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Assesement of Pink Shrimp (*Pandalus borealis*) Fishery Potential in Davis Strait and Northeastern Canadian Waters

by

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Introduction

Fisheries and Environment Canada contracted MacLaren Marex Inc. to conduct a survey for shrimp (Pandalus borealis) and groundfish species in the Davis Strait, Hudson Strait and Ungava Bay areas. The survey was planned and executed in close consultation with personnel from the Biological Station, St. John's, Newfoundland.

The contractors chartered the 46 metre, 684 ton stern trawler Canso Condor to carry out the survey during August, 1978. This paper summarizes the information obtained on that cruise concerning the distribution and abundance of Pandalus borealis. Its contents form part of a more comprehensive report by the senior author to be completed in the very near future.

Spatial Distribution

Geographic Range

An earlier research survey which was restricted to Statistical Area 0B was reported by Minet et al. (1977). Their results indicated that shrimp were found in quantity only in an offshore area east of Cumberland Sound. In the survey documented here a larger area was covered using a Sputnic 1600 shrimp trawl for 94 tows at 79 locations (Fig. 1). Pandalus borealis occurred at 38 of these fishing locations. Their distribution and areas of concentration are shown in Fig. 2 (based on corrected data as explained below). At the northern limit on the Canadian side of Davis Strait, shrimp were found as far north as the ice edge would permit trawling (67°00'N), though concentrations were low. On the Greenland side of Davis Strait pink shrimp abundance appeared high only in the Greenland shelf area where commercial exploitation occurs. The highest catch rate for the entire cruise (approximately 1 mt/hr) occurred in this area just on the Canadian side of the international fishing boundary (tow 27). Berenboim et al. (1976) also noted highest shrimp concentrations in this location.

Shrimp concentrations east of Cumberland Sound do exist but are considerably less productive than those of the area of commercial activity. Farther south, traces of pink shrimp were found in the southern Davis Strait area, eastern Hudson Strait and east of the tip of Labrador.

A carapace length frequency (Fig. 3) constructed from the three best catches in the unexploited area (tows 11, 50 and 64) exemplifies the virgin condition. There appears to be good representation of all size-groups and 50% of the animals are larger than 23 mm, a good commercial size.

Vertical Movement

Investigations on vertical movement and diel availability of shrimp are taken directly from the report under preparation by the senior author. Slight organizational changes have been made to fit the format of this paper.

Since diel variation in catch has been observed for pink shrimp in the Davis Strait (Smidt 1976), an exploratory test grid was planned to examine this variable within the study area (Fig. 4). Duplicate tows at different times were made at five proximate sites where shrimp were known to occur. Since it was noted that the proportions of ovigerous females in catches varied on a diel basis (Fig. 5), that is, proportions were lower during the day when it is likely that smaller shrimp descend to increase total biomass on the bottom, these data were used to determine the night and day plateau periods, which are indicated as periods of little or no vertical movement. The test grid (Fig. 4) was chosen to approximate the normal depth of pink shrimp concentrations in the Davis Strait, that is about 368 m (mean of sites B to E). The data for site "A" were not used as this position was significantly shallower than the others. Using a running average of threes for the ten other tows, the plateaus are evident (Fig. 5). Mean percentage levels were obtained from points 1-2 and 3-4. Beginning and end times for plateau periods were determined from intersection of these mean levels with data regressions on points from 2 to 3 and 4 to 1. The night and day periods so determined were 1 hour 50 minutes and 5 hours 20 minutes respectively. These data are used below to determine diel correction factors for pink shrimp leading to biomass estimates. As expected, these periods encompassed the mid-night and noon sun positions of this longitude - four hours later than GMT.

Minimum Trawlable Biomass Estimation

Since the pink shrimp catch is maximal at noon, it is reasonable that any biomass estimate be corrected to highest catch levels in order to more closely approximate standing crop. If it is assumed that the plateau levels of ovigerous females indicate periods of negligible vertical movement, then data for individual sites in the test grid (Fig. 4) can be regressed to the beginning and end times of the morning or afternoon periods to determine mean minimum and maximum catch levels for the test area (Fig. 6 and Table 1). The following four points are thus obtained:

Time (GMT)	Catch (kg)
0249	13.9
0439	13.9
1432	34.4
1952	34.4

When plotted (Fig. 7), a bottom availability curve using our Sputnic 1600 gear is generated, based on the assumption that a linear diel variation function adequately approximates biomass changes due to vertical migration. Hourly correction factors are subsequently derived from regressions on these data (Table 2). They indicate a maximum reduction to 40.4% of available (noon) biomass, resulting in a maximum correction multiplier of 2.47. This falls within the range of maximum correction factors derived from commercial catch data noted in other studies (Table 3). These diel corrections are also dependent upon many other factors which have not been incorporated into this study other than to centralize the test grid location. These include sea surface differences on light intensity, presence of fog or cloud, and latitudinal and longitudinal distances from the test grid site.

Application of these correction factors presupposes that the catch data are as unbiased as conditions will allow. Water mass movements and tidal currents, which would likely have had some influence on our results, were not taken into consideration.

Our pink shrimp biomass data were changed to an hourly basis and corrected for diel variation (Fig. 2, Table 4). To correct these data to a per unit area basis, the "swept-area" technique was employed, that is the corrected catch data

were related to the area covered by the net in one hour at our standard towing speed of 3 knots. The area here is a function of the net width which was estimated by Hoydal (1976) as 30 m. The "swept-area" in one hour would thus be 0.167 km², which is equivalent to multiplying the catch by a factor of six and dividing by 1000 to yield shrimp densities in metric tons per square kilometer (Table 4).

Since shrimp distributions are related to depth, biomass estimates based on strata have been attempted. Thus, all tows were categorized as to depth stratum and sub-region within the study area (Table 5), and their mean densities calculated (Table 6). The area of each selected stratum between 91 and 914 m within the study area was then determined from marine charts (Table 7). To compute minimum biomass within the study area, the mean density for each stratum in each sub-region (Table 6) is multiplied by its respective area (Table 7). Biomass estimates are summarized as follows:

SUMMARY OF SHRIMP BIOMASS ESTIMATES

(Data in metric tons based on mean catch per depth stratum and swept-area function of net, and corrected for diel variation to maximum catch levels.)

Location				
Ungava Bay and E. Hudson Strait	Southern Davis Strait	Central Davis Strait	NE Davis Strait West[1]	NE Davis Strait East[1]
372	2,590	15,089	4,441	12,377

[1]East and west of the line demarcating the national fishing zones.

These biomass estimates are of necessity only minimum approximations of the standing crop for several reasons:

(1) It is assumed that the trawl effectively catches every shrimp in the "swept-area". This is certainly not true. Undoubtedly, the larger bobbin gear and 1 m toggle chains used for rough ground allow shrimp to go under the fishing line. Similarly, some shrimp are likely to pass through the large mesh of the wings and body of the net since only the last 6.5 m of the codend were lined with small mesh.

(2) It is assumed that the trawl effectively takes all shrimp in the water column above the "swept-area", or that the diel correction factor compensates for them. Preliminary analyses of our admittedly limited mid-water trawl data suggest that some shrimp are likely to be found in the water column above the 11 m high opening of the Sputnic 1600 bottom trawl at all times of the day, and thus would neither be taken by the net nor be accounted for in the diel correction factor.

Discussion

Despite adjustment for diel variability catch rates attained in unexploited areas remain quite low. Rarely did the adjusted catch exceed 100 kg/hr and results cannot be regarded as encouraging in terms of commercial productivity.

As has been noted previously the commercially important shrimp grounds on the Greenland Shelf extend beyond the international boundary into the Canadian zone of fisheries jurisdiction. In fact the largest catch for the cruise, adjusted or otherwise, was taken from there.

Biomass estimates for all areas are relatively low. The western side of the Central Davis Strait, exceeding 100,000 sq km, has an estimated maximum trawlable biomass in the order of 15,000 tons. In other non-commercial areas densities are lower again. Biomass calculated for the northeastern Davis Strait suggest disproportionate densities on either side of the international boundary. However, much of the calculated biomass for the Canadian side is heavily influenced by one very large catch. The combined estimate for the whole commercially-important area covered in this survey seems lower than would be expected.

Additional information for the same area is presented in a paper by Veitch et al. (1978).

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Table 1. Derivation of *Pandalus borealis* mean plateau catch levels[1] for diel correction factors based on test grid tow data in Davis Strait waters during August 1978.

Test Grid Position	Morning[2]		Afternoon[3]	
	Midnight (0439)	Noon (1432)	Noon (1952)	Midnight (0249)
A	7.4 [2]	34.9	31.3	17.7
B	24.7	52.2	31.4	17.9
C	13.5	41.0	60.1	46.5
D	9.5	37.0	29.9	16.3
E	- 11.2 [2]	16.3	10.3	- 3.3

1 Plateau means (n = 10): noon, 34.4 kg; midnight, 13.9 kg.
2 Regression on B, same slope for C and D. Data for A and E based on morning regression slope projected from noon plateau levels.
3 Regression on A, same slope for others.

Table 2. Correction factors for diel variation in *P. borealis* catch in Davis Strait (as derived from test grid during August 1978).

	Time (GMT)	Factor	%	Time (GMT)	Factor	%
Midnight - EST	0400	(2.47)	(40.4)	0400	(2.47)	(40.4)
		2.45	40.8		2.47	40.4
	0500			0300		
		2.35	42.6		2.33	42.9
	0600			0200		
		2.20	45.5		2.20	45.5
	0700			0100		
		2.05	48.8		1.98	50.5
	0800			2400		
		1.91	52.4		1.77	56.5
	0900			2300		
		1.76	56.8		1.56	64.1
	1000			2200		
		1.61	62.1		1.35	74.1
	1100			2100		
		1.46	68.5		1.14	87.7
	1200			2000		
		1.31	76.3		1.00	100.0
	1300			1900		
		1.16	86.2		1.00	100.0
	1400			1800		
		1.04	96.2		1.00	100.0
	1500			1700		
		1.00	100.0		1.00	100.0
Noon - EST	1600	(1.00)	(100.0)	1600	(1.00)	(100.0)

Table 3. Comparison of maximum correction factors derived to compensate for diel variation in shrimp catches in the Davis Strait area.

Maximum Correction Factor	Mean Maximum Time (GMT)	Month	Source
1.80	1500	July	Horsted (1976)
2.47	1700	August	This study
2.80	1800	August	Berenboim et al (1976)
3.50	1500	August	Smidt (1976)

Table 4. Density determinations for *Pandalus borealis* catches by Sputnic 1600 bottom trawl during August 1978.

Tow No.	Mean Depth (m)	Catch (kg)	Corrected[1] Catch (kg/hr)	Time of Tow (GMT)	Correction Factor (Table 2)	Corrected[2] Catch (max. kg/hr)	Shrimp Density (metric tons/km²)
Ungava Bay - E. Hudson Strait:							
76	399	0.5	1.0	0459	2.45	2.5	0.015
83	436	0.02	0.04	0803	1.91	< 0.1	Trace
89	384	9.1	18.2	0653	2.20	40.0	0.240
90	407	3.6	7.2	1059	1.61	11.6	0.069
91	425	2.5	5.0	1407	1.04	5.2	0.031
Southern Davis Strait:							
74	314	1.1	2.2	1125	1.46	3.2	0.019
75	247	0.7	1.4	1511	1.00	1.4	0.008
94	418	8.2	16.4	1227	1.31	21.5	0.129
101	373	29.5	59.0	1821	1.00	59.0	0.353
Central Davis Strait:							
7	378	23.1	46.2	0611	2.20	101.6[B]	0.609
11	360	49.9	99.8	1351	1.16	115.8[B]	0.693
12	263	34.9	69.8	1725	1.00	69.8[A]	0.418
33	374	9.1	18.2	1016	1.61	29.3	0.175
36	576	1.1	2.2	1917	1.00	2.2	0.013
39	605	0.02	0.04	1726	1.00	< 0.1	Trace
40	532	3.6	7.2	0625	2.20	15.8	0.095
41	439	8.8	17.6	1057	1.61	28.3	0.170
42	430	23.1	46.2	1425	1.04	48.0[A]	0.288
45	296	10.1	36.2	0237	2.33	84.3[B]	0.505
46	393	36.7	73.4	0641	2.20	161.5[C]	0.967
47	393	29.5	59.0	1024	1.61	95.0[D]	0.569
48	354	33.6	67.2	1318	1.16	78.0[E]	0.467
49	370	16.1	32.6	1657	1.00	32.6[C]	0.195
50	366	59.9	119.8	1958	1.00	119.8[A]	0.717
51	296	25.8	51.6	2240	1.56	80.5[B]	0.482
52	402	19.9	39.8	0150	2.20	87.6[E]	0.524
55	362	6.8	13.6	2138	1.35	18.4[D]	0.110
56	346	20.4	40.8	0043	1.98	80.8	0.484
57	346	3.4	6.8	0352	2.47	16.8	0.101
64	302	39.5	79.0	1753	1.00	79.0	0.473
70	315	24.0	41.1	1829	1.00	41.1	0.246
74	314	1.1	2.2	1125	1.46	3.2	0.019
75	247	0.7	1.4	1511	1.00	1.4	0.008
Northeastern Davis Strait: Canadian fishing zone							
14	626	4.3	8.6	1804	1.00	8.6	0.051
15	547	0.5	1.0	2031	1.14	1.8	0.007
16	458	0.9	1.8	2247	1.56	2.8	0.017
17	368	2.3	4.6	0123	2.20	10.1	0.061
22	300	34.9	69.8	1906	1.00	69.8	0.418
23	371	3.2	6.4	2025	1.14	7.3	0.044
25	448	3.6	7.2	0323	2.47	17.8	0.106
26	374	5.2	10.4	0538	2.35	24.4	0.146
27	265	479.4	958.8	0727	2.05	1969.5	11.770
Fishing zone off Greenland							
18	341	6.4	12.8	0551	2.35	30.1	0.180
19	352	134.6	389.2	0854	1.91	743.4	4.451
20	282	76.2	152.4	1239	1.31	199.6	1.195
21	389	53.5	107.0	1603	1.00	107.0	0.641
28	200	12.0	24.0	1053	1.61	38.6	0.231
29	445	23.1	46.2	1437	1.04	48.0	0.288

1 All tows were 30 minutes duration except no. 70 which was 35 minutes.

2 Superscript letters refer to duplicate tows made at test grid sites; the means of these are: A = 78.2 max. kg/hr, B = 116.6, C = 107.4, D = 79.4, and E = 25.5

Table 5. Depth stratification of sputnic 1600 bottom trawl tows, as used for biomass estimation, August 1978. (Top figure is number of tows; bottom figures are tow numbers.)

Depth Stratum (fm/m)	Location[1]				
	Ungava Bay - E. Hudson Strait	Southern Davis Strait	Central Davis Strait	NE Davis Strait	
				Western side[2]	Eastern side[1]
50-100	1	—	1	—	—
91-183	(92)	—	(62)	—	—
100-150	6	1	7	—	1
183-274	(80-82, 85, 87, 88)	(75)	(12, 34, 59, 63, 71, 73, 75)	—	(28)
150-200	5	1	16	2	3
274-366	(77-79, 86, 93)	(74)	(11, 35, 43-45, 48, 50, 51, 55-58, 61, 64, 70, 74)	(22, 27)	(18-20)
200-300	6	4	14	7	2
366-549	(76, 83, 84, 89-91)	(94, 97, 98, 101)	(7, 33, 40-42, 46, 47, 49, 50, 52-54, 69, 72)	(15-17, 23,26)	(21, 29)
300-500	—	4	6	1	—
549-914	—	(95, 96, 99, 100)	(31, 32, 36-39)	(14)	—

[1] Some exceptions to these categorizations exist: for instance, tow no. 34 is placed in depth stratum 100-150 rather than 50-100 since the latter is not all inclusive but for special areas only; tow no. 27 is placed in 150-200 since 100-150 stratum is not indicated on charts; tow no. 50 is found in two categories since it lies on the border depth; and tow no. 74 and 75 are found in two categories since they lie on the border of sub-regions.

[2] East and west of the line demarcating the national fishing zones.

Table 6. Mean densities (metric tons per 1000 km^2) of *Pandalus borealis* per depth stratum and sub-region.

Depth Stratum (fm/m)	Location[1]				
	Ungava Bay - E. Hudson Strait	Southern Davis Strait	Central Davis Strait	N.E. Davis Strait	
				West[2]	East[1]
100-150 183-274	—	8.4	61.1	—	231.1
150-200 274-366	—	19.2	268.9	6094.1	1942.5
200-300 366-549	59.3	120.4	307.8	54.5	464.1
300-500 549-914	—	—	2.4	51.5	—

[1] Mean density = $1000\left(\frac{\text{Sum of densities/stratum/sub-region (Table 4)}}{\text{Number of tows/stratum/sub-region (Table 5)}}\right)$

[2] East and west of the line demarcating the national fishing zones.

Table 7. Areas of study location depth strata ('000 sq. km) based on marine chart contours.

Location	Depth (fm/m)					Totals
	50-100[1] 91-183	100-150 183-274	150-200 274-366	200-300 366-548	300-500 548-914	
Ungava Bay - E. Hudson Strait	6.53	24.77	10.59	6.28	1.76	49.93
Southern Davis Strait	—	5.76	5.72	20.21	14.96	46.65
Central Davis Strait	2.38	21.76	24.67	22.90	32.95	104.66
NE Davis Strait:						
West[2]	—	—	0.69	2.38	2.07	5.14
East[2]	—	4.36	5.43	1.77	1.00	12.56
Totals	8.91	56.65	47.10	53.54	52.74	218.94

[1] Special regions examined only.
[2] East and west of the line demarcating the national fishing zones.

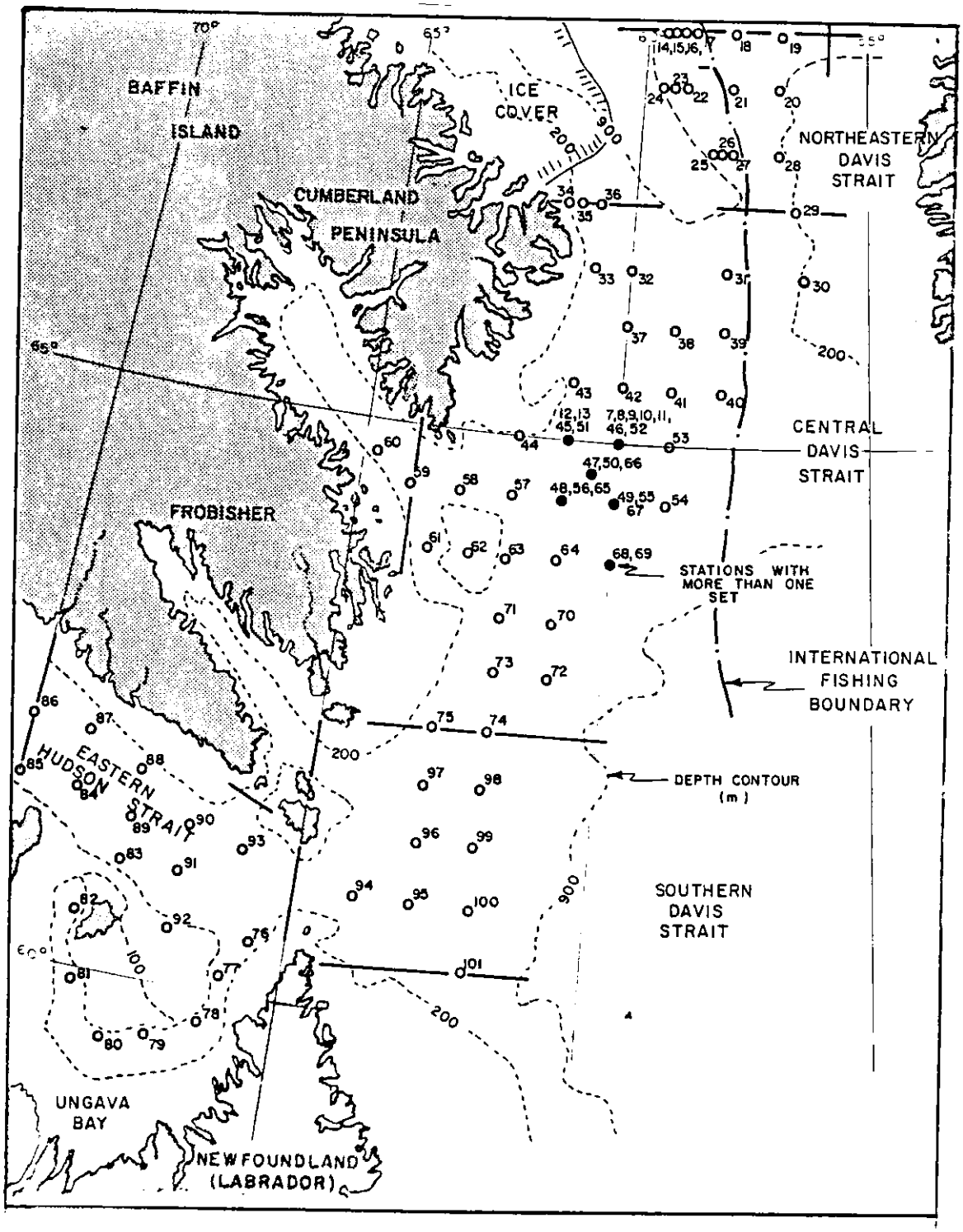

Fig. 1. Station locations of fisheries survey by stern trawler Canso Condor.

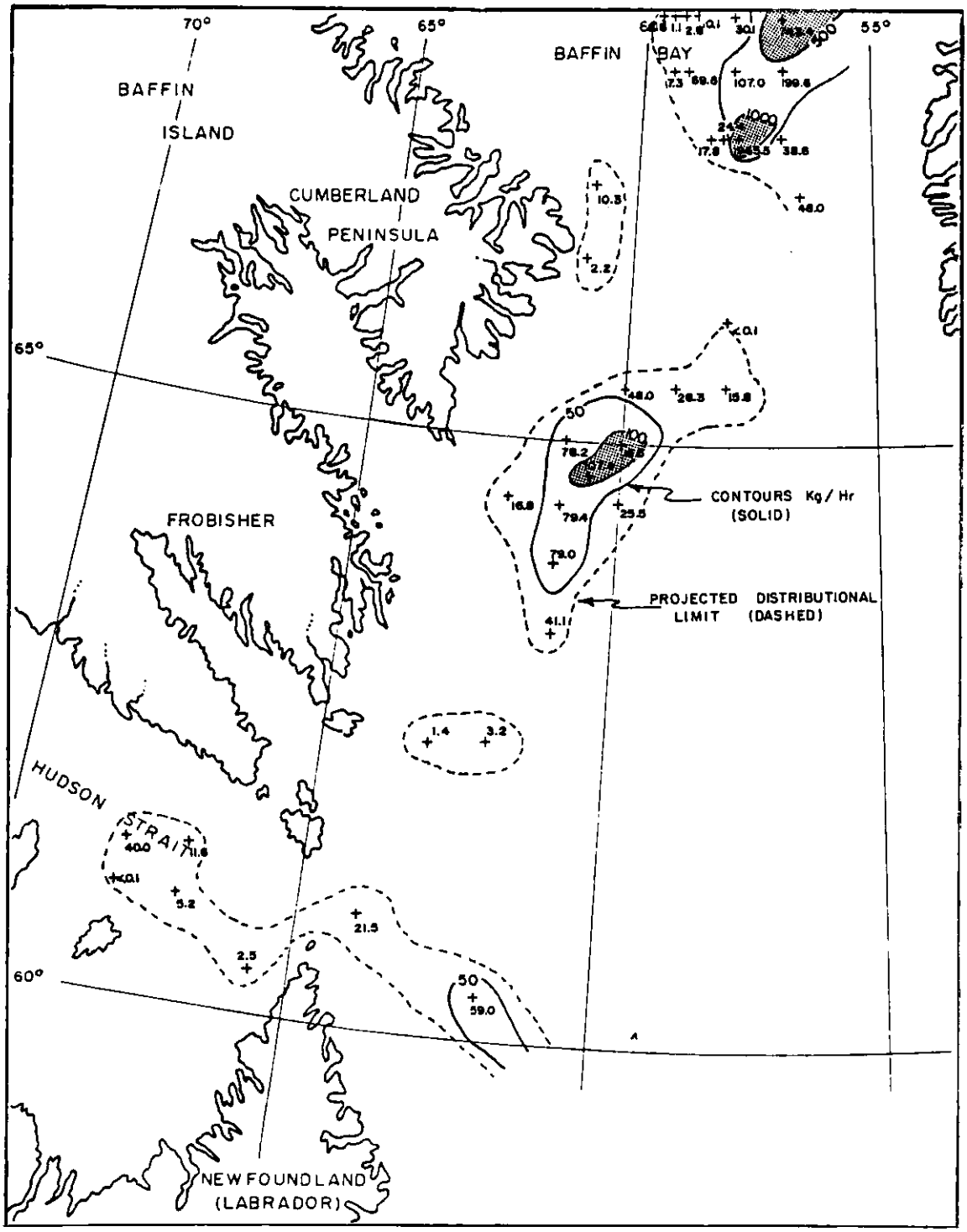

Fig. 2. Distribution and abundance of shrimp, *Pandalus borealis* (adjusted to maximum hourly catch rate level).

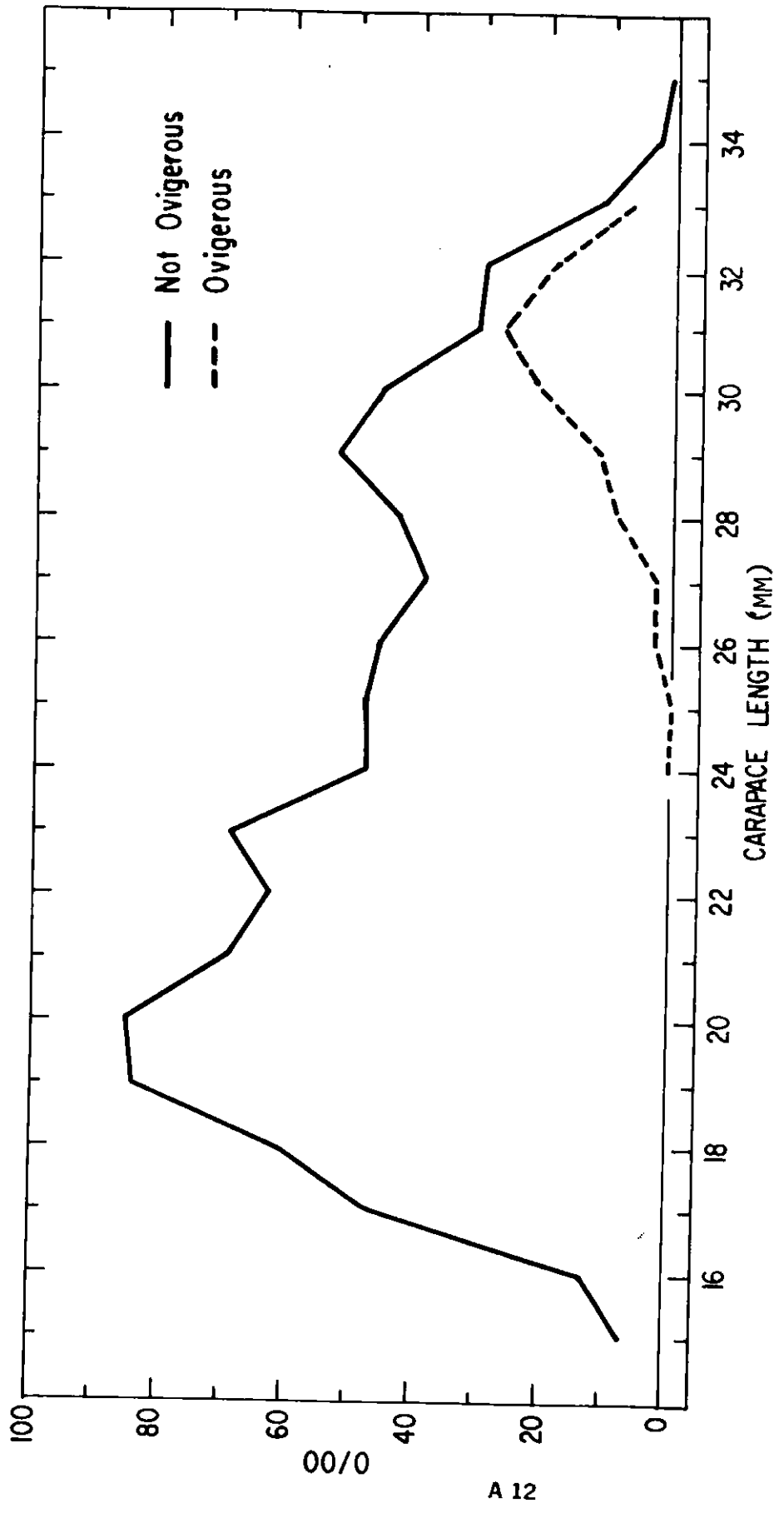

Fig. 3. Length distribution of P. borealis from best catches in the unexploited zone.

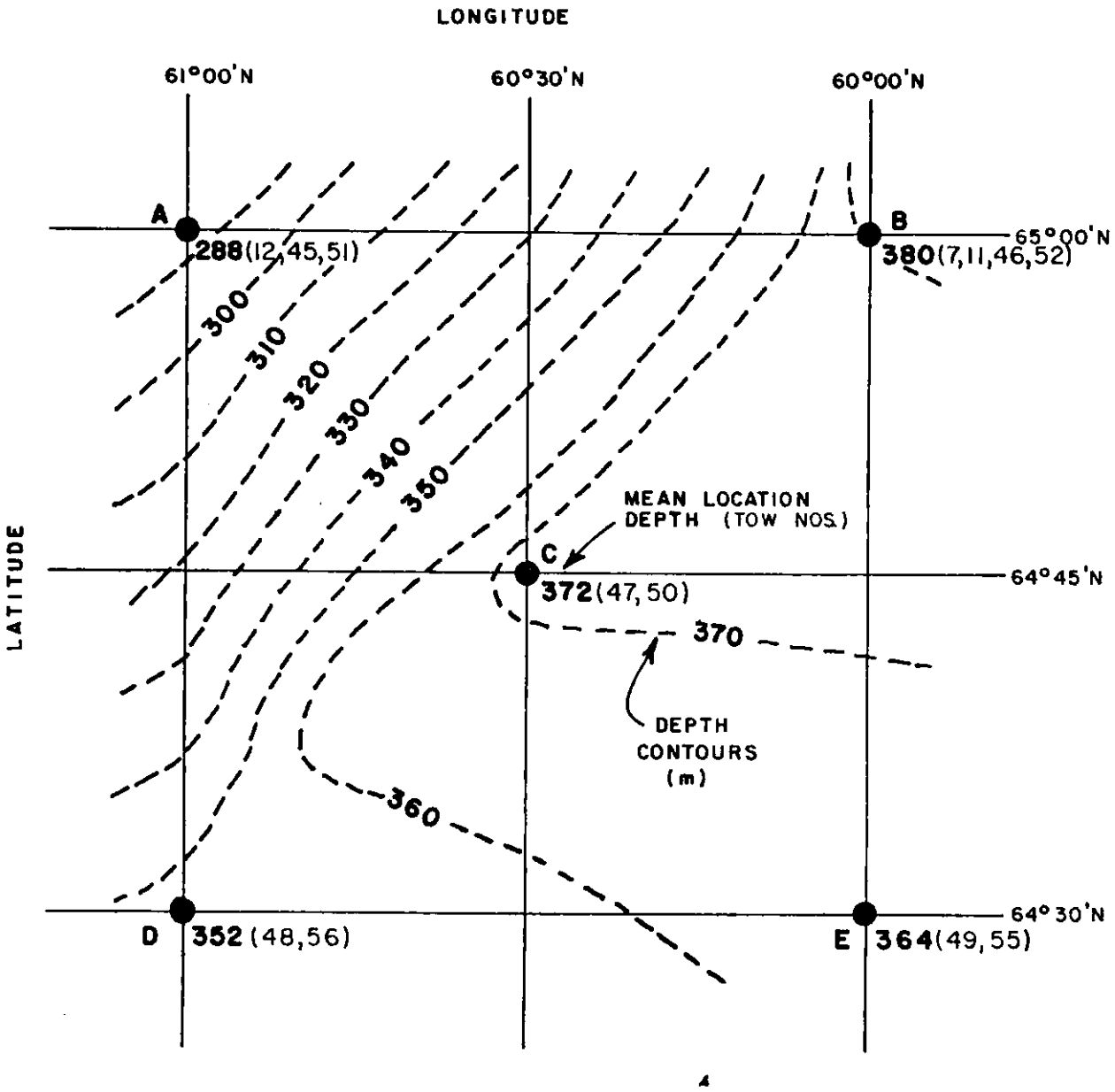

Fig. 4. Test grid for study of diel variation in P. borealis in northeastern Canadian waters.

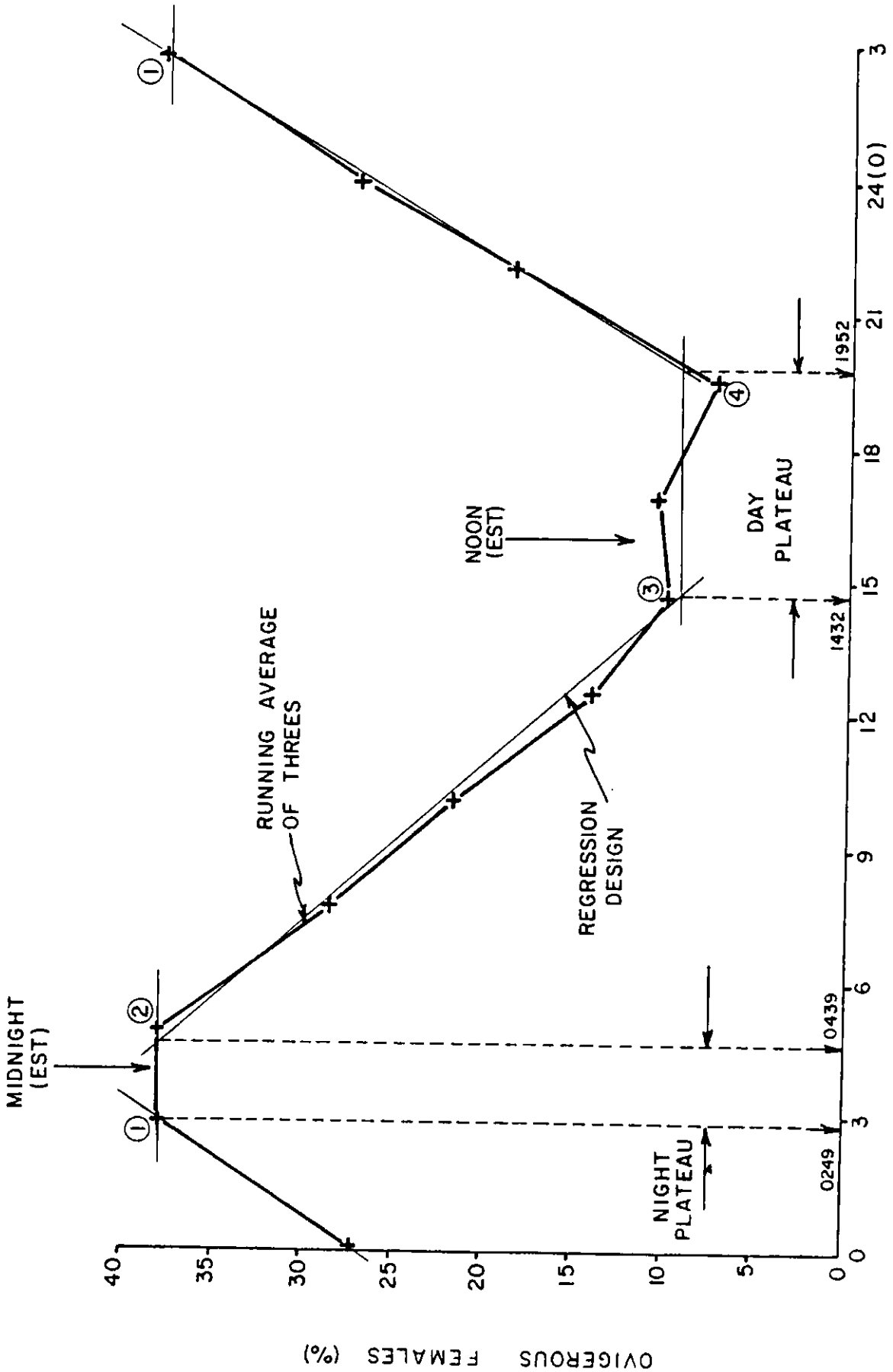

Fig. 5. Diel variation of P. borealis ovigerous females in test grid.

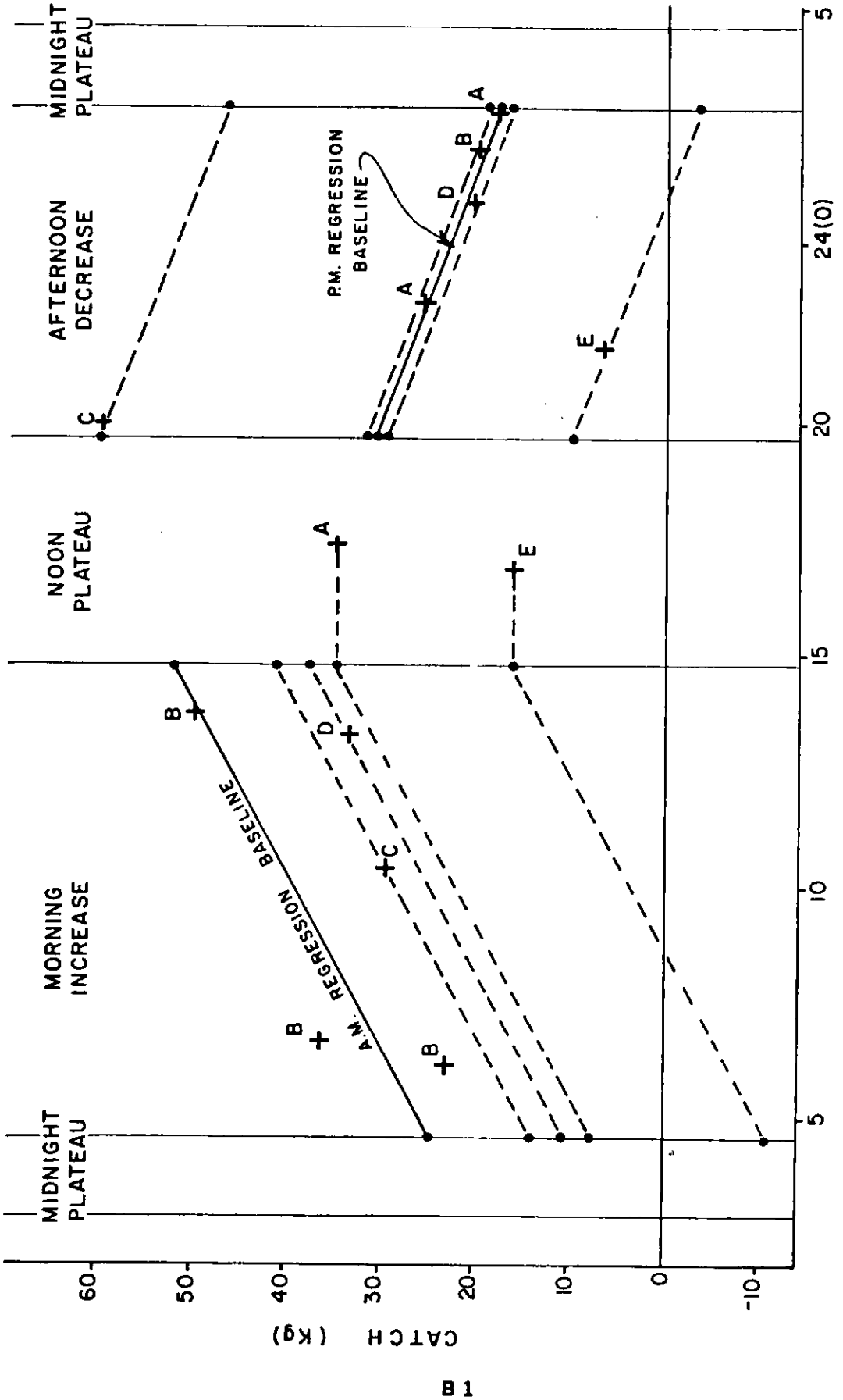

Fig. 6. Derivation of mean diel maximum and minimum levels of P. borealis catch.

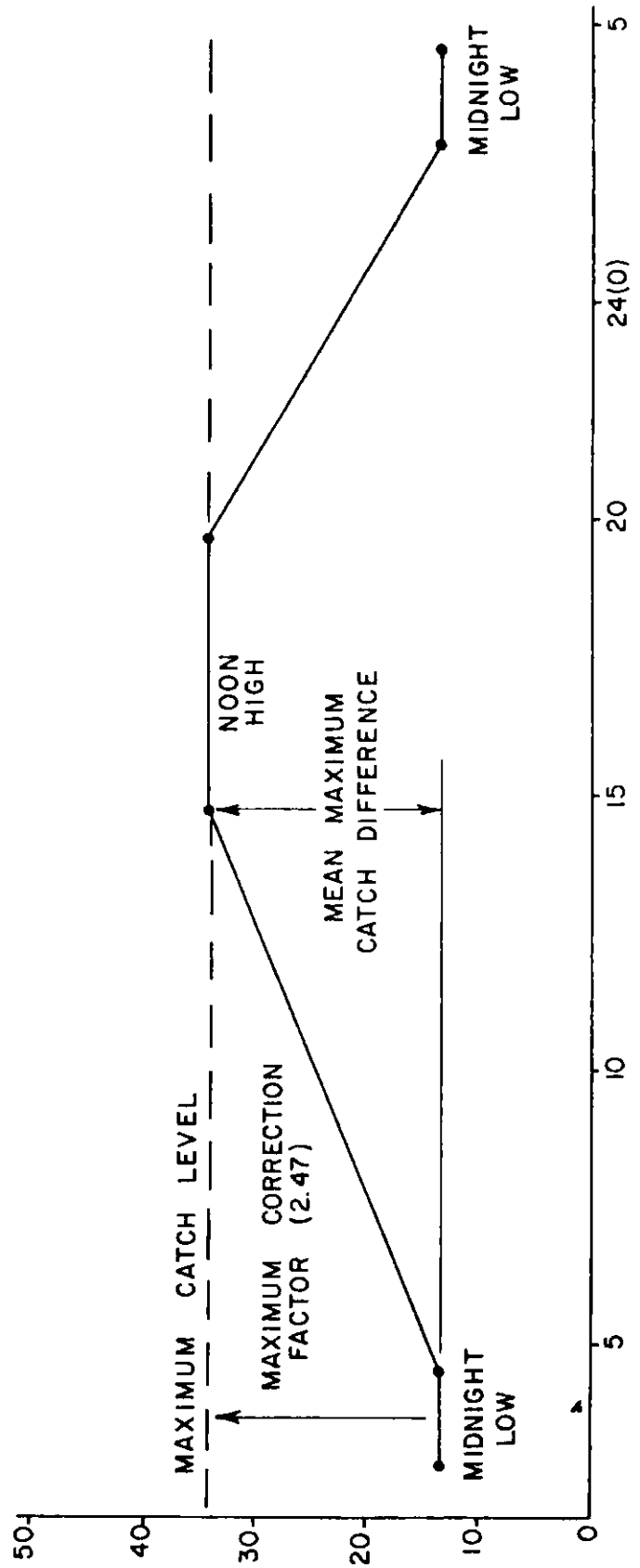

Fig. 7. Derivation of correction factors for diel variation in P. borealis catch.