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Recapture rates of lobsters first captured by trapping vs diving

by

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Summary

Within a natural population of lobsters (*Homarus americanus*), certain individuals may be caught in traps more readily than others. Such behavioral differences could induce bias in the estimates of exploitation rates and abundances based on capture-recapture data.

In the present experimental set up, we compared the recapture rates in traps of lobsters first caught by diving v.s. trapping shortly before the fishing season. The recapture rates of lobsters first caught by diving were always lower.

Size selectivity effects: Below a carapace size of 65 mm the catchability in traps appeared to be inversely correlated with size. Above 65 mm, the catchability remained maximal and eventually dropped only for very large individuals.

Behavioral effects: The catchability was always lower for females than for males of identical sizes. A subgroup of individuals among females appeared to have a reduced catchability uncorrelated with size. Among males and females smaller than the lower maximal retention size of 65 mm, a subgroup of individuals also appeared to have a reduced catchability uncorrelated with size. This effect was weak or null among males larger than 65 mm.

This differencial catchability among individuals of the same size is explained either by physiological stages differing among individuals (e.g. uncompletely synchronized individual seasonal molt and reproductive cycles), or eventually by genetically imprinted differences among individuals.

Résumé

Dans une population naturelle de homards (Homarus americanus) certains individus paraissent répétitivement plus enclins à être capturé par casier que les autres. De semblables différences de comportement pourraient induire un biais dans les estimations de taux d'exploitation et d'abondance basées sur des données de capture-recapture par casiers.

Au cours du présent protocole expérimental, nous avons comparé les taux de recapture de homards qui avaient été capturés une première fois avant la saison de pêche soit en plongée soit par casiers. Les taux de recapture par casier des homards pris une première fois en plongée étaient toujours les plus faibles.

Effets de sélectivité en fonction de la taille: Au dessous d'un seuil de 65mm de longueur de carapace, la capturabilité des individus diminue en fonction inverse de leur taille. Au dessus de ce seuil la capturabilité se stabilize à un niveau maximal, elle diminue ensuite éventuellement au niveau des très fortes tailles.

Effets de comportement: La capturabilité des femelles était toujours plus faible que celle des mâles à taille égale. Un sous groupe d'individus parmi les femelles paraît avoir une capturabilité réduite sans que cette particularité soit corrélée avec la taille.Parmi les mâles et les femelles de taille inférieure au seuil des 65 mm, il existe également une catégorie d'individus dont la capturabilité est plus faible et ceci sans relation avec leur taille. Cet effet est très faible ou inexistant chez les mâles de plus de 65 mm.

Ces différences de capturabilité par casier entre individus de même taille pourraient être expliquées par des différences d'état physiologique (décalages des cycles saisonniers de mue et de reproduction des individus par exemple), ou bien encore par d'éventuelles différences d'ordre génétique.

Introduction

Tagging and recapture data have frequently been used in order to provide estimates of exploitation rates, mortality and population abundance of lobster stocks. High recapture rates over a fishing season for individuals tagged one year earlier over the preceeding fishing season are generally considered as an index of high exploitation rates, and subsequently of high fishing mortality rates.

For the Southern Gulf of St. Lawrence it is generally thought that the recapture rates are of the order of 80%. Most of the lobsters reaching commercial size would be caught over a fishing season. After a few weeks of fishing, capture rates would drop and eventually become too low to support commercial fishing long before the end of the fishing season.

However a literature review did not allow us to find any actual report of recapture rates of the order of 80% for any recent tagging experiments. This is sometimes attributed to low tag returns by the fishermen. The only recent reference with detailed data for high tag returns we found for Northern Northumberland Strait was from Wilder's work (1963), although, the total recaptures were not actually observed to reach 80%. Wilder's estimates are based on post stratified sampling of partial tag recoveries in several harbors.

Our own observations during diving surveys show that lobsters are quite abundant after the fishing season. Concomitantly catchability of lobsters by traps seems to vary considerably as a function of many factors such as season, sex, size and age. For instance we observed that no lobsters can be caught in traps set under the ice in Malpeque Bay although they are very abundant over the winter and at least some of them are actively feeding as revealed by the gut contents of individuals caught by diving.

In order to check the reliability of estimates of exploitation rates based on tagging and recaptures we designed the present experimental set up. Lobsters were caught by diving and by trapping immediately before the fishing season. They were tagged, and we compared the characteristics and recovery rates of the various size and sex categories of individuals first caught by diving and by tagging.

Material and Methods

Raw data

The experiment took place in Northern Nortumberland Strait to the south of Cape Egmont (Figure 1). In this location the substrate is sand with sand stone patches and large kelp beds. The tagging took place from July 13 to August 8 prior to the opening of the commercial fishing season. Modified sphyrion tags were used. A filament of nylon fishing line was substitued for the standard filament provided by the factory since quite a few tags with broken filaments and lost spaghetti numbered tubing had been found at recapture over previous experiments.

Sphyrion type tags rather than simple tags hooked to the carapace were used since the latter type is lost at molting. Molting is known to occur in district 8 over the period of the year at which the experiment took place.

Three strings of five traps were used while the divers operated during drift dives which crossed the trapping area (Fig.1). Damaged lobsters with missing claws or visible injuries on carapace, as well as "soft" recently molted lobsters were discarded previous to tagging.

No standardization of data based on a selection of sex or size was made at tagging. The tagging procedure was stopped when a substantial number of tagged lobsters became recaptured by diving and trapping (3 or 4 a day).

Recaptures of tagged individuals were obtained through the commercial fishery. The experiment was widely advertised both on the New Brunswick and the Prince Edward Island (P.E.I.) coast. Rewards for the tag returns were provided through a contract with the P.E.I. Fishermen's Association.

Data processing

All calculations were conducted on the HP 9845B, desk computer, 9872C plotter and 9895A dual flexible disk of the Marine Biology Research Centre. All the software is custom made. Data acquisition was made through the text editor of the PDP 11 of Université de Moncton in order to avoid interacting with data processing time on the HP 9845. Edited data were transferred from the PDP 11 to the HP 9845 through an RS 232 interface as sets of alpha strings.

Data were first analyzed for sources of bias in recapture rates related to sex and size structure of the sets of animals captured by tagging or by diving. Recapture rates were further worked out separately for the males and for the females. In order to standardize the size frequency distributions of individuals of each sex first caught by diving and by tagging, a random procedure was programmed for selecting the tag numbers of the individuals to be used in the recapture experiment. Within each size class of the percent size frequency distributions of tagged individuals, a percent value (P) was substracted from either of the distributions which showed a higher value in that size class. This percent value was adjusted to the total number of individuals (N) in the size frequency distribution: $P' = P \times N/100$ and rounded to the nearest integer I_s. I_s tag numbers were then drawn out randomly from the set of individuals of size S and eliminated from the experiment.

The capture/recapture ratios were compared by contingency table tests. In the contingency tables the figures used were the number of recaptures vs the number of non recaptured individuals. Comparisons were made for unstandardized sex combined data, then for standardized data in separate sex sets, in a single 4 x 2 table, then separately for each sex in 2 x 2 tables. In a final stage the sex specific sets were treated simultaneously in a single test to allow checking for consistence of a trend in several separate contingency tables (Snedecor and Cochran 1967, pp 253-256).

A size selectivity curve was calculated for the lobsters caught in traps $N_t(S)$ compared to those caught by diving $N_d(S)$. The ratios $R(S) = N_d(S)/N_t(S)$ of the number of lobsters caught by diving to the number of lobsters caught by trapping were calculated within each 1 mm size class. An average value $\bar{R}$ for these ratios was calculated for the longer sizes at which the ratio values stabilized along a plateau. Ratios $1/R(S) = N_t(S)/N_d(S)$ were then multiplied by $\bar{R}$ in order to correct overall fishing power efficiency of the diving/trapping procedures on size classes not affected by selectivity: $R'(S) = \bar{R} \times 1/R(S)$. A logistic curve was adjusted to these ratios using a Marquadt non linear algorithm in which the initial estimates of the logistic parameters is obtained by linear regression on linearizing transforms of these parameters:

$$X = S$$

$$Y = \mathrm{Log}\ (R'(s)/(1-R'(s)))$$

$$Y = a + bx$$

In order to check the interations between trap size selectivity and mode of first capture (diving / trapping) we compared the recapture rates of males and of females large enough to appear on the 100% trap retention size range of the selectivity curve. This would allow checking whether the lower catchability of small animals was only due to physical gear selectivity (such as lath space) or to differencial individual bahaviour among small individuals as well.

Results

The size frequency distributions of male lobsters caught by diving and by trapping are presented in Figure 2. One hundred and thirty six (136) males were caught by diving, 411 by trapping. The female size frequency data are presented in Figure 3. One hundred and thirty six (136) females were caught by diving, and 271 by trapping.

Sex ratios:

The sex ratio's differ significantly at the .05 level in the dive and in the trap sets of data. Females are caught less easily than the males in traps at this time of the year. However the sex ratio on the grounds appears equal to 1 as shown by diving.

Selectivity of gear:

The ratios of the number of lobsters caught by diving divided by the number of lobsters caught by trapping within each 1 mm size interval as a function of size are presented in Figures 4 and 5. These ratios do not seem to vary between males (4a) and females (4b). Subsequently a curve was calculated for both sexes combined (Fig. 5). The logistic selectivity curve fitted to the corrected ratios (proportion of individuals retained by gear) is presented in Fig. 6. The fit is reasonably good between 45 and 70 mm carapace size with an inflection point at 61 mm. At sizes larger than 70 mm the variability around the line greatly increases and as such it is not possible to decide whether the overall curve may be asymptotic towards 1 or dome shaped with a maximum around 72 mm carapace size. The logistic equation is:

$$P = 1/(1 + \exp(-(-30.4140 + .5002))).$$

Capture-recapture figures

The uncorrected captures and recaptures are as follows:

	At tagging		At recapture		Ratios of recaptures/captures	
	1st caught by diving	1st caught by trapping	1st caught by diving	1st caught by trapping	1st caught by diving	1st caught by trapping
Males	136	411	23	139	16.9%	33.8%
Females	136	271	19	90	14.0%	33.2%

The captures and recaptures corrected for standardized size frequency distributions at tagging (Fig 7 and 8) are as follows:

	At tagging		at recapture		Ratios of recaptures/captures	
	1st caught by diving	1st caught by trapping	1st caught by diving	1st caught by trapping	diving	trapping
Males	67	206	11	58	16.4%	28.2%
Females	82	157	19	56	23.2%	35.7%

The captures and recaptures lobsters larger than 65 mm arc as follows :

	At tagging		at recapture		Ratios of recaptures/captures	
	1st caught by diving	1st caught by trapping	1st caught by diving	1st caught by trapping	diving	Trapping
males	35	273	12	96	34.3%	35.2%
females	27	140	5	53	18.5%	37.8%

Capture-recapture ratios, tests for significance

In the original data the recapture rates differ very significantly for individuals first caught by diving and by trapping ($p = 2.10^{-4}$ for the males and $p = 4.10^{-6}$ for the females).

In the standardized data corrected for size differences and treated separately for each sex but compared simultaneously in a 4 x 2 table, the recaptures rates differ significantly at the 0.05 level ($p = 0.01$) However this could be attributed to difference related to sex as well as to capture mode, or to both.

In the standardized data corrected for sizes the recapture rates differ significantly in 2 x 2 tables, between females 1st caught by diving and males 1st caught by trapping ($p = 0.0481$) but not quite between the males ($p = 0.0548$). The trend is the same in both sexes: Individuals first caught by trapping are caught again by trapping much more readily then those 1st caught by diving.

In such a case the two tests suggested by Snedecor and Cochran (1967, p253-256) allow taking into account all the information available. These tests for consistency of the trend provide the following estimates of the normal deviate Z.

$$Z_1 = \Sigma \chi / \sqrt{g} = 2.7997$$

$$Z_2 = \Sigma w_i d_i / \sqrt{\Sigma w_i p_i q_i} = 2.8983$$

Both estimates are significant at the 0.05 level.

In the data for individuals larger than 65 mm, the recapture rates are very slightly higher for males first caught by trapping but the difference is not significant ($p = 0.91$). The recapture rates of the females first caught by trapping are still much higher and the difference is almost significant ($p = 0.053$).

Discussion

In none of the cases studied did we get the 80% recapture rate generally assumed for lobsters over a fishing season in Northumberland Strait. This was still evident when we took into account only the animals larger than 65 mm carapace length, the size range over which traps appear to be fully efficient compared to diving (Fig 6).

Recapture rates appear to vary as a function of size but also as a function of sex, possibly due to seasonal variations in the relative efficiency of traps to capture either of the two sexes.

Recapture rates are always higher for individuals first caught by traps. This indicates that part of the population on the grounds for some unknown reason is far more easily capturable than the remaining. Among lobsters larger than the 65 mm (size range over which traps are fully efficient) the capture mode at tagging had very little effect on recapture rates for the males, but still a strong, almost significant effect for the females. Females were also less catchable in traps than males as shown by the very different sex ratios among animals caught by diving and caught by trapping. The standardization of sizes at tagging through the random procedure did not allow correcting the lower recapture rates observed for males and females first caught by diving.

Our data tend to show that apart from the size selectivity effect, there is within the animals pertaining to the size range below 65 mm a category of individuals (both males and females) which is not yet fully catchable in the traps. There is also a distinct reduced catchability of a certain category of females within sizes above 65 mm. Females overall are less catchable than the males.

Our underwater television experiments do confirm that a fair proportion of "clever" lobsters do enter the trap through the entrance, eat in the "kitchen" and walk out. Lobsters are caught only when they enter the second chamber the "parlor". This may be related to imperfect synchronization of seasonal individual life cycles or to some permanent characteristic not shared by all individuals. If this characteristic was genetically imprinted, selection through fishing pressure should be in favor of non-trappable individuals and would contribute to the stability of the population. However our data rather indicate that the physiological state of the individuals rather than a genetic factor is involved in the observed differencial catchabilities by trapping.

These discrepancies in recapture ratios should be kept in mind as a possible source of bias when one uses capture-recapture data based on trapping. Computations based on such data may lead to underestimates of lobster abundance on the grounds and over estimates of mortality by fishing with the consequence of over estimating the benefits of an increase in legal size on yield per recruit.

References

Snedecor W and W.G. Cochran 1967. Statistical Methods. 593 pp. Iowa State University press.

Wilder, D.G., 1963. Movements, growth and survival of marked and tagged lobsters liberated in Egmont Bay, P.E.I., J. Fish. Res. Bd. Can. 20: 305-318.

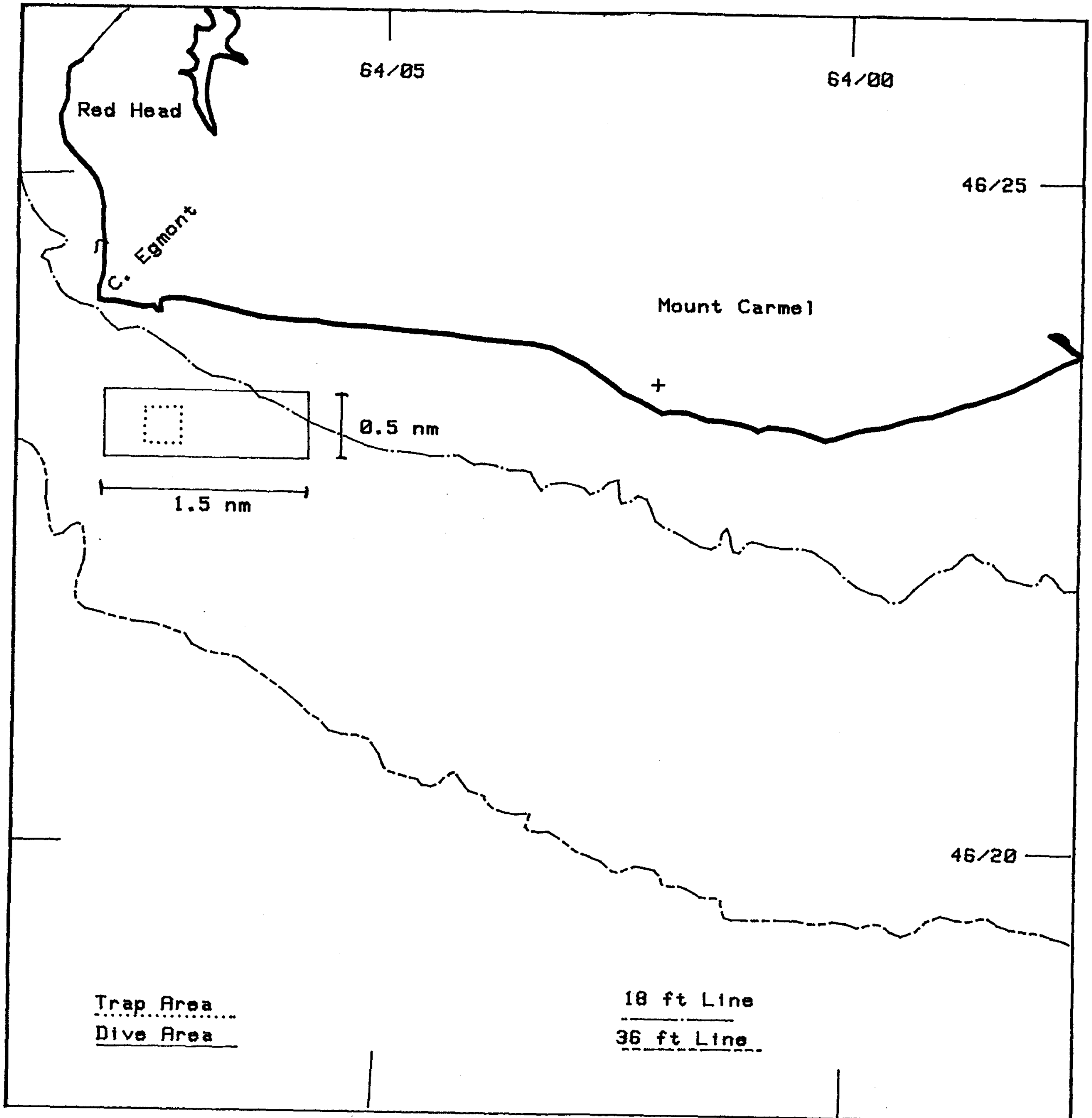

Figure 1 Geographic location of experiment.

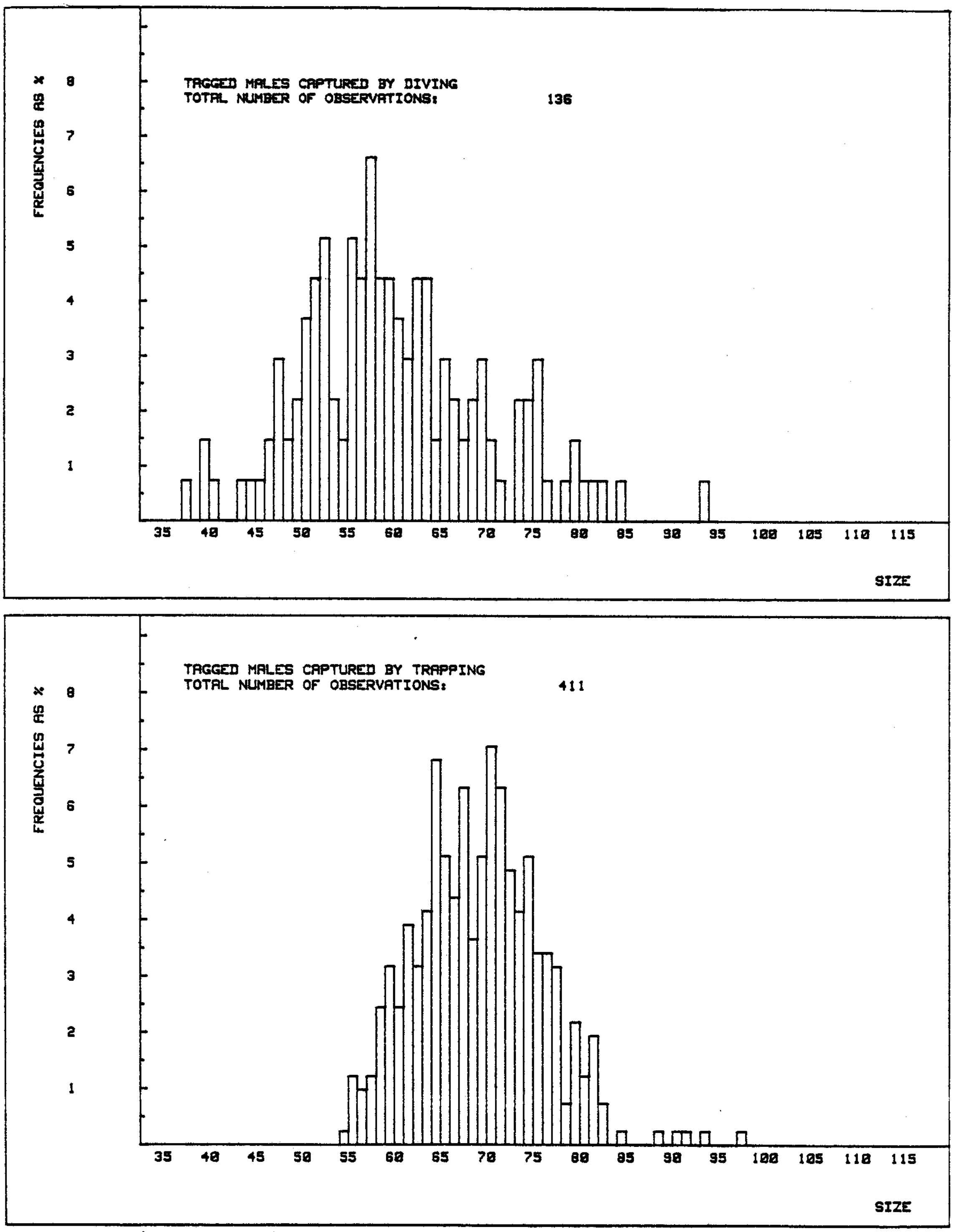

Figure 2. Size frequency distribution of male lobsters caught by diving (top) and by trapping (bottom) prior to tagging and release.

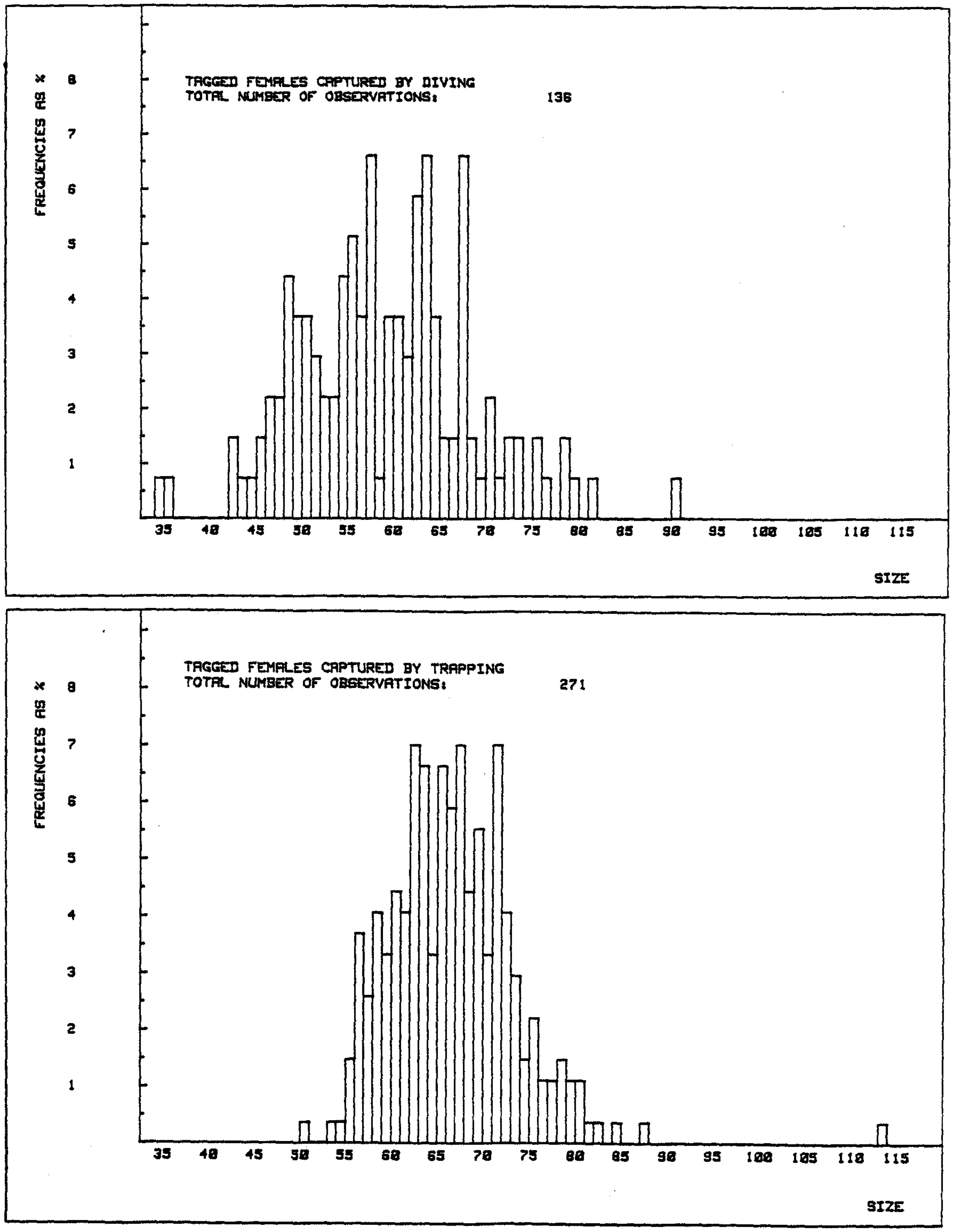

Figure 3. Size frequency distribution of female lobsters caught by diving (top) and by trapping (bottom) prior to tagging and release.

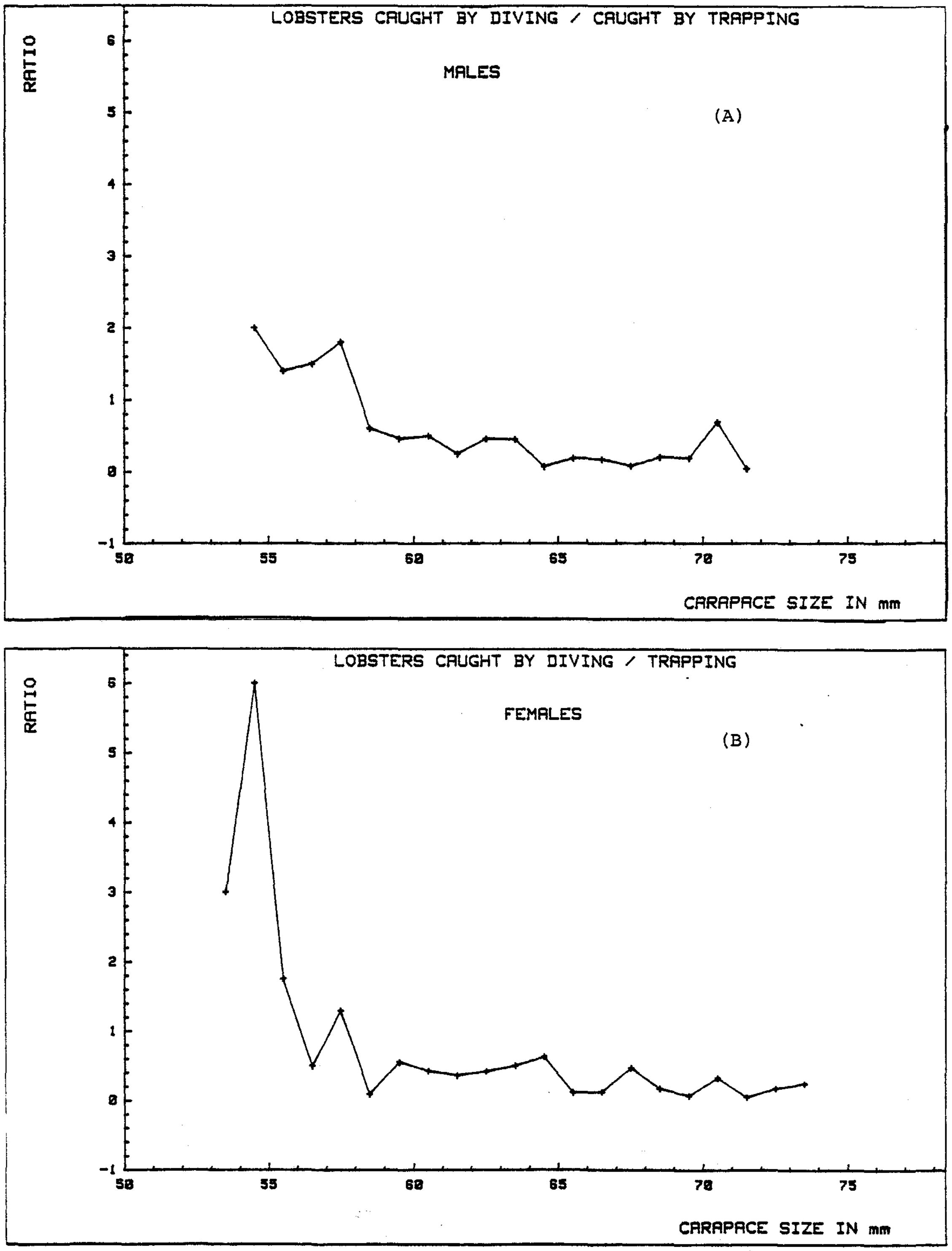

Figure 4. Ratios of number of lobsters recaptured in traps after being caught by diving versus by trapping. A: Males, B: Females.

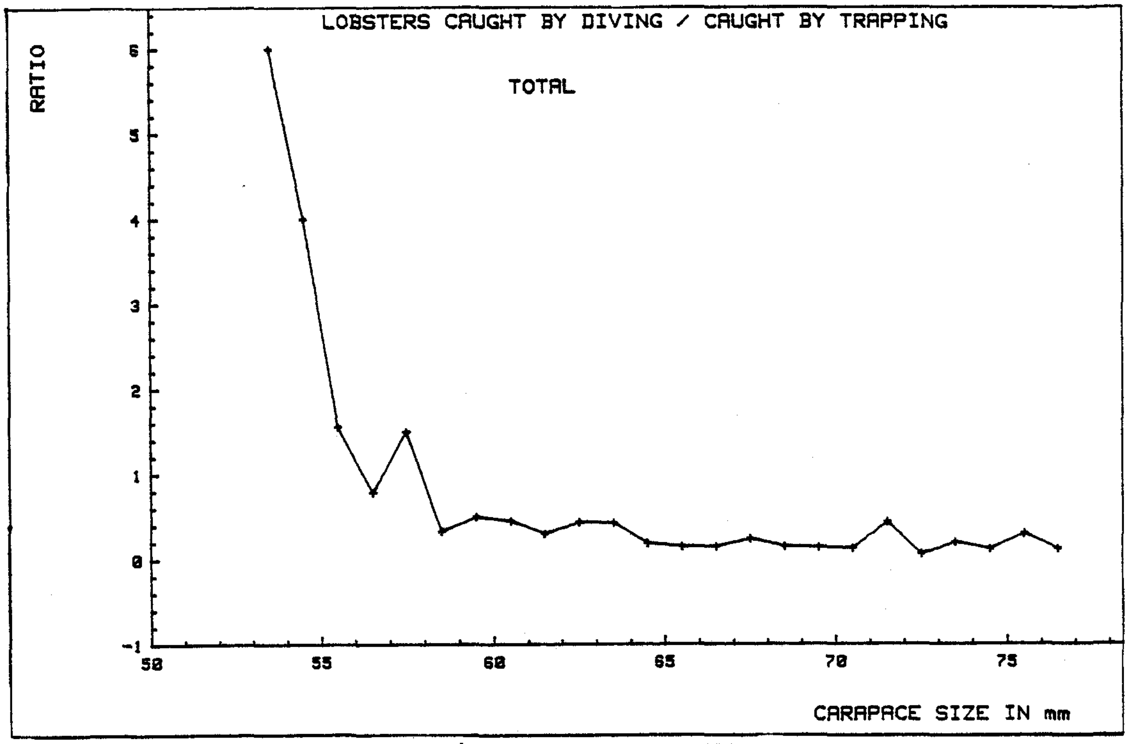

Figure 5. Ratio of number of lobsters recaptured in traps after being caught by diving versus by trapping. Sexes combined.

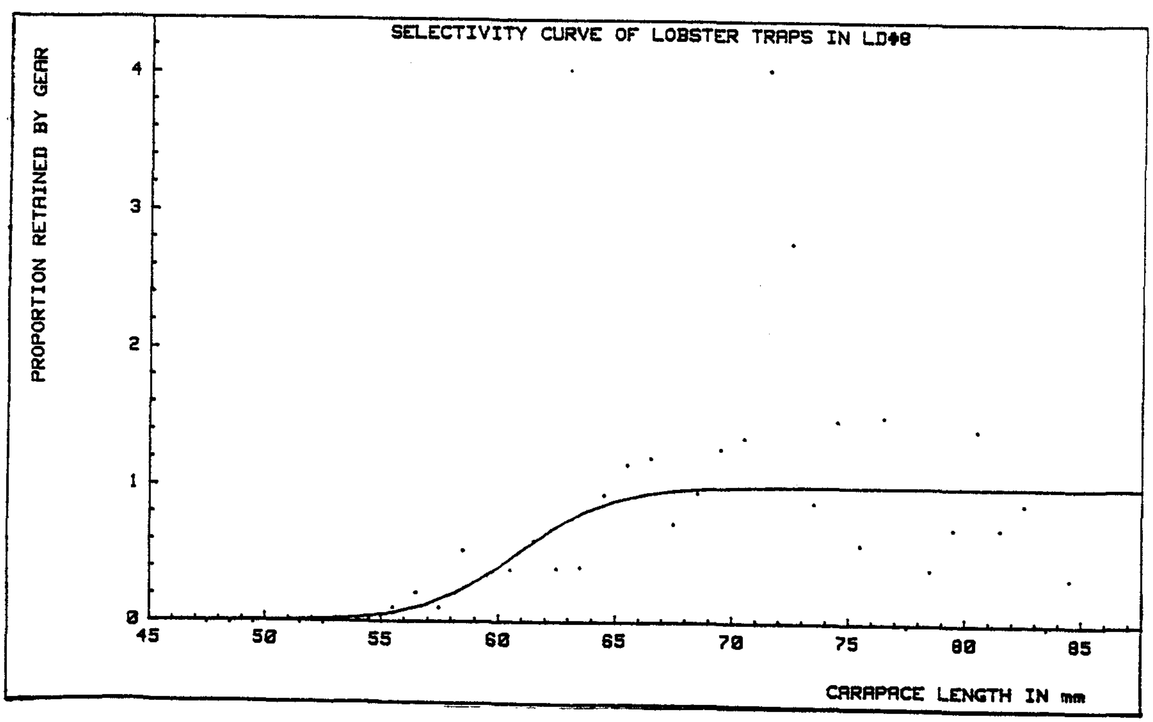

Figure 6. Calculated selectivity curve for lobsters caught in traps.

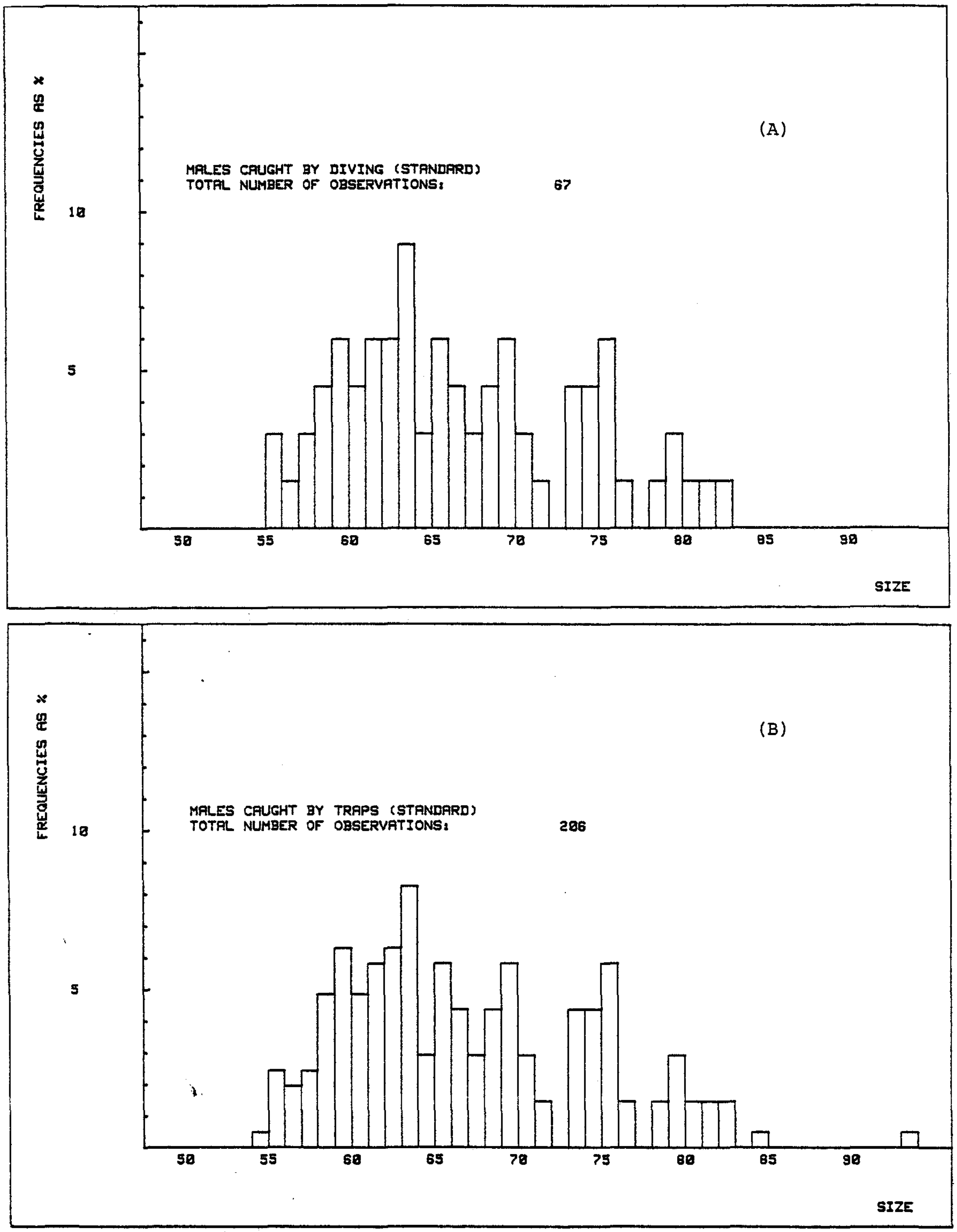

Figure 7. Standardized size frequency distributions for male lobsters caught by diving (A) and by trapping (B).

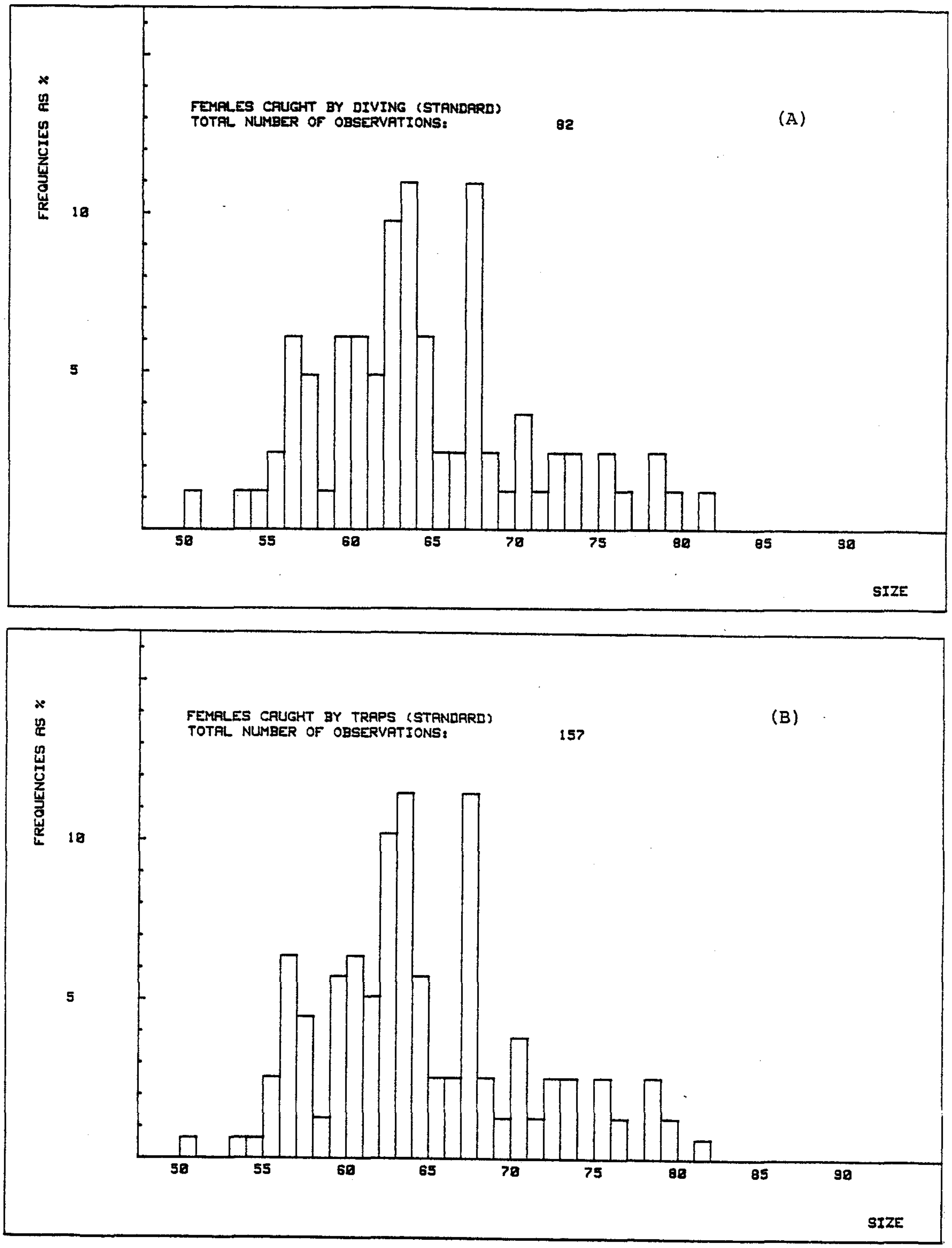

Figure 8. Standardized size frequency distributions for female lobsters caught by diving (A) and by trapping (B).