Northwest Atlantic Fisheries Organization

Serial No. N4336 NAFO SCR Doc. 00/79

SCIENTIFIC COUNCIL MEETING – NOVEMBER 2000

Spatial Structure of the Resource of *Pandalus borealis*: Results from an Experimental Trawl Survey in the Sukkertoppen Deep

by

D.M. Carlsson[1], P. Kanneworff[1] and M.C.S. Kingsley[2]

Greenland Institute of Natural Resources
[1]Pilestraede 52, P.O. Box 2151, DK–1016 Copenhagen K
[2]P.O. Box 570, DK–3900 Nuuk, Greenland

Abstract

Carlsson, D. M., P. Kanneworff, and M. C. S. Kingsley. 2000. Spatial structure of the resource of *P. borealis*: results from an experimental trawl survey in the Sukkertoppen Deep. *NAFO SCR Doc*., No. 79, Serial No. N4336, 10 p.

Pandalus borealis was experimentally fished in the Sukkertoppen Deep off West Greenland between latitudes 64°00' and 64°30' N and between longitudes 52°45' and 53°40' W, from 15 to 20 July 2000. Trawl stations were fished along transects at 300, 350 and 400 m as pairs of contiguous 15-minute tows, pairs being separated by a distance equivalent to a 30-minute tow. Each of the 50–60-km-long transects comprised 19 or 20 tows. Overall and pairwise CVs, pairwise correlations, and first-order serial correlations between the pairs' joint catches were calculated. Overall CVs were 100–200%; pairwise CVs between 15-minute tows were 24–26%. The correlations between the paired catches in each transect were 0.94 to 0.96, and serial correlation between joint catches were 45–65%. Longer-range spatial analyses along transects indicated long-range variation to be much greater than short-range, agreeing with the results of previous studies of variation.

Introduction

A research trawl survey is a component of the assessment process for the stock of northern shrimp *P. borealis* fished off West Greenland. It occupies a 722-ton trawler for about 2 months. Recent reviews of its design have raised the question of the optimum length for tows in such a survey, which motivated recent studies of the spatial structure of the resource. Large short-range variation in the density of the resource would indicate value of long tows at trawl stations, to average out the local variation, but if short-range variation were small, there would be little reason for tows to last long.

An experimental transect fishery was carried out in 1997 (Carlsson 1997; Kingsley and Carlsson 1998). It consisted of 60-minute tows contiguously disposed along transects, some isobathic at depths ranging from 250 m to 500, and 2 which crossed isobaths and each went from 250 m to 500 m. Each transect comprised 6 or 7 tows and was fished in one day, some being repeated on the following day. The study gave useful information but it was difficult to interpret the results from the 60-minute tows in terms of the effect on the survey of using shorter tows, and the transects were too short to span the range of densities commonly encountered within survey strata.

The assessment survey used a mixture of tow durations in 1999 and 2000, and analysis showed, especially for the 1999 survey, that short-range variation was a minor component compared with long-range, implying that long tows would probably be unnecessary. The results from the 2000 survey were less clear (Kingsley et al. in prep.).

The experimental fishery described here was similar to that carried out in 1997, in using a design of contiguous tows along transects, but it used shorter tows and longer transects to complement the information obtained then.

Methods

The study was executed as an interlude in the annual assessment survey in 2000. The study area chosen was the Sukkertoppen Deep, off Maniitsoq, West Greenland. It offered the possibility of long transects of continuously trawlable bottom at a range of depths. Transects were placed at 300, 350 and 400 m. The fishing was designed as pairs of contiguous tows, each tow lasting 15 minutes , and each pair separated from the next by the length of a half-hour tow. In experimental fishing in 1997, it was found that when a station was fished again on the following day the catch was nearly the same as before (Kingsley and Carlsson 1998). Therefore, it was considered allowable in the present study to extend transects over 2 days. Transects comprised 19–20 15-minute tows and were 55–60 km long.

The stations were fished using standard methods for the West Greenland assessment survey (Carlsson and Kanneworff 1998). Stations were only fished between 0700 and 1900 UTC. Trawling speed was about 3 knots. A *Skjervoy 3000* shrimp trawl with a 20-mm cod-end was used with *Greenland Perfect* doors. The start of the tow was indicated by the reading of a Furuno® trawl-eye mounted on the head-rope. Swept area was calculated from the change in GPS position between the start and end of the tow, and from the average of the door-spreads reported by Scanmar® sensors.

The catches of shrimp were weighed and recorded. Samples were sorted by species and weighed, and individual *P. borealis* were measured. The catch of *P. borealis* was divided by the swept area to give a resource density.

The CV (SD/mean) was calculated for each pair of 15-minute tows and overall for each transect. The log.-scale correlation between the pairs was calculated for each transect and overall. The catches in each pair were added together and treated as a '30-minute tow', and similar statistics were calculated: the overall CV, the CV of each pair of adjacent tows, and the first-order serial correlation of the log.-transformed data. Correlations were carried out on log.-scale data to reduce the effect of large catches.

The ratio between the catches at each possible pair of trawl stations was plotted against the distance (measured along the transect) separating stations. A kernel-smoothed RMS average of the log. ratio was plotted. A power-curve correlogram, according to which the log. of the density ratio was considered to be Normally distributed with zero mean and variance V_x of the form: $V_x = V_D\left(1 - C_D{}^{x/D}\right)/\left(1 - C_D\right)$, D being an arbitrary standard distance, was fitted by maximum likelihood. These analyses were limited to separations of 30 km, i.e. about half the transect length, beyond which the decreasing number of data points generated erratic results.

An analysis of components of spatial variance (Kingsley et al. 1999) was also carried out using the first of each pair of 15-minute tows individually and both members combined into 30-minute tows. The between-tow variation was decomposed into short-range and long-range components in a model of the form:

Var(*Catch*) = (*Tx_mean_density*^*a*) · (*b* · *Tow_length*^2 + *c* · *Tow_length* · *Length of 15-min tow*)

where the exponent *a* and the coefficient *b* measured the strength of the long-range variation, and *a* and *c* measured short-range variation.

A factor to be considered in optimising tow length in trawl surveys is the fixed time per station. This study, with controlled and intensive fishing in water depths that account for a high proportion of the stations in the assessment survey, short distances between transects, and an expert crew both on deck and in the laboratory, gave an opportunity for analysing the gear-handling time per station. As this was not a planned component of the enquiry, it is expected to be relatively free of observation bias. The time between stopping one haul and starting the next was calculated and plotted against the steaming distance.

Results and Discussion

The principal limitation of the study was the small geographical area in which it was executed. Trawlable areas in which it is possible to lay out continuous isobathic transects of these lengths are not easy to find in the West Greenland shrimp grounds. As the study was executed, therefore, the three transects parallelled each other at distances of 4 to 10 km, and the characteristics of the habitat in which they were fished may have been similar.

Catches decreased as depth increased. The mean density on the transect at 300 m was 16213 kg/sq. km, at 350 m 2835, and at 400 m 1115 kg/sq. km. Much of the large difference between the 300-m transect and the 350-m transect was due to high catches at the last three stations on the former; however, even without these points the 300-m transect averaged higher than the others. The catches on each transect were variable (Fig. 1, Table 1). The overall CV was about 100% on 2 transects, and nearly 200% on the shallowest transect, again due to high catches at the last 3 stations. These CVs are of the order of the within-stratum CVs typically obtained in the depth-stratified assessment survey, which usually average about 100%. These results differed from those of the 1997 experimental survey, in which the CVs on most of the isobathic transects were small (Kingsley and Carlsson 1998). The variations in catch in the present study were, however, mostly progressive and ordered (Fig. 1) and erratic variation, as measured by pairwise correlations, was small (Table 1).

Correlations between the members of the pairs was very high, on each transect individually between 0.91 and 0.95 (Table 1, Fig. 2). The mean pairwise CVs for the 15-minute tows were consistent at 26–27% (Table 1), corresponding to a ratio of about 1:1.45. The mean pairwise CVs of the joint catches reckoned as ‘30-minute tows’ were of the order of twice as much, although they were separated by four times the distance, i.e. the distance between the centres of the pairs was about equivalent to a 1-hour tow. Serial correlations of the 30-minute tows were moderately high at 40–60%.

The analyses of density ratio against distance along the transects showed that the power-curve correlogram followed the kernel-smoothed average quite well and appeared to be an adequate representation of the form of variation (Fig. 3). The correlogram had $C_{20} = 0.436$ and $V_{20} = 3.29$, i.e. an RMS density ratio at 20 km of 6.133 (exp(3.29)). This contrasts with the between-tows ratio estimated at 1:1.45, indicates that long-range variability is high compared with short-range variability, and implies that short tows and many of them would be an appropriate survey design. The distances in this analysis were measured along the transects. If they were measured on straight lines they would be shorter, so for any given distance the expected density ratio would increase.

Analysis by a components-of-variance model (Kingsley et al. 1999) had as maximum likelihood results: *a*: 2.33, *b*: 0.110*, and *c*: -0.032NS. To obtain a comparison with the 1999 survey data (Kingsley et al. 1999), *a* was set equal to 2 and *c* equal to zero (not statistically significant changes) and *b* then became 1.24. In the 1999 assessment survey results, with *a* equal to 1.998, *b* was 0.999*** and *c* was -0.079NS. I.e. the long-range variation in this experimental study looks larger than it was, overall, in the 1999 assessment survey.

‘Standard’ gear-handling time—i.e. the average of an obvious cluster of times with no very long or very short times—was about 42 minutes, whether tows were contiguous or separated (Fig. 5). There were a number of longer handling times. A daily lunch break was easy to identify in the data, but the reasons for the other long handling times have not been investigated for this document. The average including them was 5 minutes longer. An analysis of time interval against steaming distance for the 2000 assessment survey showed an overall average of about 45 minutes plus 3 minutes/km steaming; the average steam was about 20 km. However, this average included long and short gear-handling times. A minimum gear-handling time lay approximately on a line of 15 min. + 3.2 min./km, but there were no times less than 40 min.

Conclusion

The design, of tows disposed in spaced pairs, proved an effective method of investigating both short-range and longer-range variation in density of the resource. This study indicated strongly that short-range variation in the density of *P. borealis* was much smaller than long-range variation and long tows would probably be unnecessary for getting adequate information about local densities. It indicated large long-range variation, with density changing by a factor of about 6, on average, in 20 km. The only limitation of the study was the restricted size of its study area;

however, its conclusions do not contradict those of studies based on analyses of the data from the entire West Greenland survey area.

References

Carlsson, D.M. 1997 A first report on a special study on variations in catch of shrimp (*Pandalus borealis*) by depth in West Greenland (NAFO Sub-area 1) in 1997. NAFO SCR Doc. 97/108.

Carlsson, D.M. and P. Kanneworff. 1998. Offshore stratified-random trawl survey for shrimp (Pandalus borealis) in NAFO Subareas 0+1, 1998. NAFO SCR Doc. 98/118 Ser. No. N4027. 18 pp..

Kingsley, M.C.S. and D.M. Carlsson. 1998. An experimental investigation on spatial and depth variation in catch of shrimp, Greenland halibut and redfish. NAFO SCR Doc. 98/119, Ser. No. N4028. 7 pp.

Kingsley, M.C.S., P. Kanneworff and D.M. Carlsson. 1999. Modifications to the design of the trawl survey for *Pandalus borealis* in West Greenland waters: effects on bias and precision. NAFO SCR Doc. 99/105. Ser. No. N4184. 15 pp.

Kingsley, M.C.S., P. Kanneworff, D.M. Carlsson, and M. Pennington. In prep. Spatial structure of the resource of *Pandalus borealis* and some implications for trawl survey. *Submitted to* Fisheries Research.

Table 1: Variation in catches of northern shrimp *Pandalus borealis* along experimental trawl survey transects off West Greenland.

Transect	No. of tows	Mean catch (kg/hr)	Catch CV (%)	Log.-scale pairwise density correlation (%)	Mean CV of adjacent pairs (%)
One-hour tows, 1997					
Isobathic transects					
S-250(1)	7	1715	128	12.9	83.6
S-250(2)	7	1095	133	26.7	74.4
N-350(1)	7	719	31	-2.2	27.5
N-350(2)	7	851	19	24.6	12.3
S-375	6	1136	42	4.4	26.0
S-500	6	3	55	5.1	39.9
Variable-depth transects					
STR(1)	7	293	167	44.0	106.4
STR(2)	7	302	152	63.8	90.3
NTR	6	171	99	36.0	85.3
Isobathic transects, 2000					
Paired 15-minute tows					
300-m	18	1323	192	91.5	27.0
350-m	20	273	91	94.8	26.4
400-m	18	108	104	93.1	26.9
‘30-minute tows’					
300-m	10[1]	1653	154	29.6	48.3
350-m	10	273	93	65.2	54.1
400-m	10[1]	106	99	50.1	60.9

[1] an odd 15-minute tow at the end of these transects has been doubled and used as a 30-minute tow.

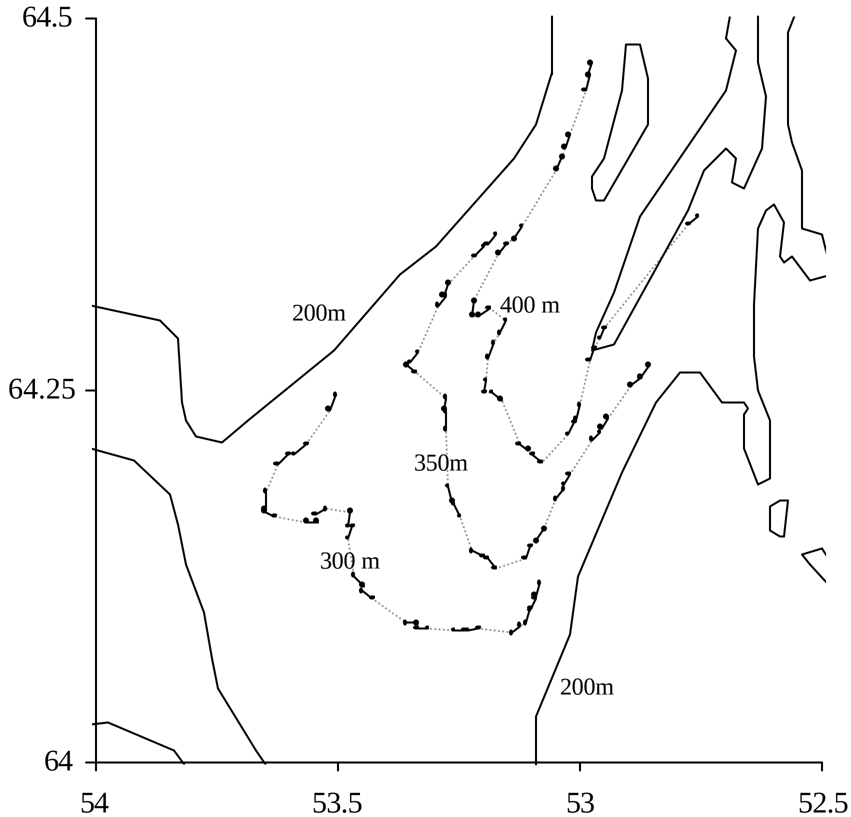

Figure 1: The Sukkertoppen Deep, West Greenland, with the layout of 15-minute tows on isobathic transects fished experimentally in 2000.

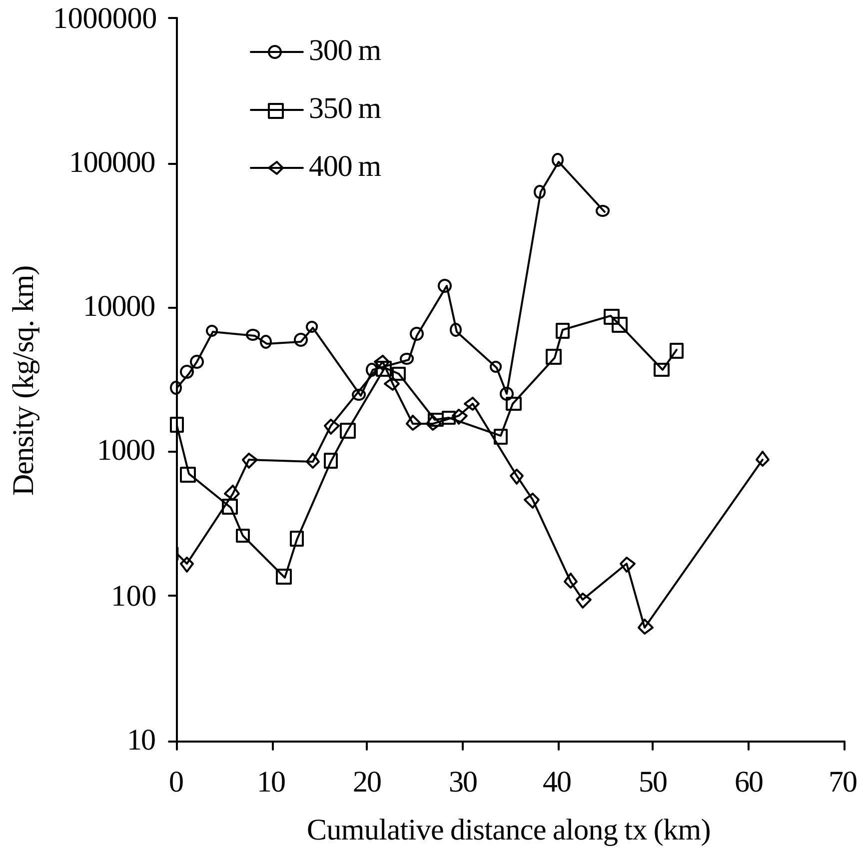

Figure 2: Density of *P. borealis* in paired 15-minute tows along isobathic transects in the Sukkertoppen Deep, West Greenland, in 2000.

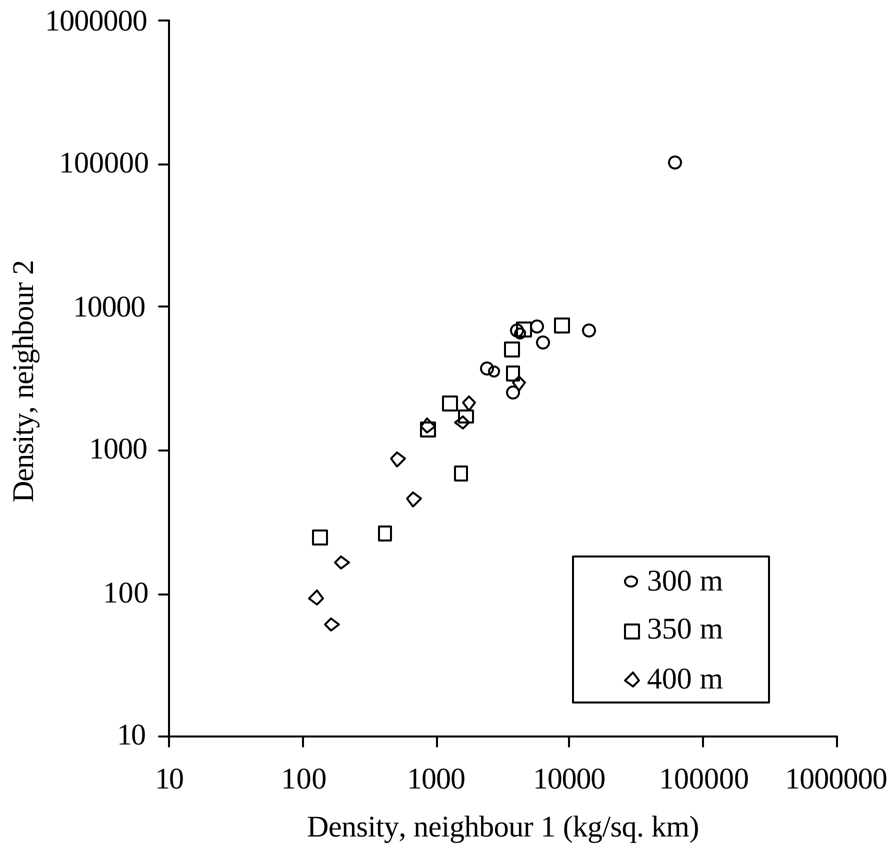

Figure 3: Densities of *P. borealis* on 15-minute tows in contiguous pairs on isobathic transects in the Sukkertoppen Deep, West Greenland, in 2000.

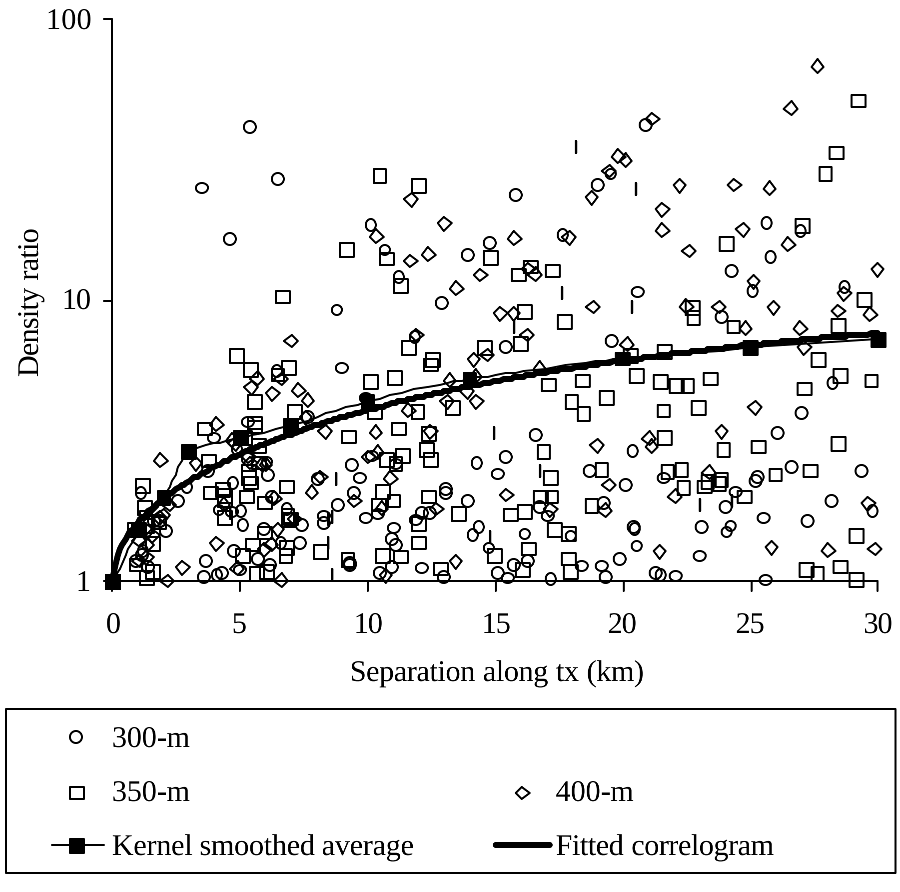

Figure 4: Spatial structure of *P. borealis*: density ratio in 15-minute tows, against station separation along isobathic transects.

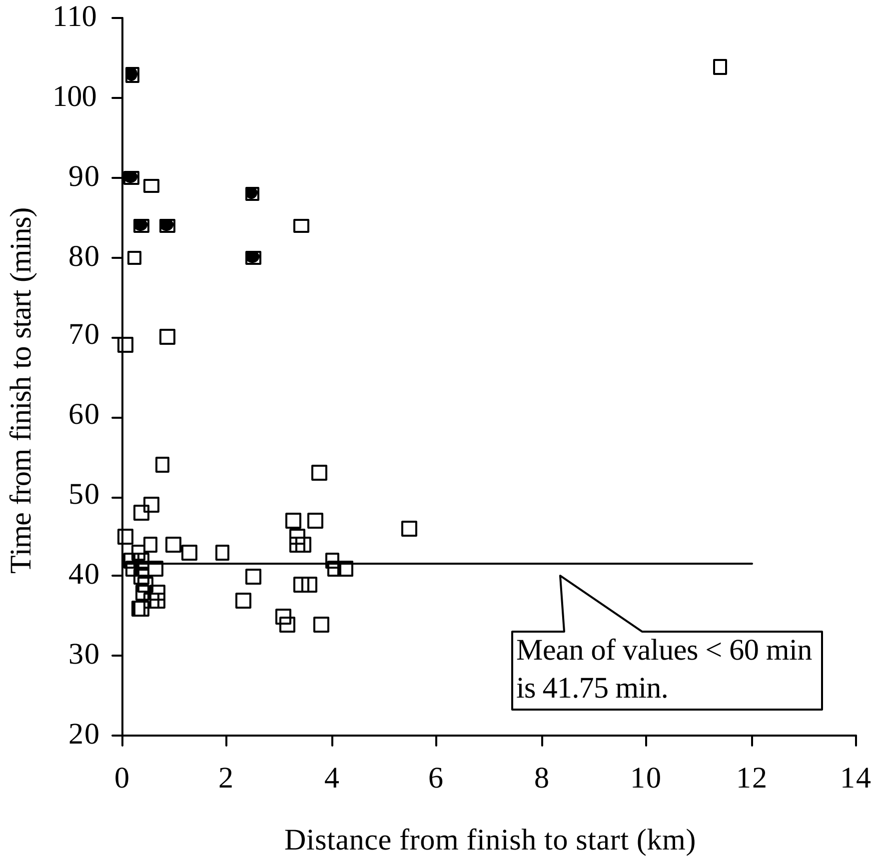

Figure 5: Trawl handling time between tows on experimental survey transects for *P. borealis* in the Sukkertoppen Deep, West Greenland, in 2000.