

Fig. 20. Functional linear regression of Log number of lobster eggs vs. Log of carapace length (car.len.) for each sample site.  
 (— = non-eyed eggs, x = observations, - - - = eyed eggs, o = observations).

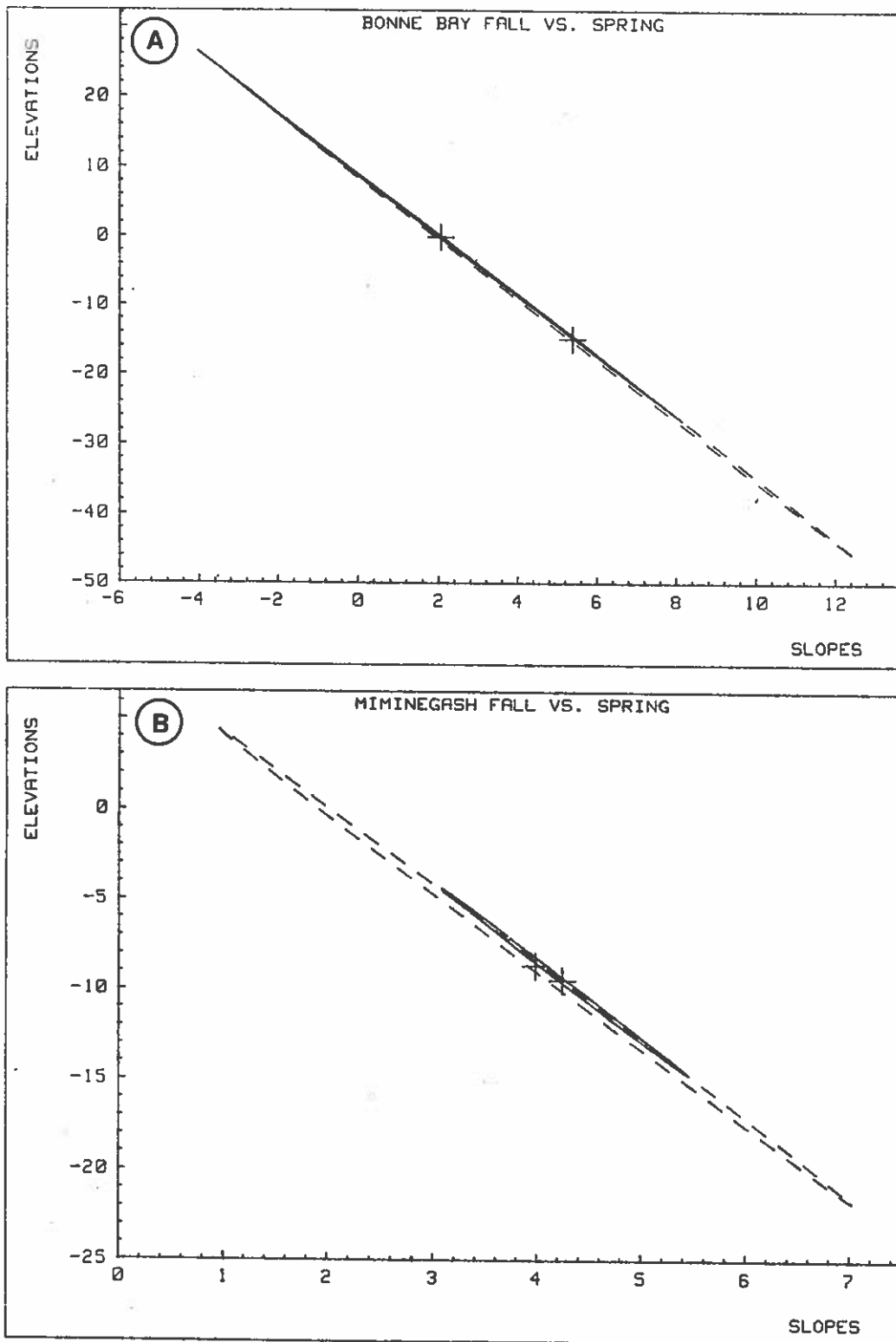


Fig. 19. Ellipses of joint confidence limit for the slopes and intercepts of the linear regression of lobster fecundity, significant to a level of 0.05, for a) Bonne Bay and b) Miminegash, fall vs. spring samples. (— = fall, - - - = spring).

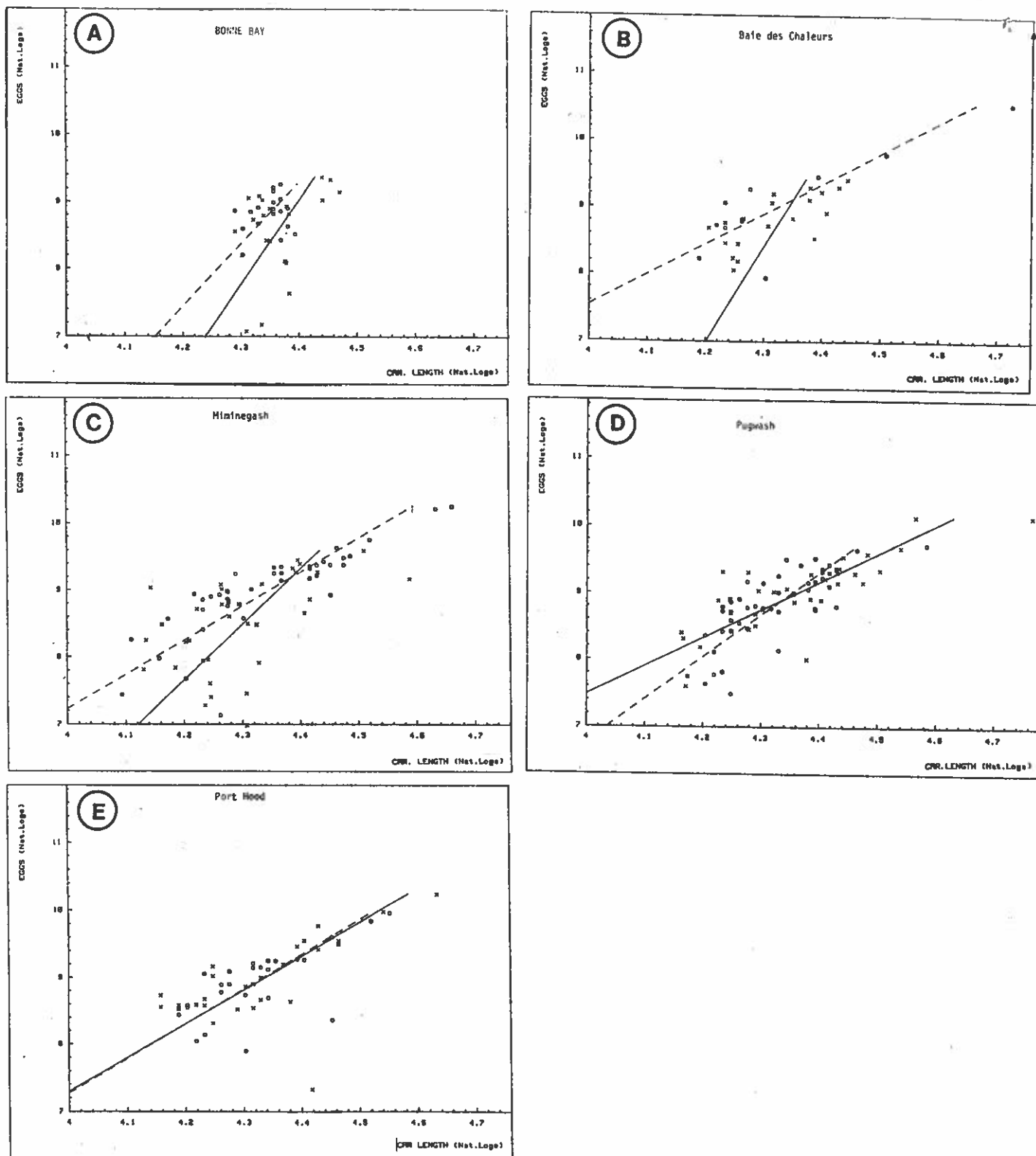


Fig. 18. Functional linear regression of Log number of lobster eggs vs. Log of carapace length (car.len.) for each sample by site.  
 (— = spring sample regression line, x = observations ,  
 - - - = fall sample, o = observations).

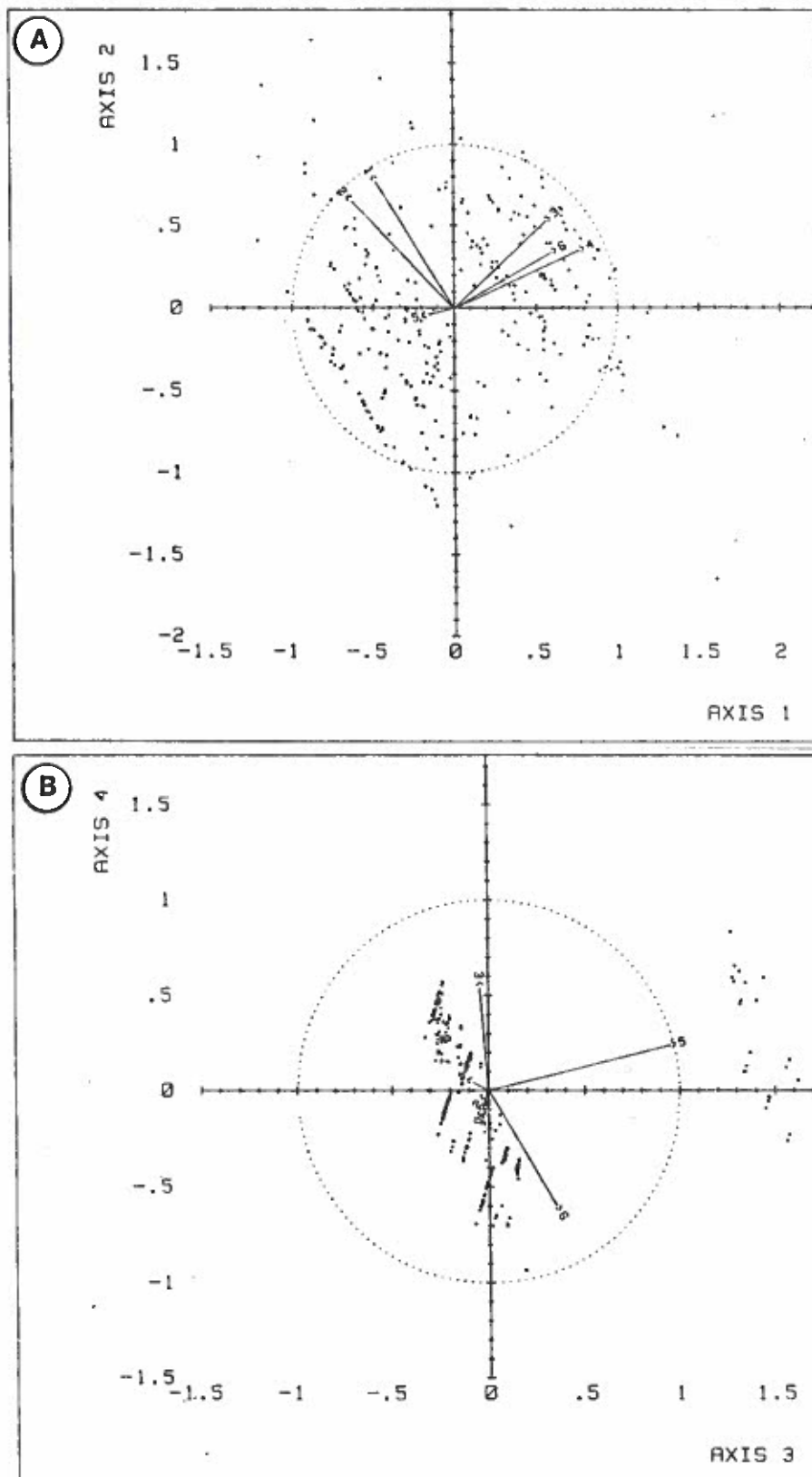


Fig. 17. Graphic principal components analysis of projection on plane defined by axes a) 1 and 2, b) 3 and 4. Each variable is a vector and each "." is an observation (lobster). (variables are; 1=carapace length, 2=number of eggs, 3=EI, 4=sample season, 5=claw loss, 6=geographic location from north to south of the sample sites).

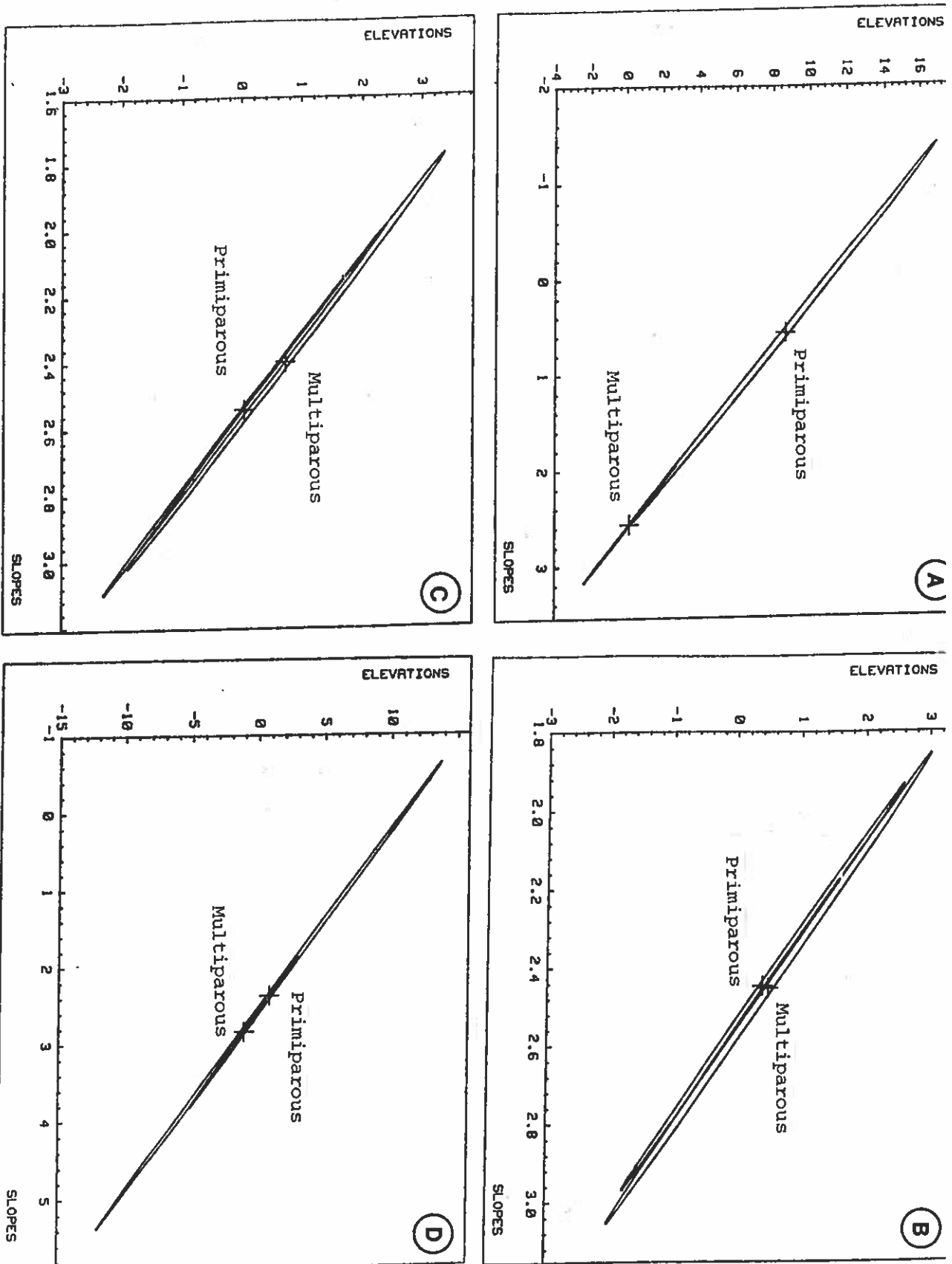


Figure 16. Ellipses of 95% joint confidence region for the slopes and elevations of the size-fecundity linear regression of primiparous and multiparous females within identical sampling and biological conditions. A: Dark orange eggs in the Baie des Chaleurs area in April-May, B: Orange eggs in the Baie des Chaleurs area in August-September, C: Brown eggs in the Baie des Chaleurs area in June-July, D: Brown eggs in the Prince Edward Island area in June-July.

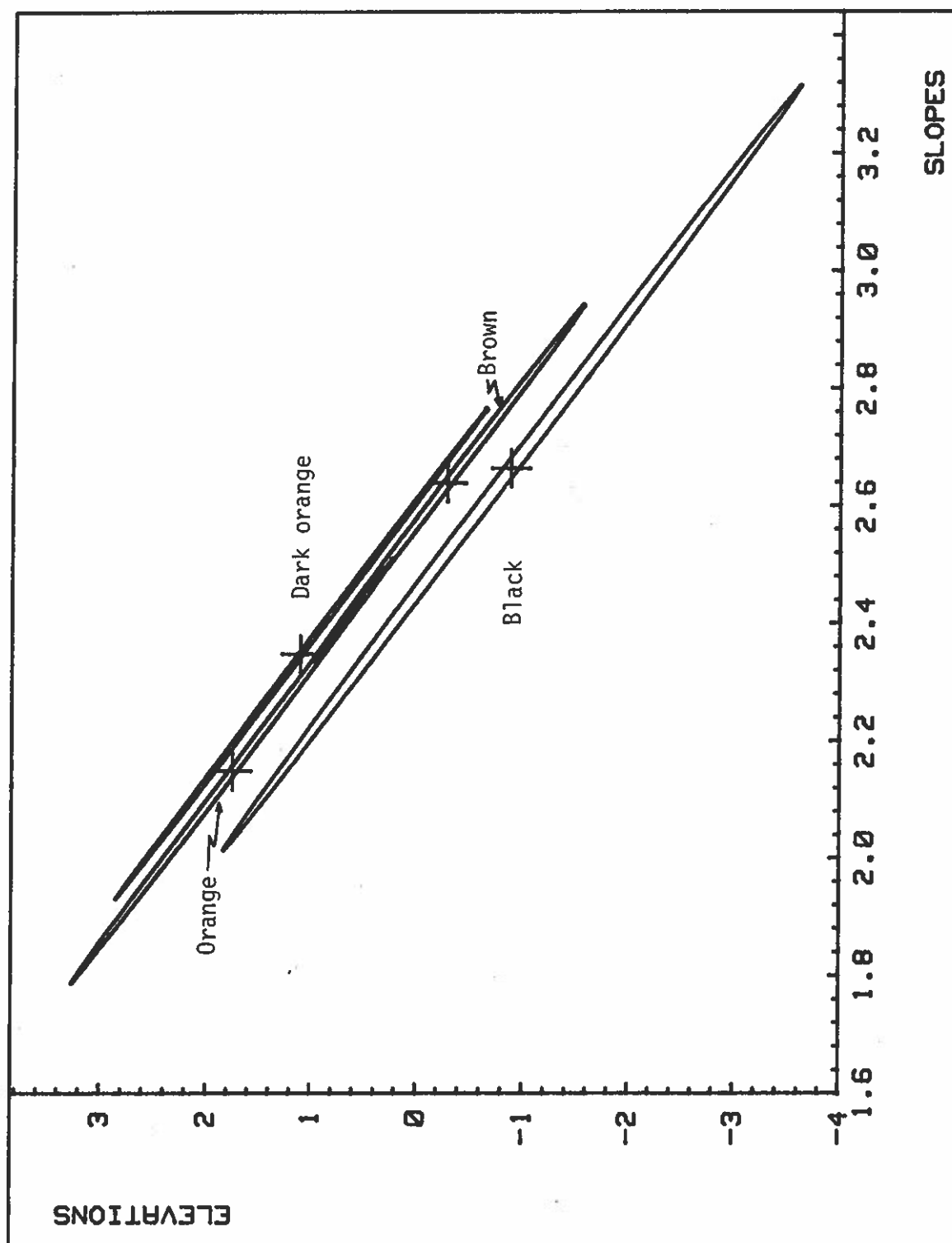


Figure 15. Ellipses of 95% joint confidence region for the slopes and elevations of the size-fecundity linear regression for each egg colour.

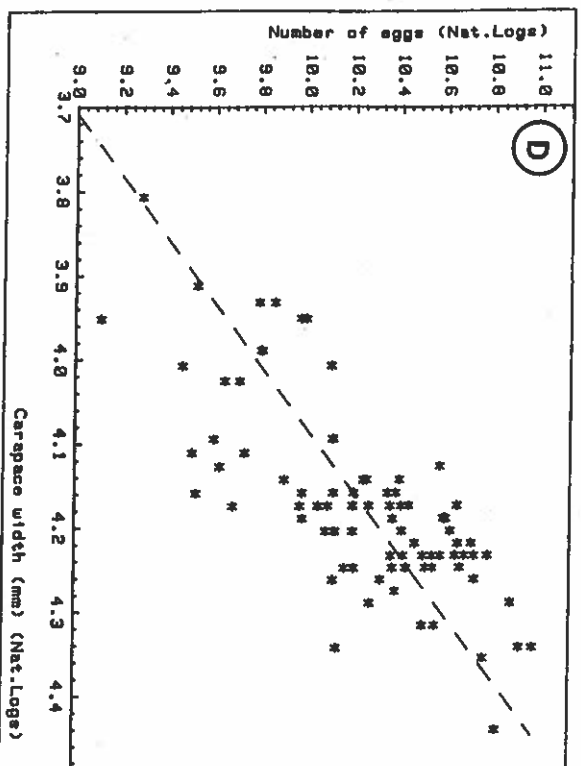
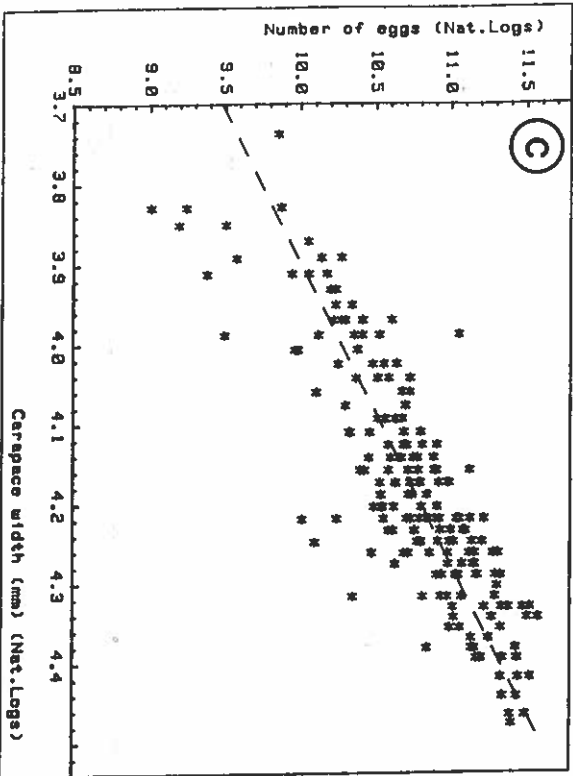
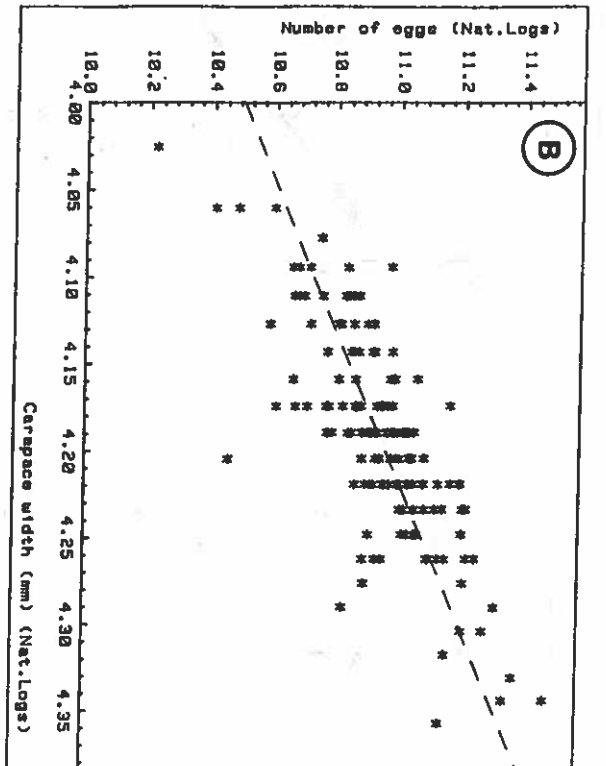
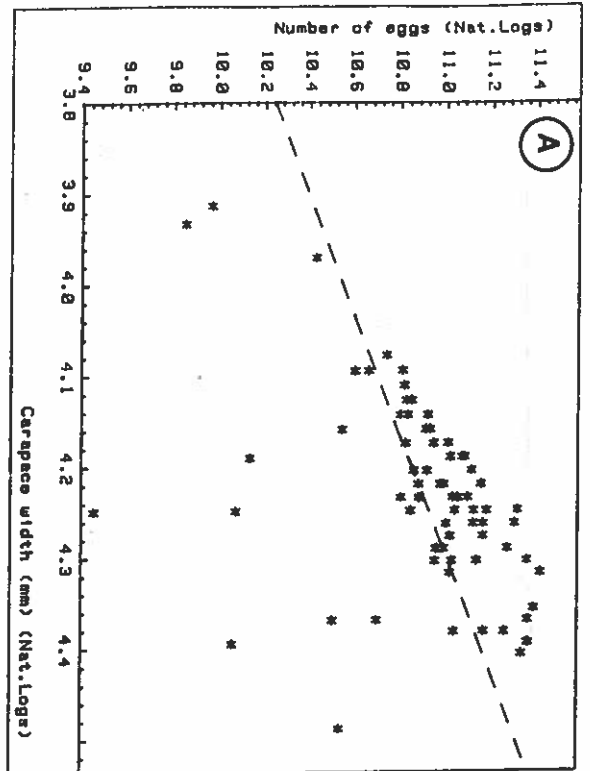


Figure 14. Functional regressions of loge number of eggs versus loge carapace width for each egg colour.

A: Orange eggs, B: Dark orange eggs, C: Brown eggs, D: Black eggs.

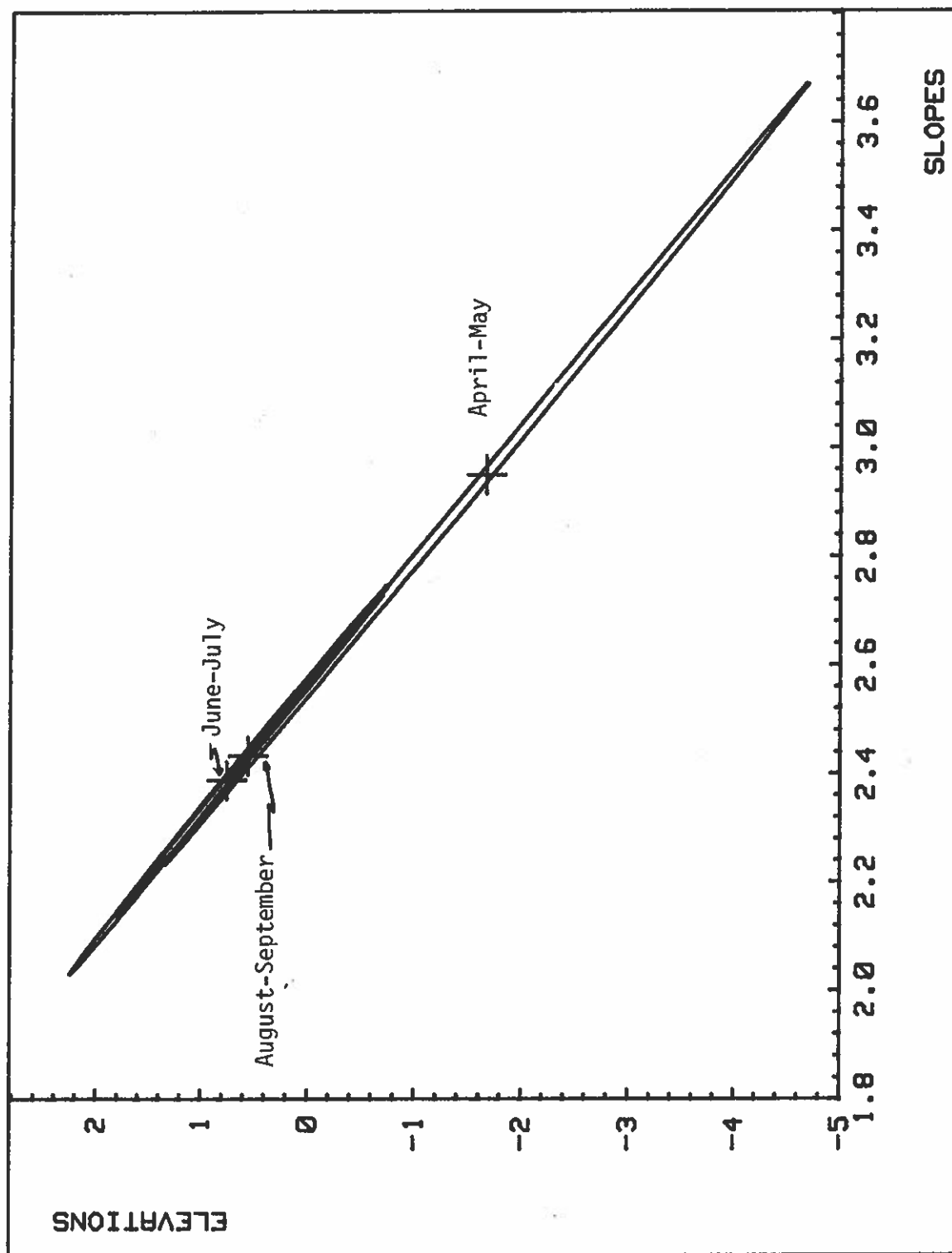


Figure 13. Ellipses of 95% joint confidence region for the slopes and elevations of the size-fecundity linear regression for each sampling season.



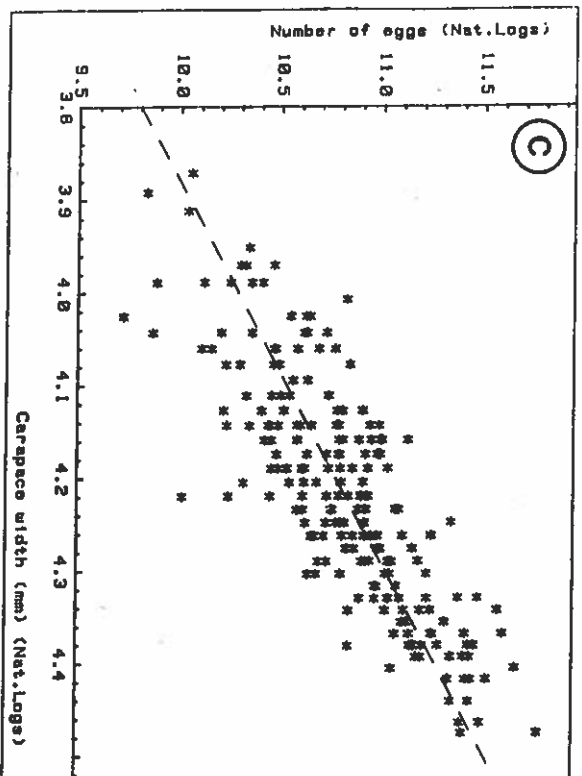
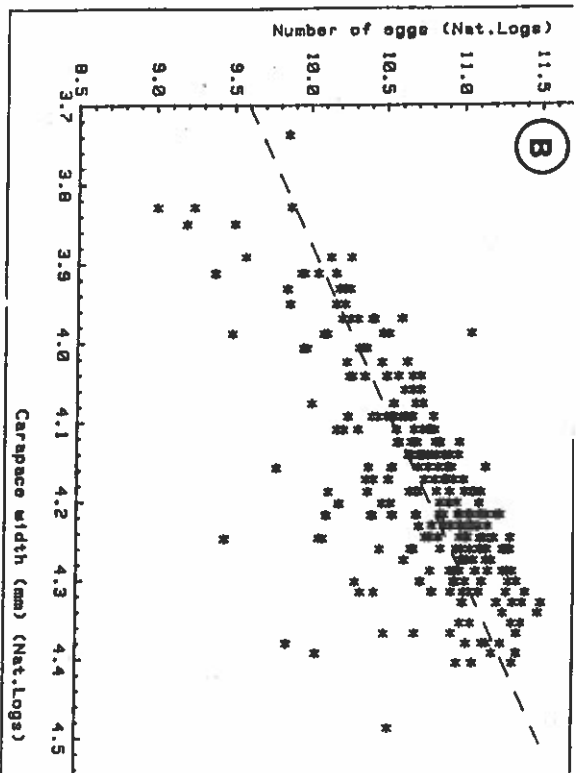
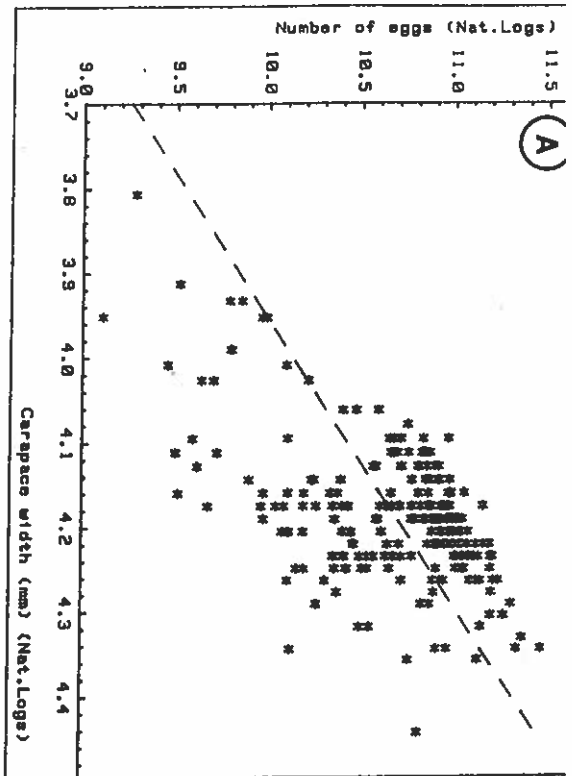


Figure 12. Functional regressions of loge number of eggs versus loge carapace width for each sampling season.

A: April-May, B: June-July, C: August-September

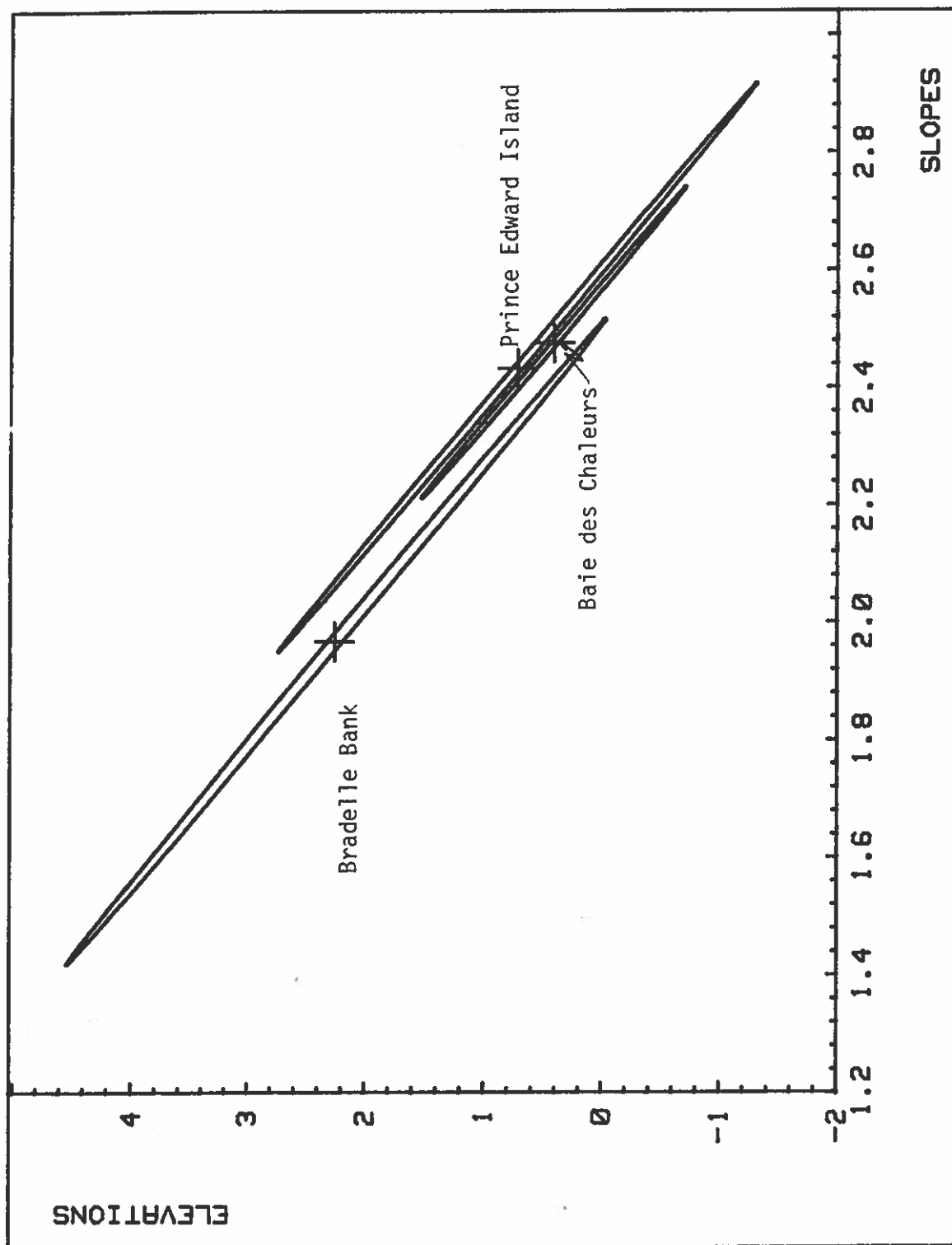


Figure 11. Ellipses of 95% joint confidence region for the slopes and elevations of the size-fecundity linear regression for each sampling location.

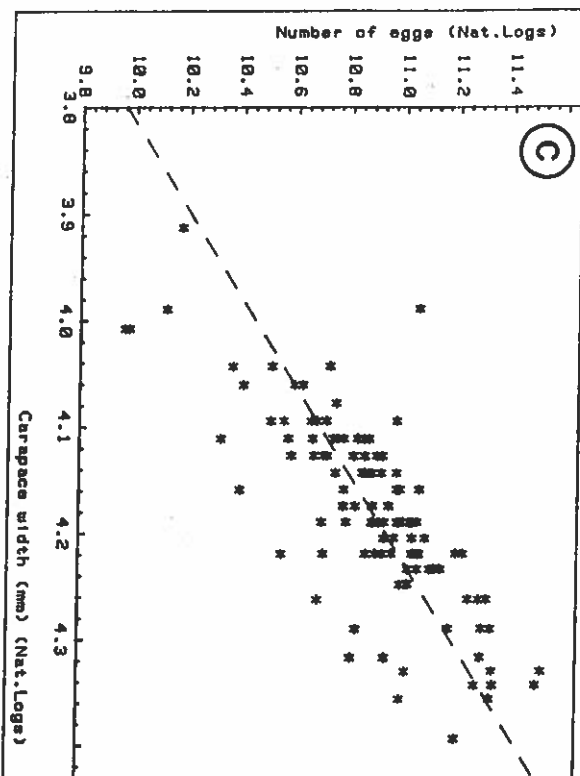
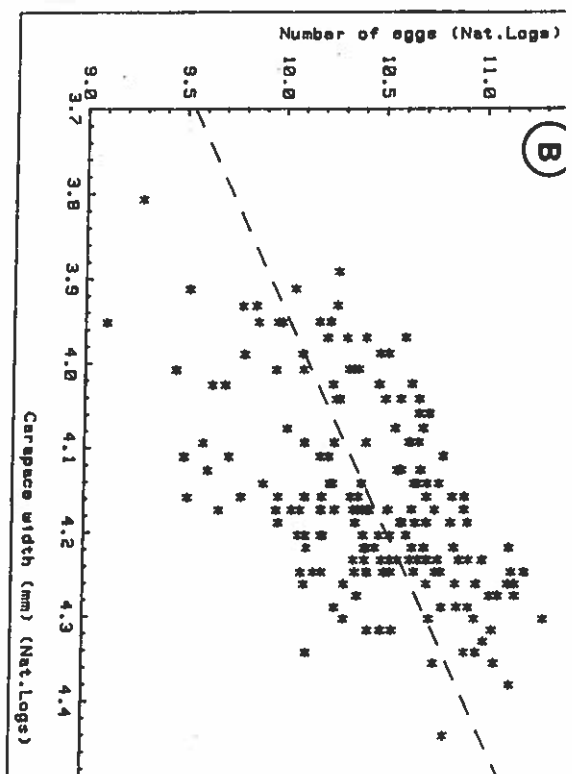
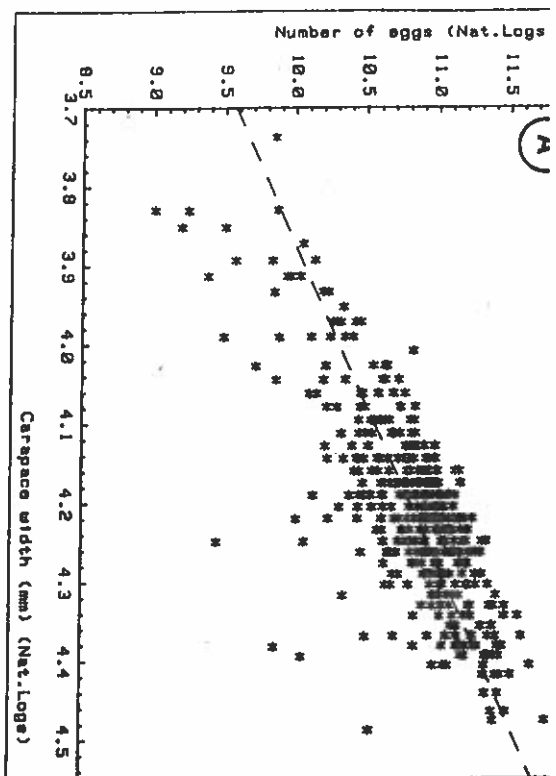


Figure 10. Functional regressions of loge number of eggs versus loge carapace width for each sampling location.

A: Baie des Chaleurs area, B: Bradelles Bank area, C: Prince Edward Island area.

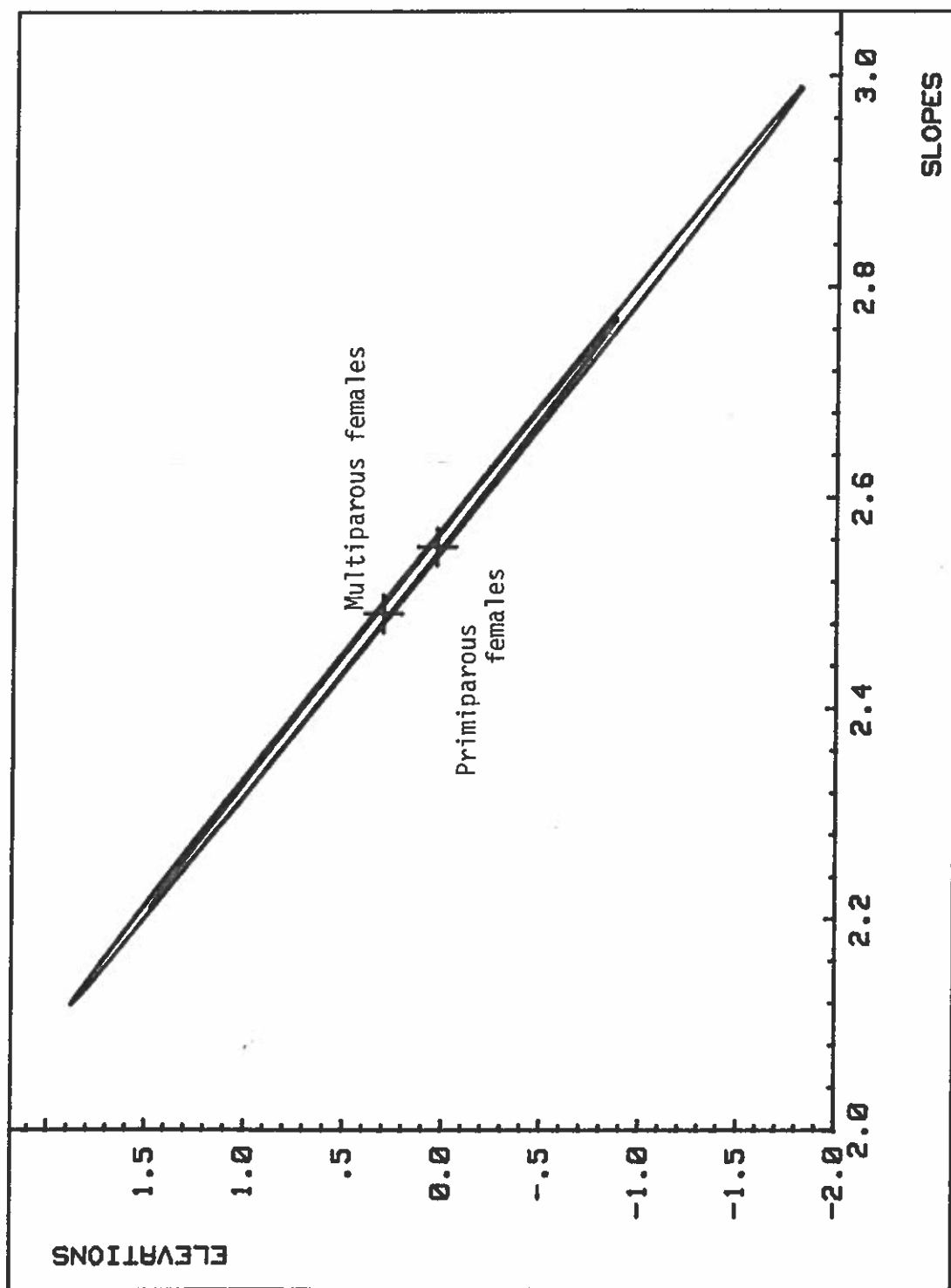


Figure 9. Ellipses of 95% joint confidence region for slopes and elevations of the size-fecundity linear regression of primiparous females and multiparous females.

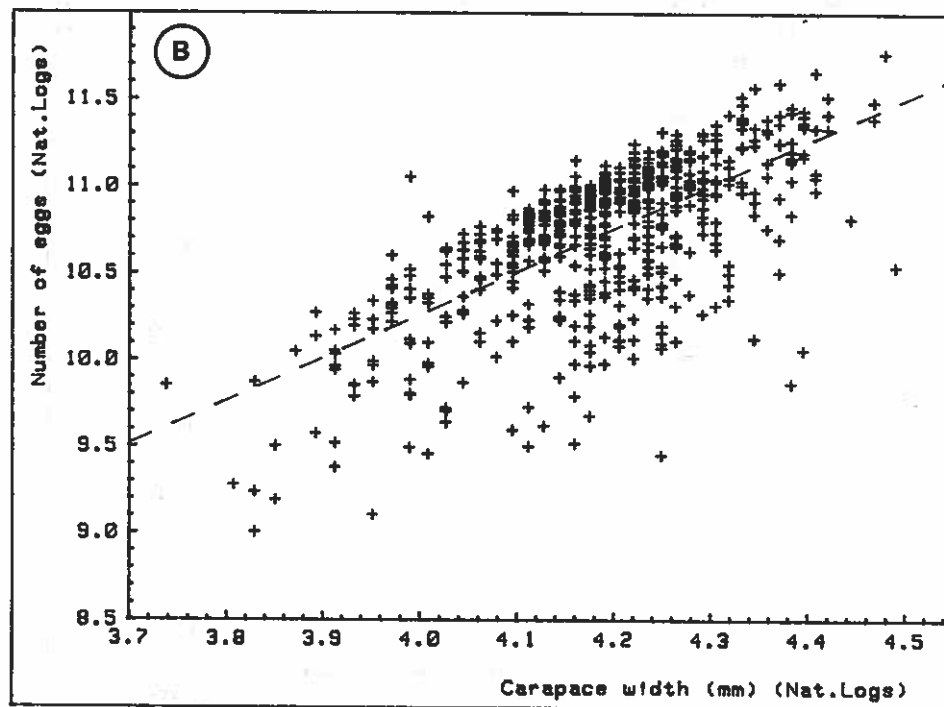
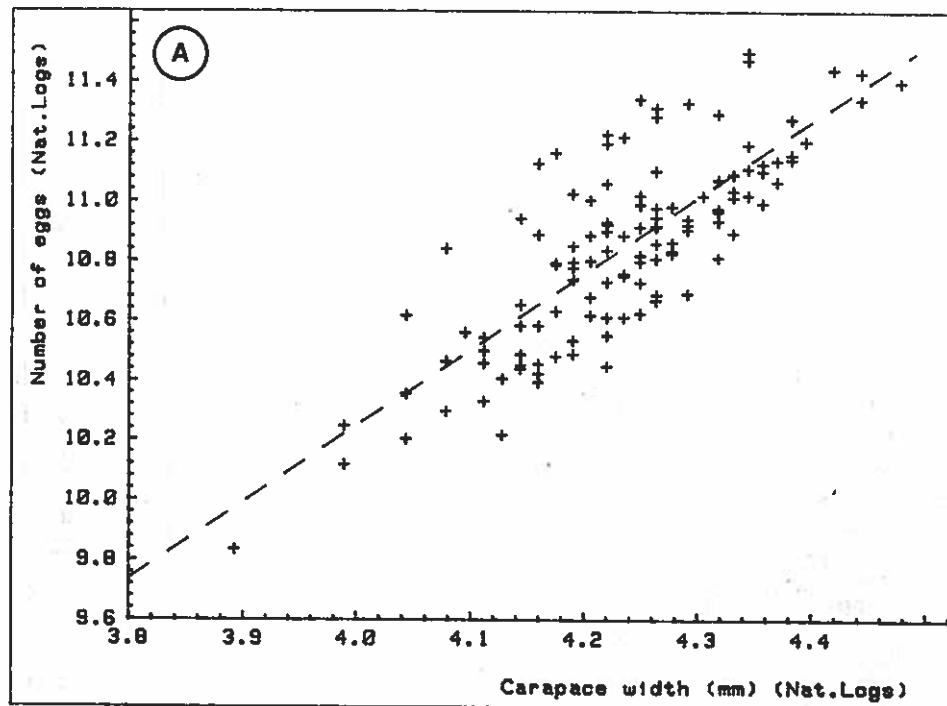


Figure 8. Functional linear regressions of  $\log_e$  number of eggs versus  $\log_e$  carapace width of overall primiparous as well as multiparous females.

A: primiparous female, B: multiparous female

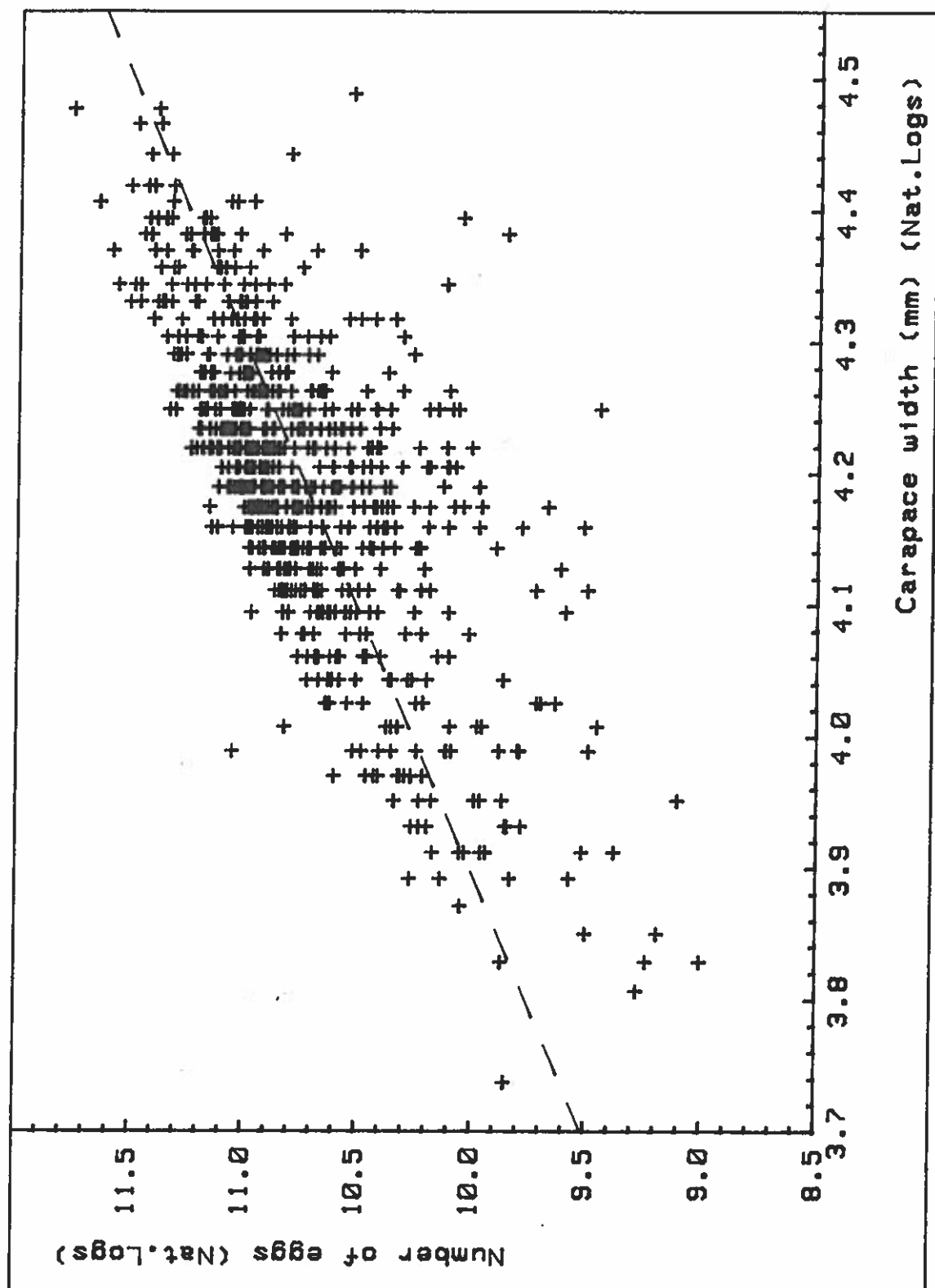


Figure 7. Functional linear regression of loge number of eggs versus loge carapace width of all available data.

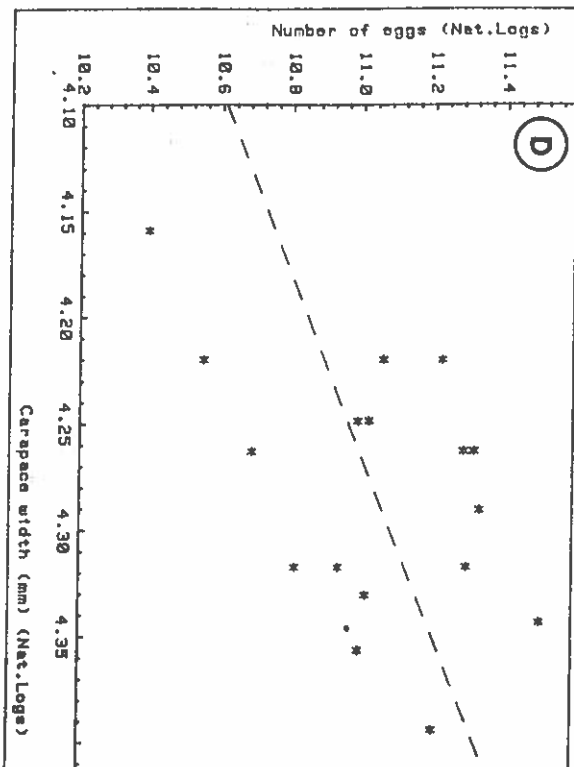
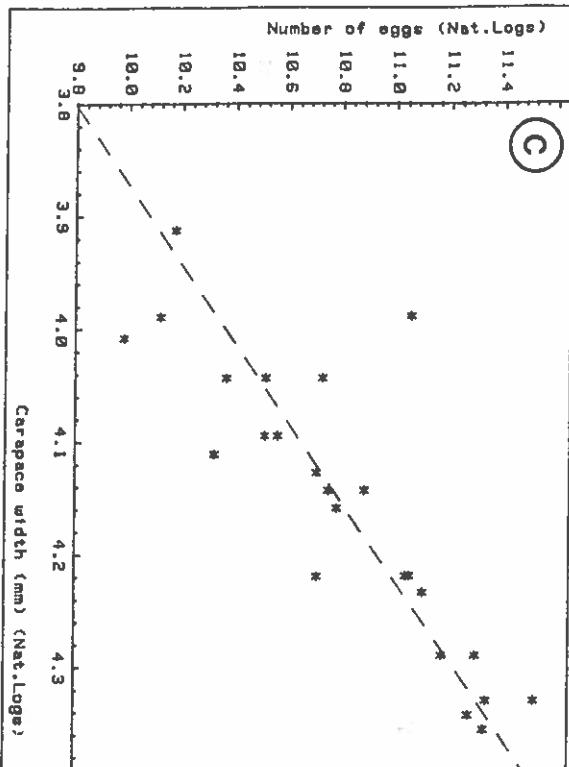
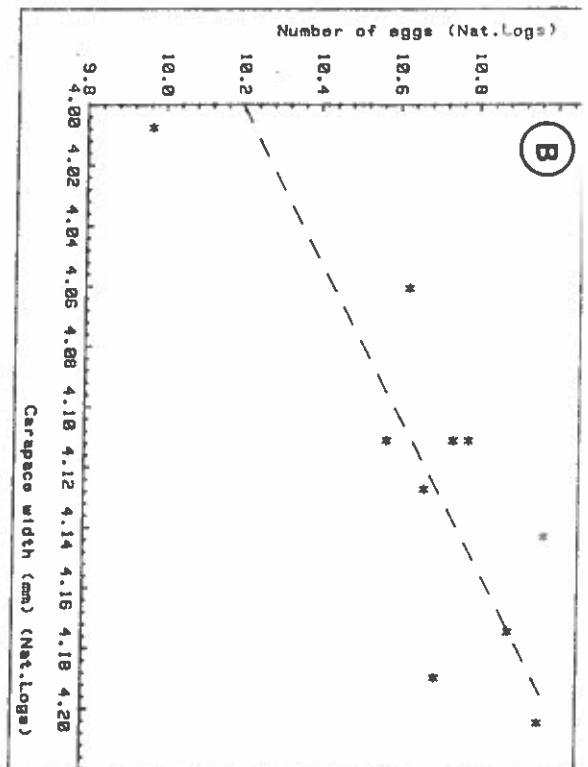
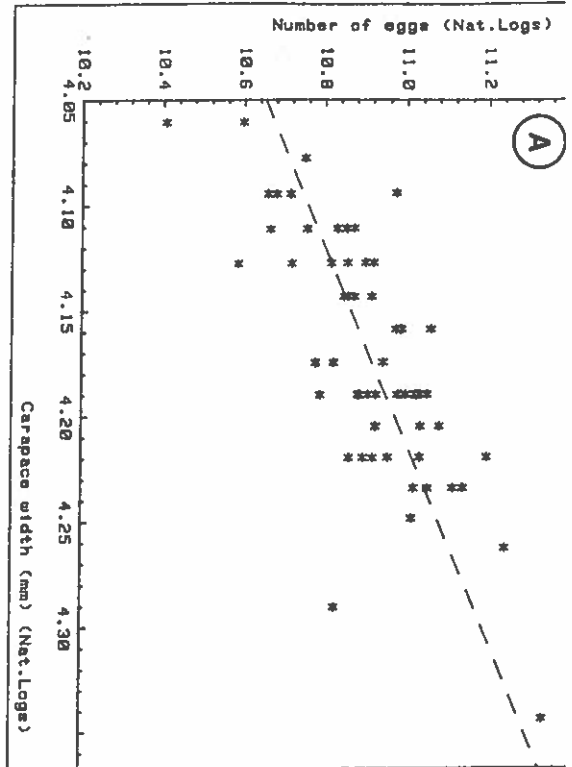


Figure 6. Functional linear regressions of loge number of eggs versus loge carapace width in the Prince Edward Island area.

- A= Multiparous female with dark orange eggs in April-May,
- B= Multiparous female with orange eggs in June-July,
- C= Multiparous female with brown eggs in June-July,
- D= Primiparous female with brown eggs in June-July.

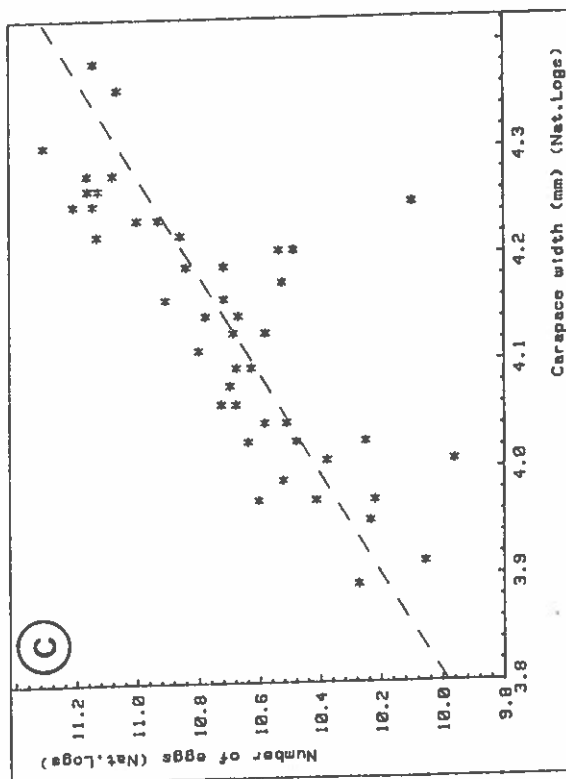
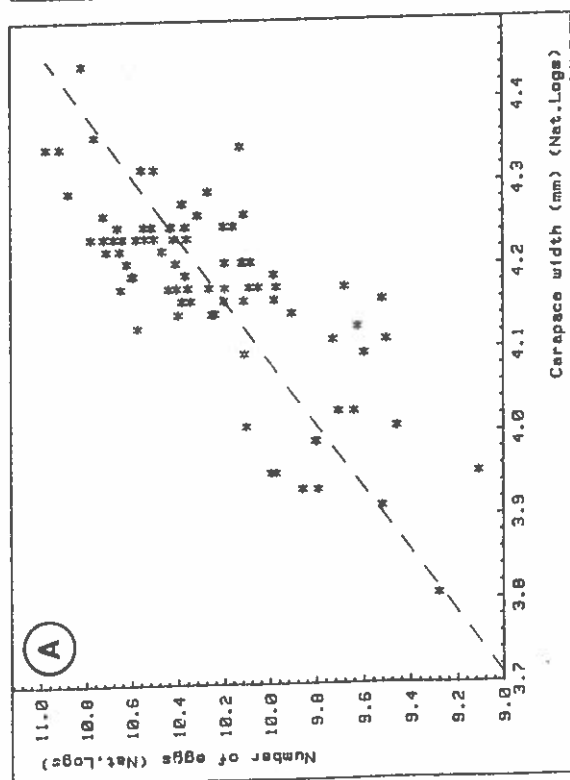
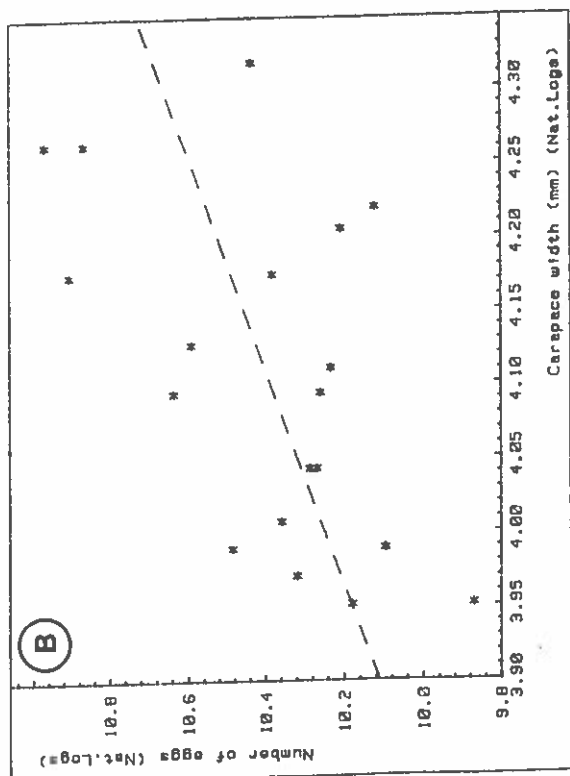


Figure 5. Functional linear regressions of loge number of eggs versus loge carapace width in the Bradelle Bank area.

A= Multiparous female with black eggs in April-May,  
 B= Multiparous female with orange eggs in June-July,  
 C= Multiparous female with brown eggs in June-July.



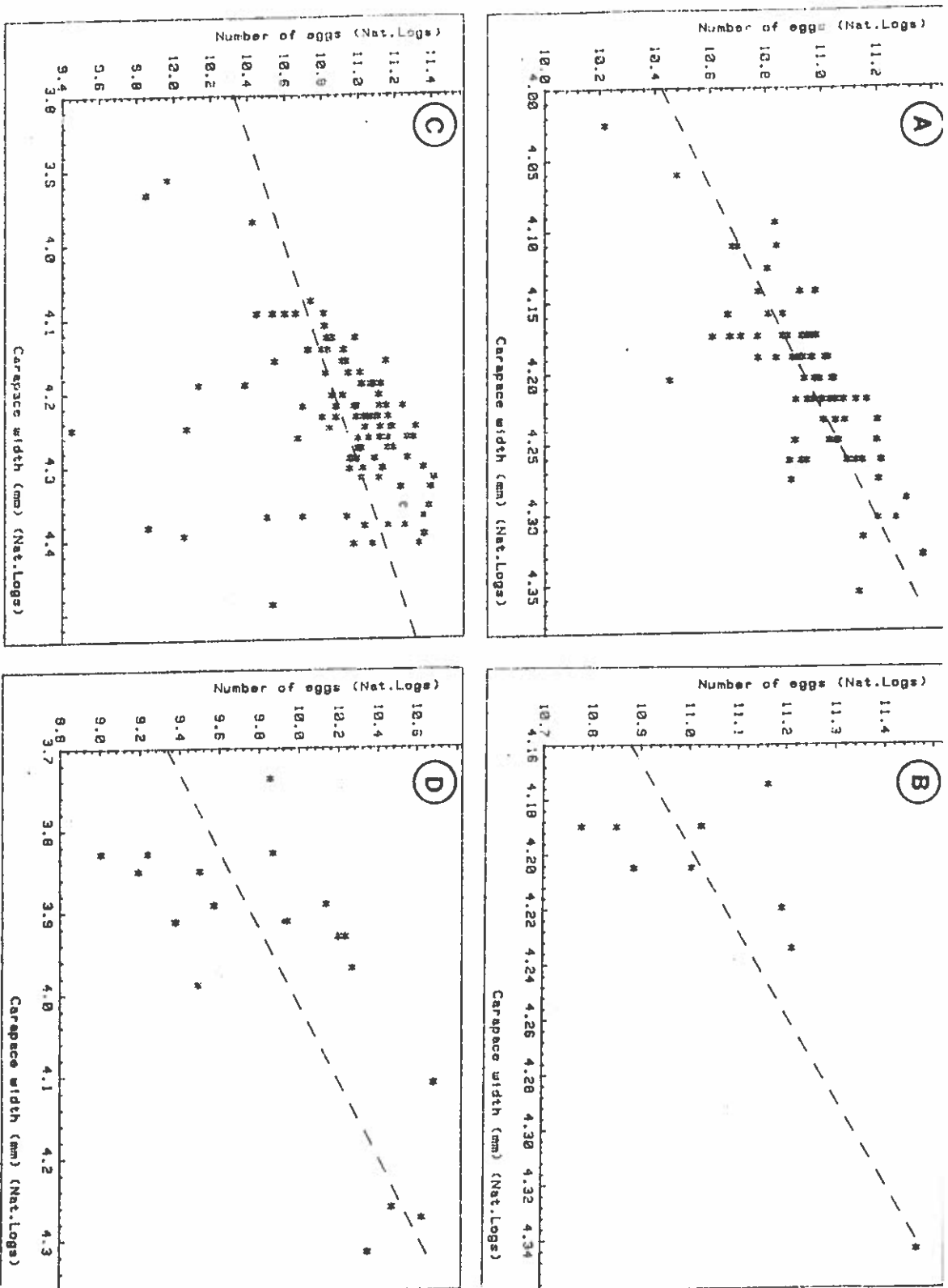


Figure 3. Functional linear regressions of  $\log_e$  number of eggs versus  $\log_e$  carapace width in the Baie des Chaleurs area:

A: Multiparous female with dark orange eggs in April-May, B: Primitiparous female with orange eggs in June-July, C: Multiparous female with orange eggs in April-May, D: Multiparous female with brown eggs in June-July.

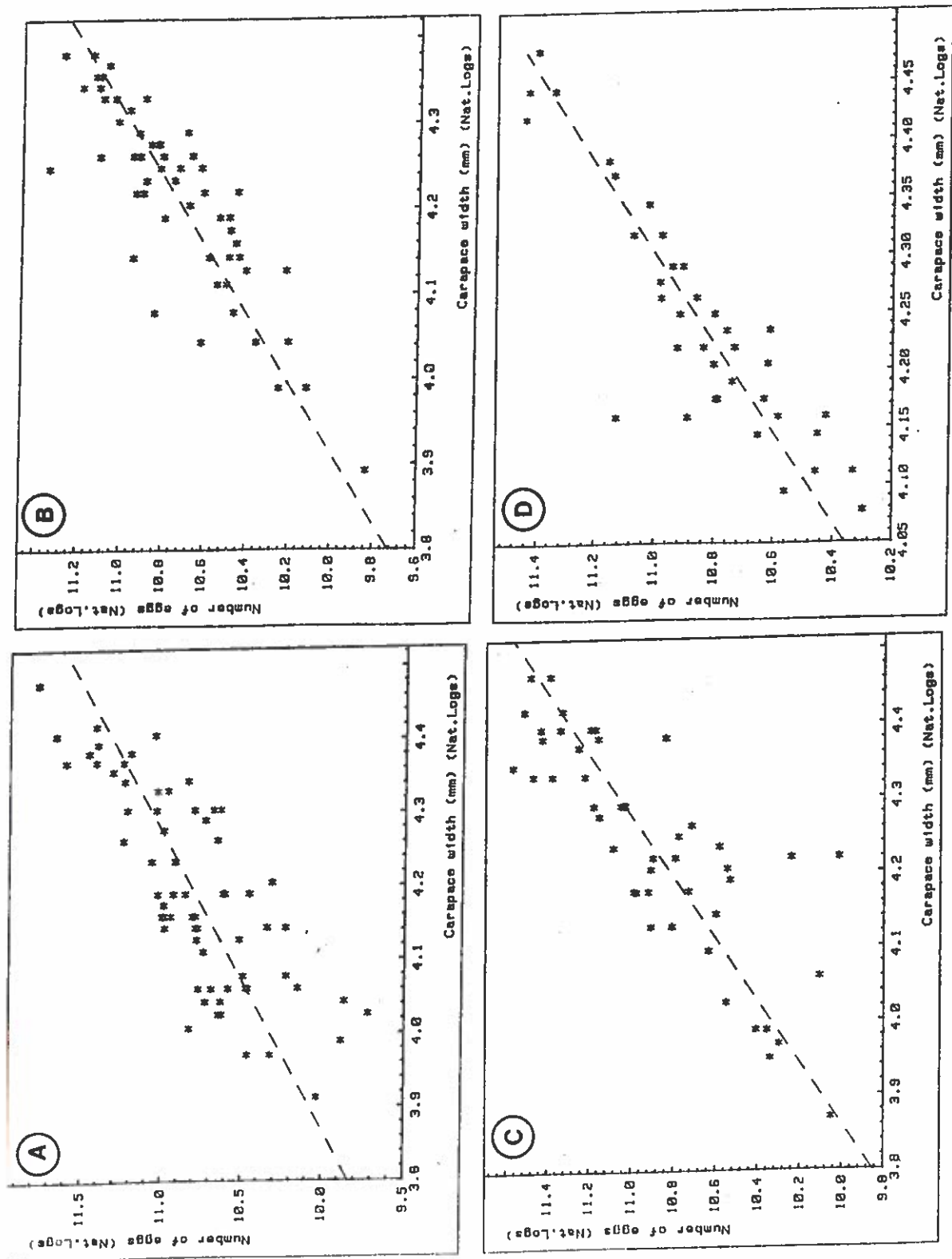


Figure 4. Functional linear regressions of  $\log_e$  number of eggs versus  $\log_e$  carapace width in the Baie des Chaleurs area.

A: Multiparous female with orange eggs in August-September, B: Primpiparous female with orange eggs in August-September, C: Multiparous female with brown eggs in August-September, D: Primpiparous female with brown eggs in August-September.

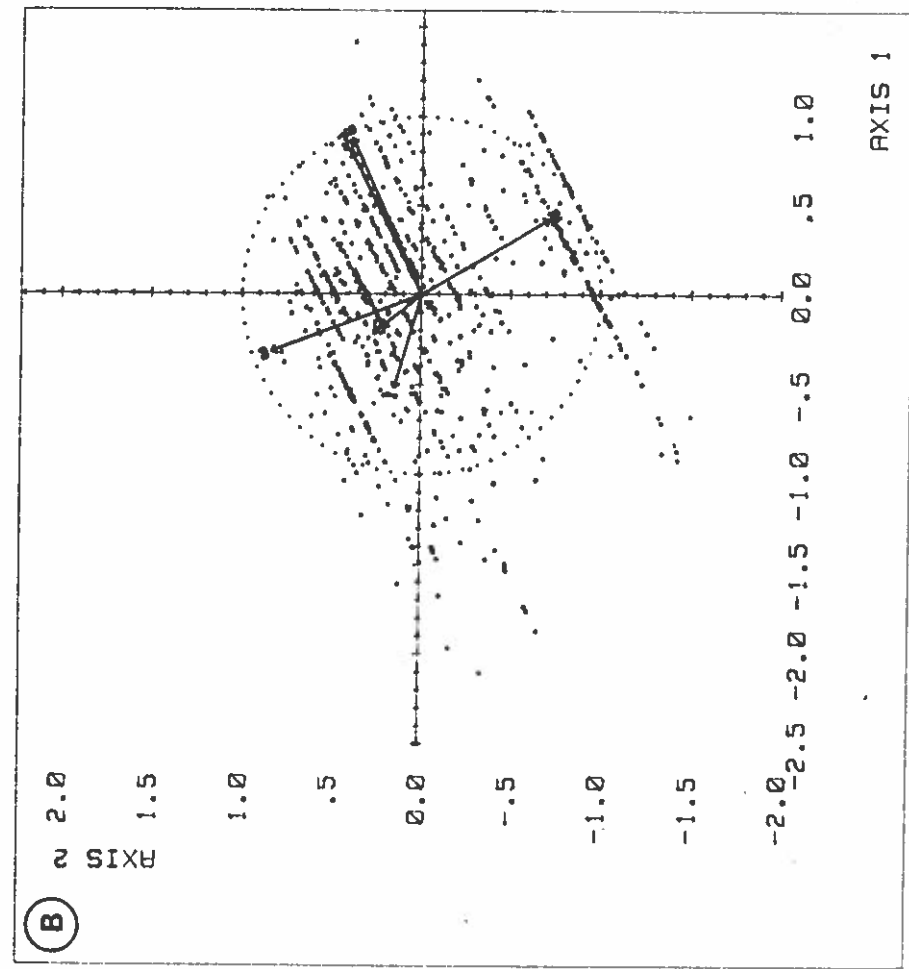
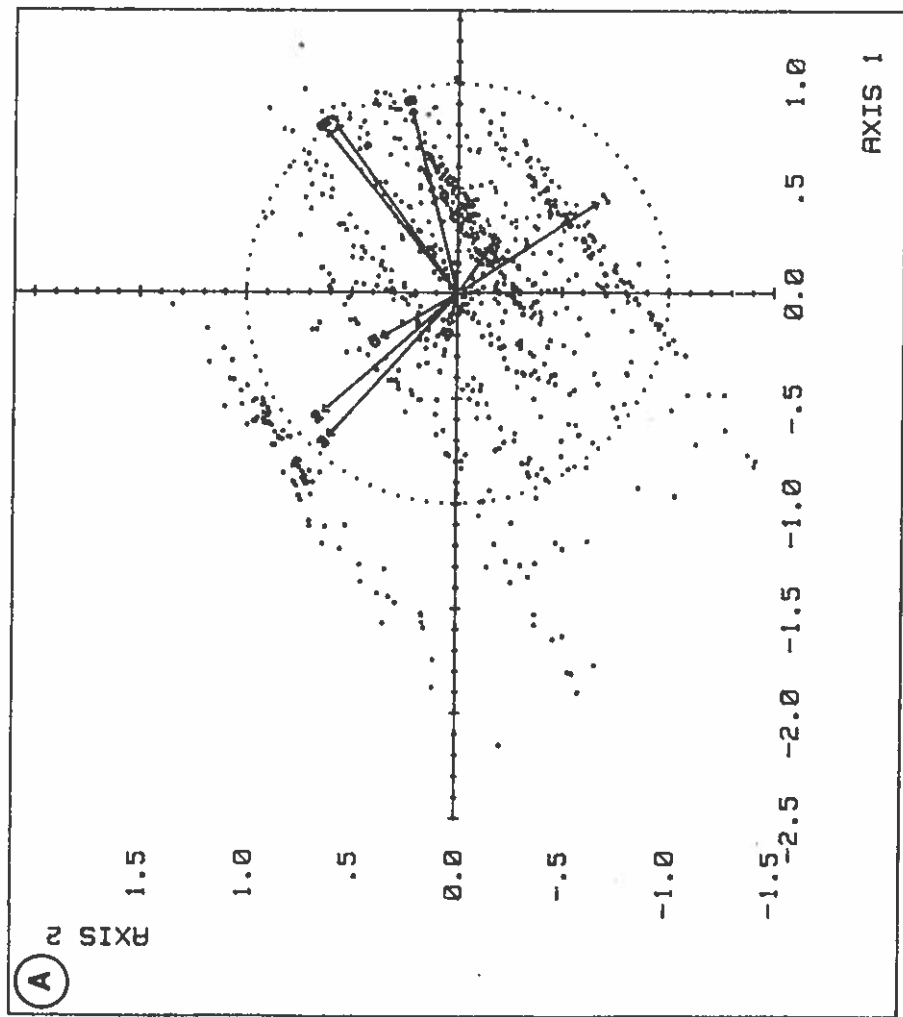


Figure 2. Graphic output of the Principal Component Analysis of observations and logarithms of morphometric measurements (Plot in the plane defined by the first and second Principal Components).

A: with 9 variables

1= Sampling location, 2=Egg colour, 3= sampling year, 4= Sampling month, 5= spawning type, 6= number of missing legs, 7= Carapace width, 8= width of the 5th abdominal segment, 9= Fecundity.

B: with 6 variables

1= Egg colour, 2= Sampling month, 3= Spawning type, 4= Number of missing legs, 5= width of the 5th abdominal segment, 6= Fecundity.

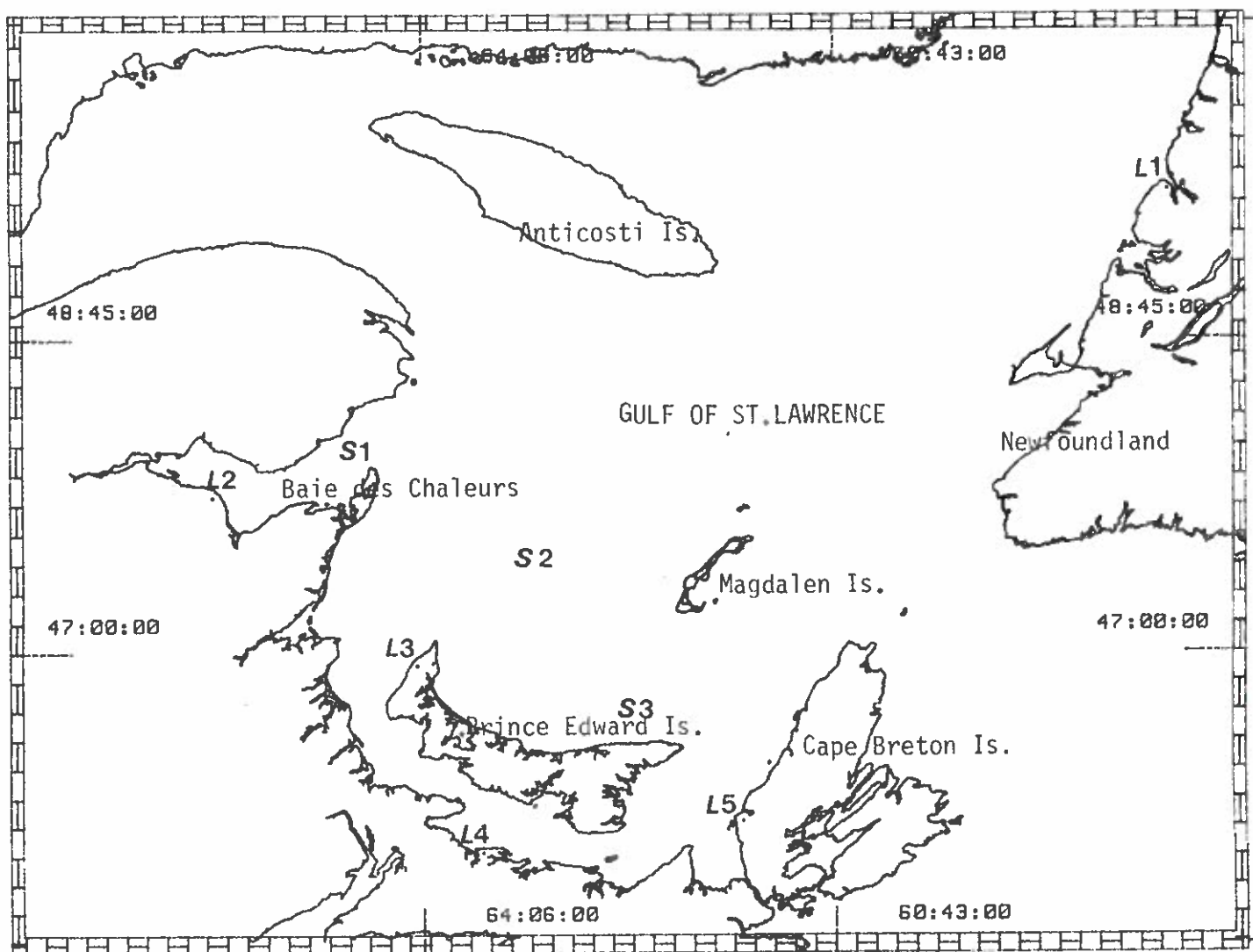


Figure 1. Geographic locations of sampling sites

For lobster L1: Bonne Bay, L2: Baie des Chaleurs,  
 L3: Miminegash, L4: Pugwash, L5: Port Hood  
 For snow crab S1: Baie des Chaleurs, S2: Bradelle  
 Bank, S3: Prince Edward Island

Table 12. Results of independent t-tests to determine if the lobsters bearing of eyed and non-eyed eggs have a significantly different mean carapace size. Fall samples.

<u>Group</u>	<u>N</u>	<u>Mean</u>	<u>SD</u>
Baie des Chaleurs, Fall eyed	5	85.6	17.401
Baie des chaleurs, Fall non-eyed	5	69.2	2.387
<u>P=0.070</u>			
Miminegash, Fall eyed	9	80.0	11.391
Miminegash, Fall Non-eyed	30	77.0	10.297
<u>P=0.497</u>			
Pugwash, Fall eyed	12	76.3	4.901
Pugwash, Fall non- eyed	39	76.2	7.077
<u>P=0.992</u>			
Port Hood, Fall eyed	14	76.3	8.922
Port Hood, Fall non- eyed	14	73.0	8.700
<u>P=0.333</u>			

Table 10. ANOVA comparisons of Log lobster egg count Log / Log carapace length for eyed and non-eyed samples from each site. (NSD=no significant difference at 0.05, DIF=0.01<P<0.05)

<u>Samples compared</u>	<u>Slope</u>	<u>Intercept</u>
Baie des Chaleurs, eyed vs. non-eyed	NSD	NSD
Miminegash, eyed vs. non-eyed	NSD	DIF
Pugwash, eyed vs. non-eyed	NSD	NSD

Table 11. Lobster EI characteristics for each sample and the mean number of weeks required to hatch the eggged eggs at an observed ambient temperature.

<u>Sample</u>	<u>%non-eyed eggs</u>	<u>%eyed eggs</u>	<u>weeks required to hatch eyed eggs at observed temperatures</u>
Bonne Bay, fall	5.3	94.7	52
Bonne Bay, spring	0	100.0	11
Baie des Chaleurs, fall	50.0	50.0	24
Baie des Chaleurs, spring	23.0	77.0	9
Miminegash, fall	76.9	10.2	46
		12.9	11
Miminegash, spring	0	100.0	7
Pugwash, fall	87.5	12.5	37
Pugwash, spring	0	100.0	8
Port Hood, fall	39.2	25.0	43
		35.8	22
Port Hood, spring	3.0	97.0	9

Table 8. Multiple ANOVA comparisons of Log lobster egg count/ Log carapace length of the fall and spring samples for each site. (NSD=no significant difference at 0.05, DIF=0.01<P<0.05, SD=P<0.01)

<u>Samples compared</u>	<u>Slope</u>	<u>Intercept</u>
Fall samples, Bonne Bay, Baie des Chaleurs, Miminegash, Pugwash, Port Hood	SD	---
Spring samples, Bonne Bay, Baie des Chaleurs, Miminegash, Pugwash, Port Hood	NSD	SD

Table 9. Regression equations (predictive) of Log lobster egg counts versus carapace lengths data regrouped by site and season, eyed and non-eyed eggs.

<u>Sample</u>	<u>n</u>	<u>Carapace length range (mm)</u>	<u>Predictive regression equation</u>	<u>R</u>
Baie des Chaleurs, Fall eyed	5	69-113	$y = -11.2001 + 4.6221x$	0.89
Baie des Chaleurs, Fall non-eyed	5	66-72	$y = -32.1485 + 9.6716x$	0.84
Baie des Chaleurs, Spring eyed	16	67-85	$y = -5.6014 + 3.3554x$	0.73
Baie des Chaleurs, Spring non- eyed	4	70-77	$y = -18.6093 + 6.3348x$	0.70
Miminegash Fall eyed	9	67-103	$y = -19.0767 + 6.3771x$	0.88
Miminegash Fall non-eyed	30	60-106	$y = -9.2585 + 4.2354x$	0.77
Pugwash Fall eyed	18	69-83	$y = -11.08597 + 4.6196x$	0.58
Pugwash Fall non-eyed	33	65-98	$y = -12.7258 + 4.9802x$	0.84
Port Hood Fall eyed	10	66-95	$y = -6.9464 + 3.7211x$	0.97
Port Hood Fall non-eyed	18	67-86	$y = -3.7958 + 2.9190x$	0.48

Table 6. Regression equations (predictive) of lobster egg count versus carapace length. Data regrouped by site, season and year.

<u>Sample</u>	<u>n</u>	<u>Carapace length range (mm)</u>	<u>Predictive regression equation</u>	<u>R</u>
Bonne Bay, Fall 1987	18	73-81	$y = -0.1047 + 2.0545x$	0.22
Bonne Bay, Spring 1988	21	73-87	$y = -14.8951 + 5.38318x$	0.42
Baie des Chaleurs, Fall 1987	10	66-113	$y = -7.6292 + 3.8497x$	0.84
Baie des Chaleurs, Spring 1988	20	67-85	$y = -7.7579 + 3.8389x$	0.72
Miminegash, Fall 1987	39	60-106	$y = -8.6732 + 4.24706x$	0.84
Miminegash, Spring 1988	39	62-98	$y = -8.6732 + 3.9844x$	0.48
Pugwash, Fall 1987	51	62-98	$y = -12.5148 + 4.9378x$	0.78
Pugwash, Spring 1988	34	64-117	$y = -5.6342 + 3.3558x$	0.79
Port Hood Fall, 1988	28	66-95	$y = -6.7456 + 3.6286x$	0.70
Port Hood Spring, 1989	29	64-103	$y = -5.7622 + 3.4036x$	0.68

Table 7. ANOVA comparisons of Log lobster egg count/ Log carapace length for fall (recently extruded) and spring (about to hatch) samples from each site. (NSD=no significant difference at 0.05, DIF=0.01<P<0.05, SD=P<0.01)

<u>Samples compared</u>	<u>Slope</u>	<u>Intercept</u>
Baie des Chaleurs, fall vs. spring	NSD	NSD
Pugwash, fall vs. spring	DIF	NSD
Port Hood, fall vs. spring	NSD	NSD



Table 5a. Percentage of variance explained by the PCA for all variables observed on 293 lobsters examined. The contributions of are well distributed between the different axes.

<u>Axis</u>	<u>Percentage of variance</u>
1	31.76
2	25.52
3	17.20
4	11.84
5	7.80
6	5.88

Table 5b. Correlations between variables (columns) associated with lobster fecundity principal axes (rows).

<u>Axes</u>	<u>Size</u>	<u>eggs</u>	<u>EI</u>	<u>season</u>	<u>c l a w loss</u>	<u>geo</u>
1	-.4815	-.6293	.5619	.7646	-.1554	.5938
2	.7666	.6476	.5302	.3539	-.0380	.3405
3	-.0324	-.0123	-.0423	-.0764	.9498	.3478
4	-.1002	-.1539	.5351	.0419	.2414	-.594
5	.0287	.0788	-.3381	.5311	.1130	-.227
6	-.4103	.4217	.0245	.0113	-.0315	.0683

Table 2. Contribution of the principal components (% variance) for snow crab.

Axis	Percentage of variances
1	30.52
2	24.33
3	17.73
4	14.87
5	8.16
6	4.39

Table 3. Correlation between variables and principal components for snow crab.

AXES	VARIABLES					
	1	2	3	4	5	6
1	-.48352	.410702	-.30273	-.15119	.770768	.848606
2	.141139	-.68352	.802103	.188598	.385380	.380858
3	-.44616	.233163	.154095	.872667	-.15812	-.01299
4	.724878	.323974	-.09083	.362682	.348033	-.02767
5	-.00195	.452132	.481712	-.21908	-.06512	-.02797
6	.147574	.019333	-.03067	.021853	-.32713	.364806

VARIABLE 1=Egg color ; VARIABLE 2=Sampling month ; VARIABLE 3=Primiparous / Multiparous ; VARIABLE 4=Number of missing legs ; VARIABLE 5=Width of the 5th abdominal segment ; VARIABLE 6=Fecundity (Number of eggs).

Table 4. ANOVA comparisons of egg count/carapace width for each group of snow crab samples. (NSD=No significant difference), DIF=Significant difference, H=Homogeneous, NH=Not homogeneous)

Reference*	Homogeneity of residual mean squares	Slope	Elevation	Ellipses
1	H	NSD	DIF	-
2	H	NSD	NSD	TOUCH
3	H	DIF	-	-
4	NH	-	-	TOUCH
5	NH	-	-	TOUCH
6	H	NSD	NSD	TOUCH
7	NH	-	-	TOUCH
8	NH	-	-	TOUCH

\* 1=Baie des Chaleurs, Total vs Bradelle Bank, Total vs P.E.I., Total ; 2=April-May, Total vs June-July, Total vs August-September, Total ; 3=Orange, Total vs Dark orange, Total vs Brown, Total vs Black, Total ; 4=Primiparous, Total vs Multiparous, Total ; 5=Primiparous vs Multiparous (April-May, Dark orange, Baie des Chaleurs) ; 6=Primiparous vs Multiparous (June-July, Brown, P.E.I.) ; 7=Primiparous vs Multiparous (August-September, Orange, Baie des Chaleurs) ; 8=Primiparous vs Multiparous (August-September, Brown, Baie des Chaleurs).

Table 1 . Regression equations (predictive) of egg count versus carapace width for each snow crab sample .

Reference*	n	Carapace width range (mm)	Predictive regression equation	R
1	76	56-78	$y = .1891 + 2.5587x$	0.78
2	9	65-77	$y = -2.8093 + 3.2904x$	0.77
3	101	50-89	$y = 5.2291 + 1.3426x$	0.38
4	18	42-75	$y = 1.4818 + 2.1222x$	0.70
5	67	50-88	$y = .5033 + 2.4556x$	0.79
6	55	49-80	$y = .4155 + 2.4503x$	0.85
7	47	48-87	$y = .7420 + 2.3979x$	0.82
8	37	59-88	$y = .0618 + 2.5426x$	0.89
9	83	45-85	$y = -.8780 + 2.6632x$	0.75
10	50	51-76	$y = 3.3602 + 1.7259x$	0.61
11	45	49-80	$y = 1.8593 + 2.1378x$	0.78
12	59	58-77	$y = 1.9642 + 2.1451x$	0.75
13	10	55-67	$y = -5.6796 + 3.9690x$	0.82
14	24	50-78	$y = -.9960 + 2.8393x$	0.85
15	17	64-81	$y = .9485 + 2.3564x$	0.48
16	410	42-89	$y = .4111 + 2.4756x$	0.75
17	178	45-85	$y = 2.2584 + 1.9665x$	0.55
18	110	50-81	$y = .7187 + 2.4324x$	0.77
19	227	45-85	$y = -1.6621 + 2.9499x$	0.56
20	265	42-89	$y = .7561 + 2.3871x$	0.71
21	206	42-88	$y = -.2831 + 2.6380x$	0.84
23	144	56-78	$y = 1.1041 + 2.3467x$	0.76
24	283	49-89	$y = 1.7500 + 2.1479x$	0.66
25	118	49-88	$y = .0350 + 2.5532x$	0.80
26	580	42-89	$y = .3044 + 2.4894x$	0.67
27	698	42-89	$y = .2717 + 2.4973x$	0.69

\*

1=Baie des Chaleurs,dark orange,April-May,multiparous ; 2=Baie des Chaleurs,dark orange,April-May,primiparous ; 3=Baie des Chaleurs,orange,June-July,multiparous ; 4=Baie des Chaleurs,brown,June-July,multiparous ; 5=Baie des Chaleurs,orange,August-September, multiparous ; 6=Baie des Chaleurs,orange,August-September,primiparous ; 7=Baie des Chaleurs,brown,August-September,multiparous ; 8=Baie des Chaleurs,brown,August-September,primiparous ; 9=Bradelle Bank,black,April-May,multiparous ; 10=Bradelle Bank,orange,June-July,multiparous ; 11=Bradelle Bank,brown,August-September, multiparous ; 12=P.E.I.,orange,April-May,multiparous ; 13=P.E.I.,orange, June-July, multiparous ; 14=P.E.I.,brown,June-July,multiparous ; 15=P.E.I.,brown,June-July, primiparous ; 16=Baie des Chaleurs,Total ; 17=Bradelle Bank,Total ; 18=P.E.I.,Total ; 19=April-May,Total ; 20=June-July,Total ; 21=August-September,Total ; 22=Brown, June-July-August-September ; 23=Dark orange,April-May ; 24=Orange,June-July-August- September ; 25=Primiparous,Total ; 26=Multiparous,Total ; 27=All samples.

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In the present study, we have not provided any information on the effect of nemertean parasites on egg masses. The reason is that we did not encounter such parasites in the broods of either of the two species. These results strictly differ from those presented by Aiken *et al.* (1985) and Campbell and Bratney (1986) for lobsters infested by Pseudocarcinonemertes homari in the bay of Fundy or at about the same time in the Gulf of St. Lawrence. It appears that the occurrence of such a parasite is not enzootic but epizootic and that such effects on lobster fecundity should be modelled as unusual catastrophic events affecting a population. The lobster population appears to have very successfully recovered. Lobsters may be contrasted with snow crab in their ability to withstand heavy variations in environmental conditions and disequilibria in population structure. The lobster population has been under heavy fishing pressure for more than a hundred years and is stable and highly productive, while the snow crab population, after some 15 years of opportunistic harvesting and only some 6 years of intense fishing, is already in a state of depletion. The features of egg production that we have outlined indicate in the lobster instance the ability to produce a large quantity of eggs under varied environmental conditions and adaptive life cycle strategies. In the case of snow crab confined to a normally very stable environment below the thermocline, it appears that artificially induced disequilibria in the population structure, generated by the fishery, have considerably compromised the renewability of the stock. It is not clear yet whether the egg production is affected, but the short life span of the mature females indicate that the production of eggs is much more sensitive to population structure variations than for lobsters.

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the fall. Large females in the Gulf are now scarce, but do not seem to carry eggs every year because the percentage of berried females decreases with size. This tends to confirm laboratory observations reporting that females may carry successive successful broods several years in a row after a single mating instance during which they store viable sperm in a seminal receptacle carried ventrally. Large females, when they do not carry eggs are available to the fishery. The more efficient a female will be to spawn every year, the less chance she will have to be captured.

The lobsters in the Southern Gulf appear to have a very dynamic fecundity with fast production of eggs allowing a rapid turn over of the population at high exploitation rate (Robinson, 1979). There is a high percentage of ovigerous lobsters (approximately 80%) that molted and extrude eggs during the same summer and the egg loss during incubation is low. The stocks in Western Newfoundland may be less fecund and more subject to the effects of environmental fluctuations. Despite a very heavy fishing pressure that has been maintained for more than a hundred years, the lobster population in the Gulf is at its high. The recruiting age group is almost entirely harvested over a very short fishing season, but year after year over the past seven years recruitment to the fishery has been stable or increasing. Lobster is an example of a species adapted to a highly variable environment, able to produce a large amount of eggs year after year over a long life span of the females, and able to withstand an disequilibrium in the age structure of the population imposed artificially by an intense fishing effort.

#### General conclusions

The statistical tools available for testing the significance of the factor effects shown by the PCA are not satisfactory. The relationships between variables are functional and multivariate rather than predictive and bivariate. The comparison of predictive bivariate regression lines by ANOVA does not provide useful inferences due to the relative disequilibrium of the strong influence of size compared to the weak influence of multiple factors on fecundity. A multivariate extension of the ANOVA for comparing linear multivariate regressions would not be satisfactory either due to the correlations observed between factors, which would be likely to generate strong interactions. It is possible but difficult to modify the sampling scheme in order to minimize non independence of the factors. At the present time a multivariate descriptive tool such as the PCA provides the best alternative for analyzing available sets of data and have provided useful if not definite results associated with levels of significance.

that Southern Gulf lobsters lose less eggs during incubation than the Nova Scotia and Gulf of Maine offshore lobsters (Perkins, 1972) that lose up to 36% of their eggs.

Campbell and Robinson (1983) estimated that the 50% maturity of female lobsters in the Southern Gulf occurred at a smaller carapace size than in the populations of the Atlantic coast of Nova Scotia and Bay of Fundy (78.5, 92.5 and 108.1 mm respectively) which concurs with our observations (Maynard *et al.*, unpublished data). While the Atlantic coast and Bay of Fundy lobsters have a larger size of ovigerous lobsters carrying a larger number of eggs the Southern Gulf lobsters have a "fast track" of an accelerated molt/extrusion cycle, maturity at a smaller size and a low egg loss during incubation.

Our data from the Western Newfoundland showed that the lobsters sampled had a low egg loss (17 %) during over the one year which we sampled. However we observed a high variability among the fecundity of the females in the fall sample (Table 6, Fig. 18), and Ennis (1980) also reports high year to year variations in the percentage of ovigerous female in the population.

Lobsters in the Gulf of St Lawrence are very mobile, at the adult stage they disperse within a depth range of 0 to 20, maximum 30 meters above the summer thermocline, in sea water with salinities as low as 20 ‰ and temperatures as high as 21°C. During the winter, the water temperature may be as low as -2°C and there is no thermocline, lobsters remain mainly inactive in burrows, but in our experience do not migrate to deep water. Under such conditions, a migration of the berried females when eggs are about to hatch towards the northwest and upflow in the St Lawrence estuary would be an adequate reproduction strategy. Our results provide some hints that such a strategy might exist and this will need to be cross checked by analysis of tagging results.

Genetic differences in fecundity are very unlikely in the Southwest Gulf, given the active dispersal of the lobsters at the adult stage. Geographic differences in fecundity would be environmentally driven, either at the extrusion of the eggs or at their survival, but are quite possible due to the variability of the environment in which lobsters live. Lobsters appear to have developed a strategy of high egg production over a long life span. Female lobsters carrying eggs are protected by law and may survive several years despite a strong fishing pressure on the stock. There appears to be an alternance of molting and spawning from year to year in the life schedule, that is not yet well understood in the wild and generates the simultaneous occurrence of eyed and non eyed eggs both in the spring and in

the proportion of female lobster that molted and extruded later in the summer. The females that did not molt extruded earlier in the summer and their eyes had sufficient time to develop eye spots.

Aiken and Waddy (1980a,b), Ennis (1980), Attard and Hudon (1987) have suggested that Adult Ib strategy of molting and egg extrusion is associated with the first spawning because it is encountered mostly in smaller lobsters. Our samples do not confirm this assertion, Table 12 shows that females with eyed and non-eyed eggs are found in any size category. It appears that females within the entire size range may follow an Adult Ib routine.

Robinson (1979) used a clean shell index to determine that his Southern Gulf sample for 1979 had 89.3% of Adult Ib ovigerous females which would concur with our findings for Miminegash, Pugwash and Port Hood (Table 11). Attard and Hudon (1987) estimated 45% Adult Ib by using EI in Magdalen Island which compares to our Baie de Chaleur results (Table 11). From Ennis' (1980,1981) data for the West coast of Newfoundland, the percentage of Adult Ib ovigerous females, as determined by clean shell index, can vary geographically and seasonally. Our Newfoundland sample site is located almost at the northern limit of the range of the species. The low percentage of non-eyed eggs observed could be a result of a longer than normal egg carrying period of 3 years instead of 2 (Ennis,1981) and where only a small percentage of newly extruded ovigerous lobsters are present each year due to low temperature conditions.

Nelson et al. (1988) suggest that females with newly extruded eggs occupy a deeper colder strata than those with more developed eggs. This may be a source of bias in estimating the proportion of newly extruded broods. Campbell and Stasko (1986) suggested that lobsters may disperse into different temperature strata to retard or accelerate their brood development and temperature gradients have been reported to affect trapability (McLeese and Wilder,1958).

Perkins' (1972) estimate of 36% egg loss during an assumed one year incubation period has been used extensively by other researchers including those working in the Southern Gulf (Aiken and Waddy 1980b). The results of this study (Table 7 and Figs.19-A,B) indicate that the egg loss is consistent in all samples, but that it considerably varies (15 to 27 %) and frequently does not reach a level of statistical significance in the Southern Gulf. The egg loss during incubation does not appear to differ for the Adult Ib and Adult II molt/extrude strategies. It appears

well in phase and progress through the season, but also that there are geographic differences between stages of development of the eggs at a given time. The correlation between season and location is a sampling artefact. In the space defined by components 3 and 4 (Fig. 17-B), the time factor is eliminated and geographic differences are emphasized, a strong negative correlation appears between the geographic gradient and the eye index which may indicate a concentration of females bearing eggs about to hatch towards the north and west side of the range. Geographic and seasonal differences in egg development can also be expected from Table 11 representing the percentages of eyed eggs in the samples located in time and space.

There is no correlation between claw loss and fecundity. Claw loss is independent from all factors except for a weak correlation with season (Fig. 17-A). The claw does not appear to be used for protecting the eggs from predation or for any activity related to the grooming of the eggs. Information on claw loss is not useful for fecundity studies unless the mortality of females is enhanced by claw loss. The projection of the observations on the plane defined by axes 1 and 2 (Fig. 17-A) shows a partition independent from fecundity, along variables 3, 6 and 4 (eye index, location, and season) into two distinct swarms. Our interpretation is that females bearing eyed and non eyed eggs are encountered in all samples. The bi-partite eyed, non-eyed distribution of broods in the samples is not restricted to the fall period (females are said to spawn in late summer). In the spring sample of Baie des Chaleur and Port Hood 20.0% and 3.0% respectively of the lobsters sampled contained eggs without eye spots.

This type of occurrence was observed by Attard and Hudon (1987) in Magdalen Island and was accounted to late spawning in the previous fall or imminent brood loss (Ennis and Collins, 1983). It appears that there are two periods of spawning in most locations. As per Perkin's (1972) technique, eye spots would appear in the eggs from 7 to 5 weeks after extrusion at the temperatures we observed.

Previous researchers have proposed that in the Gulf of St. Lawrence, ovigerous females may have different egg development due to different times of extrusion as related to molting strategy (Robinson 1979; Aiken and Waddy 1980a,b; Ennis 1980; Attard and Hudon 1987). Aiken and Waddy (1976) divided mature female lobsters into two groups, those that extrude eggs the year following the molt to maturity (Adult Ia) and those that molt into maturity and extrude the same summer (Adult Ib), lobsters that already carried broods are classified as Adult II, (Fig. 23). The proportion of eyed and non eyed broods in each sample is likely to be related to

incubation does exist. Elner and Gass (1984) suggested to compare fecundity estimates based on eyed eggs, which would avoid any bias caused by the presence of unfertilized eggs in recently spawned broods or of parasite predation in the estimation of the global fecundity of a snow crab population. If the hypothesis of a two year incubation duration is accurate for C. opilio, further work is required for estimating the egg loss during incubation year after year by each spawning group.

Sow crab live in a very cold but highly stable water mass, they appear to have a high production of eggs per female, which is strongly dependent on size (8148 eggs at 42 mm C.W. to 129200 eggs at 89 mm C.W.), and fairly stable over time and space. Females reach maturity over a very large range of sizes and stop growing. The size distribution over which an age group will reach maturity will strongly affect the global fecundity of a stock. We have some evidence that fecundity is reached at smaller sizes when a population is depleted. Females can withstand a reduction in the number of males, multiparous females will normally mate every year, but retain sperm active for two to three years in a spermatheque. However, our experiments based on radioelement dating of carapaces, would indicate that multiparous females do not survive for more than 3 to 4 years after the terminal molt.

We have been so far unable to estimate egg loss during incubation time and the fluctuations of such losses over time and from year to year.

A long incubation period of two years may be due to a low metabolism in cold water temperatures, but would be a disadvantage for egg survival between spawning and hatching. It would also imply that females may spawn only 2 to four times in their life span. The conjunction of these factors indicates that global fecundity of a stock may be prone to strong yearly fluctuations if the age distribution in a population is not stabilized.

## Lobster

The PCA indicates that a strong carapace length/egg count relationship exists for all our samples. Such a relationship is also well documented by Herrick (1909), Saila et al. (1969), Squires (1970), Perkins (1971), Ennis (1981), Campbell and Robinson (1983).

The EI, season and geographic location are intercorrelated, which shows that the stages of developpement of the eggs are

to any other published or present estimate. In the present study, the size- fecundity regressions based on data pooled for each location (Baie des Chaleurs, Bradelles Bank and Prince Edward Island), irrespectively of other sources of variation, significantly differed when the three geographic locations were compared at a time but we do not believe that these results are conclusive due to unfiltered effects from other variables, and particularly time.

In the PCA, the relationship between fecundity and time factors (either year or month) appears very weak. The year and the month are strongly correlated due to the particular timing of the sampling in the set of data. Therefore we cannot dissociate the effects of year to year variability from seasonal effects. Due to the existence of a terminal molt at onset of maturity in female C. opilio, it is not possible to identify year classes out of the size frequency distributions. A further complication may result from the fact that snow crab may have an incubation period of two years instead of one year, and that the incubation period may start earlier in the year for primiparous females than for multiparous females. Little is known about the reproductive cycle and incubation duration of Atlantic C. opilio. The duration of egg incubation (egg extrusion - egg hatching) of snow crab C. opilio is generally accepted to be of one year except for primiparous females having longer duration than multiparous females i.e. 15 to 16 months as reported by Kon (1980) for C. opilio in Japan Sea. Our preliminary observations on gonadal development, embryonic development and egg colour suggest that at least some populations have a two year embryonic development (24 months for multiparous females and 27- 28 months for primiparous females). Kanno (1987) also suggested the existence of a two year incubation duration for C. opilio in the Japan Sea based on observation of egg colour.

The results may so far be considered inconclusive due to the present impossibility to dissociate causative factors, but the loss of eggs during incubation and year to year variability appear to be sufficiently weak to be statistically undissociable at an acceptable level of significance from noise resulting from other unaccounted factors.

The effect of egg colour (state of development) on fecundity may be more informative on egg loss during incubation than our direct but composite measures of time. The PCA shows a negative correlation of the egg colour of the brood with fecundity. The fecundity/size relationships adjusted for different egg colour groups significantly differed. This information concurs to indicate that egg loss during

The present study revealed that the number of missing legs and claws has no apparent relationship with fecundity. The presence/absence of peculiar legs or claws may have influenced fecundity if these were used for egg protection and grooming. Multiparous females have undergone a terminal molt and subsequently have lost the possibility to regenerate. The number of missing legs does not affect fecundity in the PCA. However this factor is highly correlated with the spawning mode, due to the particular mating behavior of snow crab. A male will carry a multiparous female for extensive periods of time (up to several weeks), holding her by the legs, and fighting with other competing males. In the dispute females frequently lose many legs. The mating with primiparous females differs, it is short and involves no competition, it occurs while the female is still in postmolt (Moriyasu and Conan, 1988).

Since multiparous females are more prolific than primiparous females but more prone to loss of legs (Conan and Comeau, 1986), the effects of the two factors are difficult to dissociate. Regression analysis did not allow to show that a loss of legs affected fecundity of either primiparous or multiparous females and subsequently the survival of the brood through time.

The PCA demonstrates no correlation between the NW-SE trend in the geographic locations and fecundity, neither does the analysis of variance on the fecundity/size linear relationships. Jones and Simons (1983) reported that the number of eggs carried per female increased significantly with increased latitude from 35 00'S to 46 27'S in mud crab (Helice crassa). Reaka (1979) reported the existence of an inverse relationship in Stomatopod species. However, no relationship was found between latitude and fecundity for the sand crab (Emerita analoga) by Efford (1969).

In C. opilio, Davidson et al. (1985) showed high geographic variation in fecundity. However, no information is provided sampling season, spawning mode or embryonic development stage so that it is difficult to determine if a geographic factor per se was involved. Taylor (1988) reported no conspicuous differences for C. opilio between geographic locations off eastern Newfoundland. The comparison of fecundity made by Haynes et al. (1976) and Jewett (1981) between Bering Sea C. opilio and Gulf of St. Lawrence C. opilio does not provide clear results, because the authors did not test the significance of the differences between the size-fecundity regressions, and because the comparisons were made between primiparous (Bering Sea) and mixed data (Gulf of St. Lawrence). The slope that these authors estimated for the Gulf of St. Lawrence C. opilio was high (4.20) compared



## DISCUSSION

## Snow Crab

Most authors have calculated simple allometric relationships between number of eggs in the brood and size for Chionoecetes opilio without considering geographic variation (Brunel, 1961, 1962; Watson, 1969; Thompson, 1979; Elner and Robichaud, 1983). Most of these analyses also ignored the spawning mode of the female, the state of development or colour of the eggs.

This study reveals that many factors apart from the size of the female, can weakly affect the number of eggs carried in a brood. Geographic differences established on the simple comparison of number of eggs per brood/parental size relationships, without taking into account the other factors, and particularly egg development stages are most likely misleading.

Paris and Pitelka (1962) considered fecundity/size relationships for terrestrial isopods (Armadillidium vulgare) within subcategories defined by age class, season and locality. A similar approach was used by Wenner *et al.* (1987) for Emerita analoga who used age classes (modal sizes), sampling sites and sampling dates, which allowed well documented comparisons between seasons, between years and between localities.

In our work, the PCA of C. opilio data indicates that the size of the female is the most important factor influencing fecundity as in other brachyurans (Hines, 1982).

Spawning mode appears to affect fecundity, primiparous females being 91.5% as fecund as multiparous females of the same size (70mm C.W.). Somerton and Meyers (1983) reported that fecundity of primiparous C. bairdi, a Pacific species, was approximately 70% of the fecundity of multiparous female of the same size. In our data, the comparison of fecundity/size reveals no significant difference between primiparous and multiparous females, however, we could not eliminate other sources of variability in a pooled analysis of all data sets in this paired comparison and the power of the test is weak.

Egg colour as an index of embryonic development stage also appears to affect fecundity, this indicates that there is a loss of eggs during incubation.



it could be correlated with the geographic trend. The loss of legs appears to be independent from all other factors except season. It does not appear to be a useful information for fecundity studies.

## (2) Size-Fecundity Relationships:

The regressions for the fall and spring samples (Table 6 and Figs.18 A-E) were compared separately for each site in order to test the significance of egg loss during the incubation period (Table 7). At the Pugwash site, slopes differ at a 0.05 level but not at a 0.01 level. The ANOVA for the Bonne Bay and Miminegash data was invalid due to the heterogeneity of variances, but the ellipses of joint confidence limits for slope and elevation intersected, (Figs.19-A,B) revealed that the regressions were not significantly different at a 0.05 level.

The comparison of all the fall samples taken from different sites, and of all the spring samples were tested separately and are presented in Table 8. There was a significant difference in the slopes in the fall samples, while in the spring samples the slopes were the same but the intercepts were different, this may indicate geographic differences in fecundity.

In each fall sample broods containing eggs with eye spots and broods containing eggs without eye spots were encountered simultaneously, therefore size-fecundity relationship was established for each category (Table 9, Figs.20,A-D). The regressions for the eyed and non-eyed samples were compared separately for each sampling site (Table 10). The ANOVA for Port Hood data was invalid due to heterogeneity of variances, but the comparison of regressions by ellipses of joint confidence limits at 95% for slopes and elevations (Fig.21) showed no significant difference at a 0.05 level. Percentages of each of these categories, and an estimate of the time required to reach maturity was calculated in each instance from the EI (Table 11) and the available temperatures recorded at the time of sampling collection (Gregory *et al.* 1988). These times differed for the samples from Pugwash and Miminegash (Table 11), this may be an indication of geographic differences in hatching season.

The size-fecundity relationship for overall data was expressed by  $\ln(\text{Fecundity}) = -0.8079 + 4.0529 \ln(\text{C.L.})$  with  $R=0.6772$  (Fig.22) from which theoretical fecundity was estimated between 1665 eggs at 60 mm C.L. and 18825 eggs at 90 mm C.L.

d) egg colour

Separate regressions were calculated for, orange, dark-orange, brown and black eggs regardless of other factors (Table 1; #24,23,22,9, and Figs.14-A,B,C,D). Only the orange and brown categories did not differ significantly (Table 4, Fig.15).

e) spawning mode /location /season /egg colour

Separate regressions were calculated for the primiparous and the multiparous categories within the following identical egg colour, sampling season and location classifications: Dark orange eggs in April-May in Baie des Chaleurs (Table 1; #2 and 1), Orange eggs in August-September in Baie des Chaleurs (Table 1; #6 and 5), Brown eggs in August-September in Baie des Chaleurs (Table 1; #8 and 7) and Brown eggs in June-July in Prince Edward Island (Table 1; #15 and 14). No significant differences were found (Table 4, Figs.16-A,B, C,D).

American lobster

1) principal components analysis

The percentages of variance explained by each principal component axis are listed in Table 5 and range from 6 to 32%. The contributions are quite evenly partitioned between the axes. The matrix of correlations is presented in Table 5, unfortunately location and season appear to be correlated due to a yet incomplete sampling scheme; the effects of time and space are difficult to dissociate given the present set of data. Figure 17-A demonstrates a graphical interpretation of the analysis in the plane defined by principal components 1 and 2 which account for 57 % of the variance. The carapace length and fecundity are strongly correlated. The EI, location and season of sampling are strongly intercorrelated and almost independent from fecundity.

In order to isolate geographic information from time of sampling the projection of the variables was studied in the plane defined by axes 3 and 4 which are the most weakly correlated with season (Fig.17-B), but are well correlated with the north-south trend in the location of stations. The fecundity variable is not well defined in this plane, due to the sampling scheme, but its orientation does suggest that it could be correlated with the geographic trend. The loss of legs appears to be independent from all other factors except season. It does not appear to be a useful information for fecundity studies.

Thereafter the PCA was run with six variables, eliminating redundant variables and variables not correlated with fecundity.

In a second analysis, the variables retained were, the width of the 5th abdominal segment (size factor), the number of missing legs, the spawning type, the egg colour and the sampling date. The percentages of variance explained by each principal component axis are listed in Table 2 and range from 4 to 31%. The contributions are well distributed. The matrix of correlations is presented in Table 3. Figure 2-B demonstrates a graphical interpretation of the analysis in the plane defined by principal components 1 and 2. The width of the 5th segment of the abdomen and the egg colour are respectively positively and negatively correlated with fecundity.

## (2) Size-Fecundity Relationships:

Size-fecundity allometric relationships were first calculated separately for each set of observations representing a combination of factor categories: biological type, egg colour, sampling location and sampling season. The 15 sets of size-fecundity regressions and corresponding regression parameters are presented in Table 1 and Figs. 3-6. Size-fecundity regression for overall data is presented in Table 1 (#27) and Fig. 7. The sets of pairs of size/fecundity observations were then regrouped into categories defined solely by one factor at a time and the regression lines were calculated and compared

### a) spawning mode

The regressions were calculated separately for primiparous and multiparous females (Table 1; #25 and 26, and Fig. 8-A, B). The regressions do not differ significantly (Table 4, Fig. 9).

### b) location

Separate regressions were calculated for, Baie des Chaleurs, Bradelle Bank and Prince Edward Island (Table 1; #16, 17, 18 and Fig. 10-A, B, C). The regressions differed significantly at the 5% level (Table 4, Fig. 11).

### c) season

Separate regressions were calculated for, April-May, June-July and August-September data (Table 1; #19, 20, 21, and Figs. 12-A, B, C). The correlation coefficient was very low for April-May data ( $r=0.5592$ ). There was no significant differences between seasons (Table 4, Fig. 13).

### Linear size fecundity relationships and comparisons

Linear functional and predictive regressions (Ricker, 1973) were fitted to the data of log transforms of fecundity (F) versus log transforms of length component (L) e.g. carapace width (CW) for the snow crab and carapace length (CL) for the American lobster:  $\ln F = \ln a + b \ln (L)$ . For snow crab, the size-fecundity relationships were calculated separately for primiparous and multiparous females, per egg colour stage, per season and per sampling location. For lobster, size-fecundity relationships were calculated separately for fall (recently extruded) and spring (about hatching) samples, and for eyed and non-eyed fall samples.

The comparisons of predictive regression lines were made by analysis of variance (Snedecor and Cochran, 1980), and graphically by plotting the elevation estimates against the slope estimates for each of the regressions around which are drawn joint confidence limits at the probability level of 95% for the true parameter of elevations and slopes (Conan, 1978). This method enables to compare two or more regressions at a time even if the residual variances are significantly different. The elevations may still be contrasted when the slopes differ.

All software is custom made and programmed in HT BASIC running on MS DOS machines as well as on series 300/200 HP computers using a BASIC or a UNIX operating system (G.Y Conan and Elmer Wade).

## RESULTS

### Snow Crab

#### (1) Principal Components Analysis:

In a first analysis all observations and measurements were used simultaneously: fecundity, carapace width, width of 5th segment of the abdomen, number of missing legs, spawning type (primiparous or multiparous), egg colour, sampling date, sampling year and sampling location. The projection of the variables (Fig. 2-A) revealed that the fourth and the last two variables were not correlated with fecundity. The second and third variables representing size components were strongly correlated positively between themselves and with fecundity.

The data analysis was conducted into two steps, 1) a descriptive analysis of all factors taken simultaneously in order to identify redundancy, independance, negative or positive correlations between factors, 2) a more detailed analysis of bivariate linear predictive relationships between fecundity and selected factors, assorted by comparision of the linear relationships in different sets of data by analysis of variance.

#### Principal components analysis

The PCA can be considered a multivariate generalization of the functional bivariate linear regressions in which a transformation allows to represent the non independent factors and the observations as a function of calculated independent variables, the principal components. We used a graphics extension of the PCA (Lebart *et al.*, 1979) on log transforms of the measurements. The purpose of the application of PCA is (1) to identify discrete groups of individuals sharing common morphometric characteristics, in this instance fecundity, (2) to identify the contribution of the variables which differentiate most efficiently discrete groups and to eliminate redundant variables carrying identical information and (3) eventually to identify the principal components to some independent underlying factors, in this instance one principal component may represent a size factor, another one a geographic variation or environmental factor.

The variables used for the analysis are fecundity, carapace width, width of the 5th abdominal segment, biological type (primiparous or multiparous), egg colour, number of missing legs, sampling date, year and geographic location for snow crab, and fecundity, carapace length, EI, season, claw loss and geographic location for lobster.

The results of PCA are presented graphically (Lebart *et al.*, 1979) in order to visualize discrete groups of individuals among the observations and the contribution of the measurements (observations) to the principal component. The observations and the measurements were projected into bivariate planes defined by principal components taken two at a time. In this representation, the mean of the variables were subtracted and divided by their standard deviations in order to standardize the scale for all variables in the projections. The variables were represented by a vector of unit length equal to one standard deviation, projected on the plane.

## (2) American lobster (Homarus americanus)

In the Gulf of St Lawrence lobster inhabit the layer of water which is above the thermocline in summer, is unstable both geographically and seasonally, reaching 22°C and 20 ‰ salinity in the summer, -2°C and 29 ‰ in the winter. They are rarely found below 40 m depths. Their bathymetric distribution usually does not overlap with snow crab habitat. They wander over wide distances and there is no evidence for isolated stocks in the southwestern Gulf, including Prince Edward Island and Western Cape Breton. The stocks along the west Coast of Newfoundland are bathymetrically isolated at the benthic stages.

Ovigerous females were collected in traps set in the areas of Baie des Chaleurs (New Brunswick), Miminegash (Prince Edward Island), Pugwash (Nova Scotia), Port Hood (Nova Scotia) and Bonne Bay (Newfoundland) (Fig. 1). Samples were collected either 1) in late August or early September in order to study females bearing newly extruded eggs and 2) in the following spring, in late May, in order to study females bearing eggs about to hatch within the next 6 to 8 weeks. An equal number of females were sampled out of each five millimeters carapace length group. A sample of 10 eggs was taken from each lobster and preserved in 5% formalin. Using a binocular microscope the length and width of one eye of each egg was measured to calculate a mean Perkin's eye index (EI) (Perkins, 1972) for each brood. This index and the temperature regime (Gregory et al., 1988) allow to estimate the time required for the eggs to hatch.

The lobsters were labeled and preserved frozen individually in plastic bags. They were later thawed, measured (carapace length, width of fifth abdominal segment, claw volume) and weighed. The brood was removed from the pleopods and dried to a constant weight for 48 hours. Two sub-samples of 100 eggs were counted and weighed and the total number of eggs was estimated from the dry weight of the brood.

## DATA ANALYSIS

The number of eggs in the brood of a female can be assumed to be allometrically related to its length or weight; after a logarithmic transformation, the relationship becomes linear. Factors other than lengths or weights could be quantified by an index on a discrete scale. For instance, the colour of the eggs is related to developments stage and can be rated from 1 (orange) to 4 (black).

## MATERIAL AND METHODS

## THE BIOLOGICAL DATA

(1) Snow Crab (Chionoecetes opilio)

In the Gulf of St. Lawrence, snow crab live at depths of 50 to 150m, in a body of saline (circa 33 ‰) and cold ( $-1^{\circ}\text{C}$  to  $+1^{\circ}\text{C}$ ) water which is geographically homogeneous and remains very stable all year round and from year to year. Ovigerous female snow crabs (Chionoecetes opilio) were obtained from three geographic locations (Baie des Chaleurs, Bradelle Bank and Prince Edward Island) in the Gulf of St. Lawrence at depths ranging from 60 to 80 m (Fig.1). A 5 m beam trawl, 20 m Nephrops trawls as well as conventional snow crab traps were used.

Between April, 1986 and June, 1988, 11 samples totaling 698 females were collected (Table 1). The widths of the carapace and of the 5th segment of the abdomen were measured to the nearest millimeter. The position and number of missing legs, carapace rigidity (soft, medium and hard), degree of coverage of carapace by epibionts (old, medium and new) and the colour of the eggs (orange, dark orange, brown and black) were recorded as indices of respectively: ability to groom the eggs during incubation, time elapsed since the last molt, and time elapsed since spawning. The females with abnormally low clutch of eggs, unfertilized eggs and hatching eggs were not used. The spawning category (primiparous or multiparous) was identified by carapace cleanliness and presence/absence of male grasping mark on the legs. Females which spawn for the first time mate shortly after their terminal molt leading to maturity and are called primiparous, they usually bear no mating grasping marks. Females who mated and spawned several times after the terminal molt, while being in hard shell are said to be multiparous, and usually bear mating grasping marks.

The abdomens bearing external eggs were preserved in 40% formalin solution, and the pleopods with attached egg masses were later removed using scissors and dried at  $60^{\circ}\text{C}$  for 24 hrs. The dried eggs were separated from pleopods and weighed to the nearest 0.0001 g. A subsample of eggs was also weighed, and its eggs were counted. The fecundity defined here as the number of eggs per brood, was calculated by extrapolation.



## INTRODUCTION

Recruitment in large decapod crustaceans, as in most other marine species harvested by fisheries, has been mainly studied in the form of stock recruitment relationship in which it is attempted to fit data on abundance of offsprings as a function of parental stock. This global approach has sometimes been successful, but usually results in a scattergram of loosely distributed points showing little correlation. In terms of fisheries management, this would mean that the abundance of recruits is usually independent from parental stock abundance within the range surveyed. A simple yield per recruit would then apply with little need to worry about recruitment fluctuations of random uncontrollable nature. This philosophy intuitively usually does not appeal to managers, who perceive the need for a protection of the reproductive capacity of the stock.

An alternative for density dependence in the production of offsprings relies on the larval retention theory presented by Sinclair and Iles (1989). The success of recruitment would depend on physical factors such as gyres providing a retention of larvae in a given area. This theory provides a logical basis rather than a contradiction to the larval drift theory promoting the origin of recruitment from a number of localized foci.

It would be suprising however that crustacean populations would not have developed a potential to autoregulate their numbers and would rely exclusively on hydrographic factors for ensuring their continuity. It would intuitively seem logical that a combination of physical factors and intrapopulation regulation factors would work in synergy to ensure population survival. The complexity and probabilistic nature of the regulation system would not lead to global modelling of a simple stock recruitment relationship.

A logical approach would be to search for variability in time and space of biological parameters linked with recruitment, and further to search for multivariate correlations with environmental and biological factors, before attempting any modelling. This paper presents a modest contribution to this approach by attempting to analyze variability in the most basic of biological parameters linked with recruitment: egg production and egg survival.

In this paper we have used two very different decapod crustacean species as case studies in the Gulf of St. Lawrence: the American lobster (Homarus americanus) and the snow crab (Chionoecetes opilio), and we have discussed our provisional results within the context of available literature.



## SUMMARY

This paper deals with an approach to better understanding of crustacean recruitment problems by attempting to analyze variability in time and space of biological parameters linked with recruitment e.g. fecundity and egg survival, of two decapod crustaceans, snow crab (Chionoecetes opilio) and American lobster (Homarus americanus) in the Gulf of St. Lawrence.

Two principal techniques for analyzing data were used i.e. Principal Component Analysis and the establishment of size-fecundity allometric relationships then compared by ANOVA. The statistical tools available for testing the significance of the factor effects shown by the PCA are not satisfactory. The relationships between variables are functional and multivariate rather than predictive and bivariate. The comparison of predictive bivariate regression lines by ANOVA does not provide useful inference due to the correlations observed between factors, which would be likely to generate strong interactions. At the present time, a multivariate descriptive tool such as the PCA provides the best alternative for analyzing available sets of data and have provided useful results associated with level of significance.

This preliminary study revealed the peculiar characteristics of snow crab and lobster in terms of adaptability to the environmental variation as well as fishing pressure. Lobsters may be contrasted with snow crab in their ability to withstand heavy variations in environmental conditions and disequilibria in population structure. The lobster population has been under heavy fishing pressure for more than a hundred years and is stable and highly productive, while the snow crab population, after some 15 years of opportunistic harvesting and only some six years of intense fishing, is already in a state of depletion. The features of egg production that we have outlined indicate in the lobster instance the ability to produce a large quantity of eggs under varied environmental conditions and adaptative life cycle strategies.

In the case of snow crab confined to a normally very stable environment below the thermocline, it appears that artificially induced disequilibria in the population structure, generated by the fishery, have considerably compromised the renewability of the stock. It is not clear yet whether the egg production is affected, but the short life span of the mature females indicate that the production of eggs is much more sensitive to population structure variations than for lobsters.

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Factors influencing egg production in decapod Crustacea  
with two case studies: Chionoecetes opilio and Homarus americanus  
in the Gulf of St. Lawrence (Canada)

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