species	4	12	6	8	9	10	5	6	7	8	8	13	9	11	10	10	15	9

Number of specimens: + tens; ++ hundreds; +++ thousands

Appendix D: Ice map



The ice conditions at the end of the TUNU-I Expedition – cf. *Fig. 1*. See website: <http://www.dmi.dk/vejr/gron/index.html> for further information. Courtesy of Danmarks Meteorologiske Institut.

Appendix E: R/V "Jan Mayen" – Info

Technical specifications and other details concerning the R/V "Jan Mayen" can be obtained from the website: <http://www.nfh.uit.no/> or by direct contact to the Adm. Head of Research Vessels Jon Einar Hansen (e-mail: jone@nfh.uit.no).

Appendix F: Summary and main figures of the TUNU-I Expedition

Altogether the scientific activities of the TUNU-I Expedition were completed successfully. Several key stations for bottom trawling and hydrography have been established between Danmarkshavn (77° N) and Eskimonæs (74° N), and from the innermost parts of the fjords to the continental slope. New and important information has been gathered concerning fish diversity, the distribution range of fish species, and the corresponding hydrographical regimes. Furthermore, various tissue samples provide a unique material for genetical and physiological studies.

The season from medio September to medio October (at the latest) seems the most appropriate for studies of marine fish inshore NE Greenland due to optimal ice and weather conditions. Sealing, however, was less successful due to little sea ice and few seals within the National Park proper. Seals – on the other hand – were numerous in the drift ice offshore. Hence, forthcoming TUNU-Expeditions will seek permission to kill a limited number of seals both within the National Park and offshore NE Greenland.

TUNU-I in figures

STAY IN NE GREENLAND WATERS	5-13 OCTOBER 2003
Range in investigated area:	
• North – South	76° 43' - 73° 04' N
• East – West	10° 22' - 22° 01' W
No. of bottom trawl stations	19
No. of hydrographical (CTD) stations	21
Bottom area trawled (km ²)	
• Total	1.90
• Within the National Park	1.36
Range in depth (m)	121 - 1215
Range in bottom temperature (C°)	-1.7 to 1.1
No. of fish species encountered	33
No. seals killed (total)	16
• Hooded	12
• Ringed	3
• Bearded (by accident)	1
• Harp	0

The expedition map of Leo Willy Christiansen (1910-1993). The map was used during his stay in Eskimonæs (1939-1941), and shows the Clavering Ø area – the final destination of the TUNU-I Expedition. Note LWC's own writings and extensions of the map.

