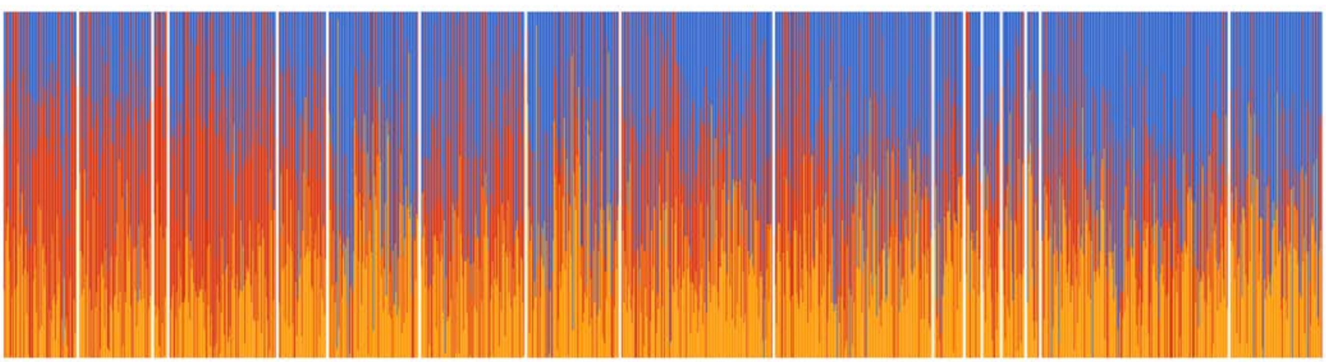
Report of

Joint meeting of the projects, Greenland halibut and coastal societies (NORSUSTAIN) and Nordic Science Group on tagging compilation for Greenland halibut (AG-Fisk)

16-18 November 2021, IPMA, Olhao, Portugal



Contents

Introduction

A joint meeting for two projects, Greenland halibut and coastal societies (NORSUSTAIN) and Nordic Science Group on tagging compilation for Greenland halibut (AG-Fisk) was held at the Portuguese Institute for Sea and Atmosphere (IPMA) in Olhao, Portugal 16 – 18 November 2021. Scientists from Canada, Greenland, Iceland, Faroe Islands, Denmark and Norway participated. The objective of the meeting was to evaluate the results of the tag – recapture data compiled under the Nordic Science Group and relate these findings to the additional approaches being conducted under NORSUSTAIN. Further, the status of NORSUSTAIN work packages were discussed and decisions on progress for the final project year 2022 were made.

The Nordic Science Group project ends by this meeting, while NORSUSTAIN runs until end of 2022. IMR have an ongoing project complementing these two projects.

Participants

Name	Institute	Country	Attendance (Physical/Online)
Adriana Nogueira	GINR	Greenland	P
Amanda Barkley	Univ. Windsor	Canada	O
Asbjørn Christensen	DTU Aqua	Denmark	P
Bjarki Elvarsson	IMFR	Iceland	P
Daniel Estevez-Barcia	GINR	Greenland	P
Denis Roy	McGill University	Canada	P
Elvar H. Hallfredsson	IMR	Norway	P
Jesper Boje	DTU Aqua	Denmark	P
Julio Ubeda-Quesada	GINR (Univ Alicante)	Spain	P
Laura Wheeland	DFO	Canada	O
Lise Helen Ofstad	Havstovun	Faroe Islands	O
Margaret Treble	DFO	Canada	P
Margrete Emblemsvåg	Møreforsking	Norway	O
Mikko Vihtakari	IMR	Norway	P
Ole Thomas Albert	IMR	Norway	P
Pedro Lino	IPMA	Portugal	P
Petur Steingrund	Havstovun	Faroe Islands	O
Torild Johansen	IMR	Norway	P

Figure on frontpage: Genetic assignment of Greenland halibut specimens to populations assuming that three populations are present in the North Atlantic (blue, red, yellow). Each bar (column) represents one fish and the range is from west (Canada) to east (Barents Sea).

Meeting agenda

<u>Tuesday 16. November</u>

9-12

1. Welcome, practicalities, short presentation of the two projects, adoption of agenda
2. Tagging:
    a. status of analyses/manuscript of the historic data from conventional tagging, compiled historic data from all institutes (Mikko)
    b. information of recent tagging activities in Greenland (Jesper)

12-13:30 Lunch

13:30-17

    c. Status of Newfoundland Greenland halibut telemetry program (Laura Wheeland, online presentation)
    d. New moorings to monitor Greenland halibut movements in the Davis Strait (Amanda Barkley, online presentation)
3. Tagging evaluation (all)
4. Use of survey information and fisheries data: Combined data base to run Gadget model and to investigate stock structure (Adriana and Julio)

<u>Wednesday 17. November</u>

9-12

5. Genetics:
    a. 1st step genetics on juveniles collected in nursery areas - discovery of discriminant genetic markers (Daniel)
    b. 2nd step genetics on adults - whole population structure in the North Atlantic (Daniel)

12 – 18 Lunch, excursion (Town walk and boat tour)

20 Project dinner (Terra I Mar)

<u>Thursday 18. November</u>

9-12

6. Genetics, continued: genetics evaluation (all)
7. Status of GADGET assessment tool; use in relation to mixed stocks/stocks with high connectivity (Bjarki)

8. Egg and larval drift modelling, preliminary results (Asbjørn)
9. Unpublished data from larvae surveys in Greenland and Iceland (Jesper)
10. Otolith microchemistry, preliminary results from IMR, Tromsø (Mikko)

12-13:30 Lunch

13:30-15:30

11. catching up: manuscripts, budget, continuation of research after 2022, final meeting in 2022
12. reports to AG-Fisk (final) and NORSUSTAIN (annual)

15:30 End of meeting

Narrative

Agenda pt 2a. – Tagging manuscript

Mikko presented a first draft of a tagging manuscript. The summary of the present work suggest high connectivity between most present management areas although most migrations were within the areas, and 7-8% of all recaptures crossed the defined areas (management areas or EEZs).

Discussions raised more issues.

The **area definitions** do not always reflect the stock or management areas, thus the West Greenland inshore areas were collated under one area for numerical purposes despite existing north and south inshore (1A vs 1B-F) divisions in management/stock areas. However, the collation should be split in new analyses. The assignment of the Faroe area (Div 5b) to the North Sea (Div 4) should be further checked, i.e. the recaptures in the North Sea. Further analyses or manuscripts might also focus on more regional scales that this manuscript cannot fully capture.

Some **tagging data** are still missing for the analyses. From Eastern Canada Amanda noticed data not included in the present manuscript. Laura noticed missing data from Newfoundland - only recapture data had been provided previously, release data will be made available. Also Greenland data from 2020-2021 are not presently available and new Icelandic tagging performed in 2020 are not in the present database.

A working version of the combined Greenland halibut tagging dataset across the North Atlantic (basis for present manuscript), that contained over 110 thousand tagged fish and over five thousand recaptures, is available in a private GitHub repository. Final version of the dataset will be published together with the paper.

On the recapture rate figures in the manuscript; it was suggested to segment this/these figures by time at sea to explore this effect.

It was noticed that smaller halibut tend to migrate more (as seen from Svalbard to Iceland). Thus the assumption that juveniles belong to specific nursery grounds may be violated (unless the migration occurs over more years).

Sex specific migration was also discussed. However, at present, little to no tagging data is available to assess this. How many recaptures that have sex information will be checked. For future experiments it was mentioned that ultrasound can be used for sex determination.

Mikko invited the group to contribute to the manuscript by no later than 31 December 021. Editing was suggested in Google docs mode. Ole Jørgensen (former GINR/DTU Aqua) was suggested to be invited as well. Some tasks on the manus were allocated. Introduction to manus by Adriana, Margaret and Elvar. References should be sent to Mikko as doi or url reference. Materials and Methods section should be considered by specific institute members. The journal for publication was discussed and a majority voted for the ICES journal and the time frame is a complete first draft before the end of 2021.

Agenda pt 2b. – Tagging update from Greenland

Jesper presented information on 2020/2021 tagging in Greenland. Approx. 600 T-bar tags were deployed offshore in East Greenland in 2020 and under the same experiment 100 DST tags with compass function. In 2021 T-bar tags were deployed in West Greenland fjords, 225 tags in Div 1F (Narsaq) , 200 tags in Nuuk fjord (1C) and 200 tags in Disko Bay (1A). At present there is no available information on recaptures from these experiments.

Agenda pt 2c. – Tagging update from Canada (Newfoundland and Labrador)

Laura gave a presentation on the telemetry program in Eastern Canada, Newfoundland and Labrador.

A discussion surrounding the efficiency of tag types in terms of retrieval of data and their costs was initiated. While pop-up tags are costly, there is better guarantee in obtaining migration data than for example DSTs that depend on the recapture and return of the fish/tag (i.e. on commercial fishery/fishing pressure). Of the 100 DSTs deployed in East Greenland in 2020 only one tag has been recorded recaptured.

Agenda pt 2d. – Tagging update from Canadian Arctic

Amanda presented Canadian work on moorings to monitor the movements of Greenland halibut tagged with acoustic transmitters. The locations were in Baffin Bay near assumed spawning grounds. The approach is innovative and likely efficient in places where halibut are forced to move in narrow corridors like fjords or submarine canyons.

Agenda pt 4. – Stock definition using survey data

Adriana presented the status of the Working Package 5 (Use of survey and fisheries data). The package was divided in two sections: 1) Create a combine database with MareFrame DB (R Package) for Canada, Greenland, Iceland and Norway. This database standardizes the data format helping running the Gadget stock assessment model. Currently, data from Norway, Iceland and East Greenland have been included in the database. Data from West Greenland (NAFO S1) and Canada (NAFO S0) are in a suitable format to be uploaded in the database. 2) Using Multivariate State-Spate Models (MARSS) to analyse stock structure of Greenland halibut. For that, a student from the University of Alicante (Spain), Julio Ubeda Quesada has been working with survey and fisheries data for his master's thesis that was defended last July under the supervision of Adriana.

Then Julio gave a presentation of his and Adriana's work investigating stock definitions using survey data from the entire North Atlantic. Based on abundance and growth rates for the entire area West Greenland –East Greenland – Iceland – Barents Sea a multivariate autoregressive state-space (MARSS) model approach suggested a split of the East Greenland

- Iceland stock. The presentation gave rise to a discussion on data handling and assumptions. It was decided to establish a subgroup to discuss the issue and further progress within this approach. Julio, Adriana, Bjarki and Mikko sat together to solve this. Concerns about splitting the data between length ranges to run the models. It has not been done before with MARSS models. The main concern is how to use the length data in MARSS models taking into account the possible temporal correlation, due to migrations, among juveniles, maturing and adults. It was proposed to lag the recruitment and use it as a covariate in the model.It was discussed if it would be more useful to use biomass data instead of abundance data for the analysis to avoid peaks of juveniles controlling the model fitting. We decided to treat East Greenland (North and South) and Iceland (East and West) as 2 regions instead of 4. Finally, it was decided to not include the split between sex (males vs females) because tagging analyses do not include the split between sex, preliminary MARSS models and genetic analyses do not find any differences between sex.

Outcome of this corrected approach will be reported within the next months.

Agenda pt 5-6. - Genetics.

Daniel presented the present progress within the genetic part of the project.

Some key terms were covered to help others understand the basic indices reported. Fis, Fst, Ho, and He, which are basic estimators on population genetics analyses, were defined. Some basic characteristics of the different multivariate analyses were also covered (e.g., PCA, DFA, ADMIXTURE, and STRUCTURE).

The first part of the project identifies SNP markers and test for difference among juvenile populations in the North Atlantic. Sampling efforts were from key nursery grounds, assuming these represent proxies of, and are fed by, nearby spawning grounds. Genotype-by-sequencing techniques (RADseq) and variant calling were used to discover discriminant genomic markers for the species. We identified 90 single nucleotide polymorphisms (SNP) that maximized differences between Norwegian juveniles and west Atlantic samples (Disco Bay, Qikiqtarjuaq, and Frobisher Bay). We then took a hierarchical approach and removed the Norwegian sample to further assess clustering in the west Atlantic finding three different clusters with Frobisher Bay as the most distinct sample.

A publication is being drafted on the first analyses where Mattis (Sæmundur Sveinsson, Mattis, Iceland) is taking the lead and GINR and IMR will be second author and corresponding author respectively.

Some key questions from this work-:

- Is time an important factor to include in these analyses? For this, we can use age estimates from otoliths, however, the average age for these samples (juveniles) is one to four years with little variance. Hence, we do not have enough date to make this to be informative.

This question is better addressed with data from the second part of the genetics work, but consistency in signals arising from juveniles would be an interesting follow-up.

• Can we use ADMIXTURE/STRUCTURE probabilities to assess a mixing coefficient for each sampled location for particle modelling? This can be easily inspected and we can provide it to the researchers responsible for particle modelling (see pt. 8 below).

•Would we see the same structure in these nursery areas if we sampled these again (i.e., what is the turnover of structure in this species)? Recent literature suggests variation in mix of population between years in the Gulf of St Lawrence (collier et al. 2020??), this raises the point of performing closer monitoring of nursery grounds. It was suggested to resample the nursery areas in 2021 which might give us some answers to possible mix of populations in the sampled nursery areas .

Next step was to analyze a larger data set of adult fish (N=1400) with the 90 SNP, but by evaluating the different SNPs using various tests we filtered them down to 63 markers of more reliable quality. Some SNPs might be highly correlated with sex. Here sample distribution is expanded including samples from fjords and offshore west Greenland, Iceland, Jan Mayen, Faroe Island and the Norwegian shelf. Samples from the Pacific Ocean were initially included as outgroup. We do have more samples from the East Canada juveniles, but they were not prioritised for the present study.

The Pacific samples were found to be substantially different from the Atlantic ones and after initial analyses, these were removed to focus on North Atlantic samples. Preliminary analyses have begun and show some interesting patterns but these need to be further investigated. The key points are as follows:

- FST matrix shows high values between westernmost and easternmost locations, but as most samples are mixed we need to redo the FST matrix after organising the samples by genetic clusters (DAPC, STRUCTURE or Geneclass).
- PCA results show an east-west gradient in how the samples come out, but this pattern is relatively week and still being analysed using more in-depth analyses.
- Overall, differentiating populations is still difficult and the only pattern seems to be a longitudinal one recovered with the discriminant function analyses DAPC (DFA) .
- Assignment from ADMIXTURE (and from STRUCTURE) show that most individuals are well assigned to the clusters they belong to and the pattern of east-west separation is also evident there. No clear boundaries differentiating any given geographic area is obvious in the data. Samples themselves seem to be mixtures of different genetic clusters.
- . This could be a basis for more in-depth analyses using other techniques such as Hybridlab to create mixtures and GeneClass to cross-validate mixed individuals. This is work in progress.
- Indications of mixed clusters across the North Atlantic is consistent with results from the tagging study. This will also be investigated further.

Some questions arising from the present work:

- Could there be inshore offshore contributions to stocks or populations? Greenland raised this question whether the fjord samples could be genetic different from the offshore samples. This will be dealt with more closely. We need to test in more detail how fjord and offshore samples are linked.
- Could some of the data be influenced by sample sizes? The sampling size is quite good. The FST can easily be influenced by sampling size, but by using the clustering program that makes use of ie MonteCarloSimilations we can include also small samples.
- Will whatever structure we see, be repeatable in subsequent years? For the Iceland samples collected in two years we can see that they varry between years. Most likely because of migrating fish.

These questions will be further focused on in the last year of the project and elaborated on in the final report/manuscripts.

Draft of paper 1 will be completed to be send around to partners for Christmas. A time frame for a draft of paper 2 is not decided yet as it will take more time to investigate the results. All partners in the projects will be invited to join these papers as co-authors.

The workflow as well as the data, both raw and processed, are being stored in two private github repositories. The curation of these has two objectives: The first is to make the data and results accessible and allow third parties to understand the methodologies used by the researchers, including the line of thought and decisions made. The second, is that the researchers involved use e-mail and cluster services to process, send and in the later stages of the project store large files (obtained DNA sequences). Thus, an online repository ensures the long term legacy and safety of these valuable data. The structure of each repository is described at the beginning in a markdown README file. Inside each folder there are also README files describing both the structure and workflow (most of the work is performed using R codes).

Agenda pt 7. - Gadget model for stock assessment and as an exploratory tool

Bjarki presented the concept of the newest development of the GADGET model (GADGET 3). The model aims to be both a tool for examination of stock structure (e.g. best fit of data for various scenarios of area assignments) and ultimately as the stock assessment tool for advisory purposes. Discussions followed on expertise required to operate the model, (i.e., user friendliness, and interface for stock assessments, and ways of assessing the quality of the model fit, i.e., diagnostics).

The model has the ability to incorporate migration or connectivity between areas derived from other approaches such as tagging/genetics, etc.

Close kin tag recapture simulations will be conducted within the project period; this is a new functionality within GADGET 3 developed under the NORSUSTAIN project.

It was noted that the GADGET 3 model as an exploratory tool for stock structure examination might not be fully developed within 2022 and, therefore, we can foresee applications to fund such activities beyond this project. An application for a Postdoc might be the optimal solution for this task.

An introduction to the GADGET concept can be found here:

https://gadget-framework.github.io/gadget-course/

Agenda pt 8. - Drift modelling

Asbjørn presented the basis for the drift modelling and an example of an output. The model uses year specific hydrographic data so a decision must be made on which period we want scenarios. Further, more specific information is required on potential spawning grounds we want to investigate, e.g., midpoints of suggested areas or margins? The initial runs for suggested spawning in the Davis Strait show that the choice of the western or the eastern part of this site has a marked influence of the outcome of the settled Greenland halibut.

Questions coming up:

Can the model predict where the juveniles from the different nursery grounds are coming from? Where in the Davis straight is the juveniles from Disco, J-Qikiktarjuaq, J-Frobisher Bay coming from? Or are they all coming from Davis straight? What about the juveniles from Svalbard -do they come from the Norwegian shelf spawning ground only?

Can the models predict more spawning areas?

Agenda pt 9 - Unpublished data from larvae surveys

Jesper presented data from ichthyoplankton surveys conducted in Greenland and Iceland within the period 1925-1995. Length measurements of the larvae will be used for growth analyses as input to the drift modelling, as well as to examine if more spawning grounds are present in the area covered by the ichthyoplankton surveys. All are invited to contribute to analyses and a manuscript on the findings.

After the meeting Mikko contributed with larvae data from the Barents Sea/Norwegian sea. The data is available at the AG-Fisk sharepoint site:
https://publicadministrationis.sharepoint.com/sites/ghltaggingworkshop-hafro

Agenda pt 10 - Otolith microchemistry, preliminary results

Mikko presented the preliminary results from 10 otoliths of juvenile halibut marked with oxytetracycline in Svalbard and recaptured in Iceland. The fish were at sea for 2-10 years. The study was aimed at age validation using an elemental fingerprint approach. There was no clear signal, however, final conclusions await further analyses.

The approach has some technological challenges as the growth of the Greenland halibut left otolith is not symmetrical in all dimensions and the laser technique may be measuring more than one layer at a time along the transect of the otolith cross-section, thereby the result could be a mix of zone composition.

Accompanying water samples might create a basis for assumptions on origin/area assignment when analysing otoliths.

Some technical considerations was raised by Margaret: NOAA had suggested the otolith nucleus had been missed in some of the cross-sections. This is not unusual, given the asymmetrical growth; often the nucleus can be visible on one side but it does not line up vertically with the 'peak' of the thickest point on the other side. This 'offset' seems to be enhanced as the fish get bigger. So, if sectioned through the thickest part of the left otolith you will most likely miss the nucleus. Step have been taken to develop guidance on where to make the cut, to maximize the transect distance and to get the best angle while still including the nucleus.

Abstracts of presentations at the meeting

Agenda 2a. - Mark-recapture of Greenland halibut in the North Atlantic.

Presenter: Mikko Vihtakari

Marine fisheries are often pragmatically allocated to stocks reflecting agreements that may not represent the actual population structure of the species, increasing the risk of mismanagement. The population structure of Greenland halibut in the North Atlantic has been especially problematic despite decades of research. Here we compile mark-recapture data across the region to discuss the population structure of Greenland halibut. The dataset contains 114 278 tagged fish from 1952 to 2021, with 5 407 (4.7%) recaptured individuals. We find evidence for large-scale migrations across management units in the North Atlantic with fish moving from West Greenland fjords and the Davis Strait to East Greenland and Iceland. Our results indicate that fish < 50 cm migrate at higher rates, and consequently, mark-recapture studies on adult individuals are likely to underestimate the migration rates. We find that the West Nordic and Northeast Arctic stocks on the East Atlantic side, currently managed separately, are likely one population spanning from the Kara Sea to East Greenland, yet possibly with multiple spawning grounds. Further, we also find non-conclusive evidence that the Newfoundland and Labrador Canadian stock belongs to the Northwest Arctic complex consisting of the Davis Strait and the Baffin Bay. There is also evidence of limited connectivity between these offshore areas and West Greenland and Baffin Island fjords. Our findings, which have implications for international fisheries management, must be tested using alternative methods and more detailed analyses.

Agenda 2c. - Update on Greenland halibut telemetry in Newfoundland and Labrador

Presenter: Laura Wheeland, Fisheries and Oceans Canada (DFO)

An update was provided outlining a new flatfish (Greenland halibut, Witch flounder) telemetry program on the Northeast Newfoundland shelf. In 2021, 80 Greenland halibut were caught on chartered fishing vessels in NAFO Div. 2J3K, implanted with acoustic transmitters (VEMCO/INNOVASEA V13 and V16 tags) and marked with floy tags. Fish were captured by otter trawl equipped with a specially designed capture box which served to maintain good fish condition upon capture. A box like this was previously used for tagging by DFO in 2012-15 and by IMR Norway. Tagged Greenland halibut ranged in size from 36 to 66cm and were caught at depths between 278-516m. Work is ongoing to deploy additional acoustic transmitters, and detections may be expected over the next 5-10 years. Additional work will look to equip 54 Greenland halibut with pop-off archival satellite tags to collect high temporal resolution information on depth and temperature use over a period of 6-18 months. Genetic samples were taken from all tagged fish and are available for use by the AG-FISK/NORSUSTAIN projects.

Agenda 2d. - New moorings to monitor Greenland halibut movements in the Davis Strait

Presenter: Barkley, A.N., co-authors: Hedges K., Treble M., Hussey N.E.

For the past six years, in a collaborative effort between multiple academic, government and industry partners, moorings have been deployed and maintained in the offshore region of Baffin Bay to monitor the movements of Greenland halibut tagged with acoustic transmitters. These moorings detect the uniquely coded signal transmitted by the tag to identify individual fish along with the date and time the animal was within the vicinity. In 2021, 30 new moorings were deployed in a grid on the northern slope of the Davis Strait in NAFO management areas 0B (Canada), 1C and 1D (Greenland). Based on previous research on the abundance and distribution of mature and reproductive Greenland halibut that suggests the region south of 67°N in the Davis Strait is a potential spawning area for this species, these moorings are in a position to help identify the occurrence of aggregations and potential migrations from regions to the north and south. These moorings will be recovered and data downloaded in 2022.

Agenda pt 4. - Using Multivariate State-Space Models to examine stock of Greenland halibut in the North Atlantic.

Presenter: Julio Ubeda-Quesada, co-author Adriana Nogueira

Understanding how populations are interconnected across geographic, temporal, and political landscapes is challenging since most marine species can migrate long distances, crossing international boundaries. There are 4 offshore stocks of Greenland halibut in the North Atlantic. Here we examine the population structure of 3 stocks: (1) Eastern Canadian Arctic - West Greenland stock (Baffin Bay and Davis Strait, BBDS), (2) East Greenland – Iceland – Faroes stock (West Nordic Stock, WNS) and (3) Norway stock (North Arctic Stock, NAS) through time and space to assess whether the stocks are part of the same larger population or not, and how fishing or environmental changes affects their dynamics. We ask, (1) if the population abundance data support the existing management boundaries or are there different alternatives that receive more support, (2) assuming the subpopulations exist , dot hey experience independent environmental variability or correlated variability, and (3) are there differences in the spatial distribution of female and males. For thiswe have mathematically formulated different hypothesis about the population structure via different multivariate autoregressive state-space (MARSS) models. We combine time-series from bottom trawl surveys conducted by 4 different countries, from 1996 to 2019: 1 from Canada (0A), 4 from Greenland (West Greenland 1CD, West Greenland 1AF, East Greenland South and East Greenland North), 2 from Iceland (East Iceland and West Iceland), and 4 from Norway. We tested 16 different models? of population structures based on the literature and biology of Greenland halibut, for both sexes and for 3 length ranges (9-29 cm, juveniles; 30-60 cm maturing; >61cm adults). Finally, for each main model , we tested different levels of complexity. We allowed the growth rate to be equal or unequal, we set the level of process variance to be equal or different across each time-series, and allowed these latter to be correlated or independent. For each combination, we run the model with and without covariates (North Atlantic Oscillation and commercial catches) to evaluate relationships with climate and commercial catches. The most parsimonious model resulted in 6 different trajectories without any effect of the covariates over the abundance, with population growth rate being equal, and having independent process errors with identical variance: (1) Baffin Bay and Davis Strait (Canadian Arctic - West Greenland); (2) East Greenland north; (3) East Greenland South; (4) West Iceland; (5) East Iceland, and (6) North Arctic Stock. These analyses suggest that the assessment of Greenland halibut in the North Atlantic Ocean should be treated carefully, keeping an eye over the West Nordic SSock, which seems to be a mix of different populations.

Agenda pt 5 - Unravelling the population structure of Greenland halibut, Reinhardtius hippoglossoides (Walbaum) in the North Atlantic

Presenter: Daniel Estevez-Barcia, co-authors: Torild Johansen, Sæmundur …?

In order to determine genetic population structure of Greenland halibut in the North Atlantic, samples were collected from expected nursery grounds. These samples were sequenced following a RAD-seq protocols followed by variant calling. The markers were analysed to discover the most discriminant ones capable of differentiating among major expected nursery grounds . A hierarchical analysis indicates further differences within the NWA stock with Frobisher Bay as the most different after Norway. As these markers are selective candidates (i.e., they are subject to natural selection), these results suggest different selective regimes between the east and the west portion of the species range as assessed here. Furthermore, the differentiation of Forbisher Bay, which are the smallest individuals sampled, suggest natural selection occurs in early life history stages and that other selection regimes may be prevalent in more inshore areas.Markers discovered in the initial study were genotyped across several samples in the North Atlantic. After quality filters, the final dataset consisted of 1294 genotypes for 63 loci. Multivariate analyses indicated a weak longitudinal gradient for genetic differences, showing samples on the Norwegian shelf differing most from those in the West Atlantic (Baffin Bay). Bayesian based clustering methods indicated most samples to be very admixed. The initial results are consistent with preliminary conclusions emanating from the tagging work.

Agenda pt 8. - Drift simulation model for Greenland halibut

Presenter: Asbjørn Christensen

A drift simulation model has been setup for Greenland halibut using realistic physical data that covers stocks in the Davis Strait, Iceland-East Greenland region and NE Arctic. The biological model has a preliminary calibration, based on literature review, and the setup is at reproduction stage (i.e. ready to run, once additional data are made available within the project and final calibration of biological processes have been settled). Preliminary simulations of eggs and larvae from the Davis Strait were presented and preliminary work points to interesting requirements that water masses in spawning areas must fulfill to sustain successful spawning, and that critical knowledge gaps in relation to early life stages of Greenland halibut still exist.

Agenda pt 10 – Greenland halibut otolith micro-chemistry

Presenter: Mikko Vihtakari

Otolith chemistry can sometimes be used to trace migrations of fish. We examined the left otolith cross-sections of 10 oxytetracycline-tagged Greenland halibut that migrated from Svalbard to Iceland, aiming to find elemental cues for the timing of the migration. We analyzed the otoliths for oxygen isotopes and element ratios using secondary-ion and laser-ablation inductively coupled-plasma mass-spectrometers. Oxygen isotope values exhibited variable patterns indicating that the fish spent their time in varying temperatures, salinities, or water masses, but these patterns could not be interpreted as consistent annual marks. There was an offset in oxygen isotope values sampled adjacent to each other, possibly indicating that the microstructure of otoliths was more complex than visible from high-resolution photographs. Calcium was evenly distributed in all otoliths except one, indicating that it could be used as an internal standard. Strontium to calcium ratio demonstrated an abrupt increase after tagging lasting until the fish died. A similar pattern was partly visible in Mg/Ca and Ba/Ca while P/Ca and Zn/Ca correlated mostly with growth bands. These results need to be further analyzed before any conclusions can be drawn.