Marine Fisheries Resource Assessment of Waters Adjacent to Kimmirut, Nunavut: Year I Report

Kimmirut Fisheries Resource Assessment: Year I
Centre for Sustainable Aquatic Resources P-543

-

Fisheries and Marine Institute of

Memorial University of Newfoundland

Centre for Sustainable Aquatic Resources

P.O. Box 4920, St. John’s, NL, A1C 5R3

March 2018

Marine Fisheries Resource Assessment of Waters Adjacent to Kimmirut, Nunavut. Year I Report

Study Conducted by:

Scott M. Grant, Philip Walsh, Margaret Folkins, Kirk Regular,
Centre for Sustainable Aquatic Resources
Fisheries and Marine Institute of Memorial University
PO Box 4920
St. John’s, NL
A1C 5R3

And

Manasie Kendell
Government of Nunavut
Iqaluit, Nunavut, XOA OHO

Submitted To:

Government of Nunavut
Department of Environment
Fisheries and Sealing Division
Box 1000 Station 1390 (1104 C Inuksugait Plaza) Iqaluit, Nunavut, XOA OHO
Tel: 867.975.7706 - Cell: 867-222-0293 - Fax: 867.975.7754 - Email: jkennedy1@gov.nu.ca

Building Nunavut Together

EXECUTIVE SUMMARY

This study summarizes the refit of the 8.2 m LOA Government of Nunavut owned research vessel *RV Papiruq* to make it suitable for fisheries research in coastal (i.e., directly from shore) and inshore environments of the Nunavut Settlement Area. This refit included new wiring, outboard motors, steering, and fuel systems. The vessel was also outfitted with a hydraulic system suitable for hauling fisheries survey gear. Also a full electronics package was added to the vessel, the details of which are summarized in the current report. The vessel was equipped with a CTD and pole mounted multibeam sonar system for physical oceanographic data collection. Once refurbished the vessel was navigated to Kimmirut where the first year of a multi-year fisheries resource assessment was initiated. During Year I, meetings were held with the Mayukalik Hunters and Trappers Organization, fleets of baited pots were deployed at 17 sites, a scallop rake was towed at four sites, hook and line fishing took place at a lake that is open to the ocean at high tide, towed video sled surveys were conducted at five sites, multibeam sonar data was collected over a broad area, and a member of the community received training on the *RV Papiruq* throughout the research program.

Four fleets (i.e., strings) of baited pots (i.e., squid) were fished during this study. Two fleets consisted of 20 whelk pots while the other two fleets were experimental and incorporated four pot types: 1) non-collapsible single entrance conical whelk pot, 2) collapsible seven entrance round shrimp pot, 3) collapsible three entrance round shrimp pot, and 4) collapsible 21 entrance square shrimp pot). A total of 24 species/genera of invertebrates and three species/genera of vertebrates were captured in baited pots and two additional plant species (seaweeds) were commonly hauled back with the pots for a total of 29 species/genera. A total of 1,441 individual organisms were captured in the baited pots with echinoderms dominating the catches (nine species and 909 individuals), followed by molluscs (eight species and 371 individuals), crustaceans (seven species and 165 individuals), and finfish (three species and nine individuals).

Most of the echinoderms (77%) were non-edible brittle stars, sun stars, sea stars, basket stars, and feather stars. Sea urchins, which are highly prized for their roe, ranked second in abundance among the echinoderms and 86% were above the minimum retention size enforced in the Nova Scotia sea urchin fishery. All of the molluscs captured were edible species. Whelks (sea snails) dominated the catches of molluscs in the pots and were comprised of two genera, *Colus* and *Buccinum* which were grouped together during this study. Most of the whelks (74%) were below the minimum retention size reported for *Buccinum* species in southern waters however it is unclear whether this minimum size applies to Arctic populations. The remainder of the molluscs captured were bivalves (i.e., clams, cockles, and mussels) and did not actively crawl into the pots. Rather, they were scooped up by the relatively heavy whelk pot as it dug into the seabed during haul back. A single bivalve mollusc was captured in the light weight collapsible shrimp pots which did not appear to dig into the seabed. All of the crustaceans captured are edible. Hermit crabs, which are edible when properly cooked, dominated the catches of crustaceans. The only other crab species captured was the toad crab and very few were captured (n = 5). The remainder of the crustaceans captured in pots were shrimps. The largest species captured was the Greenland shrimp. The finfish captured were sculpins and eelpouts.

Where suitable numbers of a particular species were captured statistical analysis indicated there was no significant difference in mean catch rates among the round shrimp pots and the whelk pot. However, these analysis are based on only seven sets of the experimental fleet of pots. When mean catches were estimated for each pot type the collapsible round shrimp pots performed best and catches in the large round shrimp pot were 2.5× to 5.5× higher for whelk, shrimp, and crabs then they were in the whelk pot. Because of the potential damage to the seabed environment caused by the relatively heavy whelk pots future studies should continue to test the capture efficiency and bycatch among these pot types.

A single scallop was captured in the four tows (6-28 minutes in duration) with the scallop rake. Greenland cod were captured during hook and line fishing in Soper Lake. All the Greenland cod captured were above the length at maturity reported for James Bay.

Density estimates of the six most common genera/ species that may be considered a source of food were assessed from the towed video sled survey. Sea urchins were the most abundant at 1.17 individuals/m^2 for a total of 1,947 individuals in the total area surveyed (i.e., 1.66 km^2). Sea cucumbers ranked second in abundance at 0.86 individuals/m^2 or 1,431 individuals in the total area surveyed. However, at the present time sea cucumbers do not appear to be consumed in Kimmirut. Sea cucumbers did not constitute a major component of the catches in the pots because they are planktivores that do not crawl into pots. The next most abundant species was the Greenland shrimp (0.51/m^2), followed by hermit crabs (0.29/m^2), whelks (0.15/m^2), and polar shrimp (0.13/m^2). These fishery independent density estimates can provide important insights into which species are most abundant and most likely to withstand various levels of fishing pressure. For example, when summed across all pots whelks ranked highest in the total catches among the six species examined but density estimates were among the lowest. Future studies should seek to determine whether CPUE estimates in baited pots can be used to predict the density from towed video sled surveys on the same grounds. If a relationship can be found it would substantiate using fisher catch data to assess the relative abundance of benthic fishery resources.

For many marine species depth is a habitat feature that determines distribution and abundance. During the current study, both the catch rates in the baited pots and density estimates in the towed video sled survey complimented each other with regard to greater catch rates and density of whelks and to a lesser extent sea urchins at depths of <60 m. This is an important finding and should be used to direct future research to determine whether these depth related distributions can be verified. For example, establishing depths where catches are most likely to be highest will help to direct subsistence or commercial fishing efforts.

TABLE OF CONTENTS

1.0 INTRODUCTION

Because economic opportunities in the Arctic are limited, fishery development is a priority for governments, native organizations, and communities. Small commercial enterprise development through fisheries diversification and building community capacity to participate in research activities that foster community based management of renewable resources are key components of the Nunavut Fisheries Strategy. Over the past two decades there has been considerable interest with regard to obtaining a better understanding of available marine fisheries resources in coastal and inshore areas of several Nunavut communities. Species of interest include shrimps, crabs, clams, mussels, scallops, whelk, sea urchins, edible seaweeds, capelin, Arctic cod, Atlantic cod, Greenland cod, Arctic charr, lumpfish, starry flounder, and Greenland halibut. During the open water season, exploratory surveys of marine fishery resources have been carried-out in several communities over the years but can suffer from poor timing, limited or 'make-do' capture gear, ill-equipped fishing vessels, difficulty coordinating local vessels, limited biological/ science focus, and in some cases lack of a well-organized approach to exploratory surveys. Further, once a potential fishery resource has been identified more focused assessments with regard to extent of geographic distribution and local abundance to direct fishing capacity (i.e., number of fishing enterprises) are generally lacking for new species and areas. It is important to establish from a quantitative and biological basis the status of renewable marine resources and from this determine whether harvests can sustain recreational/ subsistence or commercial fishery interests. Equally important is accessing local traditional ecological knowledge (e.g., Coastal Resource Inventory) and providing for direct involvement through participation and training of community members. This includes training in the use of conservation minded fishing gears that maximize product quality and avoid adverse effects on the Arctic marine environment and training in scientific data collection of local marine resources. Commonly the goal is to develop commercial fisheries for export out of Nunavut (e.g., Greenland halibut). However, identification of new resources for subsistence fishing is also important and from a food security or food replacement value perspective has been estimated at up to $50 million for all country foods harvested in Nunavut (see Nunavut Fisheries Strategy, 2016-2020).

An important advancement in marine science and research in Nunavut was the acquisition in 2011 by the Government of Nunavut's Department of Environment of the *RV Nuliajuk*, a 65 foot (19.8 m) research vessel. This vessel provides a platform entirely dedicated to inshore scientific work to support fishery development and provides on the job training opportunities. By helping to develop and monitor new and existing fishery resources in inshore waters, the *RV Nuliajuk* is paving the way for future fishery development and is also providing a greater understanding of physical and biological ocean processes in Nunavut waters. The *RV Nuliajuk* is in high demand which has led to discussions with regard to the need for a second equal size or larger research vessel to participate not only in inshore but also offshore fishery research and development. To help meet these demands the *MV Kiviuq I*, a 99 foot (30.2 m) fixed gear (i.e., longline) commercial fishing vessel owned by the Arctic Fishery Alliance has been involved in inshore and offshore fisheries research in the Qikiqtani Region since 2014. Both of these vessels are providing much needed research platforms for inshore and offshore fisheries research and development in Nunavut. Nevertheless, there are many communities with fishery development potential that have received little to no research support including Kimmirut. Kimmirut is a community located on the south coast of Baffin Island within the productive waters of the Hudson Strait. Given the variety of potential fishery species identified throughout Nunavut, the number of communities, and need for a timely response an additional cost-effective research platform that can work in both coastal and inshore environments is needed. For example, costs to simply operate the *RV Nuliajuk* are over $5,000/day while charter rates for the *MV Kiviuq I* are over $12,000/day. These costs do not include funding for the actual research that is carried-out on board these vessels.

This study summarizes the introduction of a smaller research vessel that is capable of working in coastal (i.e., directly from shore) and inshore environments of the Nunavut Settlement Area at a reduced cost. Specifically, the *RV Papiruq* (Figure 1), a Government of Nunavut owned 27 foot (8.2 m) research vessel, was overhauled to make it suitable for fisheries research in Nunavut coastal waters. This overhaul prepared the *RV Papiruq* to serve as a multi-species research survey platform for providing baseline physical and biological oceanographic information and the fishery potential of marine species. The vessel was equipeed with various types of fishing gear and video camera systems to assess the distribution and abundance of renewable marine resources. The vessel was also equipped with a CTD for oceanographic data collection and a pole mounted multibeam sonar system. Once refurbished and equipped the vessel was navigated to Kimmirut where the first year of a multi-year fisheries resource assessment was initiated. During Year I, meetings were held with the Mayukalik Hunters and Trappers Organization, fleets of baited pots were deployed at 17 sites, a scallop rake was towed at four sites, hook and line fishing took place at a lake that is open to the ocean at high tide, towed video sled surveys were conducted at five sites, multibeam sonar data was collected over a broad area, and a member of the community received training on the *RV Papiruq* throughout the research program.

At a gross weight of ≤15 t and length of ≤12 m operators of the *RV Papiruq* will only require a Small Vessel Operators Proficiency (SVOP) certificate. This allows for the introduction of an operations model wherein the operators of the vessel are also the fisheries scientists and technicians leading the research. Ultimately, this model results in substantial cost savings as the vessel is crewed by the science team with participation and on board training of local community members.

2.0 OBJECTIVES

This study represents an ongoing effort to assist communities with coastal and inshore fisheries and marine resource development opportunities. The objectives outlined in the Year I proposal are as follows:

1) Demonstrate utility and cost-savings of small vessel (*RV Papiruq*) dedicated to scientific work to support fishery development in inshore waters adjacent to the community of Kimmirut. It is anticipated that this model can be extended to adjacent waters of other inshore communities within Nunavut.

2) With assistance from local community members, carry-out science based multi-species marine fisheries resource assessments in inshore areas adjacent to the community of Kimmirut.

3) Provide community training in the use of conservation minded fishing gears, best handling practices to maximize product quality, biological sampling methodologies, and collection of data to support science and management of marine renewable resources.

3.0 METHODS

3.1 Study Date, Study Location, and Research Vessel

This study was carried-out during the ice-free season in 2017. There were two components to the study: 1) refit of an 8.2 m (27 ft) research vessel the *RV Papiruq* (Figure 1) owned by the Government of Nunavut (Department of Environment, Fisheries and Sealing Division) and 2) Year I of a fisheries resource assessment in waters adjacent to the community of Kimmirut, Nunavut (Figure 2). Kimmirut is located in the Hudson Strait and lies within the NAFO Division 0B regulatory area. Vessel refit and sea trials took place in Iqaluit from August 11-18, the *RV Papiruq* was navigated to Kimmirut from August 19-20, and fisheries research within the Kimmirut region took place from August 22 to September 5.

Mr. Matthew Akavak, a member of the community of Kimmirut joined the research team aboard the *RV Papiruq* in Iqaluit and helped to navigate the vessel from Iqaluit to Kimmirut. Mr. Akavak also helped with logistics while the research team was in the community. Once in Kimmirut the research team met with the Mayukalik Hunters and Trappers Organization to discuss the research plans and gain insights into the areas that should be investigated. Mr. Palanga Lyta, a member of the community of Kimmirut, served as a member of the crew of the *RV Papiruq* and helped to guide the vessel for safe operations while in the Kimmirut region. Mr. Sandy Akavak, provided accommodations for the research team while in Kimmirut.

The *RV Papiruq* had been in storage in Iqaluit since 2006 and was not sea worthy when examined in 2017. The vessel was removed from outside storage to a heated facility. Here the vessel was given a total refit with new wiring, outboard motors (250Hp and 25Hp), steering, and fuel systems. The vessel was also outfitted with a hydraulic system suitable for hauling fisheries survey gear. As well, the vessel was outfitted with two 1500 watt 12 volt to 110 volt inverters and a 2 kilowatt generator. The hydraulic system and generator were mounted on the roof of the wheelhouse. Also a full electronics package was added to the vessel. This included a quantum radar, chirp deep-water sonar, shallow water sonar, chart plotting system with Navionics, two multi-function displays with built in GPS, JRC satellite compass/GPS, full fleet one satellite phone and data system (Wi-Fi), a thermal camera for ice detection and night travel, and two fully functioning VHF's and a CB (some communities use CB others use VHF). All systems added to the vessel were networked and share all relevant data.

Safety at sea is a major consideration and all Marine Institute students and staff working on board the *RV Papiruq* had Marine Emergency Duties Training (MED A1) and First Aid. In addition, all operators of the research vessel had as a minimum Small Vessel Operators Proficiency (SVOP) certification.

3.2 Fishing Gear Assessments

In the current study, four pot types were fished: 1) a non-collapsible low profile conical whelk pot with a single top entrance (W) (Figure 3) and collapsible 2) seven entrance large round shrimp pot (LCS), three entrance small round shrimp pot (SCS), and 21 entrance large square shrimp pot (LSS) (Figure 4). The frame of the whelk pot was constructed with 12 mm round steel with a bottom diameter of 70 cm, top diameter of 40 cm, height of 25 cm, and weight of 4.1 kg. The jacket was made of green polyethylene mesh with a 22 mm bar length and twine diameter of 2 mm. The collapsible seven entrance large round shrimp pot weighed 0.8 kg had a diameter of 70 cm and height of 30 cm. The jacket was made of 3 mm green nylon mesh. The collapsible three entrance small round shrimp pot weighed 0.5 kg, had a diameter of 45 cm, and height of 20 cm. The jacket was made of 10 mm black nylon mesh. The collapsible 21 entrance large square shrimp pot weighed 0.4 kg, had a length and width of 61 cm, and height of 35 cm. The jacket was made of 3 mm green nylon mesh.

Four fleets (i.e., strings) of pots were prepared for this study. Two fleets (F1 and F2) consisted of 20 whelk pots spaced at 18 m intervals. The other two fleets were experimental (E1 and E2) and incorporated all four pot types arranged as shown in Figure 5. Pots in the experimental fleets were also attached to the mainline at 18 m intervals. Note, locations of the heavier whelk pots in the experimental fleets are assumed to act as anchors to keep this fleet with lighter shrimp pots on the seabed. All pots were baited with three squid that were placed in small mesh (1 mm) bait bags to prevent predation by scavenging sea lice (Figure 6). Fleets of pots were set over a broad depth range of 20 to 152 m (mean, 72 m). Soak time ranged from 25.75 to 92.25 hours (i.e., 1-4 nights). The aim was to soak the fleets of pots for 24-48 hours. However, in many cases inclement weather conditions required extending the soak times beyond 48 hours.

A scallop rake modeled after the Digby bucket was used during this study (Figure 7). The opening of the scallop rake measured 51 cm × 41 cm (L × W). The frame was constructed with angle iron steel, a small netting bag was attached with rings, and anti-chaffing rubber cookies were attached to the bottom of the rake to protect the netting. Four tows were carried-out at depths of 60-91 m (mean, 76.8 m) and tow duration ranged from 6-28 minutes (mean, 14.75 minutes).

Sampling for Greenland cod (*Gadus ogac*) by hook and line (i.e., rod and reel) took place in Soper Lake. Fishing took place with coloured lures and no live or frozen bait was used. The lake was accessed by foot and fish were angled from the shoreline.

3.3 Catch Sampling

Catches in each pot, by hook and line, and in the scallop rack were identified to species, weighed, and counted. Each species of finfish captured was measured for total body length on a fish measuring board (±1 cm). Linear measurements (±1 mm) with a Vernier caliper were carried-out for shrimp (i.e., carapace length), toad crab (i.e., carapace width), molluscs (i.e., shell height), and sea urchins (i.e., test diameter). Sea cucumbers were measured for body weight (±10 g). To avoid injury hermit crabs were not removed from the whelk shells they inhabited. Brittle stars, sun stars, sea stars, basket stars, and feather stars were enumerated only (i.e., no measurements of body size were recorded).

3.4 Underwater Video Observations

3.4.1 Camera and Lighting

A 1Cam Alpha MK6 video camera developed by SubC Imaging (http://subcimaging.com/) was used during this study (Figure 8). The 1 Cam Alpha has a built in infrared filter, is depth rated to 6,000 m, and has 24.1 MegaPixel still capability. The MK6 has internal storage that can record up to 50 hours of ultra-high definition video (4K) and is able to record in interval (i.e., intermittent) or continuous mode. In addition, the camera can be set to record in either 4K or 1080p mode. When in 4K mode the video camera speed is 30 fps while at 1080p mode the camera speed is 60 fps. During the current study the camera was set to record in continuous and 4K mode. Between sets, video was downloaded from the camera through the use of a computer and stored on Western Digital (2TB) portable USB hard drives using SubC camera software. Battery packs were also recharged between sets.

The SubC Imaging Aquorea™ LED MK2 lighting system was used during this study (Figure 8). The Aquorea lighting system is depth rated to 6,000 m. White lights were used on the towed video sled. Each light provides up to 12,500 lumens. Temperature feedback is built in to the Aquorea lighting systems. The LEDs used in the Aquorea lighting system have a greater than 60,000 h lifespan and are fully adjustable from 0-100% power output. The power output was set to 100% for the current study. Multiple lights were controlled from the same serial channel with SubC's Aquorea 1.3V 1.30 software.

During the current study, 24 V/40 amp hour deep-water lead acid battery packs depth rated to 10,000 m were used to power the lights and camera.

3.4.2 Towed Video Camera Sled Data Collection

All video was collected using the SubC video camera system previously described. The camera was mounted to the sled with two lights (Figure 8) and towed along the seabed by the *RV Papiruq*. A total of five tows were carried-out at an average speed of 0.5 knots at Camera Sites 4, 6, 7, 8, and 9 shown in Figure 2. It is notable, that these camera sites do not correspond numerically to the fishing sites shown in Figure 2. The tows were approximately one hour in duration. The camera was set at 10 minute recording intervals during a tow, meaning every 10 minutes it would stop and save the video to reduce the chance of data loss.

3.5 Data Analysis

3.5.1 Towed Video Sled Density Analysis

A total of 32 video clips each 10 minutes in duration (5.3 hours total) were analyzed for abundance and density (number/m^2) of individual organisms for the six most common species/genera that may be considered a source of food. All video was played using VLC media player and viewed on a 70.9 cm (diagonal measure) 4K monitor. The Canadian perspective grid (Figure 9), which is a calibrated oblique measurement plane, was superimposed over the monitor (Figure 10) and used to measure perpendicular distance from the vertical center line for each individual organism observed (Wakefield and Genin 1987). Four critical measurements were required to generate the perspective grid: the camera height above the seabed, the camera inclination below the horizontal plane, and the horizontal and vertical camera fields of view (Wakefield and Genin 1987). For our system, the camera height above the seabed was 32.6 cm, the camera inclination was 31.4°, and the horizontal and vertical fields of view were 72° and 48° respectively.

The perspective grid was drawn on transparent paper to scale and placed over the monitor (Figure 10). The grid consisted of 14 horizontal lanes and 8 vertical lanes, which converged toward the vanishing point (Figure 9 and 10). The video was played at slow speed and as the image of an individual organism arrived at the center horizontal line, the video was paused. At this point the video time, species, and lane number away from the vertical centre line that the species was observed in (1 thru 4) was recorded.

During the video viewing, if at any time the camera sled was tilted, view was obstructed by sediment, or the tow stopped, that portion of the video was excluded from the analysis.

3.5.2 Towed Video Sled Distance Sampling

The software program Distance 7.1 (Buckland et al. 2001; Thomas et al. 2010) was used to estimate abundance and density for six of the most common genera / species that may be considered as a source of food:

Sea urchins (*Strongylocentrotus* sp.),
Sea cucumber (*Cucumaria frondosa*),
Whelks (*Colus* sp. and *Buccinum* sp.),
Hermit crabs (*Pangurus* sp.),
Polar shrimp (*Lebbeus polaris*), and
Greenland shrimp (*Lebbeus groenlandicus*).

Line transect data collected from the 5.3 hours of video was uploaded into the Distance 7.1 program. Species positions relative to the vertical transect line (i.e., lane 1 thru 4) were used to generate detection probability plots. The program distance chose the best fitted model based on the lowest Akaike information criterion (AIC) value. Using the best probability density function, the program distance then calculated the area under the curve (Pa; probability of detection) and used this to calculate an effective strip width (ESW). The ESW was used to yield the effective area sampled in square meters. Transect length in meters was calculated by multiplying the average speed of the vessel (i.e., 0.5 knots converted to 0.2572 meters/second) by the usable video time (i.e., seconds).

Critical to the density estimates was the assumption that the detection probability at the vertical transect line was equal to 1 (100% detection). The probability of detection was plotted for each individual species so as not to assume that all species would be equally detectable.

4.0 RESULTS AND DISCUSSION

4.1 Catches in Baited Pots

A total of 24 species/genera of invertebrates and three species/genera of vertebrates were captured in baited pots and two additional plant species (seaweeds) were commonly hauled back with the pots for a total of 29 species/genera (Table 1). Invertebrates dominated the catches in the pots. Many of the invertebrate species listed and the two brown algae or seaweed species (i.e., kelp, *Laminaria saccharina* and sea colander, *Agarum clathratum*) are generally immobile or sessile and did not actively crawl or swim into a pot rather, they were scooped up by the pot as it was dragged over the seabed during haul back (Figure 11 and 12). This includes the bivalve molluscs, sea cucumbers, and the feather stars (Table 1). In addition to these invertebrates it was not uncommon to find tunicates, soft corals attached to cobble, and fragments or whole sponges in the whelk pot (Figure 13). It is important to note, that of the 155 bivalve molluscs captured in pots during this study, 99.4% (i.e., 154) were captured in the whelk pot. The remainder of the pots used in this study were relatively light weight (i.e., ≤0.8 kg) compared to the whelk pot (i.e., 4.1 kg) and did not show signs of digging into the bottom during haul back.

4.1.1 Molluscs

Clearly, dragging whelk pots over the seabed during haul back is not the most efficient or preferred method of determining the presence of generally immobile fishery resources such as bivalve molluscs. However, we cannot ignore this opportunistic information as areas where several bivalves are taken in pots would provide the cue for further assessments with drop cameras or systematic surveys with the towed video sled. For example, bivalves were well represented in four of the sites sampled with the fleets of whelk pots (Table 2; i.e., Site 2, 3, 4, 8, and 9). These sites, particularly the shallower water site (Site 8), can be revisited for more detailed assessments during the 2018 field season by deploying a drop camera and/or by towing the video sled.

Shell height frequency distributions for the bivalve molluscs captured in baited pots during this study are shown in Figure 14. In the northeast Atlantic, the size at maturity in the Iceland scallop has been estimated to range from 40-50 mm (Garcia 2006). Thus, 93% of the Iceland scallops captured in the baited pots were above the size at maturity (Figure 14). To date, an internet search has not revealed the size at maturity of the remaining bivalve molluscs. The search continues.

Whelks (*Colus* sp. and *Buccinum* sp.) were the most common and abundant mollusc captured in baited pots (Table 2). Total catches of whelk per fleet of pots was highest in the fleets comprised of only whelk pots (i.e., F1 and F2, Sites 1-10; Table 2). This may be expected, as there were 20 pots in the fleets comprised entirely of whelk pots and 12 pots in the experimental fleets that were comprised of four pot types, which included only three whelk pots (Figure 5). When mean catches of whelk in the experimental fleet were compared between pot types it was found that the large round shrimp pot captured 2.9× more whelk then the whelk pot (Table 3). Nevertheless, a one-way ANOVA comparing catches among round shrimp pots and the whelk pot indicated the catches were not significantly different ($F_{2,24} = 2.417$; $p = 0.111$). It is important to note however, that this analysis is based on limited data (i.e., seven sets). Further, the depth range fished with experimental fleet E1 was relatively high (55-73 m) when compared to the depths where whelk were captured in the highest number in the fleets comprised entirely of whelk pots (i.e., F1 and F2; Table 2). Indeed, the whelk catch-per-unit effort (CPUE; number/string of 20 pots/hour) for the fleets of whelk pots was found to be negatively correlated with depth (Figure 15B). Specifically, the CPUE of whelk was found to decrease with an increase in depth. The slope of the relationship was significantly different from zero ($p = 0.043$) and the correlation coefficient was moderately high ($r^2 = 0.420$). These results suggest that the best catches of whelk will be at depths of about 60 m or less.

As the fishery resource assessment continues in the Kimmirut region it will be important to test the four different pot types at the shallower depths where whelk appear to be more concentrated (also, see below towed video sled analysis confirming greater density of whelk (number/m^2) at depths of <60 m). If it can be demonstrated that the light weight round shrimp pots are equally or more efficient at capturing whelk, than negative environmental impacts associated with dragging the relatively heavy whelk pot over the seabed during haul back can be eliminated. For example, less destructive lengths of chain can be used to weigh down strings of light weight shrimp pots.

The length frequency distribution of the whelk captured in the baited pots is shown in Figure 16. The maturity schedule (i.e., age or shell height at first, 50%, and 100% sexual maturity) for the whelk species captured in the Kimmirut region is unknown. As such there is no biological basis for setting a conservation minded minimum legal size based on shell height (SH). For comparison, the minimum legal size (i.e., 70 mm SH) for retaining waved whelk (*Buccinum undatum*) in the Gulf of St. Lawrence (DFO 2011) is illustrated in Figure 16. This minimum legal size is based on size at maturity but is for a southern population. It is notable, that studies of Arctic populations of bivalve molluscs show that they do not attain as large a shell size as individuals of the same species from southern populations (Stewart et al. 1993). These observations suggest waved whelk captured in Arctic waters will attain sexual maturity at a smaller body size then in the Quebec region of the Gulf of St. Lawrence. Given the interest in whelk as a food item in Nunavut communities it would be prudent to make efforts towards determining the maturity schedule so as to establish a conservation minded biologically based minimum legal size. During future studies we will make every effort to distinguish the species of whelk captured in pots.

4.1.2 Echinoderms

The bulk of the individuals and species captured in pots were from the phylum Echinodermata (9+ species and 909 individuals; Table 1 and Table 4). When it comes to echinoderm species that are known mobile predators or scavengers and are likely to have actively crawled into the pots two species of brittle star (*Ophiura sarsi* and *Ophiacentha bidentate*) followed by sea urchins (*Strongylocentrotus* sp.) were the most abundant in the pots. The brittle stars captured here are unsuitable for human consumption but sea urchin roe is highly sought after. Most of the sea urchins were captured in the pot fleets that were comprised entirely of whelk pots (i.e., F1 and F2; Table 4) and there were too few urchins captured in the experimental fleets (E1 and E2) to determine whether any pot type was more suitable then another (Table 4). A one-way ANOVA indicated the mean catch rate of brittle stars did not differ significantly among the round shrimp pots and whelk pots in the experimental fleets ($F_{2,44} = 0.016$, $p = 0.984$).

A plot of CPUE (number/string of 20 pots/hour) of sea urchins captured in the whelk pot fleets versus depth indicated a negative relationship with the number of urchins captured decreasing with depth (Figure 15A). However, the slope was not significantly different from zero ($p = 0.382$) and there was a weak correlation coefficient ($r^2 = 0.097$). It is important to note that these results are based on a limited number of fleets of pots.

The minimum legal size for retaining green sea urchins (*Strongylocentrotus droebachiensis*) in the Nova Scotia fishery (Anon 1995) is a test diameter of 50 mm (Anon 1995). When this value is plotted on the sea urchin test diameter frequency distribution for the pot catches in the Kimmirut region it indicates that 86% of the urchins are above this threshold value (Figure 17).

The orange footed sea cucumber (*Cucumaria frondosa*) is a commercially valuable species harvested in Atlantic Canada (DFO 2009). However, at the present time sea cucumbers do not appear to be consumed in Kimmirut. Very few sea cucumbers were captured in the baited pots which is not surprising as they are planktivores that are generally immobile as they only appear to detach from hard bottom substrates when threatened by predators (e.g., sun stars; *Solaster endeca*). The sea cucumbers captured in baited pots exhibited a range in body weight of 44-537 g (mean, 317 g). Grant et al. (2006) found that a size index incorporating both the contracted body length and contracted body width of an individual sea cucumber was the best measure of body size and this measurement technique will be used in the future. Size at first attainment, 50%, and 100% sexual maturity for the St. Pierre Bank *C. frondosa* population is reported by Grant et al. (2006). Few sea cucumbers were captured in the pots during the current study, but they were the second most abundant species observed in the towed video sled surveys (see below).

4.1.3 Crustaceans

Hermit crabs (*Pangurus* sp.) in whelk shells were the most abundant crustaceans captured in the baited pots and were well represented in each of the fleets comprised entirely of whelk pots (i.e., F1 and F2; Table 5). In the experimental fleets of pots (E1 and E2) mean catch rates of hermit crabs were highest in the large round shrimp pots (Table 3). All five toad crabs (*Hyas coarctatus*) were captured in the whelk pots (Table 5). Carapace width ranged from 45-76 cm (mean, 63.2 cm) and only one toad crab was above the minimum carapace width retained in the Newfoundland pot fishery (i.e., ≥70 mm).

Five species of shrimp were captured in baited pots and members of the genus *Lebbeus* were most abundant (Table 1 and 5). All of the polar shrimp (*L. polaris*) and 74% of the Greenland shrimp (a.k.a., spiny lebbeid; *L. groenlandicus*) were captured in the experimental fleet of pots. Best catches of these two species of shrimp were in the large and small round shrimp pots (Table 3). Although the data is based on few sets (n =7) of the experimental fleet of pots there is evidence to suggest that the round multiple side entrance shrimp pots are more efficient at capturing shrimp then the single top entrance whelk pot and 27 entrance square shrimp pot (Table 3).

The carapace length frequency distributions for the shrimp species are shown in Figure 18. Many of the Greenland shrimp (*L. groenlandicus*) were of a size suitable for human consumption and this species ranked third in density estimates in the towed video sled surveys (see below).

4.1.4 Finfish

Only nine fish were captured in the baited pots (Table 1 and 6). The shorthorn sculpin (*Myoxocephalus scorpius*) was the most abundant and ranged in body length from 16-25 cm (mean, 19.2 cm). A single Arctic sculpin (*Myoxocephalus scorpioides*) measuring 22 cm and three eelpouts from the genus *Lycodes* ranging in length from 24-37 cm (mean, 31 cm) were also captured. Five of the six sculpins and one of the eelpouts were captured in round shrimp pots that also contained shrimp. We suspect these fish had consumed some of the shrimp and may have negatively affect shrimp catch rates. The remainder of the fish were captured in whelk pots.

4.1.5 Seaweeds (Macroalgae)

During the current study, we were not prepared to carry-out detailed assessments of the seaweeds found in the Kimmirut region. We did however observed fucoids in the intertidal and shallow subtidal zone and kelp (*Laminaria saccharina*) and sea colander (*Agarum clathratum*) in the shallow and deep subtidal zone. All of these seaweeds are brown algae of the phylum Phaeophyta. The fucoid species known as popweed or rockweed (*Fucus gardneri*) and both the kelp and sea colander are edible. Rockweed can be eaten raw, but has a 'nuttier' flavor when blanched by dipping in boiling water (Garza 2005). There are many different types of kelp and each has a different flavor and texture. For example, *Laminaria saccharina* is sweet when dried (Garza 2005). In some Nunavut communities, kelp and sea colander are commonly cooked in broth with seal meat (Nunavut Coastal Resource Inventory). Kelps are also used in the cosmetic industry. These edible seaweed species are widely distributed throughout the coastal zone in the Kimmirut region and more detailed seaweed assessments and introduction of sustainable harvesting strategies are planned for the 2018 field season. It will also be important to conduct heavy metal contaminant analysis of the seaweeds.

4.2 Catches in Scallop Rake

A single Iceland scallop (*Chlamys islandica*) with a shell height of 68 mm was captured in the scallop rake. Future surveys with the scallop rake will focus on areas where scallops have been identified in towed video sled surveys and/or where multibeam sonar surveys identify suitable habitat (e.g., sand and/or fine gravel sediments).

4.3 Soper Lake

A total of 15 Greenland cod (*Gadus ogac*) ranging in length from 28-43 cm (mean, 37.6 cm) were captured by hook and line from the shoreline of Soper Lake. No other fish species were captured. The length frequency distribution for Greenland cod is shown in Figure 19. All Greenland cod captured in Soper Lake were above the length at first attainment of sexual maturity for members of this species captured in James Bay (i.e., 22 cm; Morin et al. 1991). The weight-length relationship for Greenland cod captured in Soper Lake is illustrated in Figure 20. Members of the community of Kimmirut indicated they fish for Greenland cod in Soper Lake over winter through holes made in the ice (i.e., jigging) and fish captured at that time are larger than those captured during the current study.

4.4 Towed Video Sled Survey

All five of the towed video transects analyzed were suitable for abundance and density estimates of the six species analyzed (Table 7). Mean depth among the five transects ranged from 49-84 m (mean, 62.5). Presence of dense kelp beds made it difficult to survey at shallower depths. We will make every effort to survey shallower sites with the towed video sled during the 2018 field season and also utilize baited and non-baited drop camera deployments to better understand species distribution and abundance. During the current study, suitable video of the seabed and associated organisms for analysis within each of the five transects ranged from a linear distance of 160 to 671 m (mean, 366 m), area covered ranged from 145 to 610 m^2 (mean, 333 m^2), and total area covered was 1.66 km^2 (i.e., 1,664 m^2; Table 7).

The detection probability plots were different for each of the six species examined in the towed video survey (Figure 21). Detection was high in the first lane for all species examined and remained relatively high in the second lane for all species except the polar shrimp (Figure 21). The low detection probability for the polar shrimp is related to the small body size (Figure 18) and association with vertical structures on the seabed. Therefore, there may have been several more present that were hidden among vertical structures.

When the six species analyzed are ranked by density (number/m^2) sea urchins were the most abundant followed by sea cucumber, Greenland shrimp, hermit crab, whelks, and polar shrimp (Table 8). The high abundance of sea urchins can be attributed to the broad distribution and apparent high abundance of brown macroalgae (seaweeds) in the Kimmirut region. Macroalgae is the preferred food of sea urchins and both the kelps (*Laminaria saccharina*) and sea colander (*Agarum clathratum*) were commonly encountered in the shallow and deep subtidal zone and fucoids were encountered in the intertidal zone and shallow subtidal zone.

The orange-footed sea cucumber (*Cucumaria frondosa*) is a planktivore (Figure 22) and the abundance of this species in the study area can be attributed to the high tidal amplitude (~11 m) and tidal currents which can act as a conveyor belt providing a continuous supply of plankton. Sea cucumbers need to adhere to hard substrates with their tube feet and were most commonly observed on hard bottom. When observed on soft bottom they were partially buried suggesting they were adhering to hard substrate that was also buried.

Most of the shrimps that were observed were found associated with vertical structure most notably sponges, corals, sea feathers, and small and large rocks. For example, when sponges were encountered the video was halted and shrimps were often hiding within these structures. It is unclear whether the white light or noise from the towed video sled had an effect on the behaviour or habitat associations of the shrimp. Hermit crabs and whelks did not appear to have any substrate preference as they were found on both hard and soft bottom. Analysis of the towed video sled data is ongoing with an emphasis on quantitatively determining which seabed habitat types (i.e., sediments) each species appears to prefer.

For many marine species depth is a habitat feature that determines distribution and abundance. For example, during the current study catches in the baited pots suggest whelks and to a lesser extent sea urchins were more abundant at depths of <60 m. The towed video data was used to investigate this apparent relationship. This was achieved by grouping tows that were conducted at depths of <60 m (i.e., 49-59 m; tows 4, 6, and 9) and tows that were at depths >60 m (73-84 m; tows 7 and 8). Detection probability plots and estimated abundance and density were obtained for each species in the two depth categories.

The probability of detection was similar between depths for the sea urchin (i.e., 0.58 and 0.59) and the whelk (i.e., 0.65 and 0.67), but overall the probability of detection was greater for the whelk (Table 9). The density estimate of sea urchins within the 49-59 m depth interval was marginally higher (1.2×) than the density estimate in the 73-84 m depth interval. However, the density estimate of whelks within the 49-59 m depth interval was substantially higher (3.0×) than the density estimate in the 73-84 m depth interval. These results are similar to the catch rates in the baited pots. Although the relationship between CPUE of sea urchins and depth in the baited pots was negatively correlated the relationship was not significant. Similarly, the towed video sled data demonstrated the density of sea urchins was higher at the shallower depths but the difference was only marginal (1.2×). The relationship between the CPUE of whelk and depth in the baited pots was also negatively correlated but in this case the relationship was significant. Similarly, the towed video sled data showed the density of whelks was substantially higher (3×) at the shallower depths.

The fishery independent density estimates obtained during this study can provide important insights into which species are most abundant and most likely to withstand various levels of fishing pressure. For example, when summed across all pots whelks ranked highest in the total catches among the six species examined but density estimates were among the lowest. Future studies should seek to determine whether CPUE estimates in baited pots can be used to predict the density from towed video sled surveys on the same grounds. If a relationship can be found it would substantiate using fisher catch data to assess the relative abundance of benthic fishery resources.

5.0 RECOMMENDATIONS

Surveys with baited pots should continue. Fleets of pots should incorporate many pot designs to determine whether capture efficiency varies by pot type and by species. Potential impacts on the environment in the form of habitat destruction/ disruption (including habitat forming organisms such as sponges and feather stars) from dragging over the seabed and bycatch of non-targeted species should be assessed for each pot type. Fleets of pots should be deployed over a wide depth range in an effort to establish depth preferences of targeted species and to resolve the apparent depth related distribution of whelks and sea urchins.

Seaweeds have various minerals, vitamins, carbohydrates, and sometimes protein. They are very low in fat, vitamin and mineral content varies by species, and most are nutritious (Garza 2005). During future field seasons a concerted effort should be made to identify all potential edible seaweed species and assessments of their distribution and biomass in coastal waters within the Kimmirut region. Underwater viewers can be used over the side of a boat to identify seaweed areas of interest and a hand rake with a cutting edge can be used from a small boat to collect samples for georeferenced quadrat biomass estimates and for contaminant analysis (i.e., heavy metals). To allow regrowth and maximize sustainability it will be important to leave the holdfast and stipe when harvesting the kelps, sea colander, and fucoids. The cutting edge of rakes used to harvest seaweeds can be fitted with a device that elevates the rake above the seabed so as to leave the holdfast and stipe intact. However, to obtain more comprehensive estimates of biomass we recommend considering the use of unmanned aerial vehicles (i.e., UAVs; drones) that can fly along the shoreline at mid to low tide to estimate seaweed coverage and biomass in the intertidal and shallow subtidal zones. Studies should consider harvesting at a number of sites and monitoring regrowth rates and how harvesting influences the distribution of sea urchins and other fauna. Even at this early stage of resource assessment methods of drying seaweeds and recipes for their use should be introduced. It is also recommended that heavy metal contaminant analysis be carried-out on the edible seaweed species.

Towed video sled surveys of the seabed combined with multibeam sonar surveys should be continued. Every effort should be made to cover a wide range of depths and substrate types to better understand the distribution and abundance of renewable marine resources. High tidal amplitude and high tidal currents that can provide a continuous supply of plankton and the presence of bivalve molluscs in the baited pot surveys suggest there may be areas where these species are abundant and at depths where they can be readily harvested. Multibeam sonar surveys will help to identify suitable seabed features and towed video sled and drop video camera deployments can be used to verify their presence and estimate densities. Towed video sled surveys should also be combined with potting surveys on the same grounds to determine whether pot catch rates coincide with video density estimates of targeted species. The towed video sled survey can also be used to establish biotopes for coastal regions for comparison of the effects of climate change on benthic communities of marine organisms. Biotopes are regions with similar assemblages of animals living on the seabed in a similar physical environment (e.g., related to depth, temperature, salinity, pH, dissolved oxygen, turbidity, sediment grain-size, current speed, slope, curvature, terrain ruggedness, ridge like structures, depressions, flat plains, etc). In addition, acquisition of a multi-parameter sonde for recording baseline physical and biological oceanographic data (i.e., pH, dissolved oxygen, salinity, temperature, depth, turbidity, and chlorophyll a) should be considered to establish baseline parameters to compare against future environmental conditions (i.e., climate change).

Towed video sled and multibeam sonar surveys of the Kimmirut region can only be performed from the *RV Papiruq* while baited pot surveys, static video camera deployments (baited and non-baited), seaweed biomass estimates, UAV surveys of the shoreline, and sonde deployments can all be performed from 20-22' vessels supplied by members of the community. To expedite the fisheries resource assessment and maximize data collection and community participation it is recommended that two community supplied 20-22' vessels be secured to assist in this study. Each vessel should have two crew members and work conducted from each vessel can be supervised by a member of the study team. It has been our experience that when fishers are directly involved with fisheries research from their own vessels they contribute valuable information and insights, obtain a greater understanding and support for the study, and are better able to speak into decision making processes. We recommend that community supplied vessels be equipped with removable electric haulers supplied by this study. The haulers will be capable of hauling 150-250 kg and similar to those used inshore by small boat fishers (i.e., 20-22') in the Newfoundland region (i.e., lobster and toad crab fishers).

6.0 ACKNOWLEDGEMENTS

This study was funded by the Canadian Northern Economic Development Agency (CanNor), the Government of Nunavut (GN) Department of Environment Fisheries and Sealing Division, and the GN Department of Economic Development and Transportation. We also take this space to thank Janelle Kennedy, Alex Flaherty, Matthew Akavak, Sandy Akavak, and Palanga Lyta for their support and assistance during this study. Brynn Devine is acknowledged for her assistance with post-field season identification of some of the species.

7.0 LITERATURE CITED

Anon. 1995. Green sea urchin conservation harvesting plan, 1995-96, DFO, Halifax, Mimeo 9p.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L., and Thomas, L. 2001. Introduction to Distance Sampling. Oxford University Press, London.

DFO 2009. An assessment of the sea cucumber (*Cucumaria frondosa*) resource on the St. Pierre Bank in NAFO subdivision 3Ps. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/044.

DFO 2011. Subdivision 3Ps offshore Whelk: A preliminary assessment of male size at maturity. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/023.

Garcia, E. 2006. The fishery for Iceland scallop (*Chlamys islandica*) in the northeast Atlantic. Adv. Mar. Biol. 51: 1-55.

Garza, D.A. 2005. Common edible seaweeds in the Gulf of Alaska. Alaska Sea Grant College Program, University of Alaska, Fairbanks, Alaska. 57 p.

Grant, S.M., Squire, L., and Keats, C. 2006. Biological Resource Assessment of the Orange Footed Sea Cucumber (*Cucumaria frondosa*) Occurring on the St. Pierre Bank. *Centre for Sustainable Aquatic Resources, Fisheries and Marine Institute of Memorial University of Newfoundland, Canada.* P-137 and P-172: 75p.

Morin, B., Hudon, C., and Whoriskey, F. 1991. Seasonal distribution, abundance, and life-history traits of Greenland cod, *Gadus ogac*, at Wemindji, eastern James Bay. Can. J. Zool. 69: 3061-3070.

Stewart, D.B., Ratynski, R.A., Bernier, L.M.J., and Ramsey, D.J. 1993. A fishery development strategy for the Canadian Beaufort Sea-Amundsen Gulf Area. Can. Tech. Rep. Fish. Aquat. Sci. 1910. 135 p.

Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47: 5-14.

Wakefield, and Genin. 1987. The Use of a Canadian (perspective) Grid in Deep-sea Photography. *Deep Sea Research Part A, Oceanographic Research Papers* 34, no. 3: 469-78.

8.0 TABLES AND FIGURES

See below.

Table 1. List of species captured and number of individuals captured in baited pots in the Kimmirut region, 2017.

Phylum	Common group name	Genus species		Number captured
Chordata				
	Sculpins	*Myoxocephalus scorpius*		5
		Myoxocephalus scorpioides		1
	Eelpouts	*Lycodes* sp.		3
			Total	9
Crustacea				
	Shrimps	*Lebbeus groenlandicus*		34
		Lebbeus polaris		27
		Pandalus montagui		4
		Sclerocrangon boreas & *Argis dentra*		10
	Crabs	*Pangurus* sp.		85
		Hyas coarctatus		5
			Total	165
Mollusca				
	Snails	*Colus* sp. & *Buccinum* sp.		216
	Bivalves	*Chlamys islandica*		8
		Clinocardium cillatum		83
		Serripes groenlandicus		17
		Musculus discors		30
		Hiatella arctica & *Mya arenaria*		17
			Total	371
Echinodermata				
	Sea urchins	*Strongylocentrotus* sp.		206
	Sea cucumbers	*Cucumaria frondosa*		7
	Brittle stars	*Ophiura sarsi & Ophiacentha bidentata*		542
	Sun stars	*Crossaster papposus*		30
		Solaster endeca		32
	Sea stars	*Henricia* sp.		13
	Basket stars	*Gorgonacephalus* sp.		4
	Feather stars	*Heliometra glascialis*		75
			Total	909
Phaeophyta				
	Brown algae	*Laminaria saccharina*		*
		Agarum clathratum		*

* Fronds, commonly with holdfasts attached, were often hauled to the surface on the top of a pot.

Table 2. Catch summary for molluscs captured in baited pots set at 17 sites in the Kimmirut region, 2017. Site codes for the two fleets of whelk pots (F1 and F2) and two experimental fleets of four pot types (E1 and E2) are shown. Set numbers (S1, S2, S3, S4, or S5) for each fleet, depth, and soak time are also shown.

				Whelk	Scallop	Cockles		Mussels	
Site	Pot Fleet Code	Depth (m)	Soak time (hr:min)	*Colus* sp. & *Buccinum* sp.	*Chlamys islandica*	*Clinocardium cillatum*	*Serripes groenlandicus*	*Musculus discors*	*Hiatella arctica* & *Mya arenaria*
1	F1S1	54.9	25:45	31	0	0	0	0	0
2	F1S2	67.7	48:15	9	0	10	0	0	0
3	F1S3	91.4	49:30	8	0	10	3	10	3
4	F1S4	69.5	92:15	1	3	18	0	10	8
5	F1S5	69.5	50:45	4	2	0	1	0	0
6	F2S1	20.1	44:00	49	0	0	0	0	0
7	F2S2	20.1	53:15	33	0	1	0	0	0
8	F2S3	27.4	40:45	25	0	16	12	4	1
9	F2S4	67.7	72:30	0	2	24	0	4	4
10	F2S5	45.7	73:15	4	0	0	1	0	0
11	E1S1	73.1	50:15	5	0	0	0	0	0
12	E1S2	64.0	64:00	14	0	0	0	0	0
13	E1S3	54.9	77:00	25	0	1	0	0	0
14	E2S1	109.7	33:00	5	0	1	0	0	0
15	E2S2	142.6	41:00	0	0	0	0	0	1
16	E2S3	151.8	72:45	2	1	2	0	2	0
17	E2S4	91.4	73:45	1	0	0	0	0	0
Total				216	8	83	17	30	17

Table 3. Mean catch of sea urchins, whelk, shrimp, crab, and brittle stars by pot type in experimental fleets E1 and E2 combined (see Figure 5 for pot fleet configuration). Total number of each pot type assessed is also shown.

		Sea urchins	Whelks	Shrimps		Crabs	Brittle stars
Pot type	No. of pots hauled	*Strongylocentrotus sp.*	*Colus sp.* & *Buccinum* sp.	*Lebbeus groenlandicus*	*Lebbeus polaris*	*Pangurus* sp.	*Ophiura sarsi* & *Ophiacentha bidentata*
Conical whelk	21	0.33	0.38	0.09	0	0.28	2.70
Large round shrimp	28	0.14	1.11	0.50	0.46	0.71	3.07
Small round shrimp	28	0.14	0.43	0.25	0.39	0.21	2.75
Large square shrimp	6	0	0.16	0	0.16	0	1.0

Table 4. Catch summary for echinoderms captured in baited pots set at 17 sites in the Kimmirut region, 2017. Site codes for the two fleets of whelk pots (F1 and F2) and two experimental fleets of four pot types (E1 and E2) are shown. Set number (S1-S5) for each fleet is also shown. Soak time for each fleet is summarized in Table 3.

			Brittle stars, sun stars, sea stars, basket stars, and feather stars						Sea urchin	Sea cucumber
Site	Pot Fleet Code	Depth (m)	*Ophiura sarsi & Ophiacentha bidentata*	*Crossaster papposus*	*Solaster endeca*	*Henricia* sp.	*Gorgonacephalus* sp.	*Heliometra glascialis*	*Strongylocentrotus* sp.	*Cucumaria frondosa*
1	F1S1	54.9	10	3	2	1	0	0	2	0
2	F1S2	67.7	23	12	1	1	0	1	9	0
3	F1S3	91.4	50	5	3	2	0	9	1	0
4	F1S4	69.5	61	2	4	0	0	42	20	4
5	F1S5	69.5	23	4	1	0	0	0	17	0
6	F2S1	20.1	50	1	0	0	0	0	0	0
7	F2S2	20.1	0	1	1	1	0	0	18	0
8	F2S3	27.4	54	1	1	0	0	4	33	0
9	F2S4	67.7	35	0	10	8	0	19	23	3
10	F2S5	45.7	10	1	2	0	0	0	68	0
11	E1S1	73.1	22	0	0	0	0	0	0	0
12	E1S2	64.0	12	0	0	0	4	0	1	0
13	E1S3	54.9	47	0	2	0	0	0	4	0
14	E2S1	109.7	13	0	0	0	0	0	1	0
15	E2S2	142.6	69	0	3	0	0	0	0	0
16	E2S3	151.8	43	0	1	0	0	0	4	0
17	E2S4	91.4	20	0	1	0	0	0	5	0
Total			542	30	32	13	4	75	206	7

Table 5. Catch summary for crustaceans captured in baited pots set at 17 sites in the Kimmirut region, 2017. Site codes for the two fleets of whelk pots (F1 and F2) and two experimental fleets of four pot types (E1 and E2) are shown. Set number (S1-S5) for each fleet, depth, and soak time are also shown.

Site	Pot Fleet Code	Depth (m)	Soak time (hr:min)	Shrimps				Crabs	
				Lebbeus groenlandicus	*Lebbeus polaris*	*Pandalus montagui*	*Sclerocrangon boreas & Argis dentra*	*Pangurus* sp.	*Hyas coarctatus*
1	F1S1	54.9	25:45	0	0	0	0	4	0
2	F1S2	67.7	48:15	3	0	0	0	9	1
3	F1S3	91.4	49:30	1	0	0	0	5	0
4	F1S4	69.5	92:15	1	0	0	0	8	1
5	F1S5	69.5	50:45	2	0	0	1	6	0
6	F2S1	20.1	44:00	0	0	0	0	3	0
7	F2S2	20.1	53:15	0	0	0	0	4	1
8	F2S3	27.4	40:45	0	0	2	4	4	2
9	F2S4	67.7	72:30	1	0	0	1	3	0
10	F2S5	45.7	73:15	1	0	0	0	7	0
11	E1S1	73.1	50:15	11	2	0	0	9	0
12	E1S2	64.0	64:00	7	8	0	0	0	0
13	E1S3	54.9	77:00	0	0	0	2	6	0
14	E2S1	109.7	33:00	1	5	0	0	13	0
15	E2S2	142.6	41:00	4	3	0	0	0	0
16	E2S3	151.8	72:45	1	1	0	0	0	0
17	E2S4	91.4	73:45	1	6	2	2	4	0
Total				34	25	4	10	85	5

Table 6. Catch summary for finfish captured in baited pots set at 17 sites in the Kimmirut region. 2017. Site codes for the two fleets of whelk pots (F1 and F2) and two experimental fleets of four pot types (E1 and E2) are shown. Set number (S1-S5) for each fleet, depth, and soak time are also shown.

Site	Pot Fleet Code	Depth (m)	Soak time (hr:min)	Sculpins		Eelpouts
				Myoxocephalus scorpius	*Myoxocephalus scorpioides*	*Lycodes* sp.
1	F1S1	54.9	25:45	0	0	2
2	F1S2	67.7	48:15	0	0	0
3	F1S3	91.4	49:30	0	0	0
4	F1S4	69.5	92:15	0	0	0
5	F1S5	69.5	50:45	0	0	0
6	F2S1	20.1	44:00	0	0	0
7	F2S2	20.1	53:15	0	0	0
8	F2S3	27.4	40:45	0	0	0
9	F2S4	67.7	72:30	0	0	0
10	F2S5	45.7	73:15	0	0	0
11	E1S1	73.1	50:15	1	0	0
12	E1S2	64.0	64:00	1	0	0
13	E1S3	54.9	77:00	0	0	0
14	E2S1	109.7	33:00	1	0	0
15	E2S2	142.6	41:00	0	1	1
16	E2S3	151.8	72:45	1	0	0
17	E2S4	91.4	73:45	1	0	0
Total				5	1	3

Table 7. Summary of the site number (see Figure 2), depth, length, and area of transects used in the towed video sled species abundance and density estimates.

Tow Number	Site number	Transect depth (m)	Transect length (m)	Transect area (m^2)
1	4	49	223	203
2	6	59	172	156
3	7	84	671	610
4	8	73	160	145
5	9	49	605	550
Total			1,831	1,664
Mean		62.5	366	333

Table 8. Summary of the probability of detection for each species analyzed and estimates of density and abundance in the total area surveyed. Values were generated by distance 7.1.

Species	Probability of detection (Pa)	Estimated Density (number/m^2)	Estimated Abundance in total study area (1,664 m^2)
Sea urchins	0.59	1.17	1,947
Sea cucumber	0.62	0.86	1,431
Greenland shrimp	0.60	0.51	849
Hermit crab	0.60	0.29	483
Whelks	0.66	0.15	250
Polar shrimp	0.41	0.13	216

Table 9. Estimated sea urchin and whelk probability of detection, density, and total abundance in area surveyed at depths <60 m and >60 m.

Species	Depth range (m)	Area covered (m^2)	Probability of detection (Pa)	Estimated density (number/m^2)	Estimated abundance in area surveyed
Sea urchins					
	49-59 m	909	0.58	1.25	1,136
	73-84 m	755	0.59	1.06	800
Whelks					
	49-59 m	909	0.65	0.21	191
	73-84 m	755	0.67	0.07	53

Figure 1. Photograph of the *RV Papiruq* moored at Kimmirut.

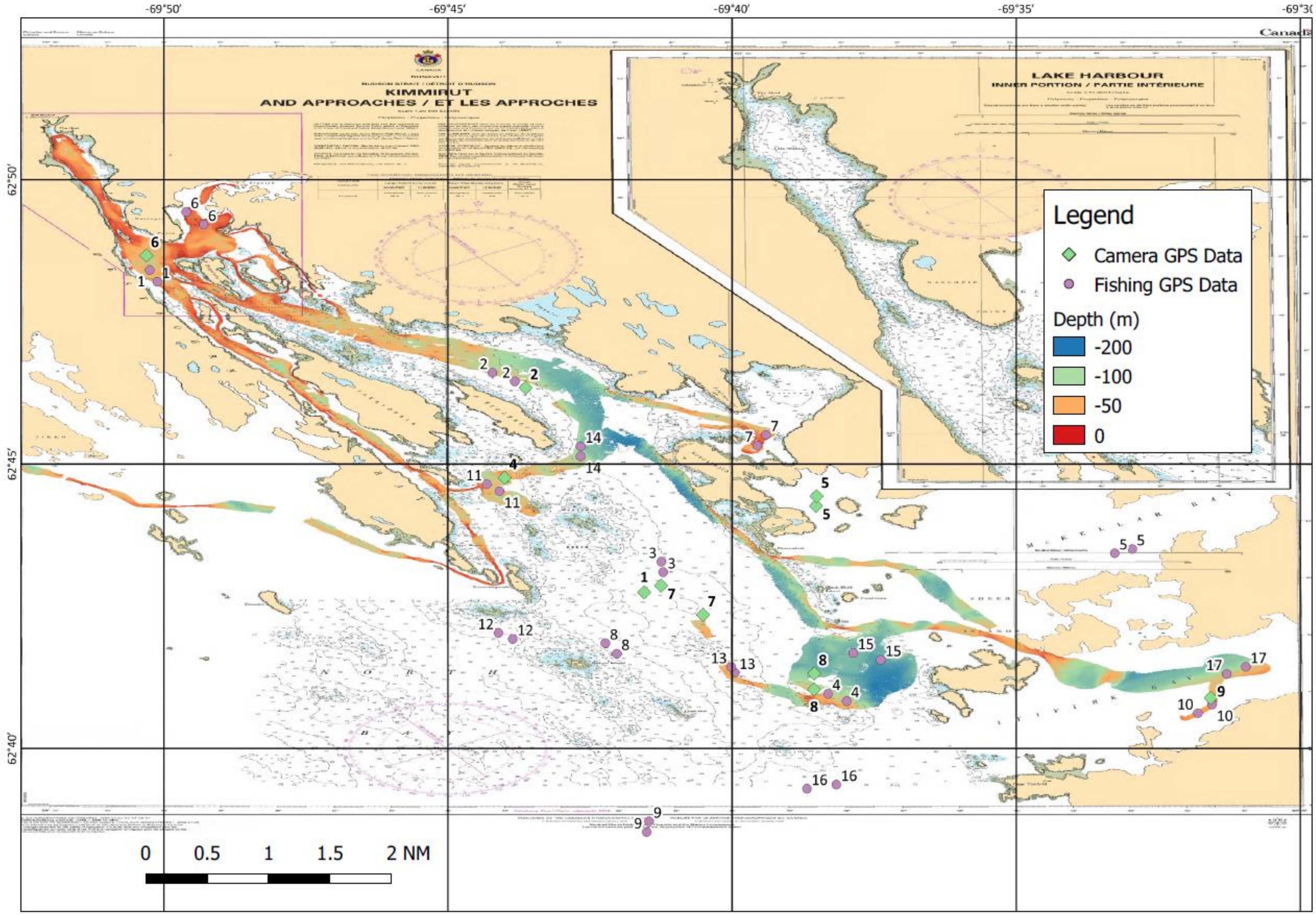

Figure 2. Map of study area showing bathymetry obtained from multibeam sonar data and location of towed video sled and baited pot deployments.

Figure 3. Photograph of low profile conical whelk pot.

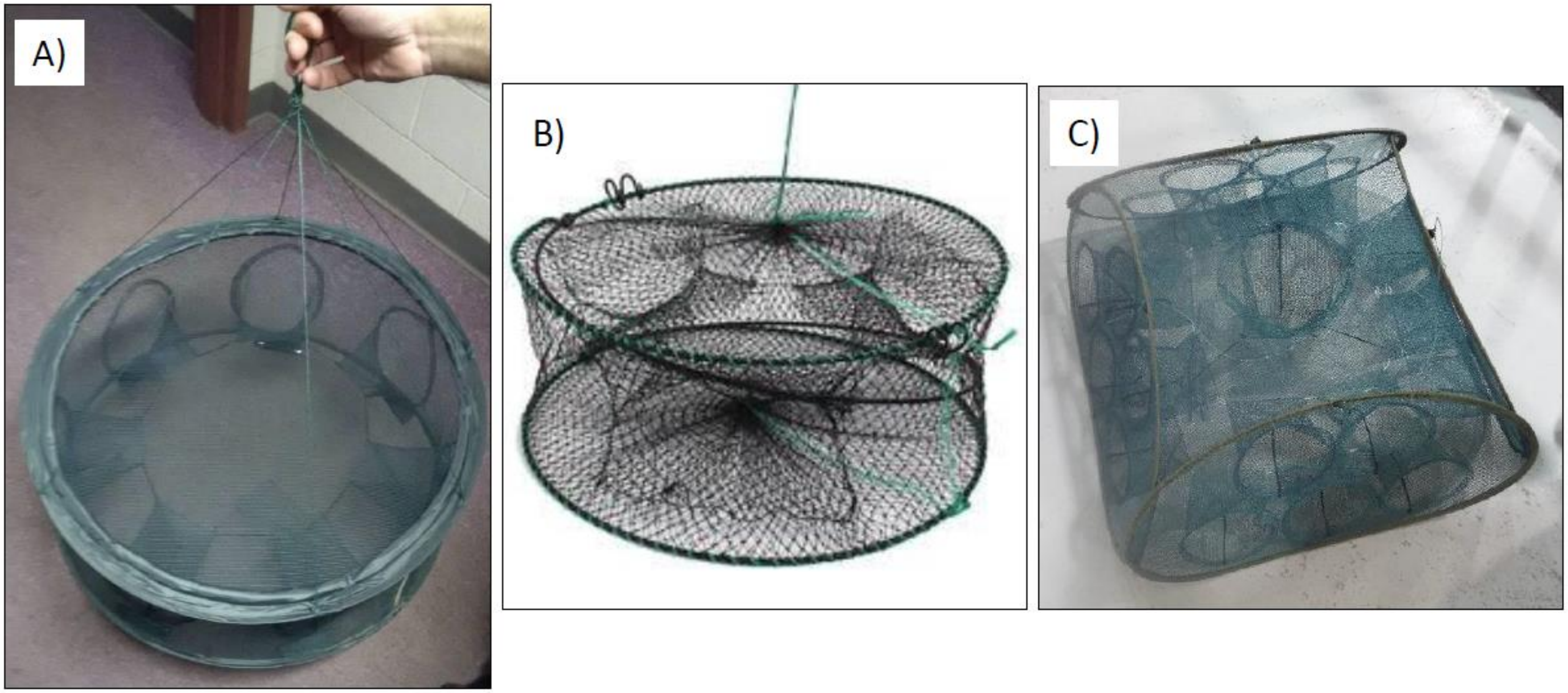

Figure 4. Photographs of collapsible pots. A) seven entrance large round shrimp pot (LCS), B) three entrance small round shrimp pot (SCS), and C) 21 entrance large square shrimp pot (LSS). Note, images are not to scale. See fishing gear assessments section for specific sizes.

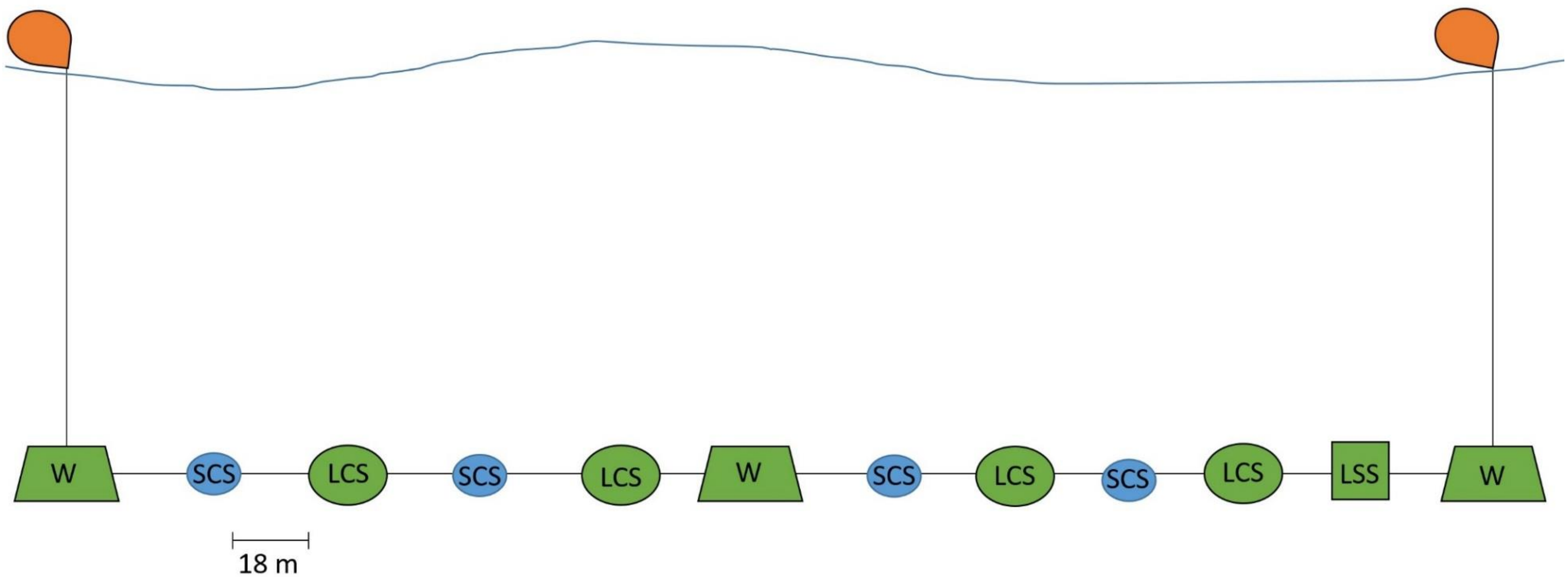

Figure 5. Order of pots in two experimental fleets of pots incorporating four pot types. 1) whelk pot (W), 2) small round shrimp pot (SCS), 3) large round shrimp pot (LCS), and 4) large square shrimp pot (LSS).

Figure 6. Photograph of small mesh bait bag covered in scavenging amphipods, also commonly referred to as sea lice.

Figure 7. Photograph of scallop rake used in the current study.

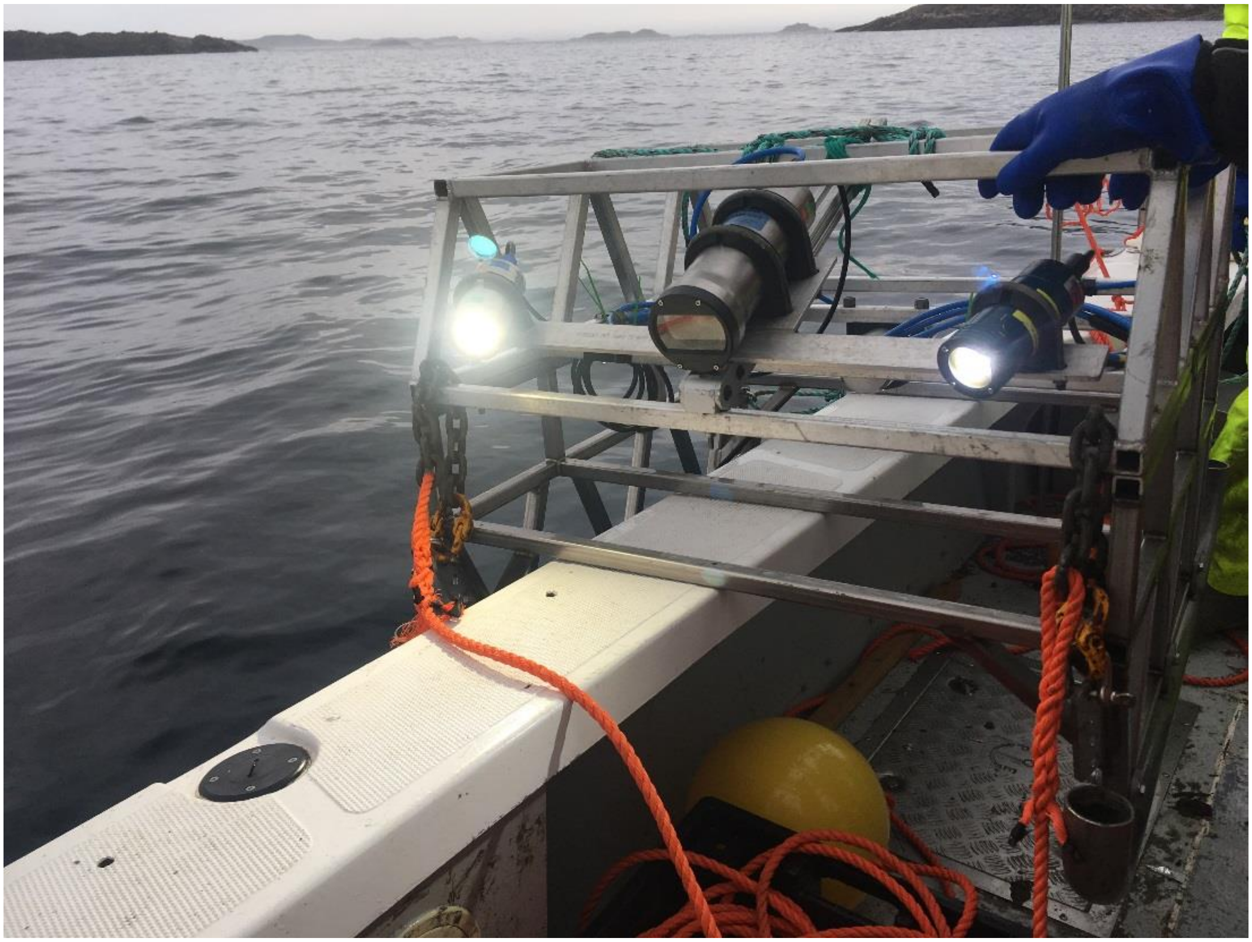

Figure 8. Photograph of towed video sled illustrating underwater video camera (centre) and lights.

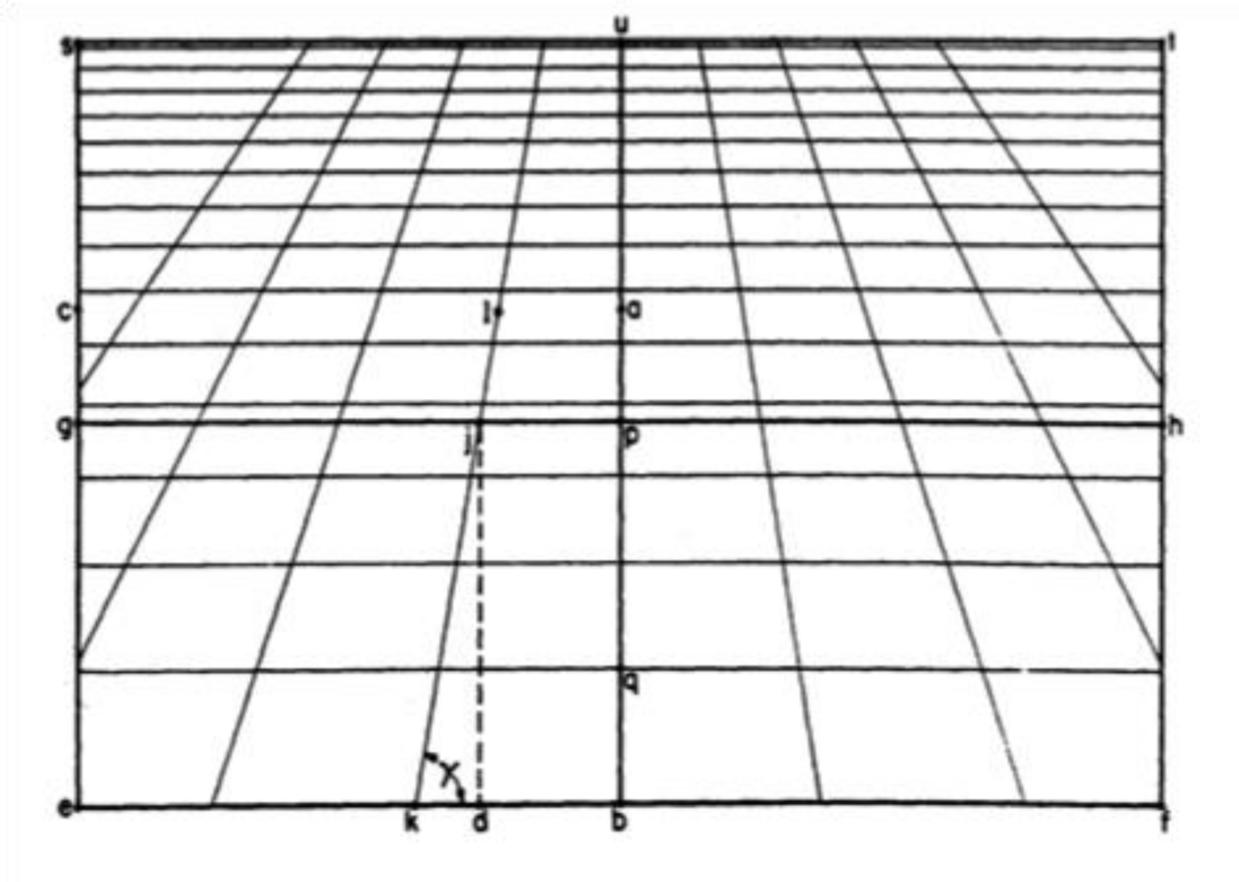

Figure 9. Canadian perspective grid (Wakefield and Genin 1987).

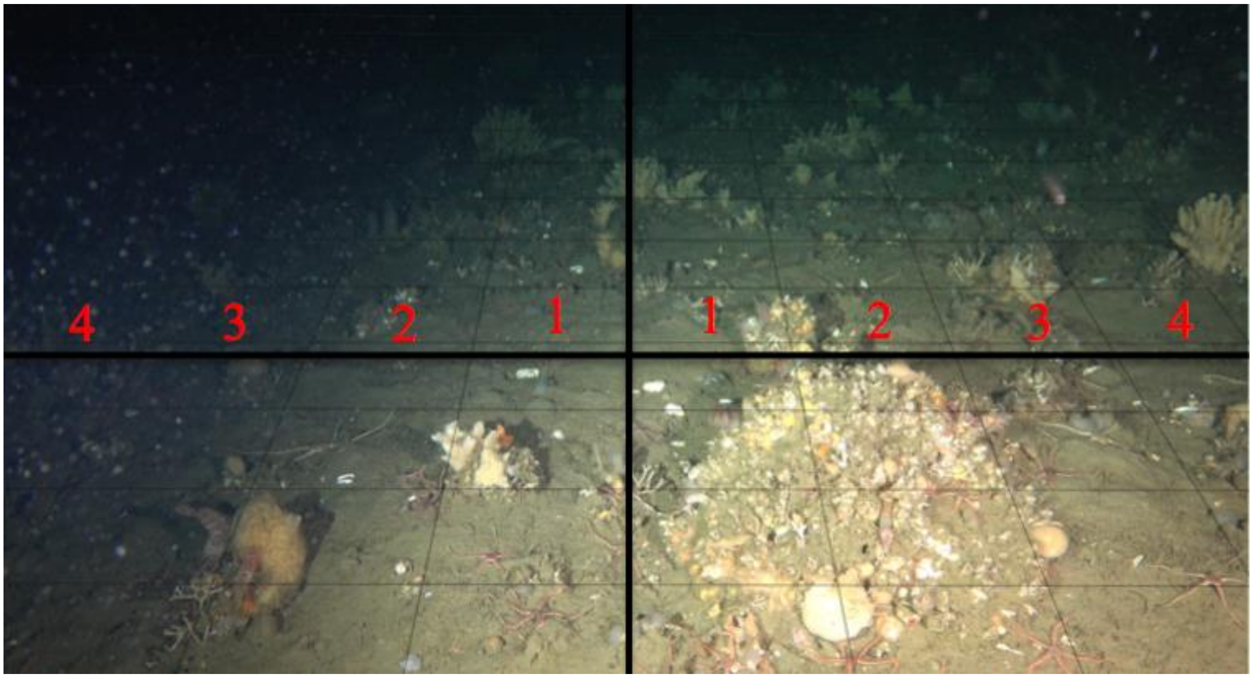

Figure 10. The Canadian perspective grid superimposed over a monitor. Vertical lanes are numbered 1 thru 4 away from the vertical transect. Species are counted and lane number is recorded as they come in “contact” with the horizontal centre line.

Figure 11. Photograph of the brown algae *Laminaria saccharina* commonly referred to simply as kelp.

Figure 12. Photograph of the brown algae sea colander (*Agarum clathratum*).

Figure 13. Photographs of whelk pot with bycatch of immobile organisms (e.g., sponges, corals, tunicates, and feather stars).

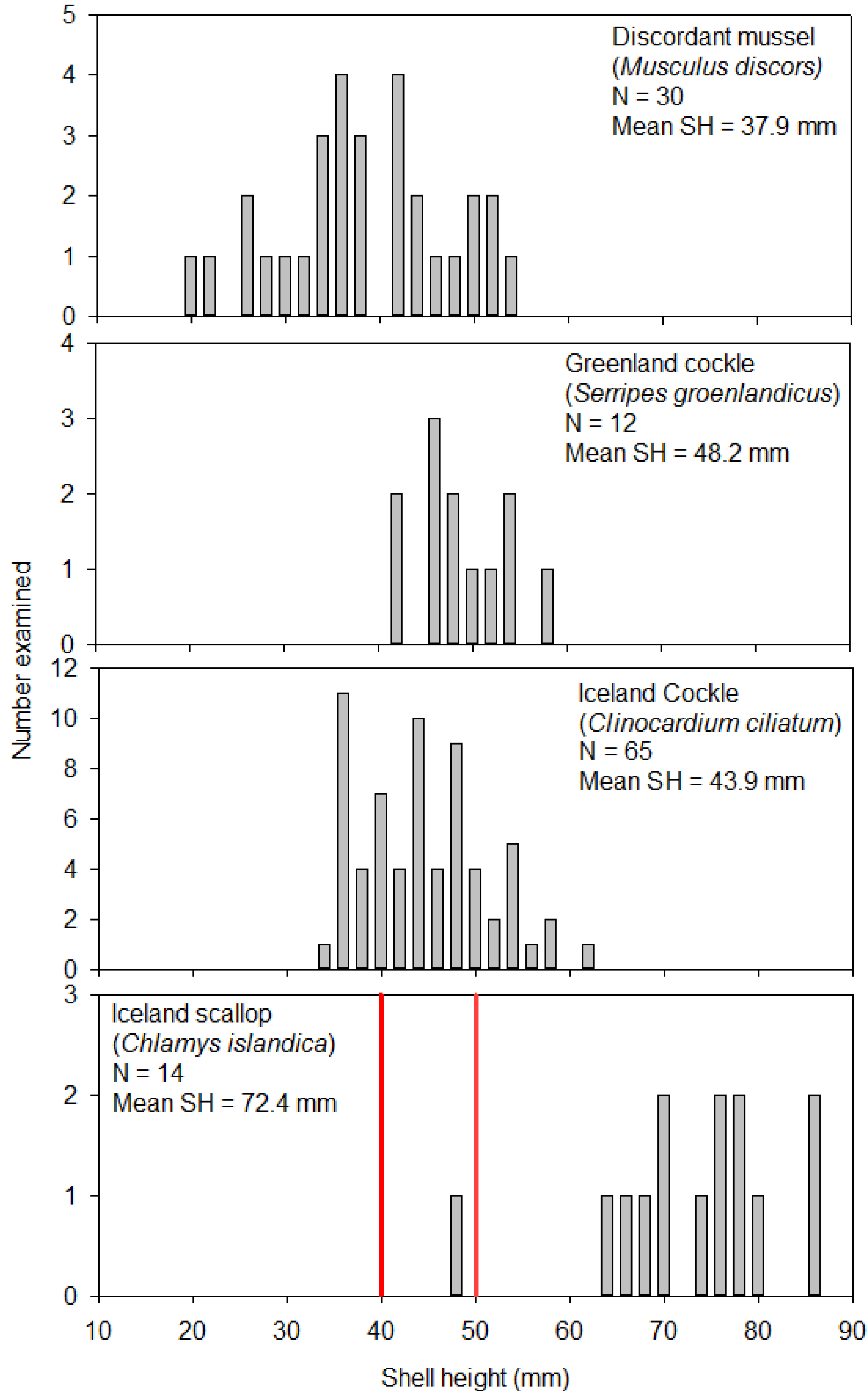

Figure 14. Shell height frequency distributions for bivalve molluscs captured in baited pots in the Kimmirut region in 2017. Total number of individuals examined (N) and mean shell height (SH) are also shown. Note, vertical axes are not equal. Red vertical lines in the lower panel indicate the range in size at maturity (40-50 mm) for Iceland scallop (Garcia 2006).

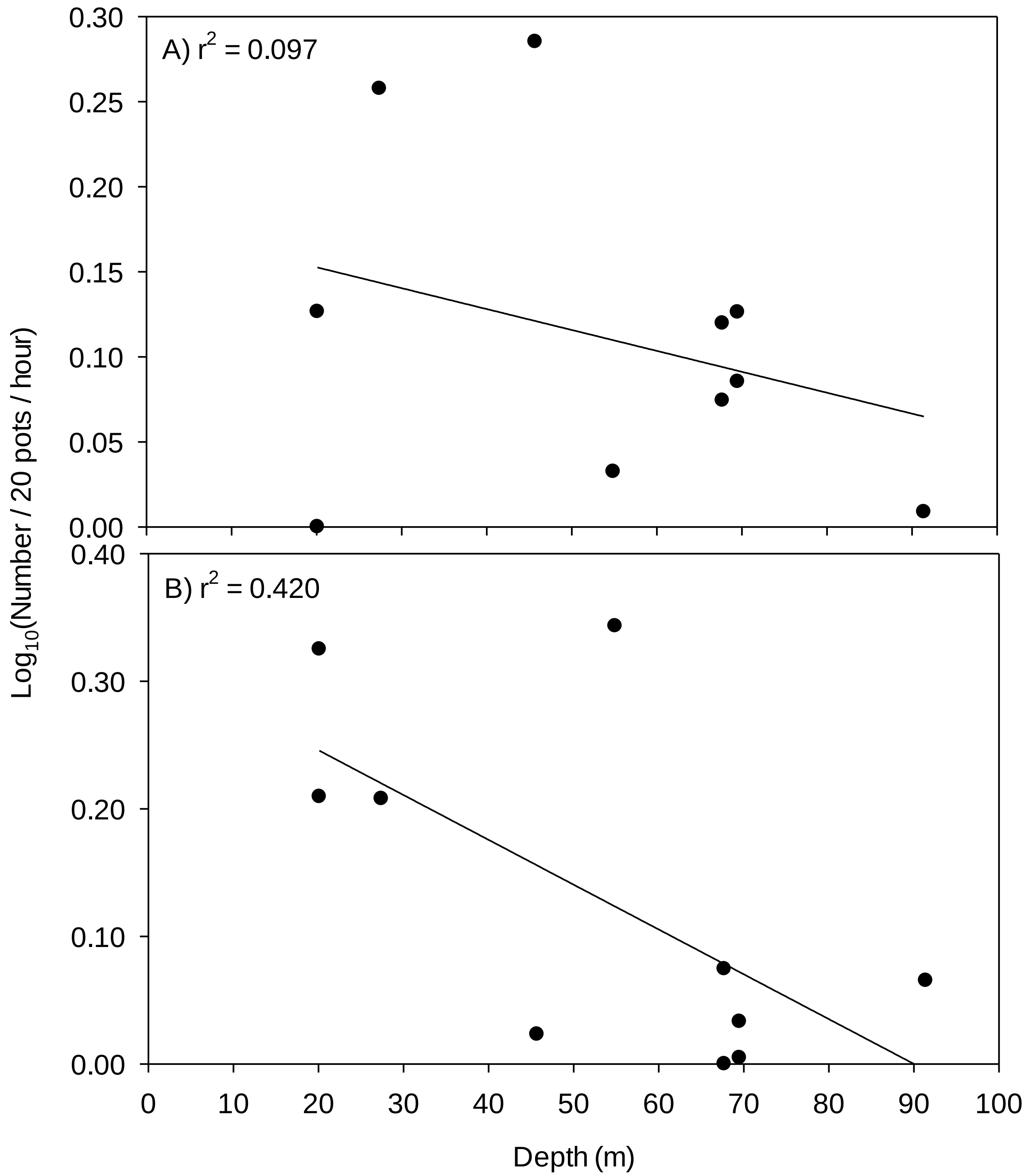

Figure 15. CPUE-depth relationships for A) sea urchins (*Strongylocentrotus* sp.) and B) whelk (*Colus* sp. and *Buccinum* sp.) captured in baited whelk pots (i.e., pot fleet F1 and F2). The line of best fit and correlation coefficient (r^2) are also shown.

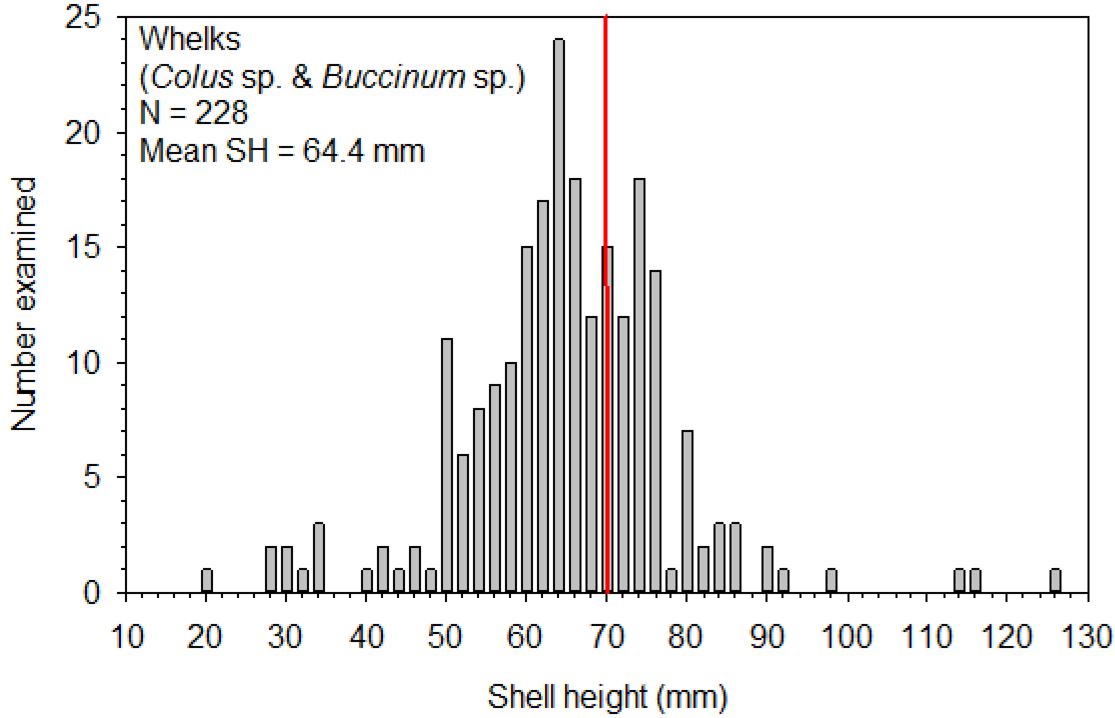

Figure 16. Shell height frequency distribution for whelks of the genus *Colus* and *Buccinum* captured in baited pots in the Kimmirut region in 2017. Total number of individuals examined (N) and mean shell height (SH) are also shown. The vertical red line indicates the minimum legal size (70 mm SH) for retaining waved whelk (*Buccinum undatum*) in the Quebec region of the Gulf of St. Lawrence (DFO 2011).

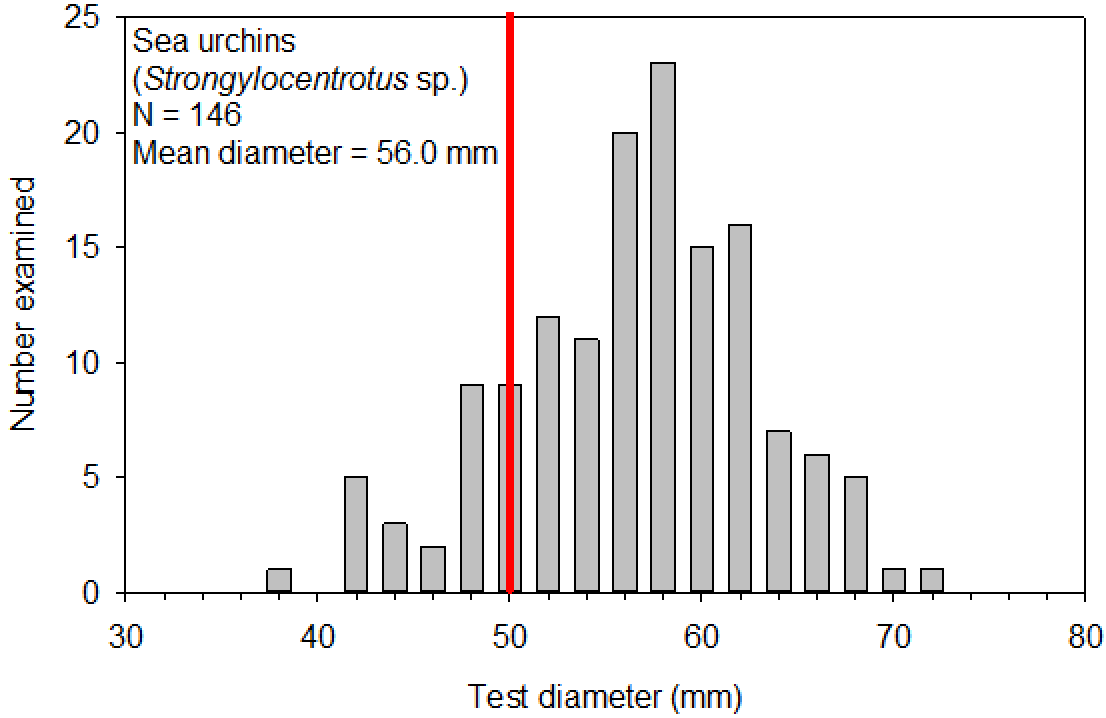

Figure 17. Test diameter frequency distributions for sea urchins of the genus *Strongylocentrotus* captured in baited pots in the Kimmirut region in 2017. Total number of individuals examined (N) and mean diameter are also shown. The vertical red line indicates the minimum legal size (50 mm diameter) for retaining green sea urchins (*Strongylocentrotus droebachiensis*) in the Nova Scotia fishery (Anon 1995).

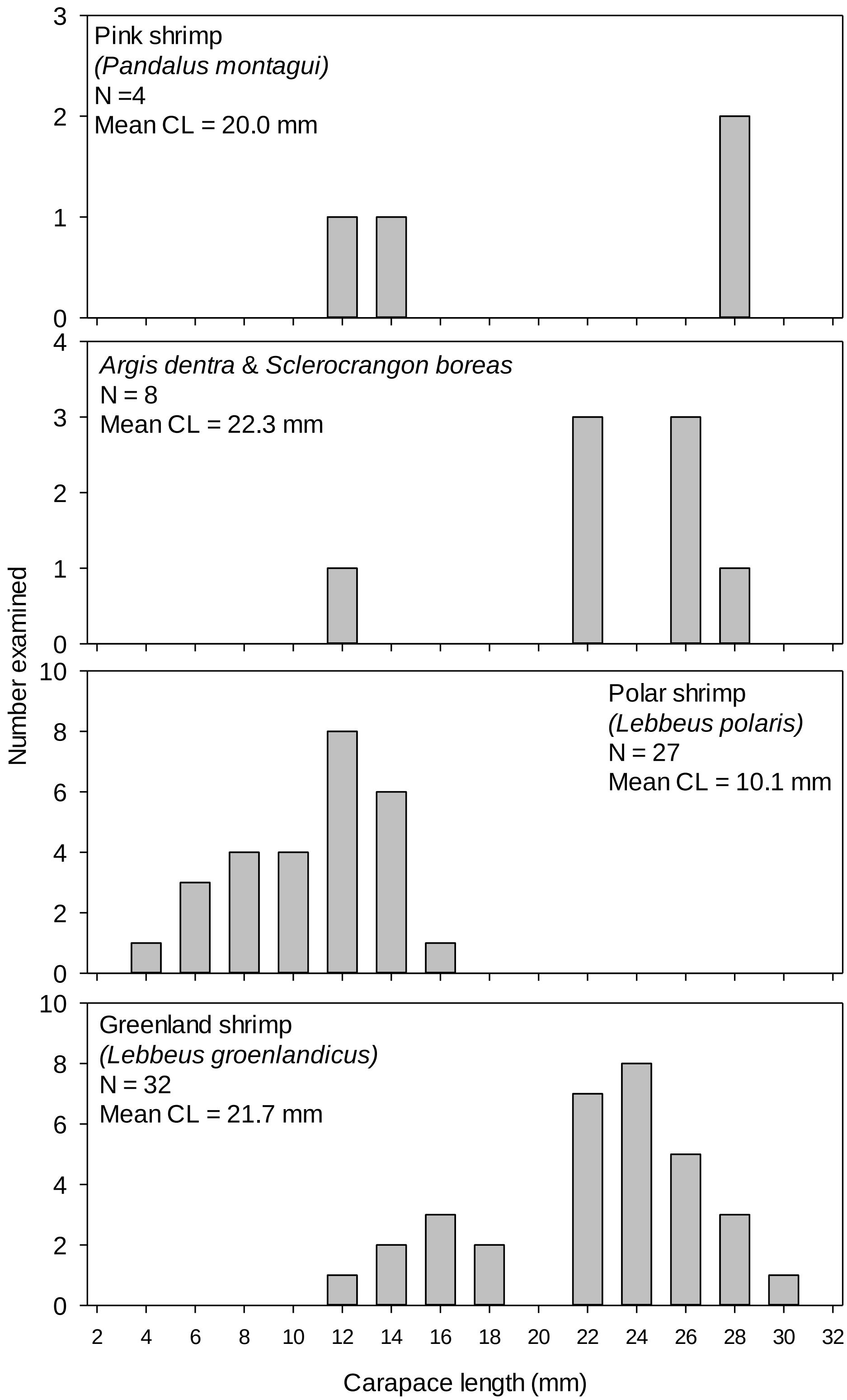

Figure 18. Carapace length frequency distributions for shrimp species captured in baited pots in the Kimmirut region in 2017. Total number of individuals examined (N) and mean carapace length (CL) are also shown. Note, vertical axes are not equal.

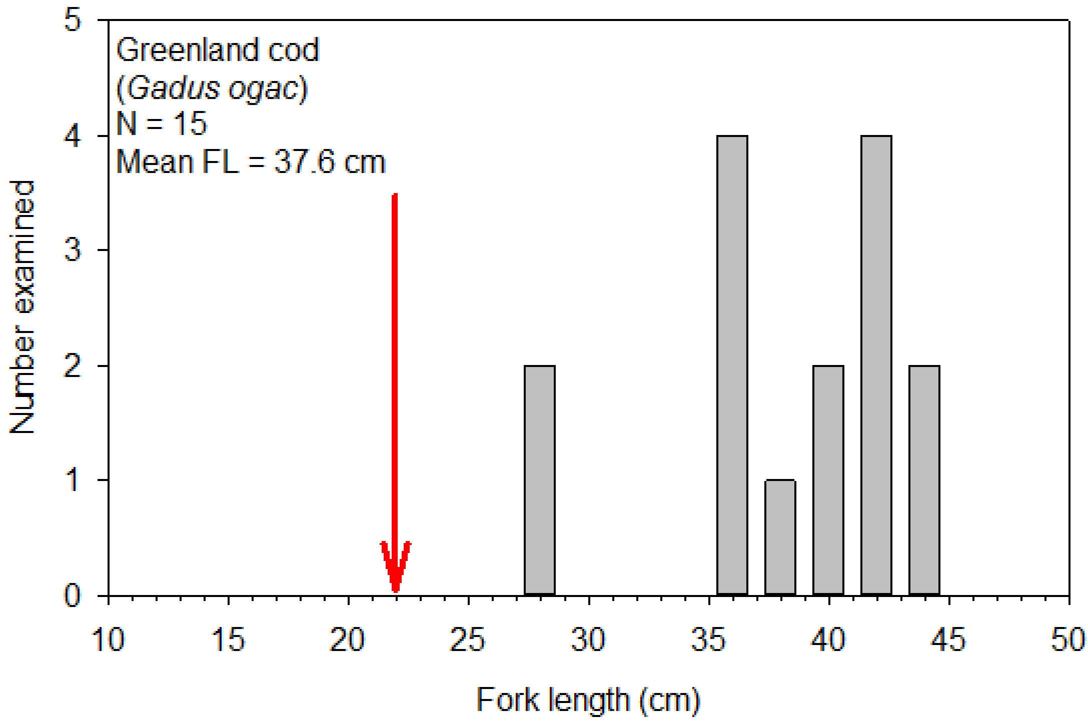

Figure 19. Fork length frequency distribution for Greenland cod captured on hook and line in Soper Lake, Kimmirut, 2017. Total number of individuals examined (N) and mean fork length (FL) are also shown. The vertical red arrow indicates the size at first attainment of sexual maturity of Greenland cod captured in James Bay (Morin et al. 1991).

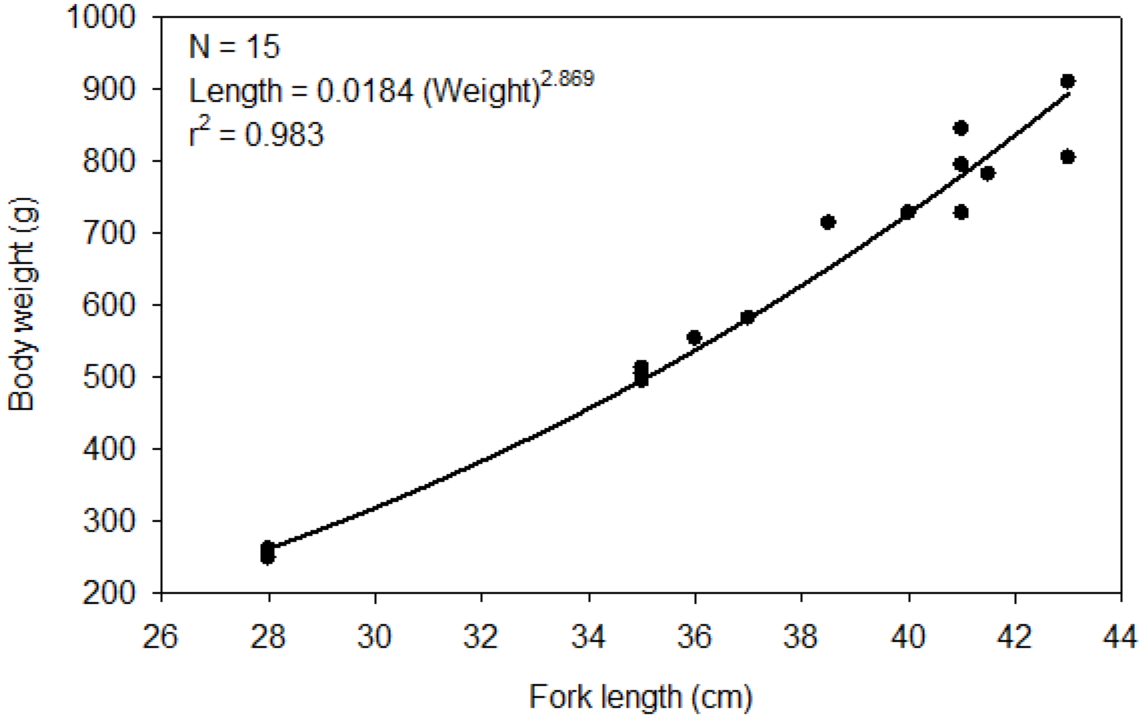

Figure 20. Weight-length relationship for Greenland cod captured in Soper Lake, Kimmirut. Number of individuals examined (N), curvilinear length-weight equation, and correlation coefficient (r^2) are also shown.

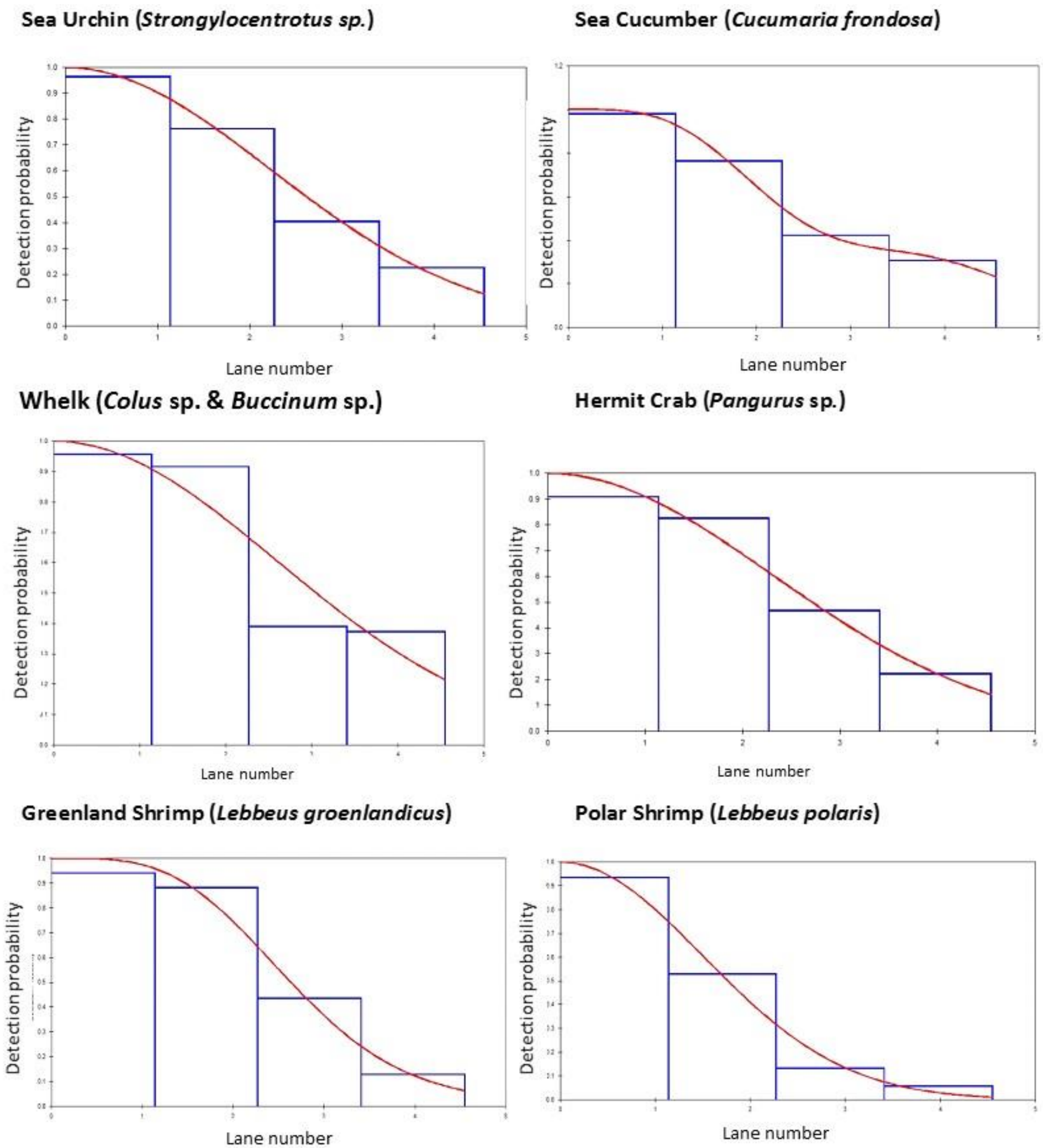

Figure 21. Detection probability plots generated in Distance 7.1 for six species.

Figure 22. Photographs of feeding by an orange-footed sea cucumber. One at a time the oral tentacles are inserted into the mouth and the adhering planktonic food particles are wiped off as the tentacle is withdrawn.