



BEST 2.0 Final Technical Report

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This report should be a stand-alone document describing all of the work completed during the entire project duration. It is important that the report is complete and accurate.

Project Details

Project title:	Sustainable fishing in the Arctic: Can the harvest of Greenland's biggest export be compatible with the conservation of benthic ecosystems?	
Project reference number:	1586	
BEST 2.0 region:	Polar/Sub-polar	
Targeted OCT(s):	Greenland	
Name of the lead beneficiary:	Institute of Zoology, Zoological Society of London	
Project start date:	1 st April 2017	
Project end date:	31 st March 2019	
Value of BEST 2.0 grant awarded (€):	296,382.86	
Total project budget (€):	324,759.18	
Names of any associated beneficiaries:	1.	Sustainable Fisheries Greenland
	2.	
	3.	
	4.	
Names of any affiliated entities:	1.	
	2.	

Report Information

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Left click on table and select 'update field' then 'update page numbers only'.*

List of Acronyms & Abbreviations

MSC	Marine Stewardship Council
GINR	Greenland Institute of Natural Resources
SFG	Sustainable Fisheries Greenland
IoZ	Institute of Zoology (a department of ZSL)
ZSL	Zoological Society of London
VME	Vulnerable Marine Ecosystem
UCL	University College London
DFO	Department of Fisheries and Oceans (Canada)
MPA	Marine Protected Area
GFLK	Greenland Fisheries License Control Authority
GFW	Global Fishing Watch

1. **Guidance:**

- *There is no word limit for the various sections. Responses should contain all of the relevant information in a concise way. It is important to ensure that the information included is complete and accurate.*
- *If you have already answered a question in one section do not repeat the information in another section but refer back to the previous section.*
- *When making statements of progress or impact please ensure you refer as much as possible to sources of evidence based on the indicators in your project logical framework.*

2. **Project overview**

Provide a brief overview of the project including information on:

- *The location of the project activities (with a map if possible).*
- *The target species, habitats, ecosystem services etc.*
- *A description of the problem the project aimed to address.*
- *The project's approach to addressing the problem.*
- *What the project aimed to achieve.*

As ice retreats in the Arctic, and polar waters are warming at unprecedented rates, there are significant challenges to Arctic communities. Warming sea temperatures are influencing the movements and distributions of organisms, including many commercially important species.

Changing patterns of biodiversity lead to changing fishing effort, which can place new pressures on important but vulnerable marine ecosystems, such as benthic habitats. Polar nations dependent on income from fisheries have to adapt to changing conditions to ensure long term sustainability of their industry. Greenland is responding positively to these challenges by engaging with organisations such as the Marine Stewardship Council (MSC) to develop and implement sustainable strategies to safeguard natural resources. The West coast of Greenland is home to commercially important coldwater prawn and halibut fisheries. Their entrance into the MSC sustainability scheme has highlighted a concerning lack of knowledge of benthic habitats (deep sea environments are logistically difficult and expensive to study). Benthic habitats play vital roles in the marine ecosystem, functioning as carbon sinks and providing nurseries and protection for juvenile fish. Trawl fisheries (such as the prawn and halibut) directly impact the local seabed environment, with removal of habitat-forming organisms, and consequently the marine ecosystem as a whole.

This project will perform photographic surveys of the West Greenland benthos to document existing seafloor communities, their structure, function and diversity. One survey will examine the continental shelf around Disko Bay, revisiting locations where benthic images were taken in the 1980s. This will create a unique time series allowing investigation of benthic habitats in response to climate change and trawling impact over 30+ years and enabling an assessment of the recovery potential of impacted communities. A second survey will be conducted in the deeper off-shelf area of the existing halibut fishery, to document for the first time the benthic habitats in this region. From these benthic community data, and environmental data sourced from oceanographic models, we will build maps of species distributions and Vulnerable Marine Ecosystems (VMEs). Observations and information collected, along with our analytical interpretations, will be made publicly available in the form of open-access data (image) sharing and publications, and will be used to develop and evaluate management plans for the sustainable use of marine resources in West Greenland. It is critical that we ensure effective and sustainable management of polar natural resources, particularly now as resource exploitation potentially expands into new territory.

Sustainable management of fisheries is a widely recognised priority for Greenland. Specimens, images, web resources, and an educational game will be used in a series of outreach events designed to engage a broad spectrum of stakeholders including fishers, industry leaders, children and the general public in the drive to recognise the importance and conservation value of Greenland's precious and wondrous benthic habitats. These events will generate teaching resources and a legacy of engagement through education.

3. Achievement of the project results and purpose

Explain whether the project has achieved the intended results and purpose (as contained in the logical framework submitted with your proposal).

If not explain the reasons why.

You should:

- *Highlight any tangible impacts the project has had in terms of biodiversity conservation/ sustainable use of natural resources/climate change adaptation and mitigation/ ecosystem services.*
- *Highlight any achievements from a local human development perspective (e.g. social/economic benefits).*
- *Assess whether the project has had any unforeseen positive or negative results.*

Result 1. Visual (photographic) surveys of benthic habitats of W Greenland

- Surveys have been conducted.
- Cruise reports are published online (Annex 2&3)
- We have developed, tested and successfully used a new benthic video sled system (developed in collaboration with GINR)
- Collated images from surveys are available on the [Biigle website](#) (user greenlandhabitats@gmail.com, password deep_sea).
- Our participation on these research cruises has enabled capacity building at GINR as we have taught a variety of staff their how to operate the deep-sea camera equipment

Result 2. Documentation and analysis of structure, distribution and change over time (40 years) of benthic habitats of West Greenland. Interpretation of this change in terms of response to disturbance impact (trawling) and climate change. Projection of potential future change under the existing impact regime.

- Analysis is presented in detail below, and will be publicly accessible in an upcoming publication
- We find that there is little tangible change in benthic fauna over time, during a period of significant climate change and substantial fishing effort
- We have comprehensively analysed data from the first systematic benthic survey of Melville Bay. We compared different sampling gears and found that initial trawling effects on faunal abundance and diversity is picked up in our camera surveys but are not reflected in biomass sampled by beamtrawl and cosmos trawl. VME species in the area included seapens (Umbellula sp.), larger and rare sponges (Asconema sp., Chondrocladia sp.) and soft corals.
- We have the first widespread assessment of the habitats of the offshore Greenland Halibut fishery. We have documented potential VMEs such as seapen and cup coral fields, as well as identifying evidence of trawling impact. These findings were presented in a report produced for SFG to inform the annual MSC [surveillance audit](#) of the fishery (Annex 11).

Result 3. Management plan for sustainable use of marine resources in West Greenland

- Management plans and all other documentation required for the fisheries to progress through the MSC certification process have been produced.
- The [West Greenland Offshore Greenland Halibut Fishery](#) has received conditional MSC certification (22nd May 2017).
- The [West Greenland Coldwater Prawn Fishery](#) has successfully entered MSC recertification (1st August 2018).
- We were invited to contribute to the assessment of the [Doggerbank Seefischerei West Greenland Halibut Fishery](#). Our comments were incorporated into the final report and this fishery has been recommended for certification subject to a final consultation (May 2019).

Result 4. Engagement of fishers, children, industry, and public with the issue of conservation value of Greenland's benthic habitats. Long-term buy-in and interest amongst these stakeholders regarding the importance of these national resources and their sustainable management.

- We have successfully conducted a variety of outreach activities, including school visits, exhibitions, the development of a game and teaching resources.
- A significant issue with certification has been the expansion of the fishery into Melville Bay. There has been a positive conservation outcome with the closure of 1,900km² of Melville Bay to the fishery and the adoption of the precautionary principle, requiring government approval for expansion of the fishery beyond the existing footprint. This is evidence of the long-term buy-in of the government and fishery to the sustainable management of marine habitats.
- We have developed a successful collaboration with the Learning Institute, University of Greenland, and have helped in the engagement of several school classes and development of materials that will be used in schools across Greenland.
- Evidence of our long term impact is supported by our continuing collaborations with SFG, GINR and University of Greenland. This includes (funded) invitation to participate in 3 research cruises in 2019 and submission of joint proposals for further research in 2020.
- The Marine Stewardship Council has routinely highlighted our work as a good example of industry & science partnership in its annual reports and talks.

4. Work completed under each project activity

Describe the work completed for each of the activities foreseen in your proposal highlighting and explaining:

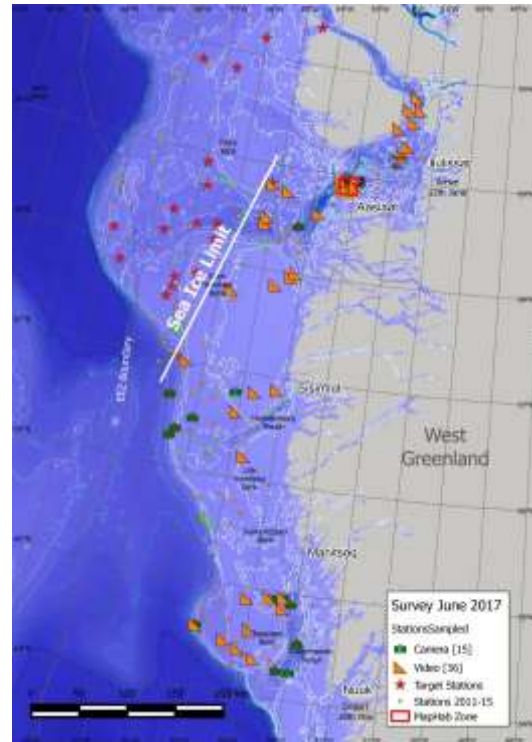
- *Any activities that have not been completed.*
- *Any deliverables/outputs as a result of the work.*
- *Any changes in approach from the original project design¹.*
- *Any problems encountered (e.g. delays, cancellation of activities) and how they were addressed (if relevant).*

¹ Any substantial change must be notified to the BEST 2.0 Secretariat and the relevant BEST 2.0 Regional Hub through a request for an addendum to the grant contract prior to the end date of the project. The BEST 2.0 Secretariat reserves the right to accept or to refuse the request.

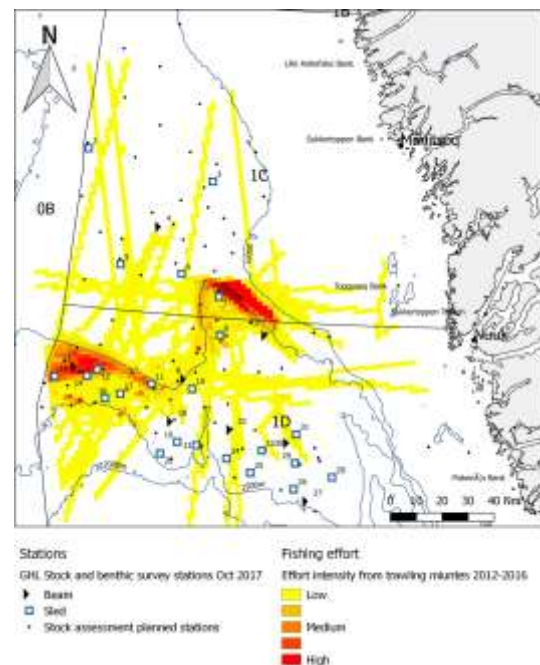
Research Cruises

Two research cruises were conducted in 2017, in line with the original plan. Cruise reports and blogs were delivered on schedule.

A survey of the West Greenland Coldwater Prawn Fishery region, in June 2017, met with significant sea-ice coverage, which limited the number of historical stations that could be surveyed with our drop-camera. However, we collected 200 pictures of the sea bed from 15 drop-camera stations and more than 9 hours of video footage from 36 stations between the latitudes 64°15 and 69°49 (between Nuuk and Disko Bay), at depths ranging from 29 to 872 m (figure right). Unfortunately, due to extensive sea ice, only 9 of the 20 target drop camera stations were accessible. We used a new benthic video sled, developed in collaboration with GINR, for the first time and found this to be a reliable and effective method for imaging the seabed. A [cruise report was published](#) along with a [blog describing our trip](#).



A survey of the West Greenland Offshore Greenland Halibut Fishery took place in October 2017. Initially this cruise was scheduled for September, but was cancelled due to equipment failure on the vessel. However, repairs were complete quicker than expected and the cruise schedule was re-arranged at short notice to encompass a shortened survey. The consequence of the cruise occurring later in the season, meant severe weather conditions curtailed some activities and the full range of the fishery could not be visited. The original workplan was for 48 hours of ship time dedicated to our surveys, but 9 hours of these were unused due to adverse weather conditions. However, we managed to successfully conduct 31 station surveys of benthic video or beam trawls in the region of the West Greenland offshore Greenland halibut fishery (figure right). We successfully sampled 31 stations at depths of 650-1500m, collecting more than six hours of seabed video spanning 300 km. A [cruise report was published](#) along with a [blog describing our activities](#).



We have developed a methodology for analysing the video sled data, involving taking stills from the video at regular intervals, and associating a location with each image by referencing the ship position and relative position of the camera to the ship.

We have revisited and surveyed 43 stations previously surveyed by Per Kanneworff in the 1970s and 1980s. Images from these historic surveys have been scanned and analysed.

Fishing data

Data on fishing effort in the West Greenland Offshore Greenland Halibut Fishery has been obtained from GFLK. These data are in the form of start and end positions and times of trawling events registered at GFLK (in theory this should cover all legitimate trawling activities in the area). However, upon examination of these data it was observed there were some 'gaps' in the data for several years that gave us cause for concern. Therefore we approached globalfishingwatch.org for an alternative dataset. We have compared both GFW and GFLK data (figure below) and have conducted analysis of impact using these data.

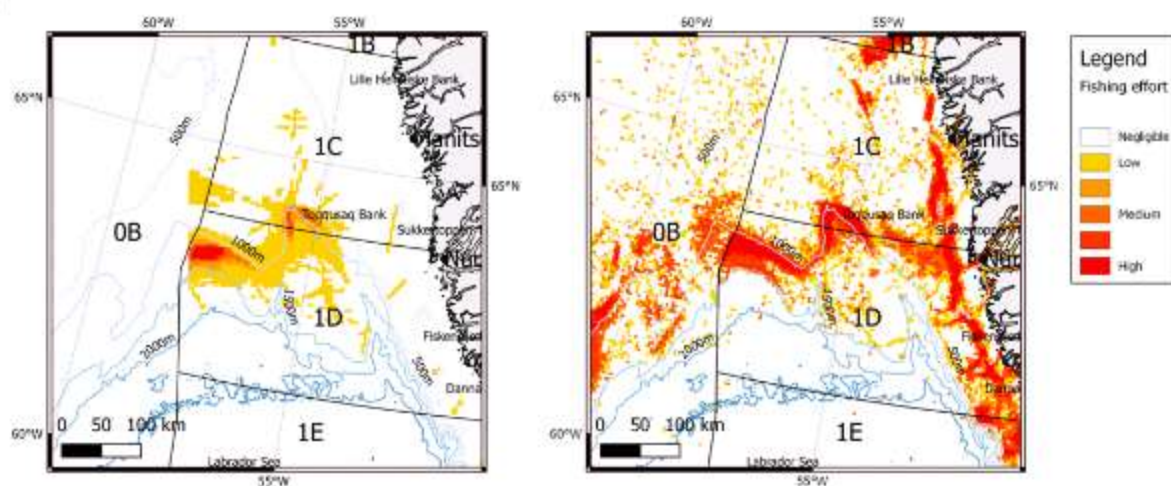


Figure 2 Fishing effort data obtained from GFLK (left) and GFW (right). Where GFLK represents hours of Greenland halibut fishery trawling effort within the Greenlandic EEZ, from 2000 to 2016 inclusive. Whereas, GFW represents hours of all trawling effort within map extent, from 2012 to 2016 inclusive. NAFO zones 0B (Canadian EEZ) and 1B-E (Greenlandic EEZ) are shown. Bathymetry is indicated at 500m intervals (blue lines).

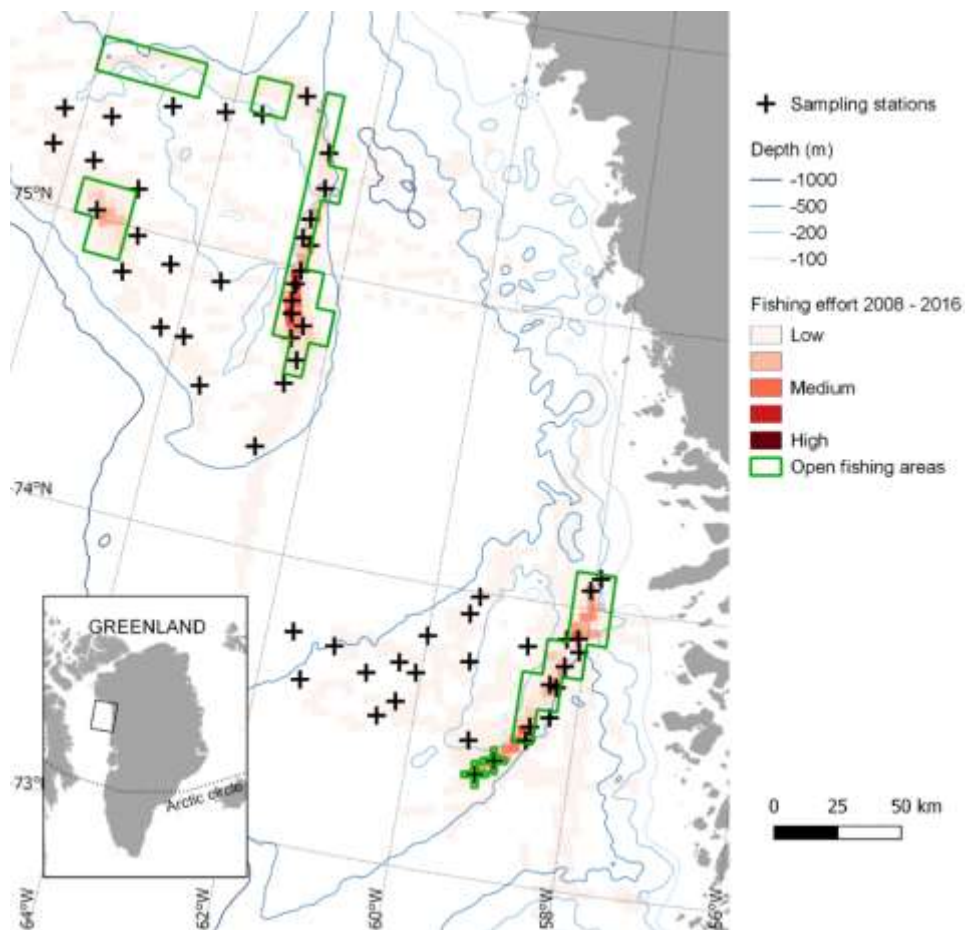
Environmental data

Datasets which model marine environmental conditions have been downloaded from the Copernicus website. These are depth-tiered grids (so called 2.5D grids). The cookie-cutter upscaling method has been used to create high resolution seabed environment grids for the parameters Temperature, Salinity, Current Speed, Current Direction, for average winter and summer conditions over the last decade. These have been used in analysis to assess the environmental influence on observed faunal patterns. These grids will be made publicly available as supplementary data with the first published paper that uses them.

Coldwater prawn analysis

Melville Bay

Conservation efforts of deep-sea habitats from impacts of fishing rely on information from assessments of vulnerable epifaunal communities and their ecological status. These assessments are usually conducted with benthic survey techniques such as camera and video, and physical sampling by sleds and trawls. Benthic bycatch surveys alongside scientific stock assessments offer a cost effective alternative and have been in place in various countries across the Arctic and Subarctic including west Greenland. Gears will differ in extractable data types (e.g. abundance vs biomass estimates) and their efficiency to survey the entire community, resulting in different ecological metrics. The generality of ecological patterns among gear types therefore needs to be assessed with the aim to develop effective impact studies. The Melville Bay dataset consist of a comprehensive benthic survey (2016) using drop camera, beamtrawl and bycatch in cosmos trawls from the ongoing fishery survey, at 59 stations. The dataset presents a unique opportunity to compare sampling gears and their ability to detect trends in abundance, biomass and biodiversity caused by environmental differences, and impacts by bottom trawling. Melville Bay was exposed to an experimental prawn fishery between the years 2014 and 2016 following recent movement of prawn stocks towards the north. The core fishery footprint for the area was set by authorities in 2017, leaving dedicated areas north of 74 degrees open for fishery and others closed based on the existing core footprint by the experimental fishery in the previous years (figure below).

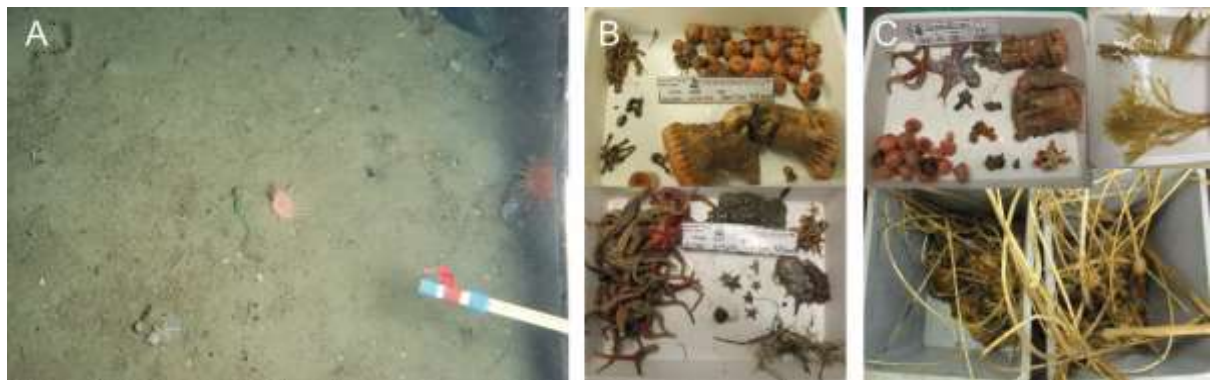


Map over the study area in Melville Bay, West Greenland. Benthic sampling positions (+) with imagery and trawl samples in 2016. Depths (m) are depicted by isobars. Fishing effort represents trawling impact obtained from the Greenland Fishery and License control for the years 2008-2016 (see Yesson et al. 2016 for details), where cumulative fishing during that time ranged from 0 to 1943 h on a 1km grid.

Our preliminary results align with previous studies, showing that the considered survey techniques act as complementary but not interchangeable techniques, providing different estimates for benthic abundance and diversity, mostly due to different taxa sampled and areal coverage (see figure below).

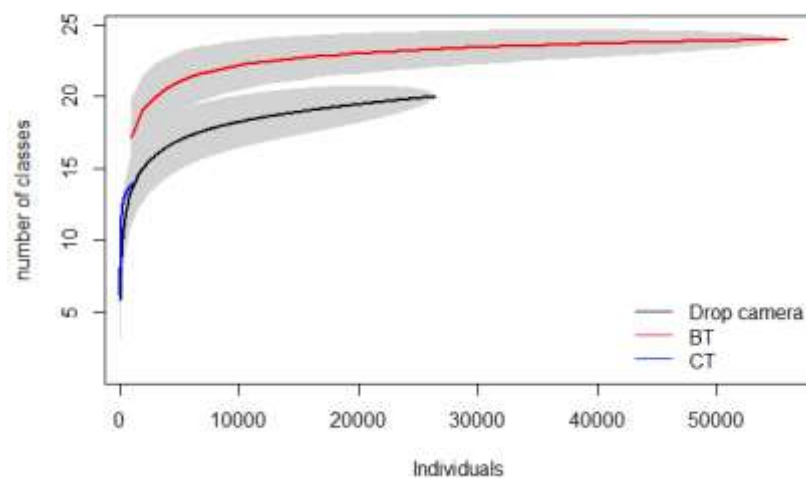


Station group 7. Drop camera image (A), beam trawl sample (B), benthic bycatch from Cosmos trawl showing a.o. *Umbellula sp. seapens* (C).



Station group 31. Drop camera image (A), beam trawl sample (B), benthic bycatch from Cosmos trawl showing large *Umbellula sp.* (C). *Umbellula* was rarely picked up in Beamtrawls due to gear selectivity and neither or by drop camera due to patchy occurrence and a small survey area.

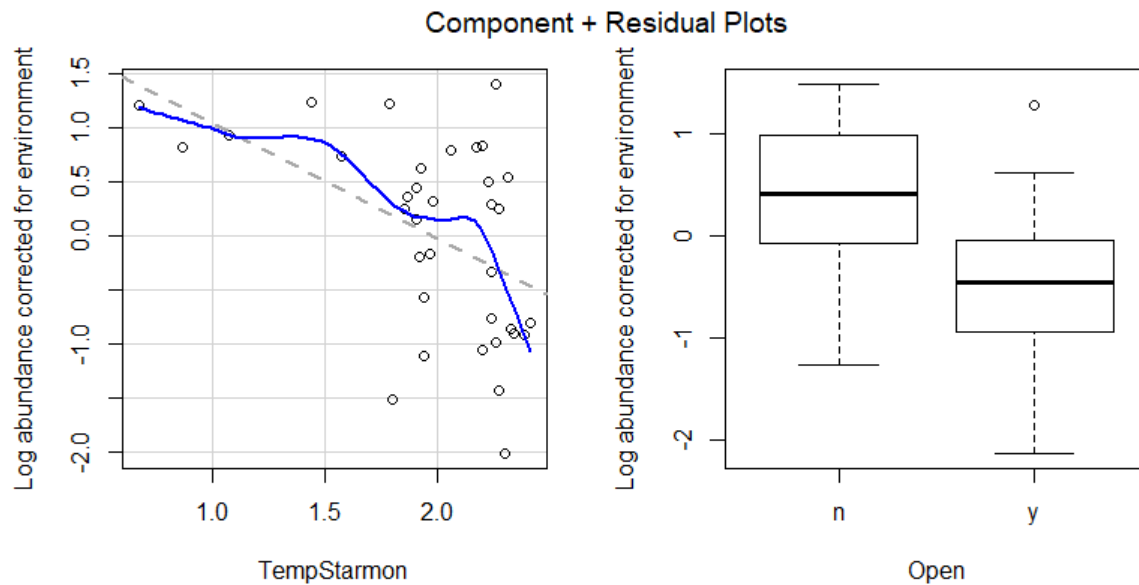
Biodiversity for the entire area was highest in BT samples and lowest in CT samples. Differences in diversity detected was both a function of sampling effort (area or individuals sampled) and gear specific selectivity (see figure below).



Species accumulation curves for benthos sampled by the drop camera, benthic sled (BT)

and *Cosmos trawl* (CT) plotted for the area sampled (a) and number individuals sampled as a measure of effort (b). Data are means \pm s.d. obtained from random permutations (999).

Our preliminary analysis shows that multivariate community structure in Melville Bay was related to depth and temperature and those variables were also influencing total community abundance and biomass. Trawling impacts were visible in camera survey data, with lower benthic abundances at stations exposed to trawling on hard or mixed substrates (see figure below), but no clear impact could be seen on soft substrates.



Partial residual plot of significant variables to the linear model, on hard/mixed substrate. TempStarmon = measured temperature, Open = Open to fishery

Complimentary beam trawl and bycatch surveys did not reveal an impact of trawling on total benthic community abundance and biomass, but typical VME indicator groups (for example *Umbellula seapens*) showed a lower biomass at trawled stations. Our study indicates that camera techniques are optimal for surveying a smaller area and are most likely to detect initial trawling impacts. For larger area coverage and the detection of large and rare VME indicator species fishery surveys seem to present the best alternative.

A manuscript is in preparation, which can be viewed on this link

https://www.authorea.com/users/266014/articles/373971-epibenthic-community-in-melville-bay-west-greenland-assessing-trawling-impacts-using-different-sampling-gears?access_token=EYIFMxoUYp_tHRs1kiocA

Historical comparison

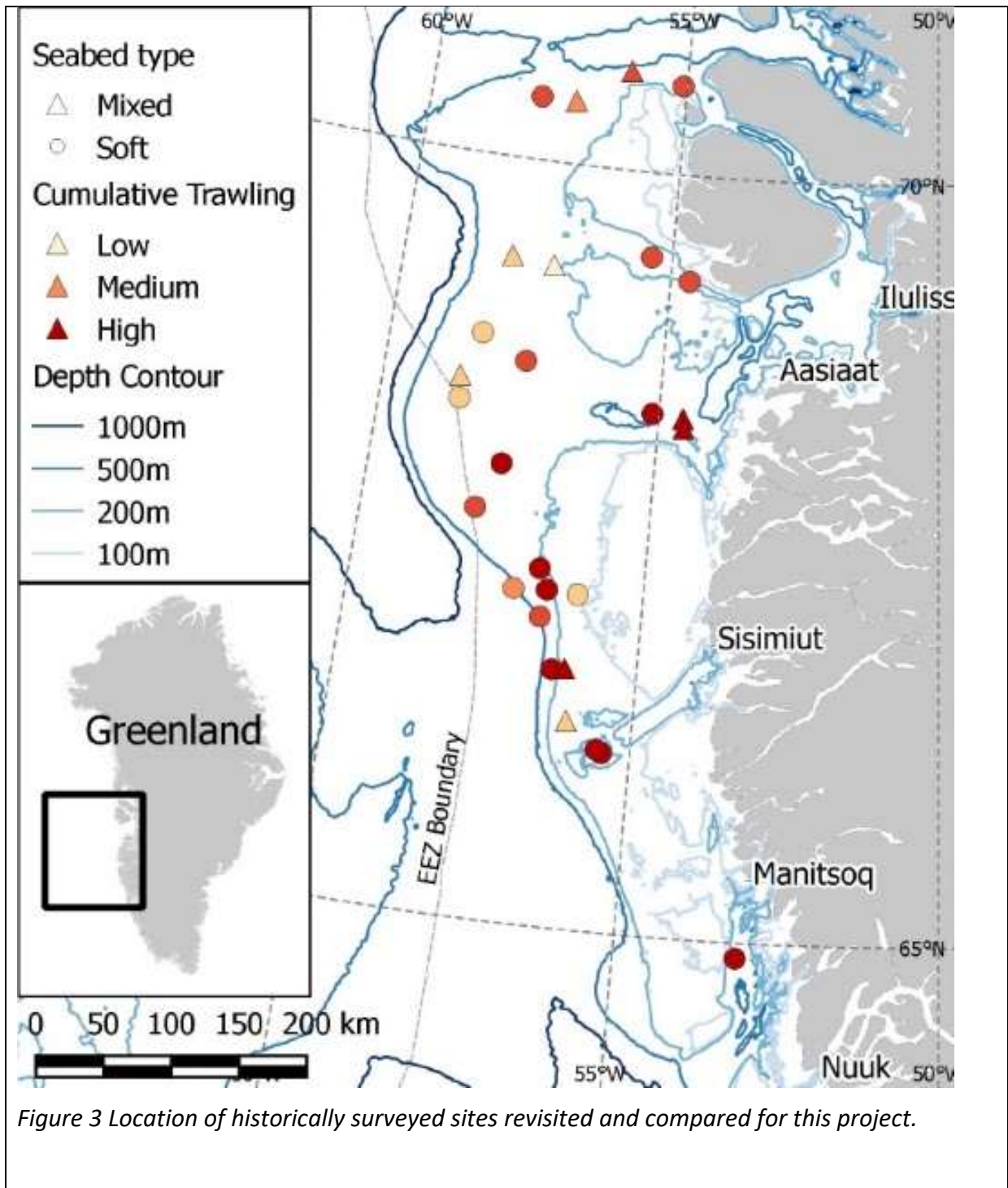
A total of 32 sites with historical benthic images were revisited (Fig 3 below) covering depths from 109m to 565m. A benthic drop camera was used to survey these sites, taking images at 1 minute intervals as the ship was allowed to drift on the current. Historical images were trimmed to the same area as the modern images. Images were analysed using the Biigle annotation platform. Initially all taxa were identified, but the quality of historical images were not as good as the present-day camera. To avoid bias due to differential observability based on the quality of image, only larger, highly distinctive taxa were selected for analysis.

The stations surveyed have seen a relatively stable pattern of fishing effort over the past three decades, although down slightly from the peak of the 1980s (Fig 4 below). The

signature of global warming is visible in both the decline in ice cover for the region and rise seabed temperature. The seabed temperature has risen at an average of 0.013°C per annum, although year on year variability is wide (Fig 4 below).

There is no overall pattern of change in abundance in our study area (Fig 5 below), 13 stations show an overall decline in abundance and 15 show an increase, and there is no clear trend in change relative to fishing effort or changing environmental conditions. When we break this down taxonomically (Fig 6 below) we see high variability between sites but typically no significant difference between historical and present-day mean abundances, with a few notable exceptions. We saw only a single soft coral colony (*Octocorallia*) in the modern images, while these were previously observed at 8 stations with a maximum 5 colonies seen at two sites. There is also a notable decline in snails (*Gastropoda*), which are only seen at 8 stations (maximum 2 per site), whereas previously these were observed at 12 stations with a maximum of 6 individuals at one site. The one notable increase is in sea peaches (solitary ascidians), which are seen in twice as many sites recently (N=14). These changes do not appear to be related to fishing effort or changing environmental conditions, although the sample numbers are low, so it is difficult to obtain statistically significant results. A manuscript detailing these findings is in preparation.

The areas of the fishery appear to be relatively stable, and this is supported by the relatively stable shrimp stocks over the same period. The decline in soft coral observations is noteworthy because these corals (all of family *Nephtheidae* commonly referred to as cauliflower corals) have previously been described as weedy and resilient to trawling. These are potentially habitat forming taxa, and coral garden habitats based on cauliflower corals are recognised as Vulnerable Marine Ecosystems in other areas of the North Atlantic. We often see these taxa in bycatch from shrimp trawls so we know there is a direct impact of trawling on populations. We are currently documenting a coral garden habitat on the continental shelf edge by Toqqusaq bank and will be presenting these findings to the ICES annual science conference 2019.



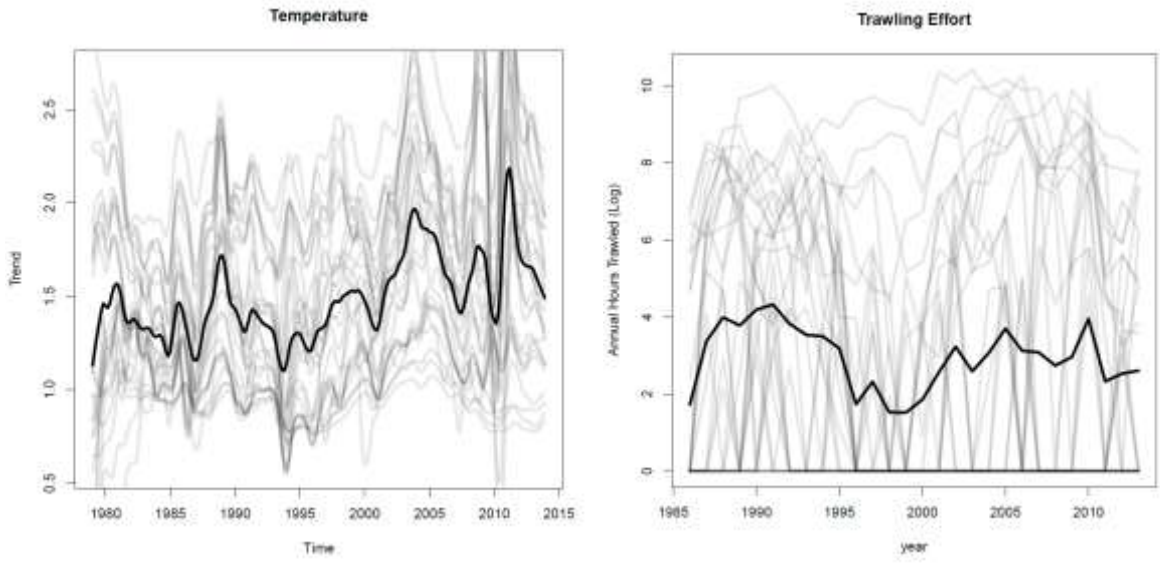


Figure 4 Time series of seabed temperature (left - ECMWF hindcast model) and fishing effort (right – logbook data) at survey sites, based on a seasonal decomposition of monthly means. Grey lines represent a single site, bold line is the median of all sites.

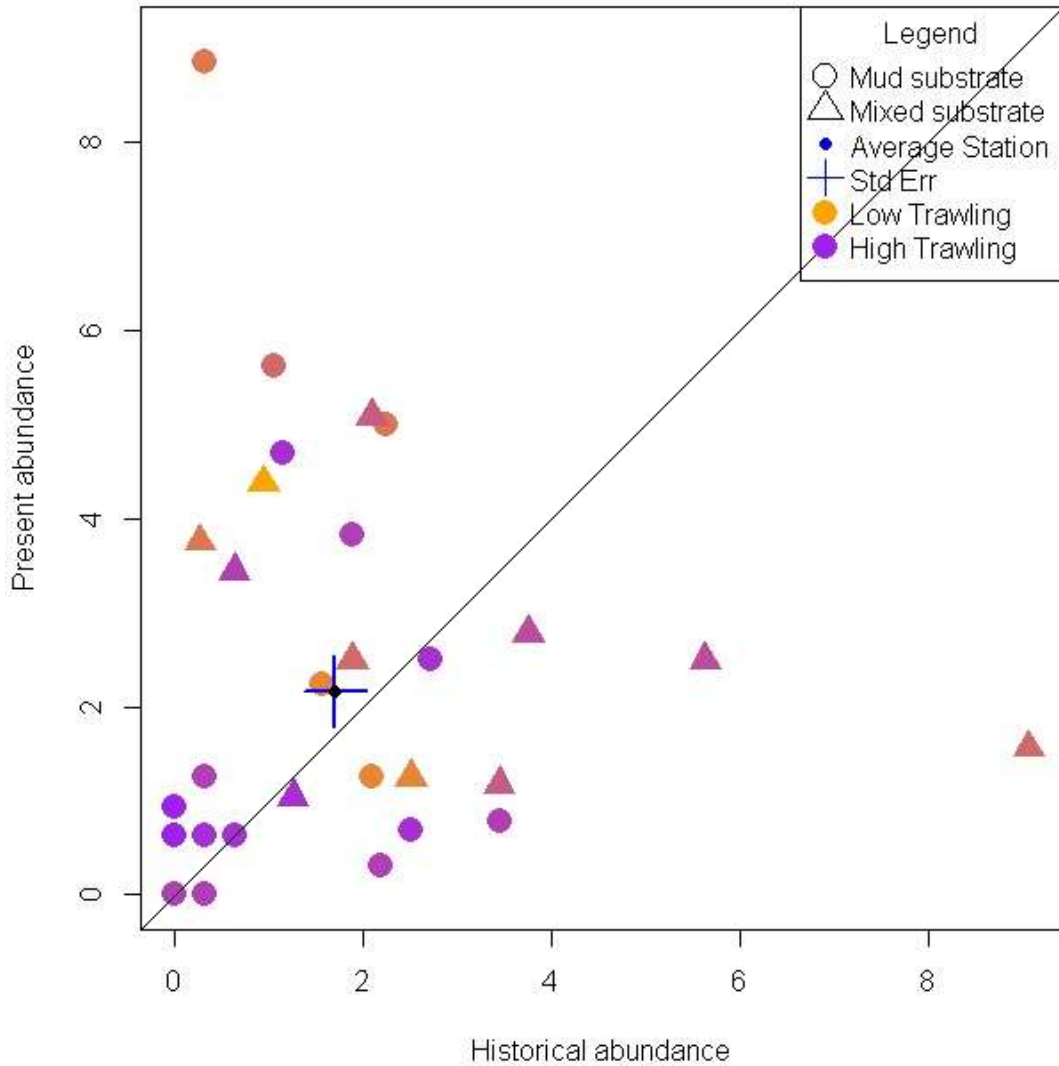


Figure 5 - Scatter plot showing historical and present day abundance of all analysed taxa by station. Although individual sites show variability there is no overall pattern of change over the 3 decades between surveys.

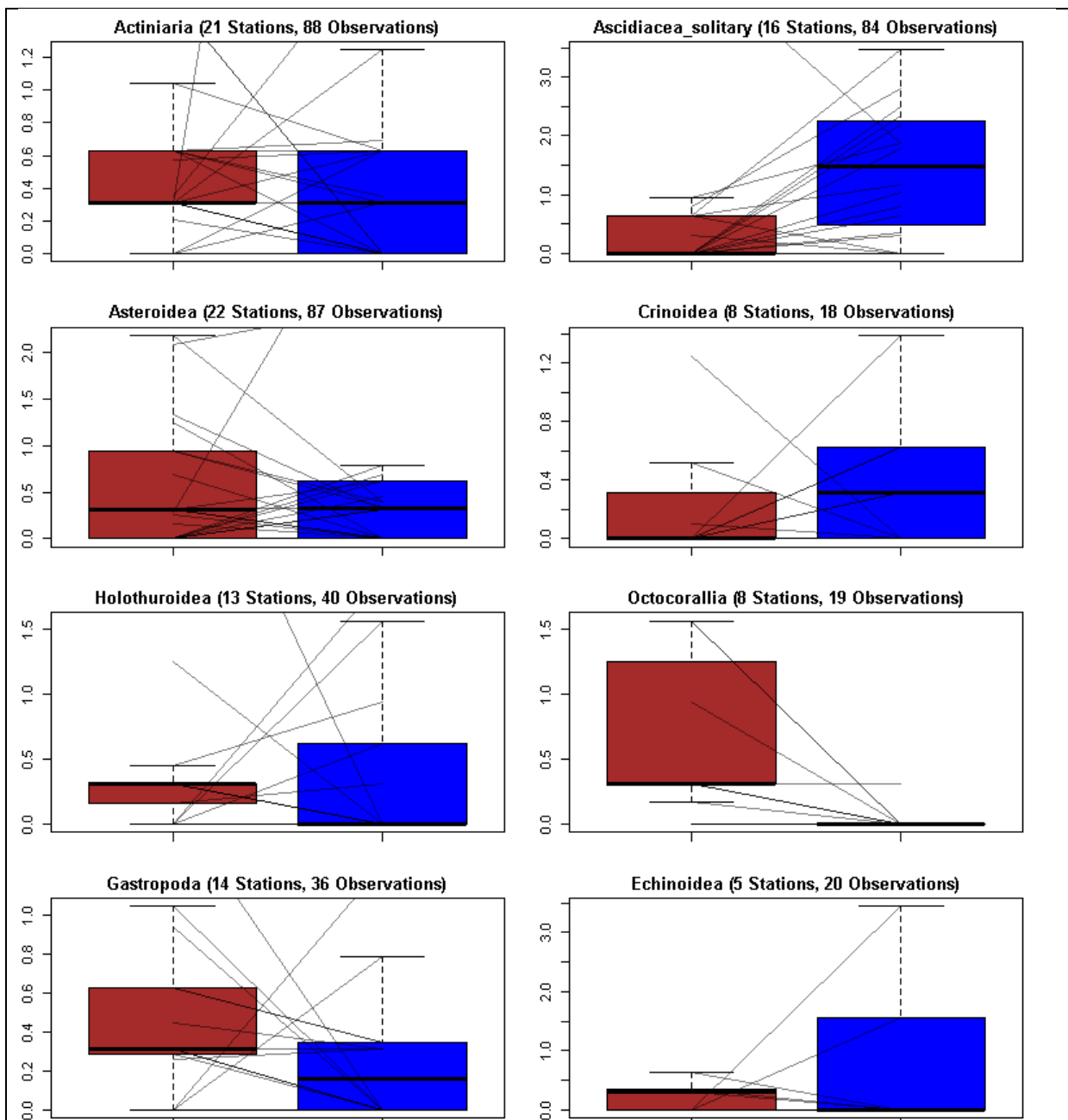


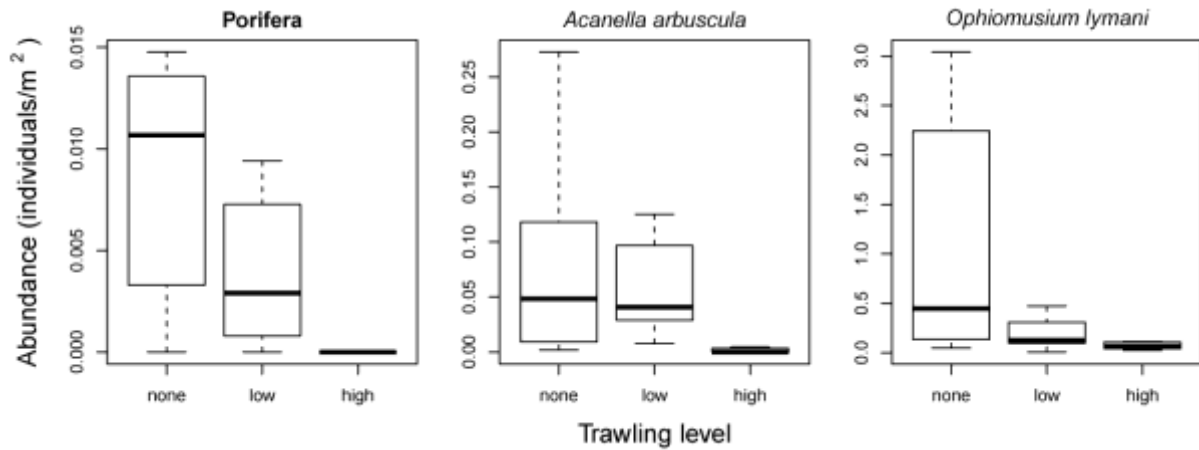
Figure 6 Density of individuals/colonies per station for historical (brown) and recent (blue) observations. Lines indicate changes observed at each station.

A manuscript describing this research is in preparation and can be viewed on this link (<https://www.authorea.com/354228/Gbj1roy2Vdl9bWa9KAjb3w>).

Halibut fishery analysis

Videos from 23 benthic video sled stations in the halibut fishing and adjacent area have been subject to a preliminary analysis. Using the speed of the sled, the estimated width of the field of view at the horizontal midline and the duration video footage, the 'swept area' was calculated for each station. The occurrence of 34 selected megafauna taxa were counted as they crossed this superimposed midline, allowing abundance to be estimated.

The intensity of fishing effort for each station was determined using trawling effort data from GFW. This highlighted that several taxa are found at significantly lower abundance where fishing effort is highest. This includes structural habitats forming fauna, such as sponges (Porifera) and gorgonian corals (*Acanella arbuscula*), among other populous taxa (see figure below).



Abundance of selected taxa against the level of trawling effort in the West Greenland offshore Greenland halibut (WGOGH) fishery and adjacent areas within NAFO 1C and 1D, Davis Strait, West Greenland. Trawling effort from Global Fishing Watch (GFW) is total inferred trawling hours, 2012 to 2016 inclusive, aggregated in a 3.5km grid. Only stations that yield clear footage were included in analysis ($n=23$). For each station the area swept by the horizontal midline of the video's field of view was determined trigonometrically. Fauna was counted as it crossed this midline. Stations were divided into three effort classes 'none' (effort = 0, $n = 9$), 'low' ($0 < \text{effort} \leq \text{median effort value}$, $n = 7$) and 'high' (effort > median effort value, $n = 7$). For clarity outliers are not drawn.

The analysis highlighted the present of numerous VME indicator taxa including some at significant densities, which may represent VMEs. Specifically the following maximum densities have been observed at individual stations: bamboo coral (*Acanella arbuscula*), 0.5 individuals/ m^2 ; cup coral (*Flabellum alabastrum*), 6.5 individuals/ m^2 and; seapens (*Halipteris finnmarkica*). Physical evidence of trawling impacts on seabed substrate was also observed, see example below.



Marks left in muddy sediment by commercial trawling within the offshore Greenland halibut

fishery. For scale green laser dots are 20cm apart.

Following the provisional analysis described above, 901 stills have been sampled using the systematic approach developed. These have been uploaded to Biigle for a more detailed analysis, the annotation process is ongoing.

Management plans

The MSC certification process requires extensive documentation of all aspects of the fisheries. Project partners Sustainable Fisheries Greenland have taken the lead on creating management plans for the fisheries to meet the MSC sustainability certification requirements. ZSL project members have assisted this process by providing advice and evidence which has been incorporated into the reports.

The [West Greenland Offshore Greenland Halibut Fishery](#) has received conditional MSC certification on 22nd May 2017. ZSL project staff contributed to this process by providing evidence to the annual audits of the fishery and research forms a fundamental part of the public certification report which incorporates the management plan for the fishery (https://fisheries.msc.org/en/fisheries/west-greenland-offshore-greenland-halibut/@@assessment-documentsets?documentset_name=Public+certification+report&phase_name=Public+certification+report+and+certificate+issue&start_date=2016-05-19&title=Initial+assessment).

The [West Greenland Coldwater Prawn Fishery](#) received recertification of sustainability by MSC on 1st August 2018. The public certification report (https://fisheries.msc.org/en/fisheries/west-greenland-coldwater-prawn/@@assessment-documentsets?documentset_name=Public+certification+report&phase_name=Public+certification+report+and+certificate+issue&start_date=2017-02-02&title=Re-Assessment) relies heavily on ZSL research. Critical to the recertification was the announcement of new protected areas in Melville Bay, along with the introduction of the precautionary principle limiting potential future expansion of the fishery. This came about thanks to the research by ZSL in collaboration with GINR.

Additionally, we were invited to contribute to the MSC assessment of the [Doggerbank Seefischerei West Greenland Halibut Fishery](#). This fishery operates in the same area as the West Greenland Offshore Greenland Halibut Fishery and is also seeking MSC certification. We contributed to the first MSC audit of this fishery and were invited to give evidence towards the management plan and assessment of this fishery. Our comments were incorporated into the final report and this fishery (https://fisheries.msc.org/en/fisheries/doggerbank-seefischerei-west-greenland-halibut/@@assessment-documentsets?documentset_name=Final+report+and+determination&phase_name=Final+assessment+report+and+determination&start_date=2018-07-10&title=Initial+assessment) and the fishery was recommended for certification subject to a final consultation in May 2019.

The MSC certification of these fisheries demonstrates that credible managements plan are in place.

Outreach events

A series of successful outreach events have been conducted, including multiple school visits and public exhibitions, which are detailed in section 7.

We were unable to attend and present at the biennial ship's captain meeting due to the last-minute rescheduling of the cruise of Sept 2017. Unfortunately, the next captains meeting will not be held until autumn 2019, after the end of this project. We have presented to fishermen and managers from Polar Seafood and Royal Greenland during the MSC audits.

We have been unable to contribute to the education of fishermen at Skipper Skolen as originally laid out in the plan, as our attempts to contact the organisation have proved unsuccessful. Our main contact with this organisation became gravely ill in 2018 and has recently passed away. . After several failed attempts to engage with Skipper skolen we decided to redirect our efforts to other engagement activities.

We have visited and engaged with school children in three countries (UK, Norway and Greenland), where we have shown videos, specimens and taught children about the impact of fishing on the seabed. Importantly we have directly engaged with Greenlandic school children in three schools in Sisimiut and Nuuk. Evaluation of these visits showed that most students enjoyed the game and were more aware of the impact trawling poses on benthic habitats. They also seemed to understand the major messages of the game and answered correctly when asked how a fishery could improve sustainability. (Annex 9)

We have conducted a series of outreach activities at public events in the UK and Greenland. In the UK we have used videos, images, specimens and equipment to engage a public audience at ZSL London Zoo, Grant Museum, Natural History Museum, Royal Society. The largest event was our participation at the Royal Society Summer Exhibition in 2018 where we engaged with approximately 4000 people over a week. In Greenland we conducted outreach at GINR offices in Nuuk during the annual Kulturnat event of 2018, which received 1046 visitors. We also manned a stall at the [2018 Polarfish Trade Fair](#) in Sisimiut (images below), where we engaged with approximately 400 people over 3 days.

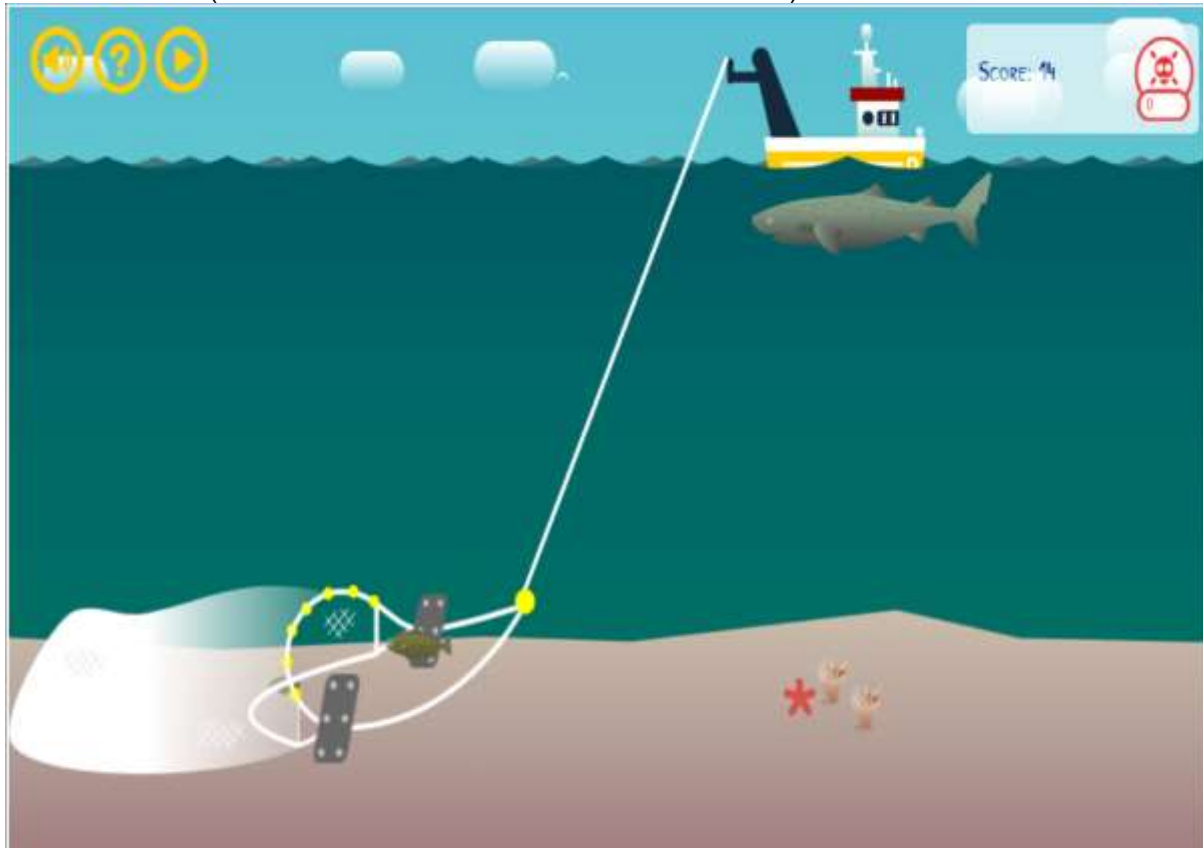


Photos from Polar Fish Trade Fair. Left some children play our fishing game. Right project members at the stall.

Game Development

We developed a fishing game to engage younger audiences in both the UK and Greenland which was launched in January 2019. The educational game, developed in collaboration with commercial game makers Octophin Digital, teaches about Arctic seafloor animals, the impacts of deep-sea trawling and sustainable fishery. The game is available in Greenlandic, Danish and English at <https://campaign.zsl.org/trickytrawling/>. It is embedded into a micro landing page, which provides more information about our research in the project and

educates on species found in Greenlandic waters. A promotion campaign surrounding the launch of the game was performed in the UK (including social media and school class visit) and Greenland (visits to school classes in Nuuk and Sisimiut).



Still from the game Tricky Trawling

The game seems to have been well received by those who played it, the analytics data shows that most people played for a considerable amount of time with many playing more than once and progressing through the full game. 3000 players have been registered so far, of which a 1000 played in Danish, and 550 in Greenlandic (which equates to 1% of the population of Greenland) with the average play time of 10 minutes (retrieved 25.03.2019). Most school children agreed that after playing the game they were more aware of trawling impacts on seafloor animals and a majority of children were able to answer correctly when posed the question what a fishery can do to become more sustainable (see Annex 8 for full evaluation).

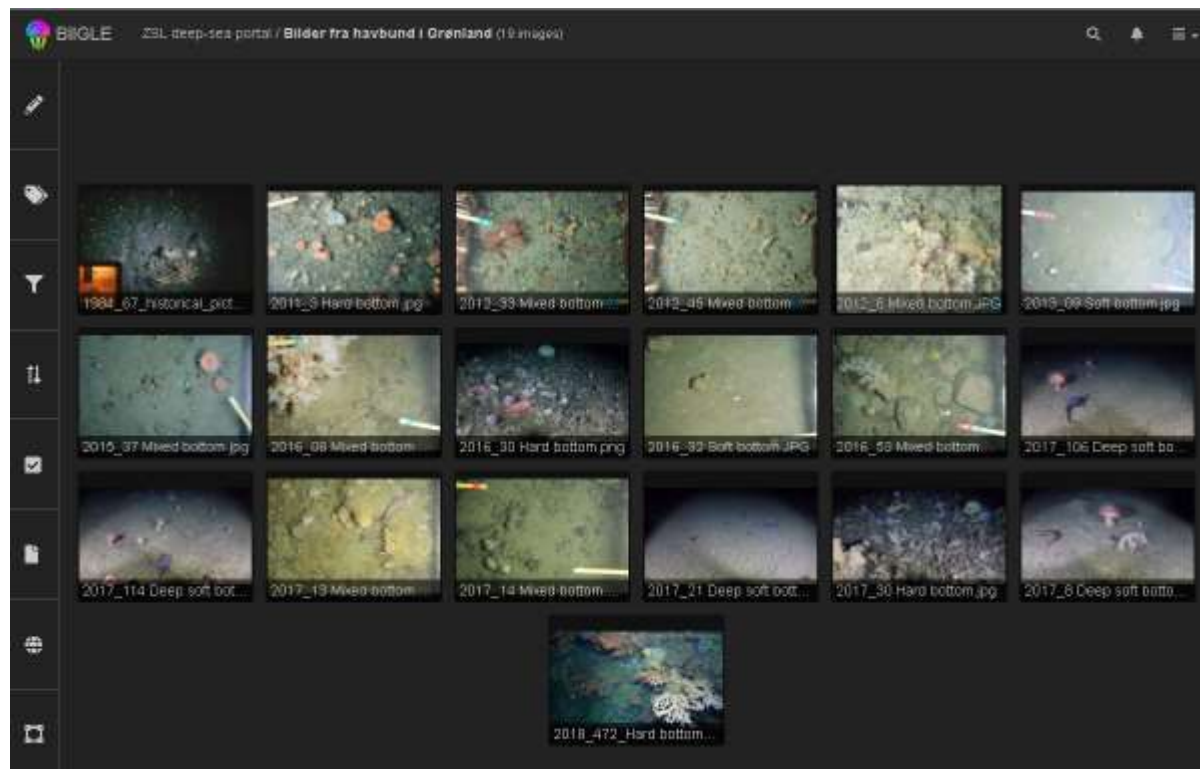
A permanent installation of the game is being set up at the restaurant in ZSL London Zoo.

Teaching materials

Through a collaboration with the Learning Institute, University of Greenland we developed a teaching manual (in Danish and Greenlandic) which includes several in-class activities on the topic of benthic biodiversity and sustainable fishery. It promotes the usage of the game as a tool in class and enables teachers in Greenland to explore the topic with their class independently. It is distributed via the game landing page and the Institute of learning (Annex 7).

The image collection at the Biigle.de portal can be used by educators to explore the benthic diversity discovered during our cruises. The collection includes images annotated with Danish common names for easier understanding. Teachers and other users can log in as a

guest and explore images and annotations. (<https://biigle.de/login> email greenlandhabitats@gmail.com, password deep_sea).



Snapshot of a selection of images available on the biigle platform

5. Stakeholder engagement

Describe the support or engagement between all key stakeholders and the project.

- *To what extent have stakeholders been involved in the project to date?*
- *Highlight any particular achievements, lessons learnt or challenges with regards to the engagement with/participation of the different stakeholders.*

We have conducted regular meetings with our project partners Sustainable Fisheries Greenland and our project collaborators at Greenland Institute of Natural Resources.

Our attendance and participation at the annual MSC audit meetings has brought us an audience with a variety of stakeholders in the fishing industry including fishers, fisheries managers, academic researchers and MSC representatives.

Our presentations at science conferences in UK, Norway and USA have presented our research findings to a wide range of academic researchers from many countries. While invited talks at the MSC head office and UK government department DEFRA has delivered our research to stakeholders and government agencies. Furthermore, at the request of the Marine Stewardship Council, members of the project wrote a submission to the House of Commons Select Committee consultation on Sustainable Seas, outlining the positive outcomes of our work in Greenland.

We are particularly proud of our role in bringing up the issue of trawling on vulnerable seapen habitats in Melville Bay. This was a serious issue for the recertification of the

West Greenland Coldwater Prawn fishery. This led to a series of meetings between SFG, GINR and representatives of the Greenland government which culminated in the closing of 1,900km² of Melville Bay to trawling and the introduction of the precautionary principle to future expansion of the fishery, whereby the fishing industry has to must seek government approval by demonstrating there are no vulnerable habitats in the areas of proposed expansion (http://naalakkersuisut.gl/da/Naalakkersuisut/Nyheder/2018/01/2301_melvillebugten). This positive outcome, with a focus on sustainability, is evidence of stakeholder buy-in and will be a long-term legacy of the project.

6. Capacity building

Provide details of any capacity building activities conducted (if relevant), including:

- *Details of how the project has supported capacity building within the territory e.g. institutional/organisational development, training and human resources development, sustainable financing, enabling environment etc.).*
- *Tangible evidence (facts/figures) of increased capacity of institutions/individuals within the targeted territory(ies) and region.*

- We established a collaboration with Lars Poort at the Learning Institute, University of Greenland, to assist the development of training material provided for teachers and teacher students in natural sciences. The first output of this collaboration is the teaching resource, which includes lesson activities, multimedia links and background information surrounding the topic of benthic habitats in Greenland and sustainable fishery (Annex 7). It also uses maps and seabed images from our project. This forms the basis for an interactive ebook (led by Lars Poort), teaching students about the marine environment in the waters off West Greenland. This ebook will be a resource of training material delivering information about Greenland's habitats for years after the life of the project and constitutes a legacy of capacity building.

- We have worked closely with our collaborators at GINR to develop a new video sled for benthic surveys (image right). The first successful deployment was during our June 2017 survey, and this was followed by deployment down to 1500m during the research cruise of October 2017. This camera equipment is housed at GINR and will expand their ability to conduct benthic surveys in the future. New GINR-led surveys using this equipment occurred in July, September and October 2018, where ZSL project staff taught GINR colleagues how to use the equipment. This gear will be a long-term asset to GINR as will the transfer of knowledge on its use.



- We have introduced the Biigle image annotation platform to members of GINR, providing informal training in its use. This platform allows for easier collaboration between ourselves and GINR and enhances the analytical capabilities at the institute.

Student training

- Project member Stephen Long has used the research from our project as part of his PhD.

- We have employed an intern Naomi Berkowitz to help with outreach activities

- During the lifetime of this project ZSL staff have supervised 4 masters students conducting research relating to the benthos of Greenland

- 1. Jack Davies (UCL Mres summer 2017) Project “Does an alternative perspective of imaging capture additional information on benthic habitats and the impacts of otter trawling at the shrimp fishery site of West Greenland's continental shelf?”

- 2. Amy Jenkins (York MSc Summer 2018) Project “Deep Sea Lebensspuren: The influence of fishing activity on benthic infauna off the west coast of Greenland.”

- 3. Lauren Cook (UCL MRes Spring 2018) “Documenting cold seeps on the west coast of Greenland”

- 4. Bridget Sparrow-Scinocca (Imperial MSc Spring/Summer 2018) “Use of deep-sea imagery to propose a candidate vulnerable marine ecosystem (VME) in the Davis Strait, Greenland”

7. Communication and project visibility

Discuss the profile of the project within the territory(ies) and describe any communication or visibility activities undertaken (e.g. events, workshops, media events etc.) to raise the profile of the project and the BEST 2.0 programme detailing:

- *The groups targeted by each activity.*
- *Any communication products produced (brochures, leaflets, videos, website, social media etc.), including figures for dissemination where possible.*

Multimedia

- A short video highlighting our project was produced by ZSL digital communications team (560 views as of 19/3/2018 - <https://youtu.be/M4qODUKXbv0>)
- A longer video highlighting our research was produced and translated into Danish (presented to Greenlandic school classes and an exhibition at the “Kulturnat”, 1046 visitors - <https://www.youtube.com/watch?v=yyctEb4HmG0>)
- The following blogs highlighting our project activities have been published on the ZSL webpage (website stats as of 27/3/2018)
 - <https://www.zsl.org/blogs/wild-science/exploring-the-deep-seafloor> (May 2017, 70 unique views)
 - <http://www.zsl.org/blogs/wild-science/sea-cucumbers-carnivorous-sponges-and-other-deep-sea-creatures> (Sep 2017, 188 unique views)
 - <http://www.zsl.org/blogs/wild-science/diving-deeper> (Jan 2018, 86 unique views)
 - <https://www.zsl.org/blogs/science/new-protection-for-vulnerable-arctic-habitats> (Feb 2018, 78 unique views)
 - <https://www.zsl.org/blogs/science/guns-gadgets-and-games-science-outreach-in-greenland> (Oct 2018, 48 unique views)
 - <https://www.zsl.org/blogs/science/tricky-trawling-science-communication-and-outreach-in-greenland> (Apr 2019)
- Project related tweets have been posted on [@MonaFuhrmann](#), [@Stephen_D_Long](#) and [@ZSLScience](#) twitter feeds (over 18.5K followers). These have generated in total 193918 impressions and 5548 engagements (Annex 10 stats as of 20/3/2018). Notable re-tweeters are MSC and WWF. The game multimedia campaign resulted in [@OfficialZSL](#) tweets which generated 25000 impressions, and over 600 engagements (Annex 10). ZSL produced a short [video](#) to go along with the campaign on twitter. The game was also featured on Twitter by [Grantham Imperial](#) and [Discover Animals](#). The game campaign also increased views of the project page <http://www.zsl.org/greenland> by 100% in the short time after the launch.
- In Greenland, the game was covered in an [article](#) and a [radio interview](#) by KNR (Greenlandic Broadcasting Corporation).
- A [TV show](#) about the Polar Fish Trade Fair was broadcast on the Greenlandic Broadcasting Corporation, including a section on about our stall.
- An article on our research cruise of October 2017 was published in the deep-sea science publication Deep-Sea Life (http://www.indeep-project.org/indeep/sites/indeep/files/documents/DSL10_Nov2017.pdf#page=3 – which is circulated to around 600 deep-sea researchers quarterly)
- The MSC published an article about our research on their website (25/9/2017 - <http://greenland-seafloor-stories.msc.org/>)
- The 2017 MSC annual report highlighted our research in their annual global impacts report (<https://www.msc.org/documents/environmental-benefits/global-impacts/msc->

[global-impacts-report-2017#page=11](#))

- MF wrote and published an article in a special issue of WWF/CAFF magazine “The Circle” <https://arcticwwf.org/newsroom/the-circle/arctic-biodiversity/trawling-fragile-life-at-the-bottom-of-the-sea/>
- SL’s research was highlighted for an article in the FSBI winter 2018 newsletter https://www.fsbi.org.uk/wp-content/uploads/2018/11/FSBI_WINTER_NEWSLETTER_2018.pdf .
- The ZSL / SFG collaboration is mentioned in the 2017/2018 annual report of the Marine Stewardship Council (https://www.msc.org/docs/default-source/default-document-library/about-the-msc/msc-annual-report-2017-2018.pdf?sfvrsn=b0c19c3_4)
- Our survey video footage appears in the Greenland Institute of Climate Research’s latest video (https://gircr.gl/news/watch-greenland-climate-research-centres-new-video/?fbclid=IwAR06JXhN2WzbTYxHk1v6ftRCdXu7zqnsuU5PO51E1V9DmPxKEd2SKIWs_R8).
- MF curated the “Little Blue letter” in March and dedicated it to deep sea research (<https://tinyletter.com/LittleBlueLetter/letters/ocean-update-from-little-blue-letter-47>).

Outreach Events

- Chris Yesson (CY) gave an outreach talk to the general public at the Grant Museum as part of the field adventures season (26/04/17 – 20 attendees)
- CY, Mona Fuhrmann (MF) & Stephen Long (SL) conducted two half-hour interviews with 58 key stage 2 schoolchildren from Devonshire Hill Nursery & Primary School in North London on 19/5/2017 to speak about our research and upcoming cruise. We spoke about our work in Greenland and the upcoming research cruise. During the cruise we sent information about our activities. We held follow-up discussion with the school children on 28/6/2017. Evaluation questionnaires were completed by the children, 90% of children said they liked the sessions (see example right & Annex 9)
- CY, SL and IoZ colleague Matt Bennion presented a stand at the Natural History Museum’s Science Uncovered evening outreach event, with Chris Yesson participating in the associated European Researchers Night (29/9/17 – 4320 came to entire event – 83% of attendees said experience was good or excellent)
- MF presented a talk on this project to school children at the Arctic Frontiers science for schools event, Tromso, Norway (25/1/17 – c. 40 attendees - <https://www.apecs.is/news/apecs-news/2308-being-a-real-scientist-at-the-science-for-schools-event-at-arctic-frontiers.html>)
- MF presented an exhibition at the “Kulturnat” annual event at Greenland Institute of Natural Resources, Nuuk. Mona showcased our research to members of the public (20/1/18 - 1046 people visited to the event). Evaluation forms were handed out at the event, but only 2 were completed, both gave positive feedback.
- CY and SL conducted an outreach event at ZSL London Zoo during the May half term, showing zoo visitors props (cameras & benthic specimens) and explaining our research in Greenland
- CY and MF conducted an outreach event at ZSL London Zoo during the Zoo Nights

ZSL LONDON ZOO

Spent five minutes drawing what you think Chris' fieldwork in Greenland looks like

1. How much did you like learning about Chris's fieldwork in Greenland? (Use the circle and face)

2. What did you like about these lessons?

3. What did you like about these lessons?

4. Circle the words that you think best describe your experience at speaking to LIZEE

Fun, Animal, Wild life, Cool, Amazing, Interesting, Educational, Fun fact, Cool, Amazing, Interesting, Educational, Fun fact, Cool

Are there any other words you want to add.....

event on World Oceans Day (8/6/18). Stickers promoting the project were given out to the approximately 120 people with whom we engaged

- CY, SL, Amy Jenkins & Kirsty Kemp (KK) took part in the Royal Society Summer Science Exhibition (July 2018). This week long event had 12000 visitors and the stand from Institute of Zoology engaged with 4000 of them. Our stand was entitled “Where the wild things are” and had a theme of using low-cost technology to access remote locations to achieve positive conservation outcomes. Selected tweets from this event are presented below:
 - Institute of Zoology: <https://twitter.com/ZSLScience/status/1013689254017368064>
 - ZSL director general: <https://twitter.com/DomJermej/status/1014971444034441218>
 - ZSL: <https://twitter.com/OfficialZSL/status/1015208826486906880>
 - Royal Society: <https://twitter.com/royalsociety/status/1014799754516197376>
- CY and game developer Filip Hnizdo from Octophin Digital took a test version of our educational game to Green Street Green Primary school to get feedback from 2 classes of 25 children (10 year olds). Feedback included request to explain the scores better and provide more info on the animals. (July 2018)
- CY, MF, SL & KK participated in the 2018 Polar Fish Trade Fair in Sisimiut Greenland. 1800 people attended the event over three days. We engaged with 400 people during the event, having as many as 12 people at the stall at one time. We showed specimens, technology, videos and images and invited many people to play our computer game. MF was interviewed by local news in Greenland during the event. We had regular discussions with members of KNAPK (The Association of Fishers and Hunters in Greenland), including with Tonnes Berthelsen, a member of the board of Sustainable Fisheries Greenland.
- MF visited the 8. class of the international school in Nuuk ('Nuuk Internationale Friskole) to tell the children about our research and gather feedback on our game. Children were in the age range of 13-14 and they responded with great interest and enthusiasm to the opportunity of testing the game in the classroom (Oct 2018)
- KK conducted 2 skype calls with 2 groups of 120+ school children, ages 9-11 from Karachi Grammar School, Pakistan. The calls lasted 30 minutes with the first half talking about our research and the second half devoted to questions from the children. This was part of a week of school activities entitled “the wonders of the ocean and the damage being done to it... and our responsibility in protecting it”
- CY and SL conducted a day of outreach at Aurora House school for children with autism
 - <https://twitter.com/AuroraHouse15/status/1085835290185555969>
 - <https://twitter.com/AuroraHouse15/status/1085848913486131200>
 - <https://twitter.com/AuroraHouse15/status/1085849902113017856>
 - <https://twitter.com/AuroraHouse15/status/1085853188543180800>
 - <https://twitter.com/AuroraHouse15/status/1085873503197376512>
 - <https://twitter.com/AuroraHouse15/status/1085873832571719684>
 - <https://twitter.com/AuroraHouse15/status/1085953605314711554>
- Naomi Berkowitz conducted 3 visits to schools in Greenland. 1. NUUK Internationale Friskole - 8th grade, 2. Nalunnguarsiup Atuarfia in Sisimiut - 10th grade and 3. Atuarfik Hans Lynge - 8th grade. She introduced the game and gave background information on the science within the project and the topic of sustainable fisheries. They performed classroom activities and also the students had time to play the game. Students filled out before- and after lesson questionnaires. This was seen as a valuable experience by students and they seemed to understand the basic concepts of biodiversity found on the seafloor of Greenland and fishery impacts (Annex 9).

Scientific Presentations

- SL presented a talk on his research at Institute of Making, University College London (Dec 2017 – c.20 attendees)
- MF presented a poster on this project to the Arctic Frontiers Science conference (Jan 2017 – see Annex 6)
- SL presented a poster at the London NERC-DTP annual conference: “Frontiers in Natural Environment Research” (August 2017 – image right & Annex 6)
- SL presented talk on our research at loZ annual student conference. The talk was highly commended by the panel of judges and received a small prize (Feb 2018)
- SL presented at the 2018 BioTweeps Twitter conference (June 2018). The four tweet presentation is viewable here (https://twitter.com/Stephen_D_Long/status/1010170361424596993). The total ‘Impressions’ (number of times seen by Twitter users) for these tweets is over 13,000. The total number of views of the three incorporated videos is over 1000.
- CY, SL & KK attended the 15th Deep-Sea Biology Symposium, in Monterey California (Sept 2018). CY presented a talk on our research in the region of the West Greenland Cold Water Prawn Fishery. SL presented a talk on our research in the region of the West Greenland Offshore Greenland Halibut fishery. Two posters were also presented showcasing our project (Annex 6).
- MF attended the 2018 Arctic Biodiversity Congress in Rovaniemi, Finland, where she gave a presentation on the project’s research findings and a second presentation on our outreach activities (Oct 2018).
- CY, MF, SL & KK attended the Institute of Zoology annual science conference (Dec 2018), where MF gave a short talk about our computer game and our institute director conducted a live demo to the audience. CY presented a poster showcasing our project outreach, and SL presented a poster (Annex 6) about our research assessing habitats in the region of the Halibut Fishery.
- CY gave an invited talk at the UK government department DEFRA head office in London to DEFRA staff, where he spoke about our project and research (Oct 2018).
- CY, MF & SL attended the “Beyond Challenger” conference at the Royal Society (Dec 2018), where CY presented a poster showcasing our project outreach, and SL presented a poster about our research assessing habitats in the region of the Halibut Fishery (Annex 6).
- CY and SL gave an invited talk at the Marine Stewardship Council head office in London, where we presented our research (Jan 2018)
<https://twitter.com/MBStudent/status/1085554337517092879>



8. Sustainability and replicability

- *Explain how the project work/outcomes will be sustained beyond the end of the BEST 2.0 funding.*
- *Highlight any project activities that will be continued.*
- *Describe the expected long-term benefits of the project and provide an assessment of the potential for the replication/transfer of the project lessons/results.*

There are a number of products from this project that will provide a sustained legacy beyond the life of the project:

- Teacher training material (details above) will provide a long term training resource
- Capacity building at GINR (see section 8) including new benthic survey equipment which will be permanently housed at GINR after the project. This new approach has already been incorporated into other projects (ghost gear survey, inshore cod survey and habitat mapping in Disko Bay)
- Establishment of closed areas and the adoption of precautionary principle in management of expansion into Melville Bay provide a long term legacy of sustainable management of habitats (see section 7)
- Entrance of fisheries into MSC scheme ensures sustainable management of the fisheries for at least the lifetime of the assessments (a 5 year cycle). In the case of the Halibut fishery, this entered the 5 year assessment cycle in 2017. The coldwater prawn fishery entered reassessment in 2018.
- There are direct economic benefits resulting from MSC certification: I) a higher price can be achieved for sustainable produce II) certification ensures access to markets (such as UK supermarkets), which are increasingly closed to non-certified products. These increase profitability and resilience for the fishing industry, which remains the major source of foreign income for the nation of Greenland.
- Our research findings, survey data and impact assessments provide a publicly accessible baseline of information on seabed habitats in the area.
- Our survey methods will be published and in the public domain, facilitating repeat surveys and assessments of change.
- All seabed images are publicly available. This is a permanent resource of deep-water benthic fauna.
- This project has provided study opportunities for PhD and masters students. Training the next generation of marine researchers of the value of Greenland's habitats. These studentships have helped to further supervisory linkages between ZSL, GINR and UCL
- Collaborative links between ZSL and GINR have been enhanced by the project. We have created new collaborations on the back of this project which will result in further research of Greenland's seabed habitats. We have been invited to participate in 3 research cruises in 2019 and have written a joint application for a further cruise in 2020

9. Lessons learnt

This can include lessons from all levels including administrative, management, technical, and M&E e.g.

- *What worked well, and what did not work so well during the project?*
- *If you had to do the project again, what would you do differently?*
- *What recommendations would you make to others doing similar projects?*
- *How are you going to build this learning into your organisation's future plans?*

Worked well

- *Video surveys* – We have developed, tested and successfully deployed our video sled system, in collaboration with GINR. This new system has collected valuable video survey data at depths ranging from 30-1500m.
- *Biigle* – The adoption of the Biigle platform for image annotation has proved a significant improvement on the Poseidon system. Our image processing is now much more efficient.
- *Kulturnat* – The exhibition at the 2018 Kulturnat at the GINR offices in Nuuk was a successful event, showcasing our project to the Greenlandic public. This has enhanced our collaboration with GINR (who waived any fees associated with this event).
- We have found displaying *360° video* of our research activities with virtual reality headsets to be an effective science communication tool. These have proved very popular at our outreach events and give a sense of 'being there' to our audience.
- Our *contact with schools* has been a rewarding experience and we were pleased by the excellent feedback we received.
- *Raising our project profile* – We have articles publicising our research published by Deep-Sea Life & MSC.
- *Enhanced collaboration with GINR* – We have worked closely with collaborators at GINR, creating new supervisory links and developing plans for ongoing benthic research collaboration
- *Capacity building of marine research at IoZ* – This project has employed a postdoctoral researcher, trained a PhD student, two masters students and an intern.

Issues, Recommendations & Future plans

- We were frustrated by the delays with the research cruise. This was entirely outside our control. Initially the cruise was scheduled for September 2017, was subsequently cancelled in August due to failure of the main trawl-winch. Repairs were expected to take several months, but were completed early and the cruise was hastily re-scheduled in September to be carried out in October. This was disruptive for our timetable, as we had to cancel meetings with SFG and fishers planned for October, as the fieldwork had to take priority. Cancelling our presence at the Biennial captains meeting has set back some of our engagement plans.
- With hindsight we would have factored in more flexibility around the fieldwork dates
- Flights to Greenland are expensive. Booking well in advance gives cheaper tickets, but the cheapest tickets are inflexible. Purchase of tickets at the last minute for the hastily rescheduled cruise was significantly more expensive. Flexible plane tickets are more expensive, but maybe worth the investment.

- The ZSL digital team have had difficulties with staff recruitment and retention, leading to limited resources available to work on our project. This meant we have had to spend more time on this project than we expected. We have now sub-contracted game development to a third party (at no extra cost) to ensure delivery on time, without disrupting our other activities.
- We were initially naive in our approach to game development. We have learnt a lot about the process. The initial plan to develop 2 games in parallel was not workable, so we have restructured our plans to produce a single, high quality game that delivers a conservation message and information about Greenland habitats in a fun and friendly way. This has been a steep learning curve, but the game was produced on time and on budget. We have received excellent feedback and the effort put into this paid off in that we reached a larger audience.
- We have faced difficulties contacting people in Greenland, when out of country. Email communication is not reliable and we have found face-to-face communication to be the most effective for positive outcomes. We believe it is a much better approach to have a greater presence in-country to facilitate communication, collaboration and data management.

10. Safeguard policy assessment

Provide a summary of any environmental and social safeguard issues that have arisen and any action taken to address them (if relevant).

Nothing has arisen

11. Location of records, accounting and supporting documents

Please indicate in a table the location of records, accounting and supporting documents for each Beneficiary and affiliated entity entitled to incur costs.

12. Additional comments/information

Add any additional comments/information not covered by the other sections in this report.

There have been several positive outcomes stemming from this project:

- *Additional research cruises* – our collaboration with GINR has expanded. We have conducted benthic surveys on other GINR funded research cruises and have been invited to participate on more cruises in 2019.
- *New collaboration* – We have begun a new collaboration with DFO Canada to investigate the habitats of the Halibut fishery in waters contiguous with the Greenland fishery, but on the Canadian side of the border. We have been awarded a NERC grant to conduct a benthic survey in this region.

We would like to take this opportunity to express our delight at the positive outcome of the implementation of a new MPA in Melville Bay, which was facilitated by our research and

collaborations with SFG and GINR. To have this outcome within the lifespan of project is beyond our expectations.

The project has been routinely highlighted by Marine Stewardship Council as a good example of industry and research working together to achieve positive outcomes (e.g. <https://www.msc.org/docs/default-source/default-document-library/what-we-are-doing/global-impact-reports/msc-global-impacts-report-2017-interactive.pdf#page=11> and <https://twitter.com/katrinvilhelm/status/1126041792347029505>)

13. Achievements against the project logical framework

Report of achievements against the project logical framework (repeat the logical framework from your proposal and include the necessary reporting)

Project summary	Indicator(s)	Achievements and reporting against indicators
Overall Objective Sustainable use of marine resources in the Arctic and conservation of benthic habitats		The project has made a substantial contribution towards the overall objective. New information on benthic habitats has been collected. New protected areas have been set up in Melville Bay.

<p>Purpose</p> <p>Forward and promote sustainable fishing in Greenland by surveying, studying and informing stakeholders about the regions benthic habitats</p>	<ol style="list-style-type: none"> 1) MSC Re-certification of the Cold Water Prawn fishery by end of the project 2) MSC certification of the Greenland Halibut Fishery by Dec 2017 3) Surveys of the seabed (Jun/Oct 2016) 4) Stakeholder meetings conducted by IoZ throughout the project 5) Teaching fishermen on identification of key species (IoZ Nov 2017/Aug 2018) 6) Analysis of benthic habitats in relation to fishing effort and environment (IoZ researchers to submit 3 manuscripts in year 2 of project) 7) Publication of web-based resources (games, interactive map, website and educational materials - IoZ/ZSL Digital Outreach Jul 2017 & Jun 2018 deadlines) 	<ol style="list-style-type: none"> 1) The prawn fishery was re-certified by MSC in mid 2018 2) The Halibut fishery has been conditionally certified. 3) Cruises have been completed and the data is ready to work up. 4) Meetings have been conducted 5) Not achieved 6) Analysis complete, manuscripts in preparation 7) The game was successfully launched in Jan 2019. Educational materials are in use. Digital materials are published
<p>Result 1. Visual (photographic) surveys of benthic habitats of W Greenland</p>	<p>Open access image library/ data resource (IoZ & ZSL Digital Outreach Team Jun 2018)</p> <p>Cruise report (IoZ Jul 2017, Nov 2017)</p> <p>Cruise blog (IoZ Jul 2017, Nov 2017)</p>	<p>Cruises were successfully conducted in June 2017 and October 2017.</p> <p>Cruise reports & blogs published</p>

<p>Activity 1.1 Photographic survey of benthic habitats at sites where historical shrimp surveys were conducted (continental shelf west of Disko Island)</p>	<p>Cruise reports documenting activities of surveys (by IoZ researchers published within 1 month of cruise)</p> <p>Approximately 1000 images of the seabed taken during two cruises (IoZ - make web-accessible by the end of the project)</p>	<p>The cruise was conducted successfully. The cruise report is provided as an annex</p> <p>A blog of the cruise is here (http://www.zsl.org/blogs/wild-science/sea-cucumbers-carnivorous-sponges-and-other-deep-sea-creatures)</p> <p>Images are accessible on the web.</p>
<p>Activity 1.2 Photographic survey of benthic habitats in the region of the Halibut fishery (off the continental shelf in NAFO region 1C & 1D)</p>	<p>Cruise reports documenting activities of surveys (by IoZ researchers published within 1 month of cruise)</p> <p>Approximately 1000 images of the seabed taken during two cruises (IoZ - make web-accessible by the end of the project)</p>	<p>The cruise was conducted successfully. A cruise report is provided in the annex.</p> <p>A blog detailing the cruise is here (https://www.zsl.org/blogs/wild-science/diving-deeper)</p> <p>Images are co-owned by GINR who have not permitted release of these images.</p>
<p>Activity 1.3 Scanning & digitising reels of images of the seabed taken in the 1970s and 1980s</p>	<p>Digitisation of approximately 500 images of the seabed taken during the surveys of the 1980s (IoZ - make web-accessible by the end of the project)</p>	<p>A total of 430 historical images have been scanned, covering all 430 areas we have been able to revisit.</p> <p>Images are accessible on the web.</p>

<p>Result 2. Documentation and analysis of structure, distribution and change over time (40 years) of benthic habitats of West Greenland. Interpretation of this change in terms of response to disturbance impact (trawling) and climate change. Projection of potential future change under the existing impact regime.</p>	<p>Minimum of 3 peer reviewed publications (Submissions by IoZ in year 2 of project)</p> <p>End of project report (IoZ/SFG)</p>	<p>Data has been collected.</p> <p>Analysis is presented in this document.</p> <p>Publications are in preparation.</p>
<p>Activity 2.1.</p> <p>Identification of benthic organisms observed in photographs</p>	<p>Seabed images will be tagged with metadata identifying taxon observations using the image processing software Poseidon (IoZ – completed in the 3 months after each survey)</p>	<p>Images have been analysed and are available on the Biigle platform. Note we have decided to process these images in the software platform Biigle, not Poseidon as originally planned. The Biigle platform offers greater functionality and enables faster processing.</p>
<p>Activity 2.2.</p> <p>Assimilation of environmental and fishing impact data for the region</p>	<p>Fishing effort data will be provided by SFG to document trawling activities in the region (SFG – 1st month of project)</p> <p>Environmental data, including seabed temperature, current speed and bathymetry data will be assembled for the regions of interest by examining oceanographic models from the http://marine.copernicus.eu/ web portal (IoZ – 1st month of project)</p>	<p>Fishing effort data has been collected both from the local regulator (GFLK) and the Global Fishing Watch Program</p> <p>Environmental data has been collected for temperature, salinity, current speed, bathymetry, slope and terrain ruggedness.</p> <p>GIS layers will be made available at time of publication.</p>

<p>Activity 2.3: Comparison of diversity and community composition in on-shelf habitats of West Greenland over the past 40 years in relation to changing environment and fishing impact</p>	<p>Analysis comparing diversity and taxonomic composition of benthic habitats in the region of the coldwater prawn fishery by comparing observations from surveys conducted by this project and those from the 1980s. (IoZ – submission of manuscript in 2nd year of project)</p>	<p>Analysis is presented in this document. A manuscript for publication is in preparation</p>
<p>Activity 2.4: Analysis of the diversity and community composition of off-shelf seabed habitats in NAFO region 1C & 1D in relation to fishing effort in the region</p>	<p>Analysis of patterns of diversity and community composition in relation to environmental conditions and fishing activities in the region of the Halibut fishery (IoZ – submission of manuscript in 2nd year of project)</p>	<p>Analysis is presented in this report, a manuscript is in preparation</p>
<p>Activity 2.5: Create a classification of off-shelf seabed habitats and predictive habitat map of the region</p>	<p>Images of off-shelf seabed will be classified into EUNIS habitats. Environmental proxies will be examined to develop a predictive model of habitat class that will be used to create a predictive map benthic habitat that will made public at the end of the project (IoZ)</p>	<p>Task completed. All areas surveyed fall into the same EUNIS category (Mud)</p>

<p>Result 3. Management plan for sustainable use of marine resources in West Greenland</p>	<p>Reports to be submitted to the Marine Stewardship Council detailing plans for the management of the Halibut and Coldwater Prawn fisheries. To be submitted by SFG at the end of the project and supported by information gathered by IoZ</p>	<p>All plans have been delivered to MSC on schedule. The Greenland Halibut Fishery has achieved provisional certification. The Coldwater Prawn fishery has achieved re-certification.</p>
<p>Activity 3.1. Create a management plan for the sustainable use of the Halibut fishery</p>	<p>SFG to submit a management plan for the sustainable use of the Halibut fishery to the Marine Stewardship Council by the end of the project. (IoZ to support with information on the impact of the fishery on benthic habitats)</p>	<p>All documentation has been produced for the MSC process. Documentation of the West Greenland Offshore Greenland Halibut Fishery can be found on the MSC website (https://fisheries.msc.org/en/fisheries/west-greenland-offshore-greenland-halibut/@@view)</p>
<p>Activity 3.2. Create a management plan for the sustainable use of the Cold Water Prawn fishery</p>	<p>SFG to submit a revised management plan for the sustainable use of the Cold Water Prawn fishery to the Marine Stewardship Council by the end of the project (IoZ to support with information on the long-term impact of trawling on the benthos of the region).</p>	<p>All documentation has been produced for the MSC process. Documentation of the West Greenland Coldwater Prawn Fishery can be found on the MSC website (https://fisheries.msc.org/en/fisheries/west-greenland-coldwater-prawn/@@view)</p>

<p>Result 4. Engagement of fishermen, children, industry, and public with the issue of conservation value of Greenland’s benthic habitats. Long-term buy-in and interest amongst these stakeholders regarding the importance of these national resources and their sustainable management.</p>	<p>Workshop at Greenland Maritime Centre (Skipper Skolen) Teaching session at Grønlands Gymnasiale Uddannelser. (Secondary school, Nuuk) and others Lecture (x2) to Officers’ conference of fishing industry leaders (Polar Seafood A/S, Royal Greenland A/S), Public exhibition at Polar Fish Trade show, Sisimiut Public exhibition and open day (“Cultural Evening”) at GINR Permanent teaching resource and exhibition lodged in Nuuk Online publication of web resources: Food-web game and project website Educational video, interactive map and species identification materials</p>	<p>A series of outreach events have been conducted. These include talks to the general public, engagement with school children of various ages, and exhibitions at major institutions. These events have taken place in UK, Greenland and Norway.</p> <p>The rescheduling of the cruise led to the cancellation of meetings with ships captains, although fishers have been engaged during the annual audits.</p> <p>Long term buy-in of stakeholders is evidenced by the adoption of new protected areas and restrictions on fishery expansion, requiring support from fishery representatives, scientists and government.</p>
<p>Activity 4.1. Workshop to inform Greenlandic fishermen on benthic habitats and provide information on the identification of vulnerable marine organisms caught as bycatch</p>	<p>A workshop will be integrated into “Skipper skolen” to inform fishing crews on vulnerable marine organisms and provide training on how the identify vulnerable marine organisms in bycatch and inform on the correct procedures when encountered. (IoZ Nov 2017, Aug 2018)</p>	<p>After prolonged efforts we were unable to engage with skipper skolen. We focussed our engagement efforts in other activities.</p>

<p>Activity 4.2 Workshops on Greenland's benthic habitats and conservation efforts to protect them will be presented to the annual officers conferences of the main fishery operators Royal Greenland and Polar Seafood.</p>	<p>SFG have arranged for presentations by IoZ researchers at annual officers conferences held by Greenland's main fishery companies Polar Seafood (Autumn 2017) and Royal Greenland (Spring 2018)</p>	<p>The 2017 meetings of both Polar Seafood and Royal Greenland were conducted in October 2017 and unfortunately overlapped with rescheduled cruise. This meant we (IoZ) had to cancel our planned involvement.</p> <p>The officers conferences are now on a two-yearly schedule, which means there will be no meeting until after the completion of the project (scheduled for autumn 2019).</p>
<p>Activity 4.3 Education of school children about the seabed of West Greenland</p>	<p>A series of school events will be set up around research cruises include skype interviews before and after cruises, blogging of activities during cruises and a live Q&A with researchers (IoZ researchers and ZSL Discovery and Learning D&L team around research cruises Jun & Oct 2017)</p> <p>Educational material on the seabed of Greenland will be tailored to secondary school groups by ZSL D&L team to circulate to schools before/after the research cruises.</p>	<p>We have conducted outreach events with 8 different schools in 3 countries, including 3 schools in Greenland.</p> <p>Teaching material has been developed in collaboration with Greenlandic educators and is in use.</p>
<p>Activity 4.4 Exhibition showcasing Greenland benthic habitats will be presented at Polar Fish 2018</p>	<p>An exhibition presenting specimens, images and information of Greenland's seabed will be created by ZSLs D&L team. This will be presented by IoZ researchers at Polar Fish Greenland (September 2018)</p>	<p>Event successfully conducted. We engaged with more than 400 people over three days and was covered by the national news</p>

<p>Activity 4.5 Exhibition showcasing Greenland benthic habitats will be presented at the Royal Society Summer exhibition, 2018</p>	<p>An exhibition will be given at Royal Society Summer exhibition by IoZ in 2018</p>	<p>Event conducted successfully</p>
<p>Activity 4.6 An evening outreach event will be given as part of the “Cultural Night” program held at the Greenland Institute of Natural Resources, presenting the project findings to the general public</p>	<p>An evening cultural event will present the findings of the project to an audience of the general public at a meeting room in the Greenland Institute of Natural Resources. (IoZ Summer 2018)</p>	<p>This event was successfully conducted in January 2018. A total of 1046 people visited “Kulturnat” at the GINR offices.</p>
<p>Activity 4.7 Development of web resources to highlight the diversity of life in Greenland’s benthic habitats</p>	<p>Publication and promotion of web resources (on www.zsl.org), an interactive map using benthic images to showcase and educate about habitats, teaching materials (IoZ/ZSL Digital Outreach July 2017)</p>	<p>Images and associated map are accessible via the Biigle platform. A selection of videos, blogs and resources are available on our project website</p>
<p>Activity 4.8 Development of a game using seabed video and images to inform, educate and entertain on the subject of Greenland’s benthic habitats</p>	<p>Publication of i) a game to inform on food webs of Greenland’s seabed (IoZ/ZSL Digital Outreach July 2017) ii) a game to identify key species based on images of bycatch and direct on the seabed (IoZ/ZSL Digital Outreach Jun 2018)</p>	<p>The game is complete and was launched in Jan 2019 (https://campaign.zsl.org/trickytrawling/)</p>

<p>Activity 4.9 Production of an educational video</p>	<p>Publication, presentation and promotion of an educational video documenting the diversity and conservation of Greenland's benthic habitats (IoZ/ZSL Digital Outreach Jun 2018)</p>	<p>A short video outlining our research was developed by ZSL digital</p> <p>An extended video with Danish translation was presented at the Kulturnat event, and reused at subsequent events</p>
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Submission Checklist

(Please ensure that you have included all of the following before submitting your report)

	Check
Standard request for payment – Not applicable as pre-financing exceeds spending	<input type="checkbox"/>
Financial report (signed) covering expenditure up to the end of the reporting period	<input checked="" type="checkbox"/>
All relevant documents as annexes	<input checked="" type="checkbox"/>

14. Annexes

Annex 1 – Monthly activity reports

Annex 2 – Cruise report for the survey of June 2017

Annex 3 – Cruise report for the survey of October 2017

Annex 4 – MSC documentation for the West Greenland Offshore Halibut Fishery

Annex 5 – MSC documentation for the West Greenland Cold Water Prawn Fishery

Annex 6 – Poster presentations at various scientific meetings

Annex 7 – Teaching materials accompanying the Tricky Trawling game (English version)

Annex 8 – Game evaluation

Annex 9 – Outreach evaluation

Annex 10 – Summary of Twitter activity

Annex 11 – Research report presented to SFG July 2018