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The Blue Mussel Harvest Testing Program in Nunavik

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Introduction

Widely distributed throughout Nunavik, the blue mussel, *Mytilus edulis*, provides an alternative to expensive sources of protein imported from the south. Whereas intertidal mussels are harvested for subsistence purposes at many communities, subtidal mussels are largely unexploited due to a lack of familiarity with, or the absence of the required fishing gear. An exception to this is the community of Akulivik (Figure 1). There, subtidal mussels are harvested in summer using drags and long-handled scoops and in winter using the scoops (KRC 1995).

A field program was carried out in September 1994 and February 1995 by Kuujjuaq Research Centre Staff to document the methods used by the Akulivimuit and to improve gear design (if necessary). If trials prove successful, the technology will be promoted for use in subtidal harvesting operations elsewhere in the region.

Materials and Methods

Design of mussel drag

The gear used in the trials was constructed from material salvaged from the municipal dump or available at the community's heavy equipment garage (Figures 2 & 3). The drag measures 80cm wide x 45cm high x 90cm deep. Flat steel plate (0.6 x 2.5cm) forms the frame which is covered by a salvaged radiator grill from a domestic refrigerator. Teeth, made from 0.3cm steel plate, are bolted on the upper and lower sides to form the scraping edges. This design allows the drag to be used regardless of which side contacts the bottom. Weighing less than 12 kg, the drag can be easily handled by one person. The dragline, a 22 m length of 13mm polypropylene rope, is attached to the drag by a bridal of 9mm galvanized chain.

Design of mussel scoop

Scoops have been in use at Akulivik for about ten years (H. Alayco, pers. comm). During that time a basic design has emerged. The scoop is composed by a rectangular basket (Figure 4) attached to a long pole. The rim of the basket, made from concrete re-enforcing rod, or similar material, is welded to square (hollow) bar stock which forms an insert for the handle. The handle is a long wooden pole, often 2x2s joined together. Whatever netting is available is used for the basket. The netting of the scoop used for sample collection was 1.6cm stretch mesh which was suitable for gathering all age classes of mussels. To harvest commercial sized mussels and the lessen by-catch of smaller mussels, 4cm stretch mesh is recommended.

Dragging Operations

Six sites were sampled using the drag. Geographic position of the beds was determined either by an Ensign GPS (Trimble Navigation, Sunnyvale, CA, USA) or from maps using dead reckoning (DR). Prior to dragging, the sea-bottom was checked (visually) to set the best course through the mussel beds. The drag was attached to the front of a 22′ (6.7m) freighter canoe and the gear towed with a 40hp outboard motor in reverse gear (to prevent entangling the gear in the propeller). Drags took two to three minutes over estimated distances of forty to one hundred meters. The sites dragged were within 100m of the shore.

Gross landed-weight of the haul was estimated based on a full 5 gallon (23L) bucket of mussels weighing 18kg. Species composition of the by-catch was recorded.

Scooping

Long-handled scoops are used to harvest sub-tidal mussels in water up to 8m deep. In summer, scooping is conducted from freighter canoes whereas, in winter, a meter square hole is made in the ice using an ice auger and ice chisels. The leading edge of the scoop is pressed firmly into the bottom, at a location vertically displaced from the operator (Figure 5). Using a pivot, the scoop is then drawn towards the operator using a vertical jiggling motion. On passing the vertical position, the operator continues to push the scoop away until the handle forms a 60°-45° angle with the horizontal (Figure 6). The scoop is then lifted to the surface by hauling along the handle.

Technically, scooping in winter is easier as the ice provides a solid edge on which the operator can pivot the scoop. In summer, the gunnel of the canoe is used as a pivot, but is less satisfactory than the ice-edge as the canoe is not completely stationary in the water.

Contaminant Analysis

A pooled sample of the mussels, harvested October 27 and 30, was shipped fresh to DFO (Quebec City) for detection of paralytic shellfish poisoning (PSP) toxin.

Age Determination

Ages of mussels were determined following methods outlined in Lutz (1976) and Thompson et al (1993). They are summarized in KRC (1995) as follows:

> "Mussels were aged by counting the bands in the nacreous layer of the shell (Lutz, 1976). Shell preparation and age-determination methods followed those outlined in Thompson et al (1993) and Doidge et al (1993). Thin

sections, 0.5 to 1.0 mm thick [modified to 0.2 to 0.5mm, February 1995] were cut with a diamond-tipped blade on a Buehler Isomet saw (Buehler, Lake Bluff, Illinois, USA). If necessary, sections were polished with No. 600 grit or a fine polishing stone on a Dremel engraving tool (Emerson Electric, Racine, WI, USA). Sections were viewed wet, using a binocular microscope at 20 power. The number of annuli were counted by one observer and given a subjective rating from A (excellent) to D (poor). Mussels lacking clear annuli (bands) in the nacreous layer were aged when possible, by examining the banding pattern on the outer surface of the shell. Reading of the nacreous layer was preferable; interpretation of the banding on the shell surface is considered reliable by us, only when the reader has had sufficient exposure to assessing age by both thin-section and shell band methods."

Meat yield

Meat yield was measured using wet and dry weights of mussels, sampled February 17, 1995. Total weight was measured while the mussels were still closed and frozen, so they include shell liquor. The meat from thawed mussels, having shell lengths between 50 and 60mm, was weighed wet, dried at 90°C in a Fisher Isotemp® oven overnight, then re-weighed (KRC 1995).

Commercial potential

The manager of the only local retailer in town (the Co-op Store) was interviewed to determine the current status of mussel sales within the community. Frequency of availability, volume, method of storage, buying and selling price and potential of export to adjacent communities was documented. This information and an assessment of the cost of harvest operations are used to evaluate the commercial potential of mussels in Akulivik.

Results

General description of beds

Subtidal mussels are more abundant in the Akulivik area than implied in KRC (1995). A number of the subtidal mussel beds in the waters surrounding Smith Island were sampled (Figure 7). Beds occur in water two to eight meters deep with mussels most numerous in three to five meters of water. The bottom is mud, varying in the degree to which it is strewn with boulders and stones. Seaweed is prevalent at one site (AK-4) which is near a reef. At other sites, seaweed was sparse or absent. Babs Bay (site AK-3) is sheltered from the open sea; current is evident at the other more exposed sites.

Open water trials

Yield per drag was variable. At times the drag came up empty; only during one haul was the drag near full containing 40kg of mussels (Figure 8). Closer observation of the gear revealed a problem which had not been anticipated. On a flat bottom, mussels were scraped loose and collected in the cage. However, on contact with an obstruction, such as a stone or crevice, the drag tipped forwards dumping its contents.

Site AK-1 (60°48'55.9"N/78°14'13.4"W-GPS)

On October 27, 1994 the drag was tested near the NE end of Smith Island, a site which is also harvested in winter. Overall, 50 kg of mussels was landed here (Table 1). The mussels were clean and the by-catch was less than 10 kg.

Site AK-2 (60°51'32"N/78°13'40"W-DR)

This site is located on the lee side of a moderate sized island, NE of Smith Island. Drag contents were negligible so the location is not considered a harvestable bed.

Site AK-3 (60°46'16.8"N/78°20'13.9"W-GPS)

On October 30, gear was tested at Babs Bay, site #AK-3. Here, the mussel bed runs parallel to the shoreline. The bottom is uneven with many boulders. The drag did not perform well, often setting firmly like an anchor in the substrate. Six attempts at dragging yielded less than 10 kg of mussels. Drag contents included as much debris as mussels (50% seaweed and empty shells).

Site AK-4 (60°46'30"N/78°16'45"W-GPS)

This is a small reef where mussels are abundant but are attached to seaweed. The gear did not work well here. The mussels which were gathered were attached to the seaweed and therefore difficult to clean. The quality of mussels (low meat mass) of these mussels appeared to be below those from other areas.

At this reef, mussels are gathered by local town's people after severe storms from Hudson Bay wash them ashore. The outer edge of the small island is covered by a 3m band of mussel shells to a depth of more than a metre and a length of more than 80 metres. This attests to the abundance of mussels along the reef.

Site AK-5 (60°49'27"N/78°15'00"W-DR)

This site is fully exposed to the sea on the NE coast of Smith Island. An attempt was made to sample this site since local knowledge indicated mussels were present. However, a large (2 m) swell prevented safe operation of the canoe close inshore where the bed was located.

Site AK-6 (60°46'41"N/78°15'00"-DR)

Mussels are numerous in the gaps between stones on boulder strewn substrate. The drag performed poorly; no mussels were collected despite repeated efforts.

Winter harvesting

Site AK-1 is also harvested in winter. It was visited by a KRC staff member (DWD) on February 16, 1995 to observe the scooping technique used in winter. As this site is routinely harvested by the Akulivmiut during winter, a hole in the ice already existed. The two experienced harvesters gathered two, 23 L buckets (aprox. 40 kg) of consumable mussels in two hours.

On February 17, KRC staff and two mussel harvesters from Akulivik revisited the site to collect samples and document catch-effort and yield. A new hole was made aprox. 5m from the previous one, forming a line parallel to the coast. During 1 hr 15 min of operation, the scoop yielded 24.2 kg of biological material at an average of 1.34±0.65 kg (n=18) per scoop. Consumable, i.e. marketable, mussels made up 68% of the haul. The harvesting operation was slowed somewhat by the individual weighing of the scoop contents and consumable mussels.

By-Catch and debris

At the summer sampling sites, debris composed of seaweed and dead mussel shells varied from site to site. In summer, non-target species included polychaete worms, sea urchins, toad crabs

(Hyas spp.), brittle stars (Ophiuroidea spp.), comb jelly (Ctenophora) and a Prickleback fish (Family Stichaeidae). No brittle stars or fish were caught in the winter sample.

Growth

Earlier samples of mussels from Akulivik were obtained by drag (KRC 1995). These samples lacked the younger age classes necessary for estimating growth parameters, other than asymptotic length. A more complete sample, containing all age classes was obtained in February 1995 using a fine-meshed, mussel scoop.

Previous experience indicated that the von Bertalanffy growth equation offered the best description of the age - length relationship of mussels in Nunavik (KRC 1995, Thompson et al 1993). Growth of mussels from site AK-1 is depicted in Figure 9 and described by the curve:

shell length = 61.01(1-EXP(-0.225xAGE+0.039))

The 95% confidence limit on asymptotic length is 58.2 to 63.8mm, a similar size to mussels sampled at Akulivik in 1993 (KRC 1995).

Age structure

During the age-determination procedure the age-frequency sample was inadvertently combined with the more uniform sample collected for the growth curve. Because the two samples were mixed, the resultant sample can no longer be considered representative of the standing age distribution. Therefore, no estimates of mortality rate can be made.

Meat yield

The 53 mussels of commercial size (50-60cm) sampled from site AK-1 on February 17, 1995 have the highest meat yields of any mussels sampled to date by KRC (1995). Average meat weight was 5.8 ± 1.1 g which represents 34 per cent of total body mass. Meat dry-weight averaged 0.89 ± 0.20 g indicating water content is 85 ± 2 per cent. These weights represent a ca. 50 per cent increase from summer biomass (Figure 10).

Contaminant Analysis

Bio-assays of mussels, sampled at sites AK-1 and AK-3, contained less than the detectable limit of PSP toxin (46µg/100g; DFO Laboratory No. WR01, Nov. 8, 1994) and are therefore fit for sale and human consumption.

Commercial Potential

The local Co-Op store (the only retail outlet in town) sells mussels at a dollar per pound ($2.20/kg), the same price it pays fishermen. Occasionally, there are requests from the neighbouring communities to provide mussels; usually these are supplied as a gift, one community to another.

Costs of harvesting:summer versus winter

Table 2 outlines the capital and operating costs for the equipment needed to harvest mussels in winter and summer. The capital cost of transport (freighter canoe versus snowmobile) is similar in both seasons. A mussel scoop is used in both seasons. In summer, an additional cost is that of a drag (if used) whereas in winter an ice auger and ice-chisel are needed to make an opening in the ice. Operating costs are cheaper in winter since snowmobiles consume less gasoline per distance travelled than outboard motors. Summer and winter equipment depreciate at similar rates.

Discussion

The drag used in the field trials did not work well. The tendency of the drag to tip out its contents needs to be overcome if this method is to be a viable means of harvesting. In Canada, cultivated mussels dominate the commercial market so there are few experienced harvesters with whom consultations can be made. Fipec Industries Inc. of Grande-Riviére, Quebec, a company specializing in fishing gear design and manufacture, was contacted for their knowledge and opinion of gear suitable for the harvesting of wild mussels. A new design is being considered which is similar to the Bedford drag which is used for scallops. Tipping and spillage are thought to be less of a problem with this design. This drag would be deployed from small vessels, such a freighter canoes, common in the Nunavik region.

Summer harvesting though does not appear to be as economically viable as a winter one. Operating costs are higher in summer due to the relatively poor fuel mileage of outboard motors. Capital costs are also higher because of the requirement of a canoe and motor. Normally, harvesting in summer or winter would be a two person operation. In summer, this is a necessity for boating safety. In winter, one person performs all harvesting operations alone, but would not be expected to be able to harvest 100 kg of mussels in the same time period that two persons could.

Other factors make winter harvesting more favourable. Mussel meat yields are higher in winter (Figure 10). Although the weather is colder in winter, it is more stable. Because fast-ice forms between the mainland and Smith Island, the sea-ice offers a safe platform from which to work. In summer, harvest operations must cease on windy days due to bad sea states. However, in winter, harvesting can take place on windy days as long as the operators have adequate clothing or shelter from the elements.

Most families possess, or have access to the expensive capital equipment (canoes and snowmobiles) necessary for harvesting mussels. If the capital costs of equipment are not considered a business expense but used on a rental basis, daily earnings, in both summer and winter, would be greater. However, a fully commercial winter operation could provide employment for two person at aproximately $90 per day if the target harvest of 100 kg of mussels per day can be met, and is sustainable.

Production rates of Akulivik's subtidal mussel beds are not yet known. A field program is planned for 1995-96 to ascertain density of the beds and to widen our knowledge on the variablity of growth rates between beds. The continued exploitation of the beds near site AK-1, for subsistence purposes over a period of 10 years, attests to either the abundance or the productivity of the mussel resource in the Akulivik area.

Acknowledgements

Funding was provided by the Fisheries and Aquaculture Testing and Experimental Program (FATEP) of the Department of Fisheries and Oceans Canada, Quebec Region. We thank Gilles Chantigny of DFO for his help and guidance during this study. Henry Alayco, Sackarisie Nappatuk, Jimmy Ematuluk participated in the fieldwork and shared their knowledge of mussel harvesting techniques. Mangella Boudreaud's input into gear design is appreciated. KRC staff provided logistic support and criticism of the manuscript. We thank Peter May for drawing Figure 5.

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Table 1a. Haul times and drag contents at Sites AK-1 and AK-3, October 1994.

Site	Haul #	Duration (mm:ss)	Haul weight (kg)
AK-1	1	1:00	<1
	2	2:30	50
	3	2:45	4
	4	2:05	8
	5	2:30	3
AK-3	6	2:20	0
	7	3:35	<1

Table 1b. Total time on site and marketable mussel yield of drag trials at sites AK-1 and AK-3, October, 1994.

Site	Time on site (min.)	Mussel yields (kg)
AK-1	60	50
AK-3	25	4.5

Table 2. Capital cost estimates for summer and winter harvesting operations for subtidal mussels at Akulivik.

Equipment	Capital cost Summer	Capital Cost Winter	Depreciation Summer	Depreciation Winter
Canoe	6,000		1,200	
Outboard 35hp	4,500		900	
Snowmobile		4,500		900
Ice drill		400		80
Sled		200		40
Drag	150		30	
Scoop	100	100	20	20
Ice chisel		50		10
Shovel		40		8
Total	$10,750	$5,290	$2,150	$1,058

Note: Assume capital equipment depreciates @ 20% per annum of original cost.

Table 3. Daily costs of consumables, assuming harvest of 100 kg per day for summer and winter seasons.

Item	Summer	Winter
Gas & oil (4hr@5gal/hr)	100	
Gas & oil (2hr@1.25gal/hr)		13
Onion bags ($2 per 20 kg)	10	10
Misc. gloves, cord, etc	2	2
Equipment spares	3	3
Total daily cost	$115	$28

Table 4. Comparison of summer and winter estimated operating costs and gross for harvesting 100 kg of mussels per day at Akulivik, N. Quebec.

	Summer	Winter
Season length (days)	mid July to Oct 105	Dec - May 165
Excluding weekends and bad weather (3/7 days)	60	94
Gross per day	$220	$220
Expenses per day	$115	$28
Daily Net	$105	$192
Seasonal Net	$6,300	$18,048
Annual depreciation	- $2,150	- $1,058
Annual profit	$4,150	$16,990
Average daily profit	$69	$181

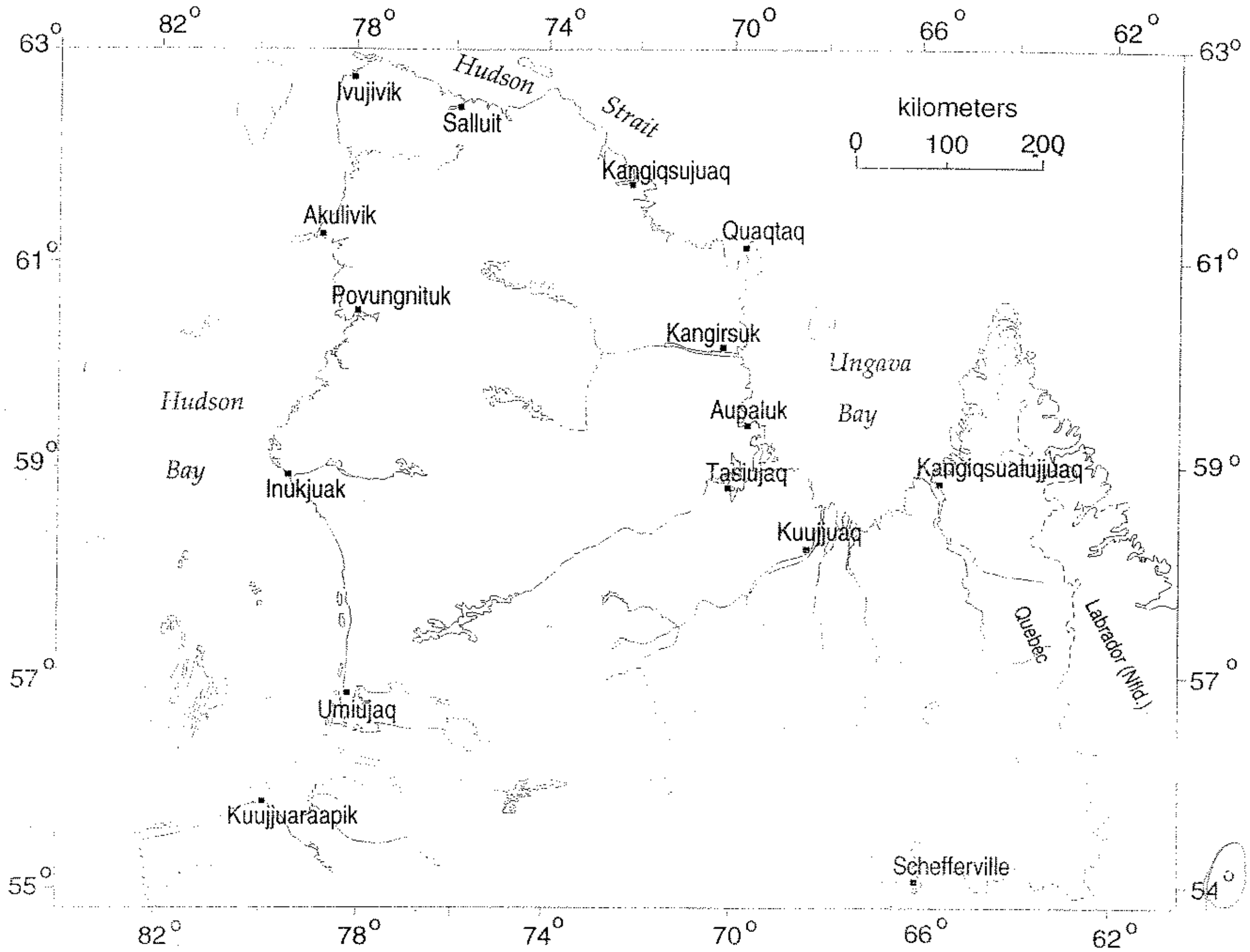

Figure 1 Map of Nunavik. Akulivik is located on the NE coast of Hudson Bay.

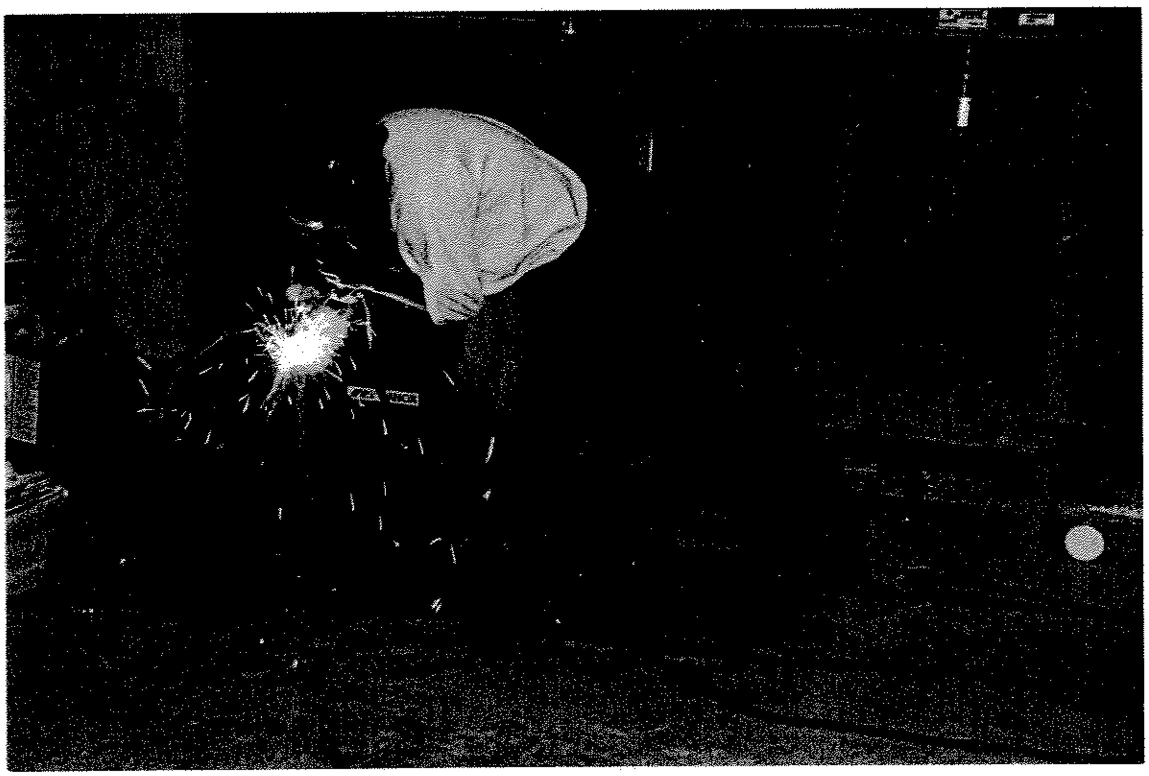

Figure 2 H. Alayco of Akulivik constructuring the prototype mussel drag (Photo C. Mesher).

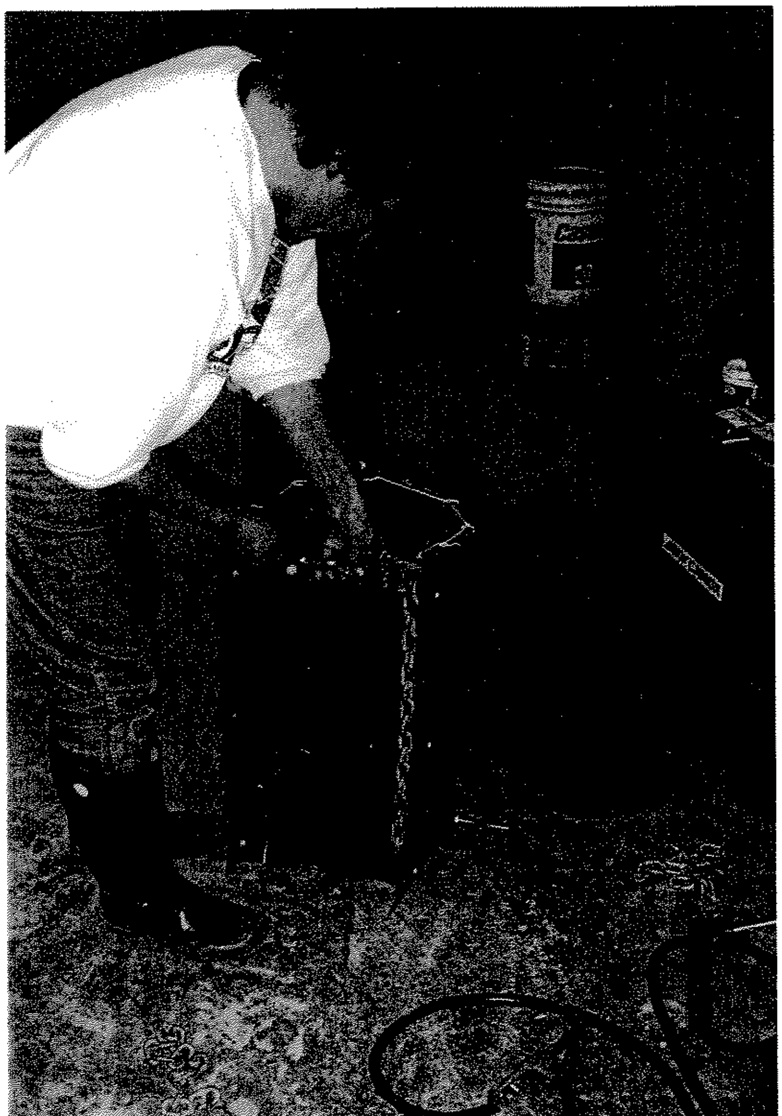

Figure 3 Attaching the chain bridal to the drag.

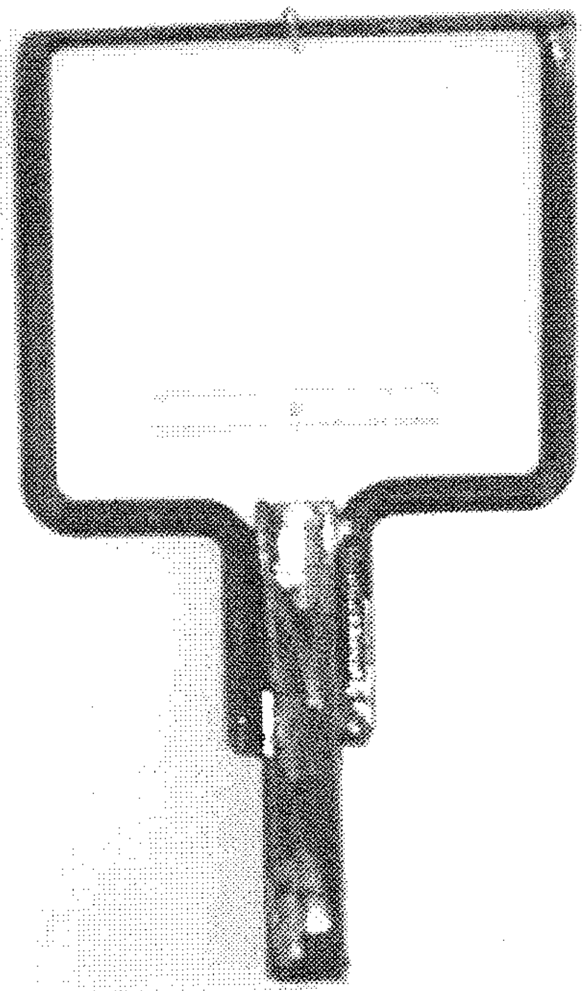

Figure 4 Metal frame which forms the scoop's basket

Figure 5 Method used to scoop mussels in winter

Figure 6 Scoop extended at angle to reach maximum distance from hole

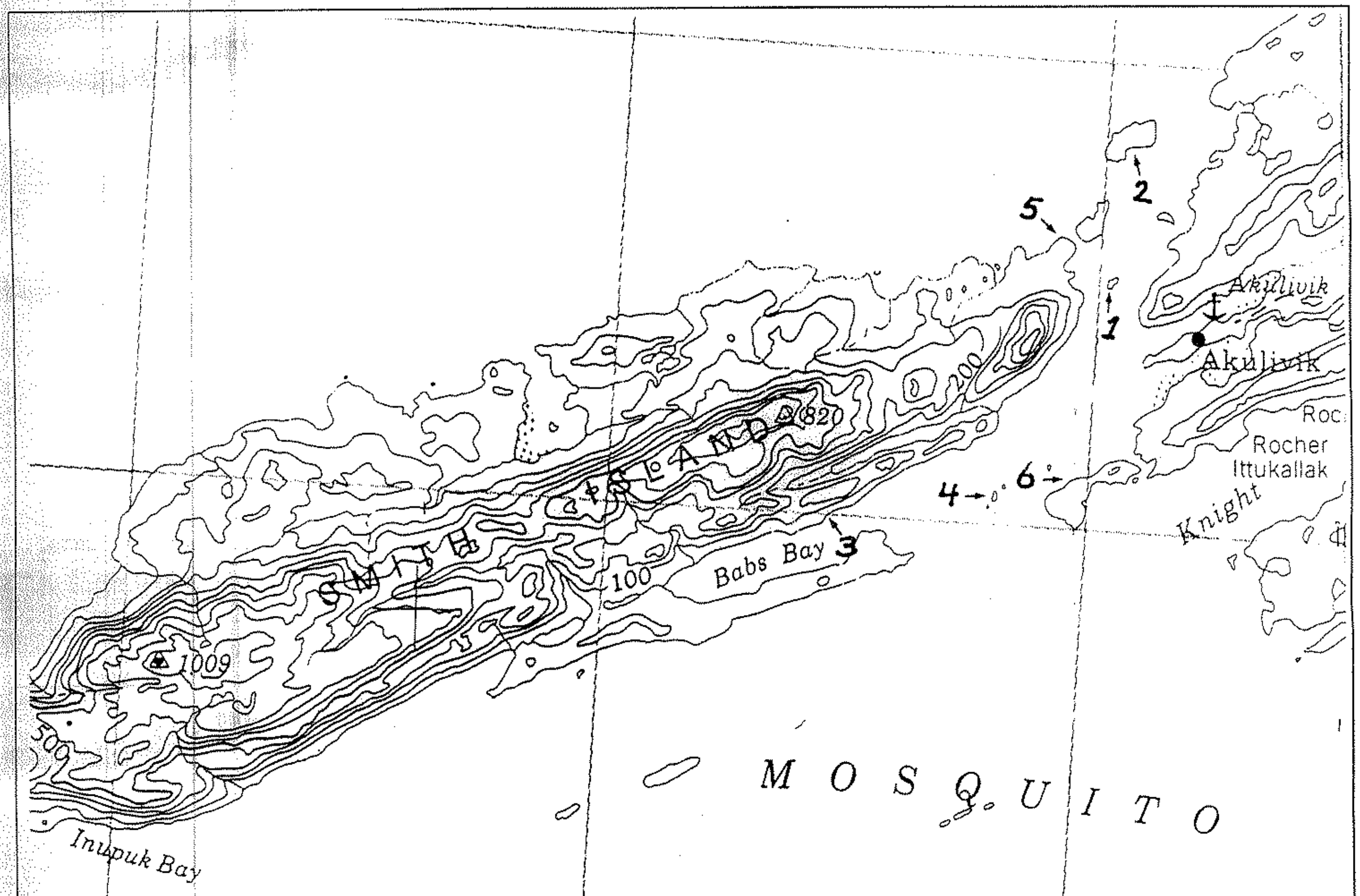

Figure 7 Location of sampling sites

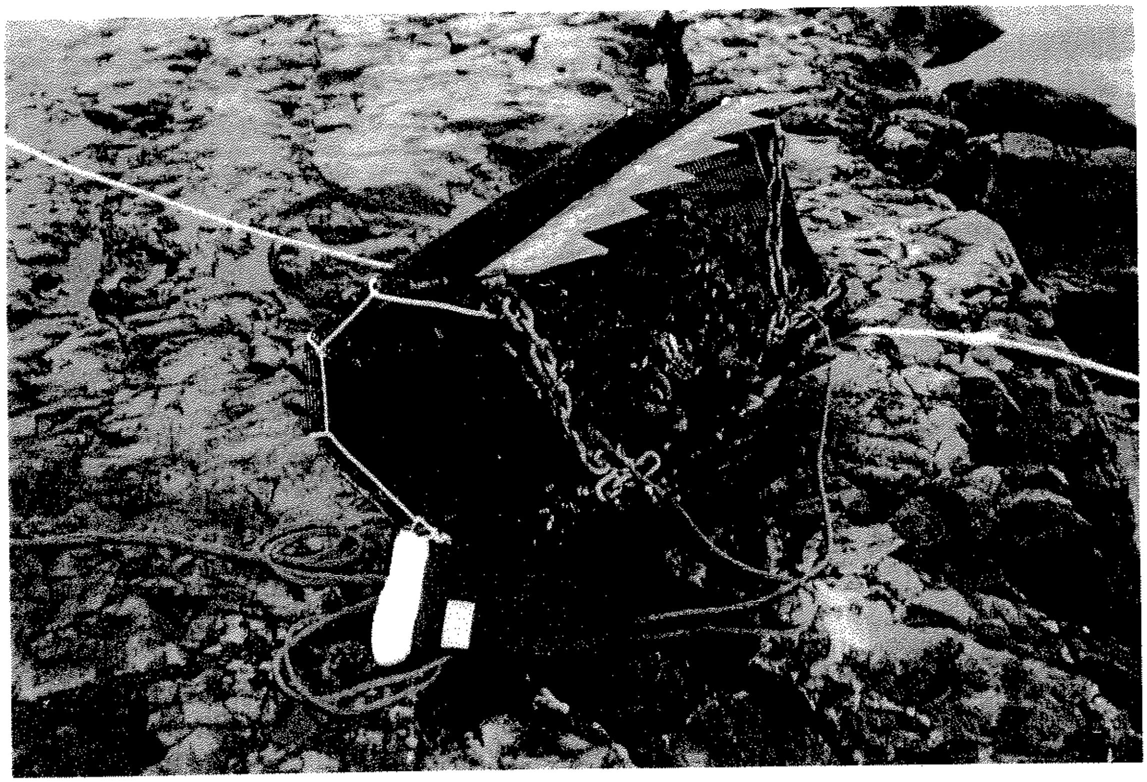

Figure 8 The drag containing a full haul of mussels.

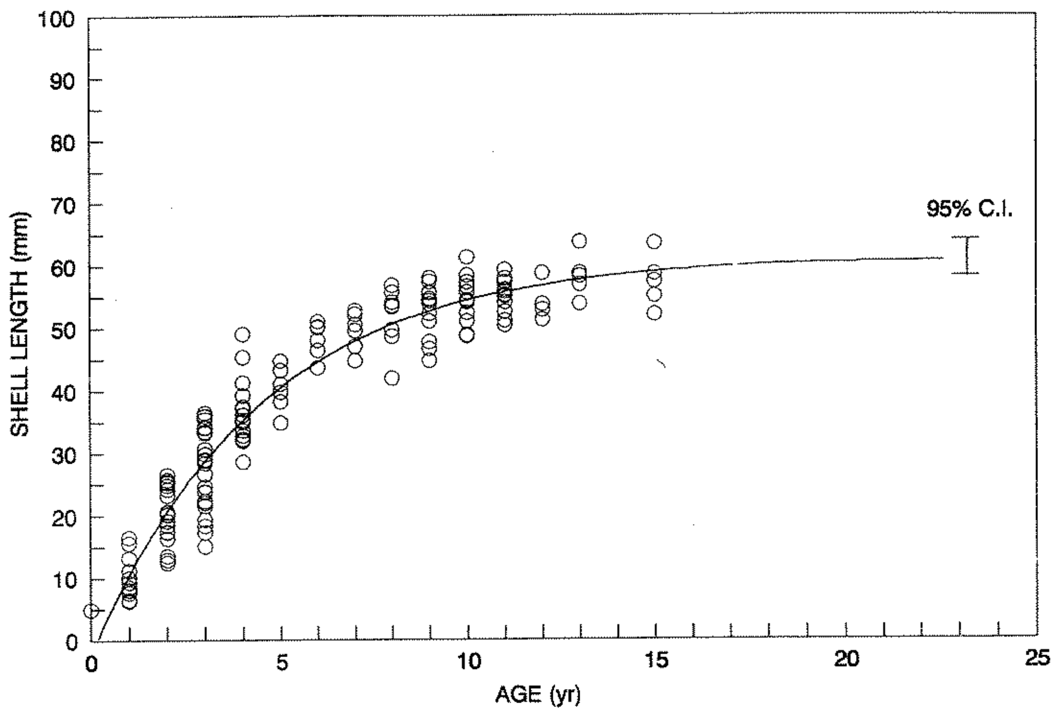

Figure 9 Von Bertalanffy growth curve of mussels from site AK-1, Akulivik, N. Quebec

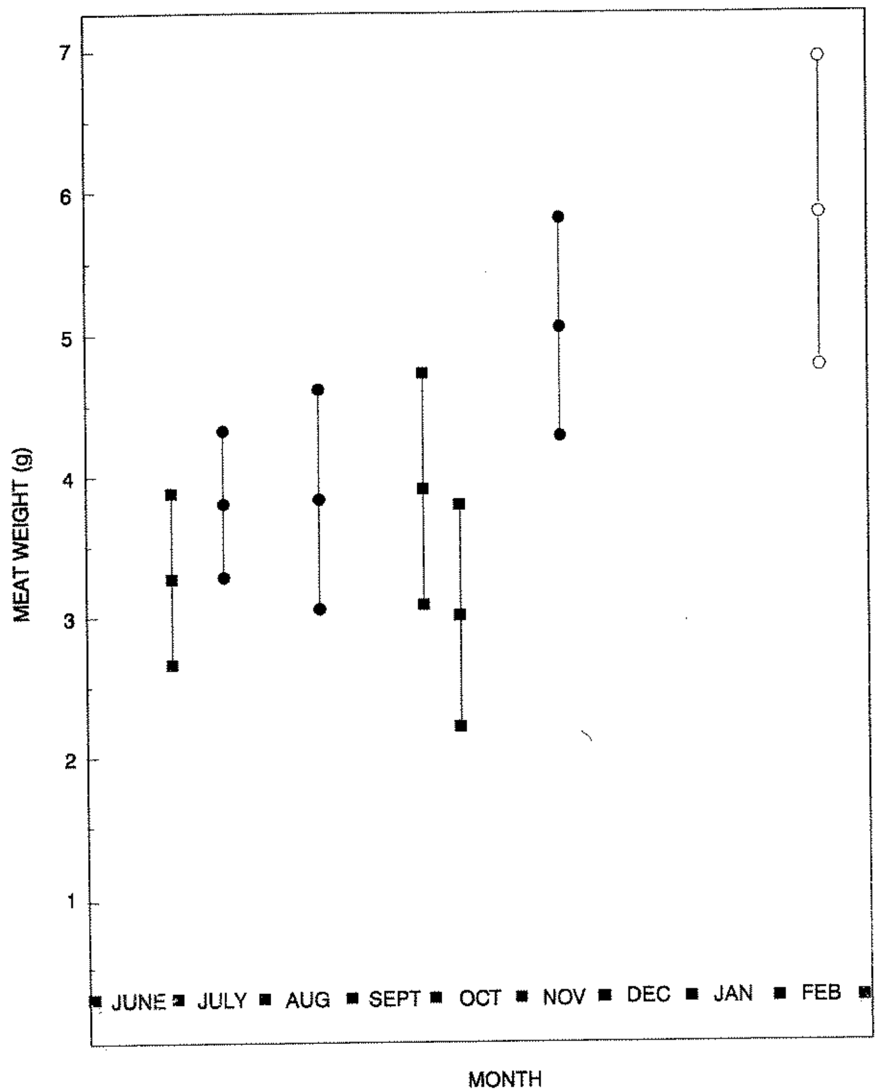

Figure 10 Seasonal changes in meat yield of mussels from Quaqtaq (1993 - solid circles), Kangiqsualujjuaq (1993 - squares) and Akulivik (1995 - open circles)