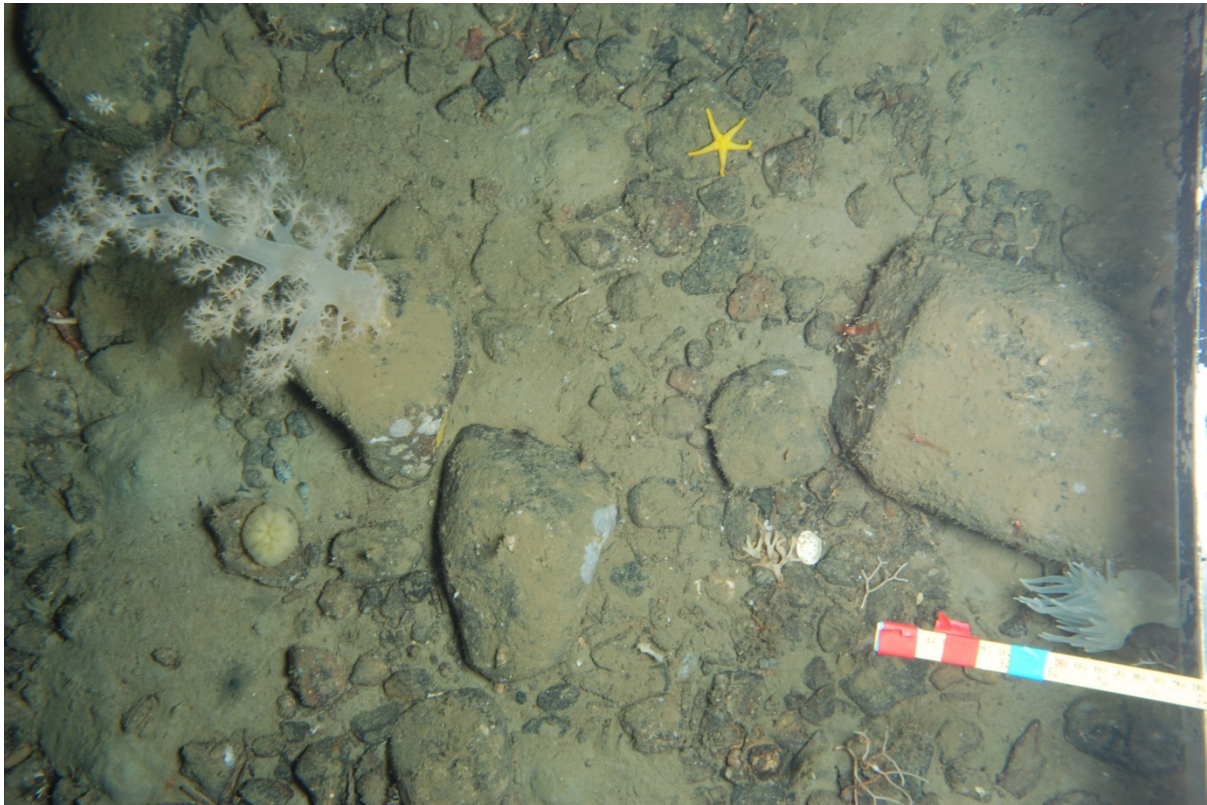


November 2016

Annual Report - 2016

Institute of Zoology Greenland Benthic Assessment

Dec 2015 – Nov 2016



Report compiled by
K. Kemp & C. Yesson
*Institute of Zoology, Zoological Society of London, Regent's Park, London, NW1 4RY,
United Kingdom*

For
Sustainable Fisheries Greenland
*c/o Grønlands Arbejdsgiverforening, Jens Kreutzmannip Aqq. 3, P.O. Boks 73, 3900
Nuuk, Greenland*

Greenland Climate Research Centre
Kivioq 3, P.O. Boks 570, 3900 Nuuk, Greenland

Contents

- 1. Executive summary**
- 2. Cruise report for 2016 survey**
- 3. Output**
 - 3.1 Provisional analysis of 2016 survey data*
 - 3.2 Acceptance of manuscript in ICES Journal of Marine Science*
 - 3.3 Manuscript submission – Benthic habitat classification*
 - 3.4 Manuscript preparation - Temporal comparison of benthic macrofaunal communities*
 - 3.5 Software development*
- 4. Other updates**
- 5. Summary and plans for 2017**
- Appendices**

1. Executive summary

- This report describes work undertaken between December 2015 and November 2016
- A successful benthic research cruise was conducted in Autumn 2016, surveying 59 sites around Melville Bay
- Provisional analysis shows relatively high benthic diversity and abundance in the Melville Bay region
- A manuscript describing benthic impacts of trawling has been accepted for publication in ICES Journal of Marine Science
- A manuscript classifying the benthic habitats of the West Greenland Shelf is in revision
- Research outcomes were presented at the 3rd annual MSC audit
- Proposals have been submitted to continue benthic research in West Greenland

2. Cruise report for 2016 survey

Summary of work: A dedicated 10 day benthic survey was undertaken aboard M/T Paamiut during September/October 2016. The ship left Upernavik on September 20th, conducted surveys between 73°21'N and 75°36'N, and returned to Aassiat on October 2nd. The first day was lost to bad weather but once they had begun operations ran continuously (24 hours a day) for the duration of the cruise. Fifty-nine stations were visited (Figure 1).

Personnel: Dr Chris Yesson (IoZ), Irina Chemshirova (IoZ)

Mission: This cruise was a dedicated benthic survey, designed to sample the benthic organisms of the Melville Bay region. The western shelf north of 73°N is outside the current extent of the West Greenland Coldwater Prawn Fishery. There has been some recent exploration of this region to test the viability of extending the fishery northwards. This survey was designed to sample potentially fish-able areas within the depths associated with the current fishery (~300-500m). The survey was a joint venture between the Greenland Institute of Natural Resources (GINR) and the Institute of Zoology.

At each station visited, three surveys were conducted:

i) IoZ's benthic drop camera was used to take photographs of the seabed. Deployment followed the methodology of previous surveys, taking 10 images per station, using a 1 minute drift to spatially separate the images. Additionally, the camera frame was fitted with a GoPro video camera and torch (detailed in the 2015 cruise report), which was used to collect video footage at the same time as the still images. After the tenth still image was taken, the camera was lifted approx 1m above the seabed and allowed to drift for 1min to take a 'video transect' of the area.

ii) After each camera survey was complete a beam trawl survey was carried out in the same area. The beam trawl samples benthic organisms. These trawls were conducted as part of the benthic survey of the Greenland shelf currently being conducted by Martin Blicher (GINR). Specimens were identified and documented by a team of benthic taxonomists.

iii) After each beam trawl was complete, a cosmos trawl was carried out. All catch was assessed following the protocols of the annual shrimp stock assessment surveys. The cosmos trawl survey was led by Nanette Hammeken of GINR. Benthic bycatch was examined and documented by the benthic taxonomists.

Equipment:

Camera

The IoZ drop camera was used to conduct photographic surveys. Initial setup of the camera revealed a fault in the camera system. The flash did not go off during surface testing. The fault was traced to the camera, but could not be diagnosed or rectified in time for the first deployment. However, a duplicate camera system, owned by Martin Blicher, was on board and parts from this camera were substituted into our system to enable surveys to proceed

without a delay. At the end of the cruise, the fault was eventually traced to the flash mount point of the Nikon digital SLR camera. The repeated screwing-in of the connector had worn an indentation in the flash mount point and the electronic connection was broken. Placing a small piece of aluminium foil over the connector was sufficient to restore the connection and the camera should function for future deployments.

Temperature logger

As in 2015, a Starmon temperature logger, borrowed from Nanette Hammeken of GINR, was installed on the drop camera, to record the temperature at the seabed during deployment of the camera.

GoPro

A GoPro video camera, placed in an underwater housing was used to capture video footage of the seabed, following the protocol outlined in the 2015 cruise report. The protocol was slightly amended this year in an attempt to obtain more detailed video footage of life on the seabed. At the end of the drop camera deployment the camera was raised 1m above the seabed and allowed to drift for 1 minute. Maintaining the camera at 1m above the seabed was a difficult procedure. Any swell would result in the camera bobbing up and down, and as this sometimes exceeded 1m, the camera would sometimes hit the seabed during this drift period. Furthermore, the winch slips slightly, causing the camera to move slowly downwards when the winch is not in action.

For the first time, we attempted to capture video during the deployment of the beam trawl. The ship's engineers built a steel-plate housing for the GoPro camera and torch, which was fitted to the top of the beam trawl (Figure 2). The camera recorded the deployment of 5 beam trawl surveys. Three of these deployments used the camera to record video, while the remaining two deployments used time-lapse photography. The time-lapse photography was largely unsuccessful, with the majority of images being blurred due to the combination of low-light and rapid movement of the beam trawl over the seabed. The video was more successful, recording reasonable quality footage, suitable for taxonomic identification of many organisms (Figure 3).

Observations: A number of notable observations were made from the images taken during the cruise. The seapen genus *Umbellula*, known locally as the “sea flower” was observed for the first time in our images and video footage. Although this genus is relatively commonly in bycatch from the cosmos trawl, it is rarely taken in the beam trawl and before 2016 has not been seen in our benthic images. This year one camera deployment resulted in the camera landing directly on top of a specimen (which commonly reach more than 1m in length) and we also recorded several small specimens by our drop camera and larger specimens from the video footage (Figure 4). Another first was an observation of the carnivorous sponge *Chondrocladia* (Figure 5). This sponge has been recorded in East Greenland, but has never been seen before in our West Greenland images, nor has it been seen in the bycatch (Martin Blicher pers. comm.). We can find no records in NAFO reports of sponge bycatch, but the genus is listed in the NAFO sponge ID guide. However we note that *Chondrocladia* was only

seen in the shallow (<200m) and deep (>500m) stations, in areas likely to be unsuitable for the fishery.

There were two videos taken that highlight the mobility of apparently fixed, sessile benthic taxa. An anemone (*Hormathia digitata*) and a sponge (*Asconema* sp.) were observed in separate videos that were floating along the seabed, apparently drifting on the wave caused by the lowering of our camera. These appear to be attached to small stones that provide sufficient ballast to allow for stable orientation and normal development for life on the seabed. Several specimens showing attachment to small stones were brought up in bycatch. This observed capacity for passive mobility has important implications for survival of these animals after disturbance. Fauna which stand erect on the seabed and are characterised by permanent attachment to fixed hard surfaces are at high risk of suffering irreparable damage during impact disturbances.

We selected stations to provide a comparison of lightly fished and unfished areas. However, this selection was made based on the exploratory fishing operations made in 2014 and 2015. No data were yet available for the 2016 trawls. During the cruise we saw several fishing vessels trawling in the same areas of our surveys, so our initial assessment of trawled and untrawled areas will require revision. These data will be provided by Nanette Hammeken of GINR as soon as they are available.

Figure 1. Locations of camera stations and test fishing stations during the 2016 benthic survey

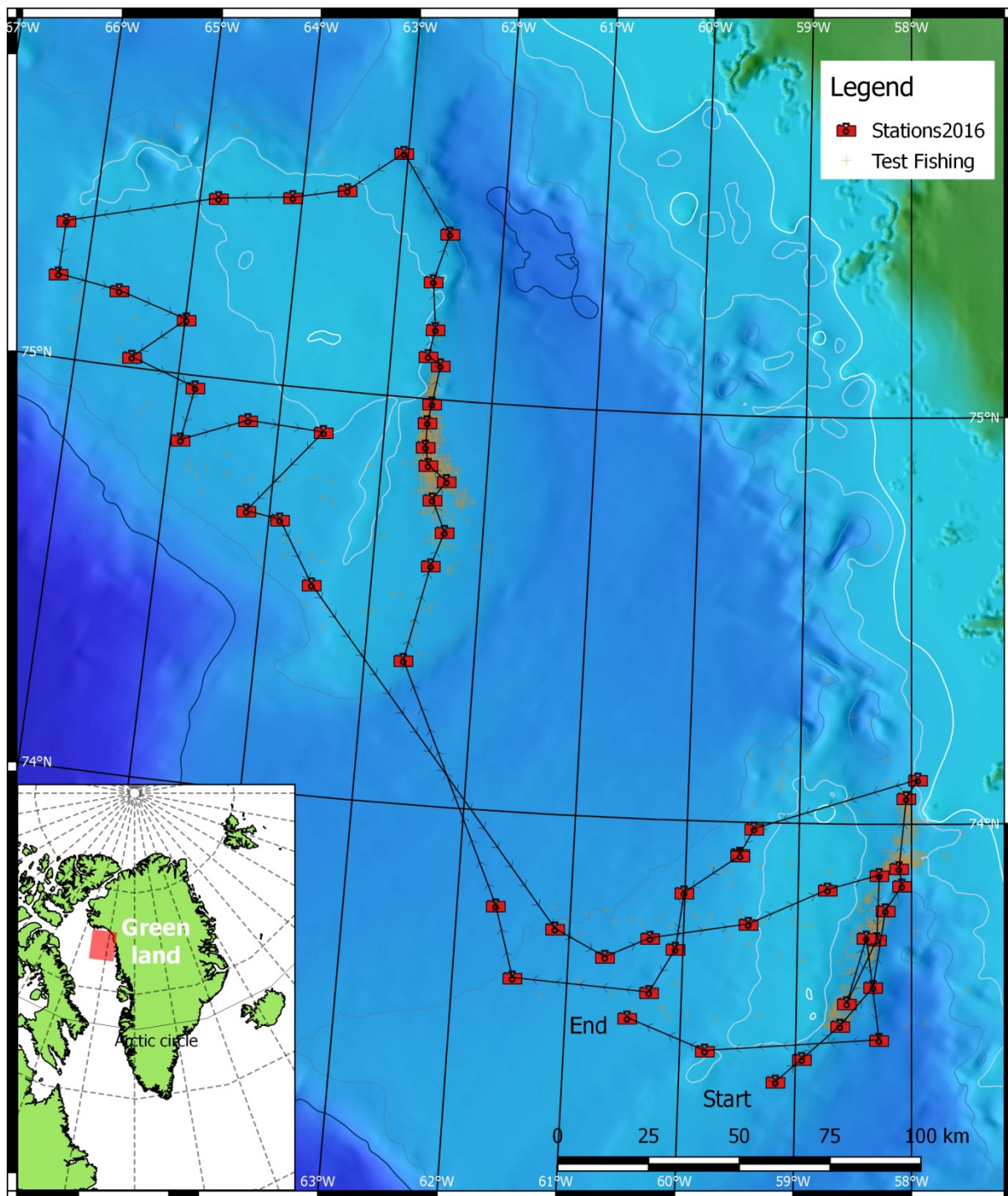


Table 1. Stations sampled during the 2016 survey

Station	Date	Time	Latitude	Longitude	Depth (m)	GoPro
1	22/09/16	07:15	73°21.881'N	59°09.99'W	382	Yes
2	22/09/16	11:48	73°25.29'N	58°56.57'W	376	Yes
3	22/09/16	15:02	73°30.26'N	58°36.98'W	377	Yes
4	22/09/16	19:22	73°36.024'N	58°19.959'W	516	Yes
5	22/09/16	23:45	73°47.330'N	58°13.612'W	484	
6	23/09/16	03:58	73°50.99'N	58°04.94'W	354	Yes
7	23/09/16	07:21	73°53.55'N	58°06.48'W	405	Yes
8	23/09/16	13:27	74°03.90'N	58°02.70'W	435	Yes
9	23/09/16	16:48	74°06.63'N	57°56.39'W	461	Yes
10	23/09/16	22:19	73°59.113'N	59°24.085'W	335	Yes
11	24/09/16	01:05	73°55.36'N	59°31.24'W	385	Yes
11-repeat	24/09/16	01:49	73°55.105'N	59°31.212'W	381	Yes
12	24/09/16	05:15	73°49.382'N	60°00.310'W	426	Yes
13	24/09/16	08:42	73°41.048'N	60°03.903'W	358	Yes
14	24/09/16	11:52	73°34.511'N	60°16.871'W	345	Yes
15	24/09/16	16:32	73°35.631'N	61°28.497'W	492	Yes
16	24/09/16	21:24	73°46.099'N	61°39.515'W	586	Yes
17	25/09/16	05:00	74°21.244'N	62°38.602'W	381	Yes
18	25/09/16	08:49	74°35.490'N	62°27.697'W	298	Yes
19	25/09/16	11:45	74°40.577'N	62°21.445'W	335	Yes
20	25/09/16	14:18	74°45.228'N	62°29.662'W	334	Yes
21	25/09/16	16:55	74°48.104'N	62°22.464'W	391	Yes
22	25/09/16	19:34	74°50.273'N	62°33.492'W	366	Yes
23	25/09/16	22:17	74°52.946'N	62°35.810'W	365	Yes
24	25/09/16	00:57	74°56.546'N	62°35.908'W	358	Yes
25	25/09/16	03:41	74°59.380'N	62°34.085'W	382	Yes
26	26/09/16	06:46	75°05.113'N	62°30.979'W	381	Yes
27	26/09/16	09:34	75°06.315'N	62°38.399'W	177	Yes
28	26/09/16	12:32	75°10.394'N	62°35.588'W	251	Yes
29	26/09/16	15:33	75°17.408'N	62°38.941'W	385	Yes
30	26/09/16	18:35	75°24.641'N	62°31.428'W	381	Yes
31	26/09/16	23:51	75°35.998'N	63°02.566'W	319	Yes
32	27/09/16	04:16	75°29.708'N	63°34.032'W	183	Yes
33	27/09/16	07:07	75°27.850'N	64°05.656'W	171	Yes
34	27/09/16	10:30	75°26.503'N	64°49.104'W	188	Yes
35	No images at this station due to camera malfunction					
36	27/09/16	17:24	75°20.253'N	66°16.063'W	313	Yes
37	27/09/16	20:42	75°12.319'N	66°16.177'W	283	Yes
38	27/09/16	23:52	75°11.097'N	65°39.893'W	290	Yes
39	28/09/16	03:15	75°08.096'N	64°59.267'W	282	Yes
40	28/09/16	06:17	75°01.598'N	65°27.674'W	350	Yes
41	28/09/16	09:40	74°58.275'N	64°49.578'W	327	Yes
42	28/09/16	12:41	74°50.342'N	64°54.406'W	392	Yes
43	28/09/16	16:00	74°54.339'N	64°17.583'W	275	Yes
44	28/09/16	19:08	74°53.755'N	63°34.226'W	194	Yes
45	28/09/16	22:41	74°41.026'N	64°13.075'W	378	Yes
46	29/09/16	02:11	74°40.240'N	63°53.752'W	343	Yes
47	29/09/16	05:26	74°31.152'N	63°32.650'W	402	Yes
48	29/09/16	14:25	73°43.212'N	61°07.603'W	503	Yes
49	29/09/16	17:53	73°39.431'N	60°40.675'W	443	Yes
50	29/09/16	21:04	73°42.507'N	60°17.431'W	407	Yes
51	30/09/16	00:48	73°45.041'N	59°25.882'W	252	Yes
52	30/09/16	04:35	73°50.314'N	58°44.345'W	156	Yes
53	30/09/16	09:12	73°52.526'N	58°16.984'W	297	Yes
54	30/09/16	12:20	73°43.047'N	58°18.128'W	509	Yes
55	30/09/16	16:38	73°33.575'N	58°33.597'W	379	Yes
56	30/09/16	20:07	73°43.273'N	58°23.610'W	381	Yes
57	01/10/16	00:15	73°28.222'N	58°16.702'W	181	Yes
58	01/10/16	03:06	73°26.187'N	59°46.866'W	297	Yes
59	01/10/16	06:03	73°30.618'N	60°27.669'W	354	Yes

Figure 2. Framework and housing for GoPro camera (left), and fitted to the beam trawl (right)



Figure 3. Still image from GoPro video recorded from a beam trawl

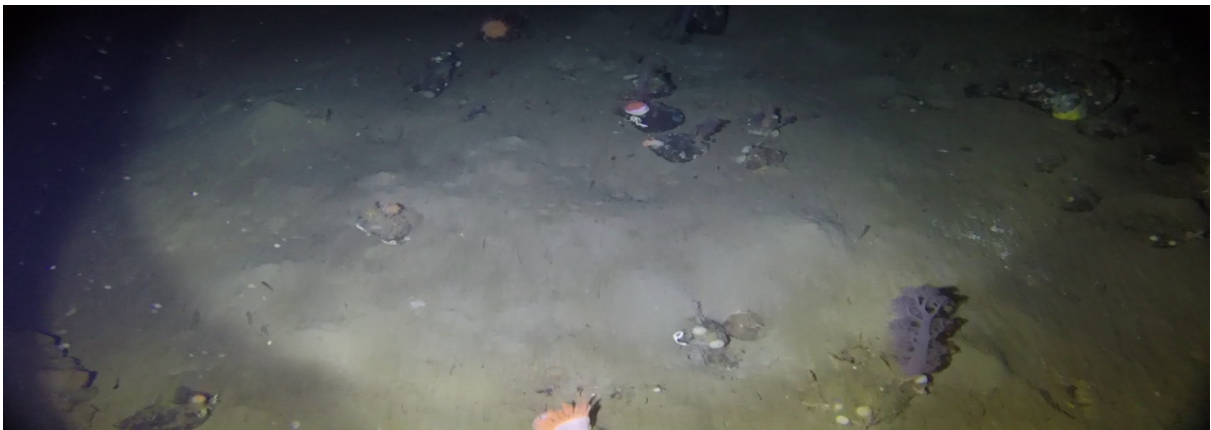


Figure 4. The “sea flower” *Umbellula*



Figure 5. A first observation of the carnivorous sponge *Chondrocladia* in West Greenland.



3. Output

3.1 Provisional analysis of 2016 survey data

The 500+ images taken during the 2016 benthic research cruise have been examined and the organisms observed have been identified. As the cruise was completed in early October, there has been limited time for the analysis of these data. These identifications were completed just 1 week prior to the production of this document. The analysis has not been thoroughly checked and should be treated with caution.

A provisional analysis indicates that there is generally a higher level of abundance and diversity in the Melville Bay area than many other areas along the Western shelf (Figure 6). The areas below 72°N, within the current fishery extent, are notably less abundant and less diverse. Note that identifications have not been standardised between areas, so there may be some revision to these findings.

Limited fishing has taken place above 72°N, focussed on the eastern edges of the two survey loops (Figure 1). The data presented in Figure 1 are based on the start-of-trawl locations for trawls conducted in 2014 and 2015. Data are not yet available for 2016 fishing.

There is a somewhat contradictory pattern in the relationship between trawling activity, diversity and abundance. Along the southern loop of the survey, the southern region is both the most fished but also the most diverse, whereas in the area of the northern loop the SE region has seen highest trawling and has the lowest diversity. Overall, we see a significant negative impact of trawling on diversity, but positive impact on abundance (Figure 7). This would fit a pattern of post-disturbance colonisation by a limited number of taxa, although this should be treated as speculation at this early stage of analysis.

3.2 Manuscript acceptance – *Benthic impact of trawling*

A manuscript entitled “The impact of trawling on the epibenthic megafauna of the West Greenland shelf” was accepted for publication by ICES Journal of Marine Science. This paper describes patterns of benthic diversity and abundance in relation to trawling impact and the environment and concludes that areas with soft sediment are less impacted by trawling.

Reference: Yesson C., Fisher J., Gorham T., Turner C. J., Hammeken Arboe N., Blicher M. E. & Kemp K. M. “The impact of trawling on the epibenthic megafauna of the West Greenland shelf”. ICES Journal of Marine Science. Accepted 4th October 2016.

3.3 Manuscript submission – *Benthic habitat classification*

A manuscript entitled “Mapping and classifying the seabed of the West Greenland continental shelf” was submitted to the journal Estuarine and Coastal Shelf Science. This manuscript is based on the MSc thesis of Sarah Gougeon described in the 2015 annual report. We are currently revising the manuscript in response to some constructive reviewers' comments.

Figure 6 – Map of all camera survey stations. Top left (North of Upernavik) shows the regions visited during the 2016 survey. Larger circles show higher abundance (log transformed).

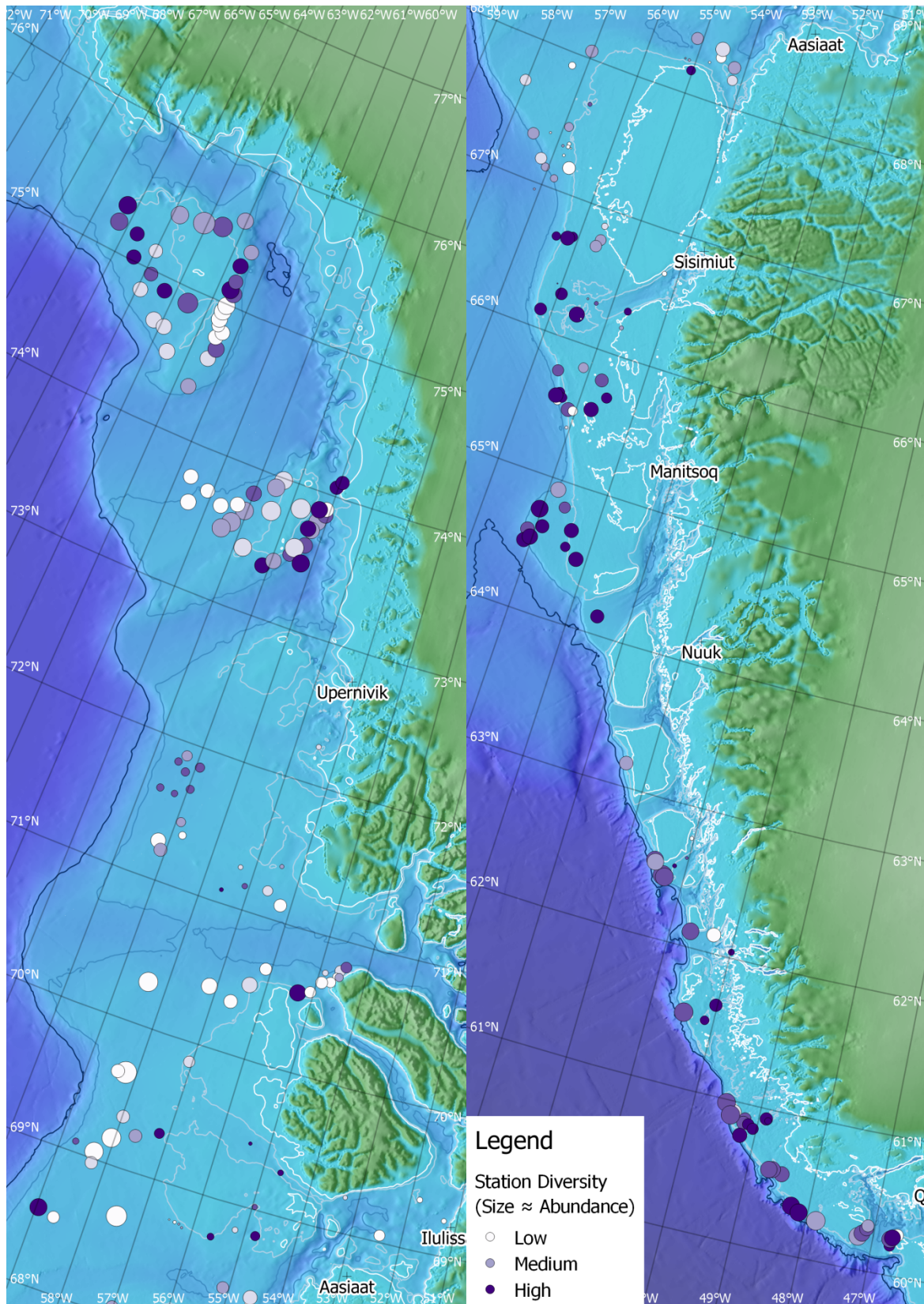
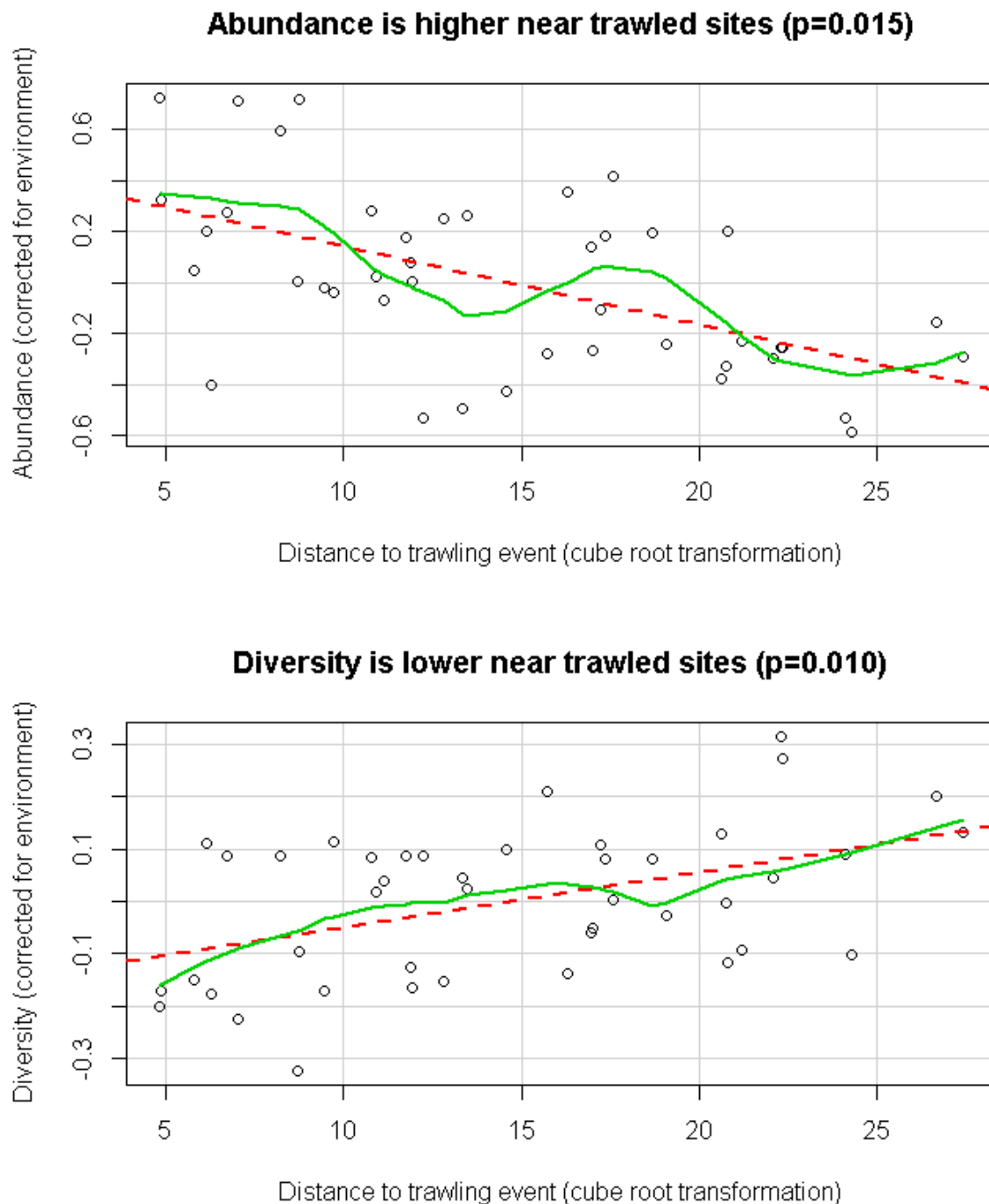


Figure 7 – Provisional results of analysis of 2016 survey data. There is evidence of higher abundance near trawled locations, but lower diversity. These figures show the pattern of abundance (top) and diversity (bottom) in relation to trawling impact (distance to the nearest trawling event). These are partial residual plots based on models of diversity ~ environment + impact, which explore the relationship of diversity and impact after adjusting for differences in environment. Red lines show linear trends, and green lines show loess smoothing



3.4 Manuscript preparation - Temporal comparison of benthic macrofaunal communities

A manuscript is being prepared describing a historical comparison of benthic diversity and abundance based on images taken in the 1970s and 1980s. This will expand on the work presented in Mate Vakarc's MSc thesis described in the 2015 annual report.

3.5 Software development

A student from the computer science department of Queen Mary College, University of London worked on the development of our image analysis software over the summer of 2016. Samprit Bains was awarded a NERC DTP summer placement of 10 weeks. Samprit worked on providing additional features to the software package Poseidon. His main task was to create a fully functioning, stand-alone, distributable version of the software to enable sharing with other researchers.

4. Other updates

Dr Kirsty Kemp and Dr Chris Yesson attended the 3rd annual MSC audit of the West Greenland Coldwater Prawn Fishery, held in Aalborg in Feb 2016. Drs Kemp & Yesson gave a presentation highlighting their research findings and the implications on the certification process.

Mud samples from the seabed collected during the 2014 & 2015 cruises were sent to Dr Andrew Thurber of Oregon State University. Dr Thurber is leading a project to perform a global analysis deep-sea sediment microbiomes. Sequencing has finished and the biome analysis is ongoing. Once this is achieved we will examine the microbiome over a gradient of fishing impacts.

Genetic samples of several seapen species collected in Greenland, were analysed as part of a collaboration with National University of Ireland (NUI). Dr Chris Yesson, Kevin Hopkins (IoZ), Raissa Hogan and Louise Allcock (NUI Galway) used next generation sequencing to reconstruct the mitochondrial genomes of more than 20 seapen species. These data will provide a unique genetic resource to allow investigation into the evolution of seapens in Greenland and the wider North Atlantic.

5. Plans for 2017

The IoZ/SFG contract of work comes to an end in February 2017. This coincides with the end of the MSC certification process for *Pandalus borealis*.

Applications have been made to various funders to continue research into the benthic habitats of West Greenland. If successful these could involve three new research cruises in 2017.

- Application to IUCN BEST 2.0 for two years of funding to revisit historical survey sites and perform benthic habitat surveys of the Halibut fishery region (partnered and co-funded by SFG).
- Application to Sea Pact for 4 months of funding to revisit historical survey sites during leg 1 of the 2017 stock assessment survey.
- Application to Dancea: this project is led by GINR and aims to produce a detailed map of benthic habitats following the MAREANO model. Application requests 2 month of funding for IoZ to collect ground-truthing images for benthic habitats modelling. This would involve revisiting historical survey sites during leg 1 of the 2017 stock assessment survey (as above) and a new 6 day survey aboard GINR's vessel "Sanna" to the Disko Bay area to perform video and photographic surveys.

We are pleased to announce that Dr Kemp & Yesson have received substantial Institutional support from IoZ. Dr Kemp has been awarded a 2 year fellowship by IoZ that will begin on her return from parental leave. Dr Yesson's current contract will continue until at least March 2018. This will permit continued benthic research at IoZ and enable us to conduct the 2017 field surveys outlined in the BEST proposal, regardless of whether the BEST application is successful (conditional on SFG supporting the cruises committed in that proposal).

We are currently in talks with two PhD students who are interested in conducting benthic ecological research in Greenland. These students have been funded by the Doctoral Training Program led by UCL. One student is interested in researching functional ecology and would like to collect samples of benthic organisms for stable isotope analysis. The other student is interested in ways to measure fisheries impacts and fisheries management.

Appendix

Appendix 1 – Yesson et al (Accepted 4th October 2016) "The impact of trawling on the epibenthic megafauna of the West Greenland shelf". ICES Journal of Marine Science. (doi:10.1093/icesjms/fsw206). Proof of article, prior to corrections. Not for public circulation. Final print version will be circulated in a couple of weeks.