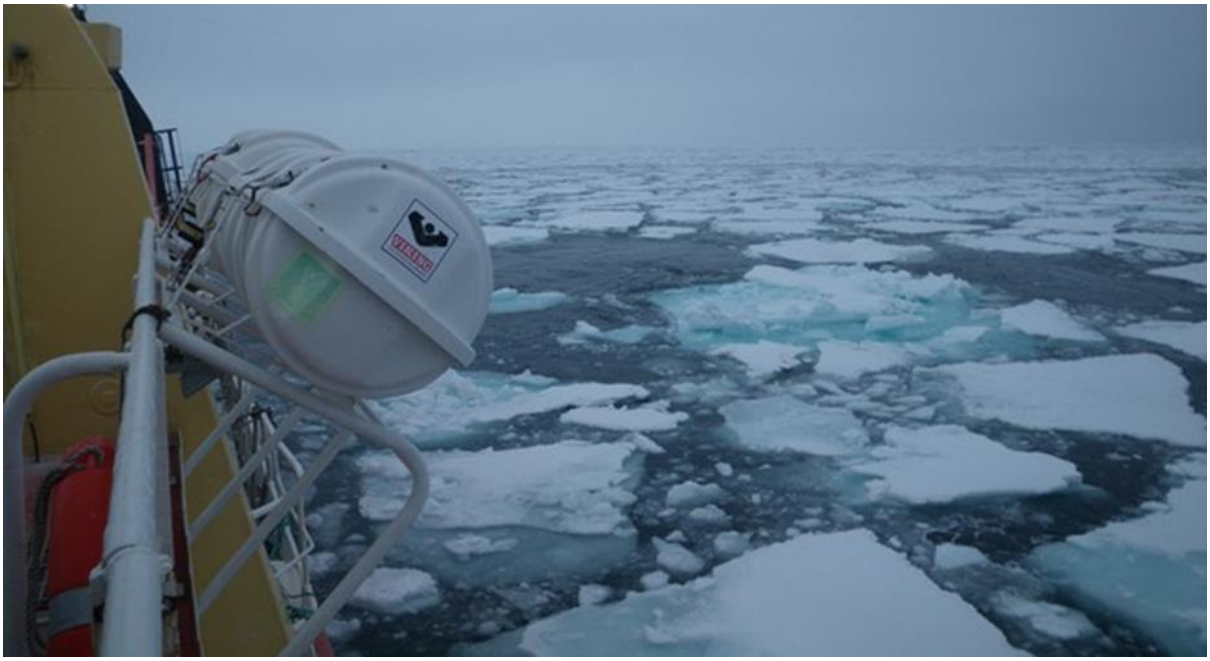
November 2015

3rd Annual Report

Institute of Zoology Greenland Benthic Assessment

Dec 2014 – Nov 2015



Report compiled by
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1. Executive summary

- This report describes work undertaken between December 2014 and November 2015. and includes **one season of fieldwork** conducted aboard M/T Paamiut in the summer of 2015
- The development of a comprehensive and shareable **image database** was undertaken
- A seabed **habitat classification map** for the region was generated
- Analysis of community patterns of **functional diversity** was undertaken
- **Historical imagery** was formally compared to recent images of the same region
- A **full assessment of all environmental and community data** gathered between 2011-2013 was undertaken to produce a peer-review publication describing the benthic habitat and species distributions that characterise the west Greenland continental shelf
- Previously developed **image analysis software** was further developed
- Work from this project was presented to an international audience of marine scientists at a **conference** in Aveiro, Portugal
- Plans for **2016 survey** and analysis are underway

2. Cruise report for 2015 survey

Summary of work:

The benthic survey undertaken on Togt 1 of the Paamiut Rejefisk survey was successful. Although the original survey plan was curtailed by extensive and unseasonal ice cover, 394 usable photos of the seafloor were collected over 14 days from 51 stations spanning 64°N to 69°N (Figure 1 – Table 1). This year bottom temperature readings and video footage were also collected for the first time.

Personnel: Dr Kirsty Kemp, Dr Chris Yesson

Mission: The priority for this trip was to continue our work taking benthic images over a gradient of trawling effort in order to investigate the relationship between community composition and fishing impact. We were targeting locations for which there were images taken in the 1970s and 1980s to continue our study of historical change over the past 40 years. We managed to successfully sample 7 of these sites on this trip (Figure 1). The majority of targeted stations were inaccessible due to extensive ice cover (Figure 2).

Equipment:

Winch

ZSL's benthic camera was used for imaging the seabed. Unfortunately the digital depth display of the winch used to deploy the camera was not operational. Initial trials of camera deployment, without knowing the depth of camera and relying solely on 'feeling' when the camera hit the bottom, were not successful. An attempt was made to use an acoustic depth signaller (used on the trawl doors) to give real-time depth readings, but this proved unreliable. A mechanical pulley was found (thanks to Martin Blicher) as a replacement. This system measures the length of deployed winch wire and required that the winch be operated from the top deck where the guage could be viewed, rather than the winch room, but proved a workable solution.

Camera

Initial deployments of the camera (when camera depth was not known) resulted in the prolonged dragging of the camera across the sea bed. The trigger weight was lost during this deployment. This gave the camera a bit of a battering and caused a series of camera malfunctions that resulted in poor quality, blank or no images being taken for a handful of the earlier stations. We systematically checked and tuned the camera settings (which had been changed by excessive shaking). After several deployments the issues were resolved and the camera functioned well. At station 8 the flash hood fell off the camera (probably loosened by the earlier shaking). We used the hood from Martin Blicher's equipment to continue our sampling until the chief engineer was able to construct a replacement hood with a more secure fastening, which was then used for the remainder of the cruise.

GoPro

This year we trialled the use of a GoPro video recorder placed in an underwater housing rated to 2,700 m. This was used alongside an LED torch in an underwater housing rated to 1,250 m. Several test deployments were made, attaching the GoPro and torch to different parts of the camera frame. The chief engineer designed a mesh attachment to the camera frame to hold the GoPro and torch at a 45 degree angle, inside the camera frame (Figure 3). This setup proved successful and the GoPro camera was deployed at 15 stations. The video footage taken at an oblique angle proved a useful aid for identification of fauna (Figure 4).

Temperature logger

For the first time on our surveys, the camera frame was fitted with a temperature logger. A SeaStar Starmon Mini recorder was attached to the top of the camera frame, and took temperature readings at 10 second intervals for the duration of the cruise. Seabed temperatures ranged from -0.3 to 6.8°C. *In-situ* temperature measurements will be a useful additional dataset for analysis.

Mud sampler

The mud sampling device, which attaches to the base of the camera frame, (designed during the 2014 cruise), was deployed at 7 stations. Two samples were taken per station; one was stored in RNA later for potential genetic analysis and the other simply placed into empty tubes for morphological analysis of grain size.

Bycatch processing:

This was the first survey to include researchers who were dedicated to the sampling and identification of benthic bycatch. This project was run by Martin Blicher and included three benthic specialists who were examining the bycatch from each shrimp trawl survey, as well as deploying a beam trawl for in-depth, dedicated benthic sampling. The onboard taxonomic experts proved a great help in the identification of organisms observed in our images. Benthic images were taken at stations surveyed with the beam trawl with the hope of comparing taxa observed by both methods.

Ad-hoc collections of benthic samples were taken. Twenty samples of the soft coral Nephtheidae were collected for genetic analysis. Additionally samples of benthic invertebrates were collected and dried for use during public engagement and outreach activities.

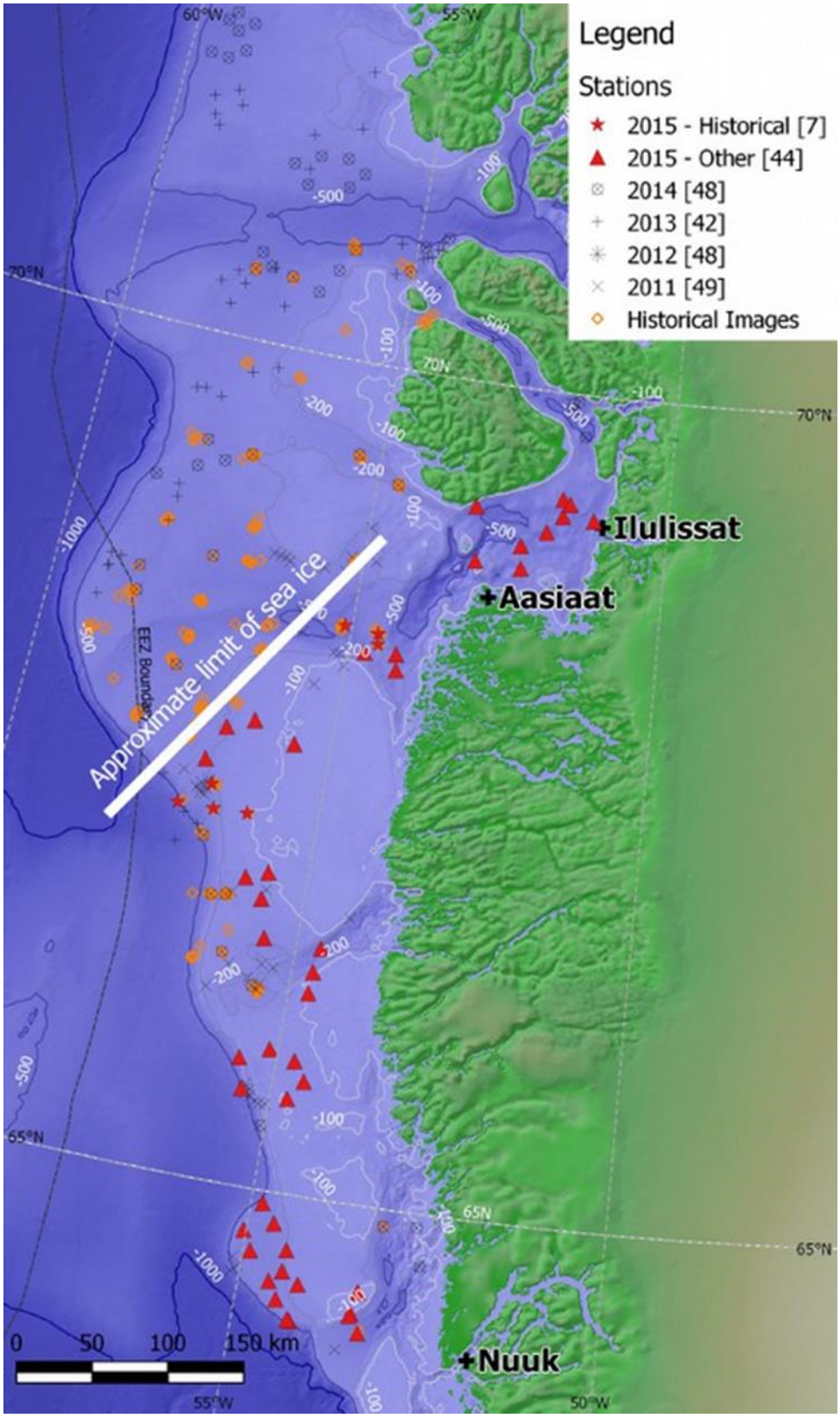

Figure 1. Locations of camera stations sampled in 2015

Table 1. Stations sampled during the 2015 survey

Number	Date	Start Time	End Time	Longitude	Latitude	Depth	Historical	Temperature	GoPro	Mud
1	29.05.15	20:59:00	21:21:00	53° 15.831' W	64° 15.056' N	350	No	4.561	Yes	
2	29.05.15	23:25:00	23:39:00	53° 23.777' W	64° 21.721' N	75	No	0.439		
3	30.05.15	00:22:00	00:33:00	53° 24.992' W	64° 20.885' N	126	No	1.562		
4	30.05.15	02:10:00	02:20:00	53° 20.207' W	64° 29.566' N	70	No	0.414	Yes	
5	30.05.15	18:52:00	19:07:00	54° 12.697' W	64° 15.779' N	319	No	4.574	Yes	
6	30.05.15	20:26:00	20:44:00	54° 14.59' W	64° 16.269' N	295	No	4.486		
7	30.05.15	22:23:00	22:38:00	54° 26.363' W	64° 22.632' N	236	No	3.181		
8	31.05.15	00:46:00	01:11:00	54° 34.564' W	64° 28.673' N	269	No	4.936		
9	31.05.15	03:33:00	03:53:00	54° 24.787' W	64° 32.838' N	250	No	3.521		
10	31.05.15	05:04:00	05:18:00	54° 10.414' W	64° 29.088' N	143	No	1.448		
11	31.05.15	21:33:00	21:53:00	54° 53.851' W	64° 38.198' N	293	No	4.449		
12	31.05.15	23:13:00	23:27:00	55° 2.249' W	64° 45.129' N	295	No	4.336		
13	1.6.15	01:10:00	01:29:00	54° 50.358' W	64° 55.68' N	460	No	4.674		
14	1.6.15	02:46:00	02:59:00	54° 38.104' W	64° 49.184' N	258	No	2.753		
15	1.6.15	04:16:00	04:36:00	54° 24.063' W	64° 40.502' N	196	No	2.057		
16	1.6.15	19:45:00	20:00:00	54° 44.849' W	65° 33.817' N	107	No	1.27		
17	1.6.15	21:10:00	21:31:00	54° 33.066' W	65° 40.828' N	126	No	1.753	Yes	
18	1.6.15	22:44:00	22:57:00	54° 44.039' W	65° 47.528' N	120	No	1.6		
19	2.6.15	00:29:00	00:45:00	55° 7.105' W	65° 50.196' N	128	No	1.702		
20	2.6.15	02:08:00	02:20:00	55° 32.052' W	65° 45.416' N	291	No	2.778		
21	2.6.15	03:13:00	03:29:00	55° 25.526' W	65° 34.744' N	210	No	2.866		
22	2.6.15	21:24:00	21:41:00	55° 29.701' W	66° 29.045' N	191	No	2.475	Yes	Yes
23	3.6.15	00:19:00	00:32:00	54° 37.546' W	66° 28.836' N	372	No	3.018		Yes
24	3.6.15	01:50:00	02:08:00	54° 41.143' W	66° 20.035' N	157	No	0.798		
25	3.6.15	03:08:00	03:18:00	54° 42.113' W	66° 12.295' N	97	No	0.567		
26	4.6.15	01:03:00	01:21:00	55° 36.623' W	66° 52.397' N	100	No	5.447		
27	4.6.15	02:41:00	02:52:00	55° 56.268' W	66° 49.288' N	137	No	0.516		
28	4.6.15	04:08:00	04:23:00	55° 38.611' W	66° 42.792' N	136	No	0.401		
29	4.6.15	22:00:00	22:16:00	57° 11.49' W	67° 10.885' N	565	Yes	5.248		Yes
30	5.6.15	00:24:00	00:36:00	56° 43.77' W	67° 19.739' N	208	Yes	2.399		Yes
31	5.6.15	01:49:00	02:07:00	56° 37.623' W	67° 11.221' N	265	Yes	4.536		
32	5.6.15	03:43:00	03:56:00	56° 6.128' W	67° 11.834' N	109	Yes	0.606		
33	5.6.15	19:49:00	20:06:00	56° 54.365' W	67° 28.271' N	204	No	3.156		
34	5.6.15	22:59:00	23:12:00	56° 40.904' W	67° 41.003' N	199	No	3.521		Yes
35	6.6.15	00:55:00	01:11:00	56° 15.693' W	67° 45.31' N	147	No	1.499		
36	6.6.15	03:58:00	04:09:00	55° 34.824' W	67° 39.46' N	79	No	-0.319	Yes	
37	6.6.15	19:14:00	19:27:00	54° 11.149' W	68° 12.115' N	244	No	6.826	Yes	
38	6.6.15	21:23:00	21:36:00	54° 43.969' W	68° 16.592' N	381	No	4.586		
39	6.6.15	23:18:00	23:33:00	55° 7.087' W	68° 24.908' N	471	Yes	4.486		
40	7.6.15	01:12:00	01:23:00	54° 33.815' W	68° 23.976' N	261	Yes	4.449	Yes	
41	7.6.15	02:20:00	02:35:00	54° 32.474' W	68° 20.159' N	241	Yes	4.449		
42	7.6.15	03:49:00	04:01:00	54° 13.414' W	68° 17.754' N	349	No	4.073	Yes	
43	8.6.15	00:29:00	00:31:00	53° 9.917' W	68° 55.601' N	666	No	4.186	Yes	
44	8.6.15	03:48:00	03:59:00	53° 16.524' W	69° 15.139' N	370	No	3.973	Yes	
45	8.6.15	21:46:00	21:58:00	52° 23.6' W	68° 54.897' N	350	No	3.709	Yes	Yes
46	8.6.15	23:17:00	23:29:00	52° 26.293' W	69° 3.054' N	300	No	3.709		
47	9.6.15	01:39:00	01:41:00	52° 1.917' W	69° 9.064' N	450	No	3.885		
48	9.6.15	03:52:00	04:06:00	51° 49.065' W	69° 21.577' N	307	No	3.282	Yes	Yes
49	9.6.15	19:57:00	20:12:00	51° 47.291' W	69° 15.419' N	427	No	3.772	Yes	Yes
50	9.6.15	21:25:00	21:39:00	51° 41.223' W	69° 19.986' N	330	No	3.609	Yes	
51	10.6.15	00:28:00	00:41:00	51° 15.528' W	69° 15.043' N	374	No	3.621		

Figure 2. Extensive sea ice encountered between 67-68°N, which severely limited sampling in target areas of historical surveys (Photo: Chris Yesson)

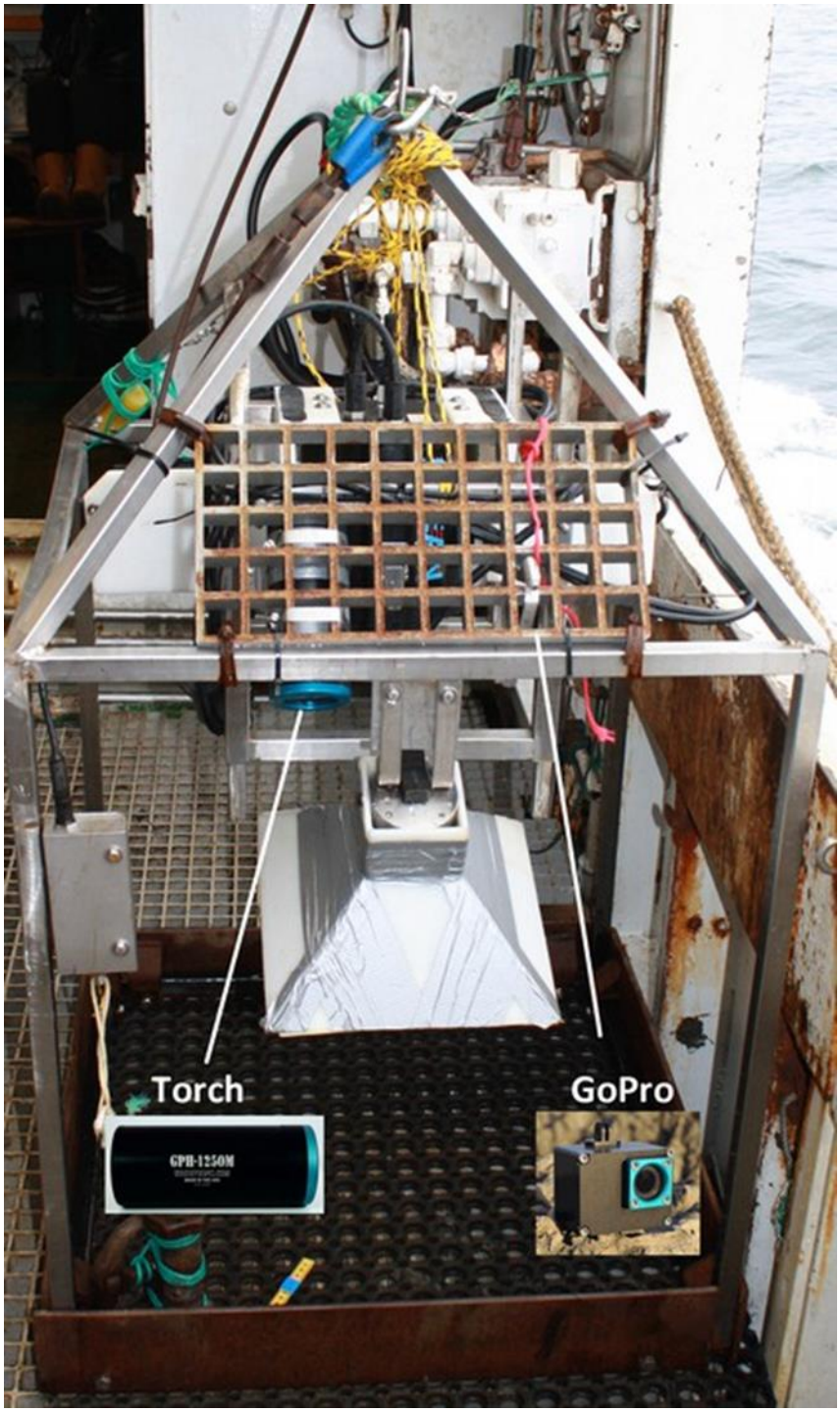

Figure 3. GoPro camera and torch in deep water housings, fitted to the side of the frame to capture video footage of the seabed. (Photo: Chris Yesson)

Figure 4. Still from GoPro video footage (above) and still camera image from the same station (below). (Photo: Institute of Zoology).

3. Output

3.1 Development of image database

Chris Turner was employed as an intern during the period January-August 2015. Chris was a masters student in 2014 working on modelling the distribution of soft corals (see 2nd Annual report). His internship was partially funded by this project. Chris spent a large part of his internship managing and updating our database of benthic images. All images taken between 2011-2015 have been input into the Poseidon system (see below), and identifications have been cross-checked for consistency. During the lifetime of this project there has been a considerable development in our understanding and knowledge of the benthic fauna present in West Greenland, so it was an important process to review and revise earlier identifications. There are now 1,892 analysed images on the system and 180,772 animals have been identified.

A second element of Chris's internship was to produce an online inventory of taxa seen in the benthic bycatch of annual shrimp trawl surveys. In collaboration with the Greenland Institute of Natural Resources, Chris produced a spreadsheet documenting all morphologically distinct taxa based on images of benthic bycatch taken during the 2014 surveys. This is viewable as a google spreadsheet here (https://goo.gl/bW1dx9). This was shared with collaborators working on the benthic bycatch monitoring program, and was used during the 2015 field season to aid the identification of bycatch.

A final component of Chris's internship was working on a benthic photography project in Iceland. This was part of a project funded by Eurofleets (EU) to collect and examine images of the benthic habitats of northern Iceland in the region where the shrimp trawl fishery operates. In the future we hope to use these data to perform a comparison with the benthic habitats of Greenland.

3.2 Mapping and classifying the seabed

A study to map and classify the seabed in the regions surveyed to date (2011-2015) was undertaken by Sarah Gougeon, a masters student from Imperial College London.

The study used the 2000+ photographic images collected over 5 years, from 223 sites ranging from 60ºN to 72ºN, 61-725m. Images were grouped into habitat classes based on a modification of the EUNIS classification scheme. For this scheme, benthic habitats are defined by the the substrata observed in the area (such as 'Gravelly, muddy sediments' or 'coarse rocky ground'). Seven classes were identified, providing a level of detail suitable for broad-scale classification. The occurrence of these habitat classes were compared with anthropogenic and environmental data from the same region. A classification model, based on the environmental characteristics of the survey stations was used to classify the entire western shelf. The spatial distribution of habitats correlates with temperature and latitude. Muddy sediments and colder water temperatures characterise northern areas. Southern sites are characterised by sandy and rocky areas, with warmer temperatures and higher-

energy input. Trawling effort is concentrated on the northern muddy-sand habitats, and some small areas of rocky habitat.

The production of the first habitat classification and map of the West Greenland shelf enables mapping of species and habitat distributions, which is highly valuable information for future management efforts and conservation of the benthic ecosystems.

Full details are given in Appendix 1.

3.3 Macrobenthic functional diversity

A study to determine patterns of functional diversity in benthic communities along the west Greenland shelf (2011-2014) was undertaken by Jess Fisher, a masters student from University College London.

The study used four years of photographic data (2011-2014) from 156 survey stations. Diversity indices were calculated, and together with non-metric multidimensional scaling used to investigate differences in benthic communities that have been subjected to trawling activity. Observed taxa were categorised into functional groups based on mobility and other ecological factors.

Hard substrate environments support significantly greater benthic diversity ($p < 0.01$). Differences in species composition correlate with fishing impact in the region. Total trawling effort at a survey site, and years the site has been left untrawled, both correlate with functional diversity measures. The abundance of sessile organisms on soft substrate is significantly lower in high trawl areas. There is early evidence of time-dependent recovery in the region.

Full details are given in Appendix 2.

3.4 Temporal comparison of benthic macrofaunal communities

A study to compare the benthic community macrofaunal composition and diversity observed today with that observed 30-40 years ago, was undertaken by Mate Vakarcs, a masters student from Imperial College London.

‘Historical’ (1978-85) and ‘recent’ (2011-15) photographic images of the benthos of the West Greenland shelf were examined in relation to fishing activity undertaken in the region since 1975 with the aim of examining the impacts of trawling and recovery time on seafloor communities.

Historical stations were found to be more diverse than recent counterparts, but had lower abundances, possibly due to selection pressure and observation bias. There was a greater proportion of ecologically important sessile epifauna including Anthozoa, Porifera, and Asicidacea in historical stations and a greater proportion of motile scavengers, such as Ophiuroidea in recent stations.

This study is the first long-term temporal comparison to be undertaken of benthic diversity in the region.

Full details are given in Appendix 3.

3.5 Assessment of benthic habitat and community composition of the West Greenland shelf

A full assessment of all environmental and community data gathered between 2011-2013 was undertaken to produce a peer-review publication describing the benthic habitat and species distributions that characterise the west Greenland continental shelf.

Scientific knowledge of the diversity, complexity and sensitivities of these habitats is limited, particularly at higher latitudes and greater depths and few published records exist describing the benthic community structure of the region.

We report results from benthic camera surveys conducted at 119 sites, over 3 years, spanning 1400 km of the West Greenland continental shelf (61–725 m depth). A total of 29 classes of epibenthic taxa were identified from the images. There are significant differences of composition and diversity in sites with hard and soft substrate. Hard-substrate communities are relatively diverse with higher abundances and are characterised by sessile, attached groups such as Hydrozoa, Anthozoa, Bryozoa and Porifera. Soft-sediment sites are less diverse and dominated by Polychaeta and have specialist Malacostraca such as the commercially exploited shrimp, *Pandalus borealis*. Distribution patterns and variation in epibenthic megafauna are related to substrate and the environmental parameters of depth, temperature and current speed.

This study represents the first quantitative characterisation of epibenthic megafaunal assemblages on the West Greenland continental shelf. These data constitute a highly valuable baseline, albeit in a region already impacted by trawl fisheries, to make possible the assessment of further change and potential (rates and patterns of) recovery.

Full details are given in Appendix 4. (Polar Biology manuscript)

3.6 Further development of image analysis software

A student from University College London's computer science lab worked on the development of our image analysis software over the summer of 2015. James Durrent is a student of our UCL collaborator Dr Gabriel Brostow and was employed under a UCL scheme to give undergraduate students work experience. James worked on providing additional features to the software package Poseidon. His main task was to migrate the main Poseidon server from UCL to ZSL and work on the creation of a stand-alone, distributable version of the software to enable sharing with other researchers.

4. Other updates

Chris Yesson and Kirsty Kemp presented two posters outlining work from this project at the 14th international Deep Sea Biology Symposium held in Aveiro, Portugal, in September 2015. This was an opportunity to discuss and promote our work with other researchers.

Chris Yesson visited the St John's office of the Department of Fisheries and Oceans, Canada. He met with coral and sponge expert Vonda Wareham, who's job involves monitoring benthic bycatch in Canadian trawl surveys. He collected a number of coral specimens for comparison with those collected in Greenland.

Full details of the poster presentations are given in Appendix 5 and 6

5. Summary and plans for 2016

A 10 day cruise aboard MT Pamiut is scheduled for 2016. Tentative plans under discussion are to visit areas north of the current limit of the shrimp fishery, examining grounds that may be fished in the near future.

Timing of this cruise is not yet determined, but it could potentially be undertaken between leg 1 and leg 2 of the annual GINR stock assessment survey, to take advantage of the logistics of being as far north as Illulissat.

People expected to undertake the survey are: Kirsty Kemp and Chris Yesson (benthic images), Martin Blicher (benthic sampling), Helle Jorgensbye, plus potentially some of the benthic taxonomists who took part in the 2015 surveys.

24 hour sampling will be undertaken, incorporating: benthic image collection following the protocol of previous ZSL/SFG fieldwork (not determined whether this will be nighttime sampling), possible beam trawl surveys of benthic fauna to augment and enhance the benthic bycatch project (dependent on replacement of beam trawl), and CTD and grab surveys.

Appendices

Please go to: https://www.zsl.org/benthic-habitats-of-west-greenland
to find links to all appendices, or access directly from the links below.

Appendix 1 – Sarah Gougeon – MSc Thesis - Mapping and classifying the seabed of West Greenland

Appendix 2 – Jess Fisher – Mres Thesis - Impacts of otter trawling on macrobenthic functional diversity in western Greenland

Appendix 3 - Mate Vakarcs – MSc Thesis - A temporal comparison of benthic macrofaunal communities and the impact of bottom trawling, West Greenland continental shelf

Appendix 4 – Yesson et al. (2015) Community composition of epibenthic megafauna on the West Greenland Shelf. Polar Biology. doi:10.1007/s00300-015-1768-y

Appendix 5 ( Benthic habitats of the West Greenland shelf: What is the impact of shrimp trawling? (14.62 MB)

Appendix 6 Sarah Gougeon - Mapping and Classifying the seabed of West Greenland (2.16 MB)