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A Report of the 19th Northeast Regional Stock Assessment Workshop

A Preliminary Analytical Assessment for White Hake in the Georges Bank - Gulf of Maine Region

by

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ABSTRACT

White hake are distributed on the continental shelf from the Gulf of St. Lawrence to North Carolina. Landings increased from a low of 1100 mt in the late 1960s to a high of 9500 mt in 1992. The majority of the landings are in NAFO areas 5 and 6 and have been taken by US vessels. Sink gill nets and otter trawls are the dominant gear used to land white hake in the second and third quarters of the year. Recreational catches are insignificant. Discards are believed to occur in large quantities in both the otter trawl and the sink gill net fisheries. The length compositions from both the port and sea sampling databases indicate that fish < 40 cm are usually not landed and that the length mode of landings is 60 cm. Landings per unit effort (LPUE), calculated using all commercial otter trawl trips landing white hake, has been stable since 1980. The research vessel abundance and biomass indices tend to agree with the first LPUE index. Total mortality (Z) estimates derived from the NEFSC survey data for 1987-1989 ranged from 0.9 and 1.3. Analyses of 1985-1993 data using a modified DeLury model indicate that fishing mortality has been increasing while stock biomass has fluctuated without a definite trend. An estimate of maximum sustainable yield (MSY) of 7,700 mt was produced from a surplus production analysis. Landings levels in 1992 and 1993 exceeded this value and stock biomass was below that needed to support these landings. Yield-per-recruit analyses indicate that $F_{max} = 0.22$ and $F_{20\%} = 0.33$. Fishing mortality in 1993 was estimated to be slightly above these reference points.

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INTRODUCTION

White hake (*Urophycis tenuis*) are distributed from the Gulf of St. Lawrence to North Carolina (Bigelow and Schroeder, 1953). Much confusion on the distribution of this species exists because of the close resemblance to its congener, the red hake (*Urophycis chuss*). Both species occupy much of the same habitat (mud bottom) and have often been described together (Bigelow and Schroeder, 1953; Musick, 1974; Markle et al. 1982). White hake tend to be found in deeper water than red hake, but are also found with red hake in shallow bays and estuaries in the Gulf of Maine. This is especially true for juveniles which are the hardest size classes to distinguish from red hake.

Landings of white hake have been viewed as less important than more desirable species of groundfish such as cod and haddock. In 1993, however, white hake landings exceeded those for Gulf of Maine cod (CUD 1995). There is concern that such high landings are not sustainable and that more information on the fishery is needed. This paper summarizes all current information on the white hake fishery and population structure and gives estimates of current fishing mortality rates and stock levels.

STOCK STRUCTURE

Little is known about the stock structure of white hake. Studies aimed at determining the existence of more than one stock tend to be confounded with the presence of red hake and the timing and location of sampling.

Fahay and Able (1989) used several sources of data to attempt a solution to this problem. The evidence presented suggests that two groups of white hake exist in the Gulf of Maine-Georges Bank-Scotian Shelf region. The first group arises from a late winter-early spring spawn which occurs in the deep water of the continental slope from the northeast Gulf of St. Lawrence to Southern New England. The second group spawns in the relatively shallow waters of the Scotian Shelf during the summer. No larvae were found in the Gulf of Maine itself and, therefore, it appears that the Gulf of Maine population is supported by the two spawning events described above.

A study by Lang et al. (1994) supports the existence of a deep water spring spawning population that recruits to the estuaries in the Gulf of Maine. White hake first appeared as pelagic juveniles occurring in deep, offshore areas. Larger fish (50-80 mm) were found inshore later in the year as demersal juveniles. There was a northward progression of size and age from spring to summer, but no evidence of summer spawned fish recruiting to the Gulf of Maine estuaries was found. The timing of sampling suggests that the study may have missed these fish.

An age validation study (Bohan and Burnett, pers. comm.) revealed that three growth patterns exist among Gulf of Maine - Southern New England white hake. The predominant pattern indicated a winter-spring spawn and accounted for over 90% of the samples. The second pattern showed a later spawning period because the fish were smaller in size at age and the size of the nucleus of the otolith was much smaller than the predominant pattern. This growth pattern occurred in fish from offshore strata 29, 30, and 36, closest to the Scotian Shelf. The third growth pattern was found in a limited number of white hake caught on the southern slope of Georges Bank. These had poorly defined annuli which made ageing impossible.

In light of the evidence above, all the white hake found in US waters were treated as one stock. Information from the NEFSC spring and autumn bottom trawl surveys reveals that in the spring (during or just after spawning) white hake are located in deep water and are not found in inshore waters as often as in the autumn surveys (Figures 1 and 2). These fish may be spawning in deeper waters beyond the range of the survey coverage in the spring. Survey indices from various strata sets (Figure 3) demonstrate that the Gulf of Maine area (Strata 26-30, 33-40) exhibits the same basic pattern of abundance and biomass as the Georges Bank area (Strata 13-25), although the levels of abundance and biomass are quite different. Southern New England (Strata 1-12) did not show the same abundance and biomass pattern but this area contributes insignificantly to the total stock biomass. Therefore, for the purpose of the current assessment, landings from the Gulf of Maine and south (SA 464, 465, 511- 626) and the survey strata set from the Gulf of Maine to Northern Georges Bank (21-30, 33-40) were used. This area accounted for over 90% of landings (see section on Commercial Landings).

THE FISHERY

Commercial Landings

Total landings of white hake decreased from about 3,000 mt in 1964 to a low of 1,100 mt in 1967 (Table 1, Figure 4). Landings then gradually increased and peaked at 8,300 mt in 1985. Landings fluctuated around 5,000 to 6,000 mt until they peaked again in 1992 at 9,600 tons and declined slightly to 9,100 tons in 1993 (Table 1). The US has accounted for the major portion of Division 5Y (Gulf of Maine) landings with small amounts landed by Canada. The US has also dominated NAFO Division 5Z (Georges Bank) landings, but in recent years, Canadian landings have increased to 30% of the Georges Bank total. Subarea 6 landings are insignificant, accounting for less than 1% of the total. Landings from other countries have been negligible since 1977.

United States landings reported in Table 1 differ from those reported in Burnett et al. (1984), NEFC (1986), NEFC (1990), and in the NEFSC Status of the Stocks Documents (CUD 1993) (Figure 4), due to a difference between live pounds calculated using current conversion factors and live pounds in the NEFSC Weighout Database. Table 2 shows the landed pounds, live pounds from the database and calculated live pounds, as well as the appropriate conversion factors. All subsequent figures, tables, and Table 1 use the calculated live weights.

The primary gear type used to catch white hake is the otter trawl (Table 3). Historically, line trawls were also important, but from 1980 to 1991, this gear accounted for less than 2% of the total. Recently, however, line trawls increased in importance and, in 1993, represented 16% of the total landings. Sink gill nets have historically accounted for less than 10% of total landings but the share enlarged in the 1970s to between 20 and 40% of the total. Figure 5 shows the landings by gear type from 1963 to 1993 in the Gulf of Maine, Georges Bank and the Mid-Atlantic. Line trawls were more active in the Gulf of Maine in the early part of the period than in the other two areas. More recently, the contribution of this gear to the landings has grown in all areas. Otter trawl landings dominate all areas whereas sink gill net landings occur mostly in the Gulf of Maine.

The primary season for landing white hake is summer (Table 4). The highest percentage of landings occurs in August, with the months of July, September and October each accounting for over 10% of the annual landings. Landings peak in the third quarter in the Gulf of Maine (Figure 6), but on Georges Bank, the landings are more evenly distributed among the four quarters. Landings are highest in the second quarter in the Mid-Atlantic area.

Maine landings have averaged between 50 and 70% of the total US landings since 1964 (Table 5, Figure 7). Massachusetts landings exceeded those of Maine from 1968 to 1974 but have since accounted for 30 to 40% of the total landings. Other states contributing to landings are New Hampshire, Rhode Island, New York, New Jersey, and Virginia. The two primary ports for landings are Portland and Gloucester, which together account for at least 50% of annual landings.

Undertonnage vessels (less than 5 GRT) traditionally accounted for between 20 and 40% of US landings (Table 6), but have since become less important and, in 1993, represented less than 3% of total landings. Tonnage classes 2 and 3 (5-50 GRT and 51-150 GRT, respectively) have accounted for the majority of the landings with tonnage class 3 dominating landings for the last ten years. Tonnage class 4 vessels (151-500 GRT) have increased in importance, however, and, in 1993, were the most important tonnage class, accounting for 36% of the total landings.

The increase in the contribution of larger vessels (tonnage classes 3 and 4) to total landings is also seen in the shift of landings from inshore (SA 511-513) to offshore (SA 515 and 522) areas (Table 7) as the larger vessels are able to travel farther offshore than the smaller vessels. Landings in statistical area 522 doubled from 1992 to 1993. During 1983-1987 white hake were taken by otter trawls primarily in the central Gulf of Maine (Figure 8A), but between 1989 and 1993, the fishery appears to have shifted toward the western Gulf of Maine (Figure 8B). Landings along the edge of the shelf off Southern New England have increased. During the same period, the sink gill net fishery for white hake expanded from the western Gulf of Maine to the offshore banks and ledges (Figure 9).

Separation of otter trawl landings into large mesh (>= 5.5 in.) and small mesh categories was possible only for interviewed trips in the NEFSC Weighout Database. Large mesh otter trawl landings exhibit the same shift from the central Gulf of Maine to the inshore and offshore areas (Figure 10) as the combined otter trawl data (Figure 8). Small mesh landings (excluding the Gulf of Maine northern shrimp fishery), however, show a completely different pattern in the two time periods (Figure 11). This is mainly due to the implementation of the large mesh area requirements in 1985. In the offshore areas depicted by the solid line in Figure 11, mesh sizes < 5.5 inches were not allowed, except for exempted fisheries such as the Cultivator Shoals whiting fishery. The lack of any landings north of Latitude 43° 40' in the period 1989-1993 is most likely due to poor interview coverage of the inshore fishery in that area.

The white hake fishery in the United States has traditionally been a bycatch fishery. Directed trips, defined here as trips in which white hake comprised 40% or more of the total trip catch, have generally accounted for less than 5% of the total trips landing white hake and 30% of the total landings of white hake (Table 8). In the past few years, however, a slight shift has occurred with directed trips now accounting for almost 10% of the total trips and 50% of the total white hake landings. This apparent increase in directivity could occur for three reasons. First, targeting of white hake could have increased. Second, as other more desirable species of groundfish (i.e., cod and haddock) have declined in abundance and total landings of vessels have diminished, the proportion of white hake to the total may have increased. Finally, the abundance of white hake could have increased. Examination of the survey abundance indices (see section on Research Vessel Abundance and Biomass Indices) indicates that abundance has not increased in recent years but has remained stable. Therefore, the most likely cause appears to be a combination of the decline in other groundfish and increased targeting of white hake.

Recreational Catches

The amount of white hake recreational catches reported in the Marine Recreational Fishery Statistical Survey since 1979 is insignificant (< 0.1 mt per year).

Discards

No attempt was made to quantify the amount of discards at this time because expanded estimates have not yet been developed from the Domestic Sea Sampling Program (DSSP) database. However, a qualitative examination of discards from the DSSP indicates significant amounts of white hake being discarded in both otter trawl and sink gill net fisheries (Figures 12 and 13). For otter trawls (Figure 12), the discards of white hake occur around the ten-minute squares where the landings of white hake are highest. The cod, pollock, and white hake sink gill net fisheries in the northeastern Gulf of Maine account for a large portion of white hake discards in sink gill nets (Figure 13). White hake discards occur in both large and small mesh otter trawls (Figures 14 and 15).

Sampling Intensity

Since the majority of white hake are landed in headed and gutted condition, length measurements have not generally been available from port samples. A regression developed to convert dorsal fin-caudal fin length to total length (Creaser and Lyons, 1985), has allowed measurements obtained from landed catch to be used to evaluate overall length composition since 1985. Age samples are still unavailable from port samples since otoliths are the structures used for ageing and are lost when the head is removed.

Table 9 shows the summary of commercial length samples from the ports by market category. Since medium white hake were poorly sampled at the beginning of the sampling period and since there appeared to be no difference in length composition between small and medium market categories, the two size categories were pooled. The sampling intensity overall has been adequate (< 300 mt/sample), except in 1989 when only 13 samples were taken (one sample taken for every 349 mt landed).

Biological samples of the commercial fishery were also obtained from the Domestic Sea Sampling Program. Length samples and age samples can be taken from both the kept and the discarded portions of the white hake catch. Unfortunately, length samples and age structures have not been consistently taken from both portions for all gear types (Table 10). The sink gill net kept portion of the catch is very well sampled, but the discards are infrequently measured. Otter trawl catches are more sparsely sampled.

Length Composition

Commercial length composition during 1985-1993 was estimated by market category (pooling small and medium size categories together) from length frequency samples, pooled on a semiannual basis. Mean weights were obtained by applying the NEFSC survey length-weight equation,

$$\ln \text{Weight (kg, live)} = -12.58 + 3.2196 * \ln \text{Length (cm)}$$

to the semiannual market category length frequencies. Mean weight values were then divided into semiannual market category landings to derive estimated numbers landed by market category. These numbers were then summed over market categories and half-years to produce the annual length compositions shown in Figure 16. White hake less than 40 cm in length are usually not landed in large numbers, but, in 1988 and 1991 some white hake less than 30 cm were landed. This is probably due to the market accepting smaller fish in those years. For the years 1991-1993, there were enough length samples by gear type to estimate the numbers landed by the two major gear types, otter trawl and sink gill net. The length compositions of the two gear types are different with otter trawl landings containing larger proportions of small fish in at least two of the three years (Figure 17).

The length composition of white hake from the Domestic Sea Sampling Program database was estimated by applying the NEFSC survey length-weight equation shown above to the sampled length frequencies from each catch disposition category (kept or discarded). The mean weights were then divided into the total trip weights of the kept and discarded portions to derive estimated numbers landed for each sampled trip. The numbers have not been raised to the total catch of all the sea sampled trips because the sampling of the two groups was not in proportion to the totals caught in the sea sampled trips (i.e., on a given trip, more discards were measured but the majority of the catch was landed). This tended to give total numbers that did not make sense. Therefore, the length frequencies (Figures 18 and 19) are expressed as a percentage of the total for each group (i.e., kept at length/total kept and discard at length/total discard). Since so few discarded white hake from sink gill nets were measured, only the kept portion of the catch is shown. The sink gill net length compositions (Figure 18) are very consistent from year to year with the mode occurring at 63 cm in all five years. The length compositions of both the kept and the discarded portions are more variable in the otter trawl fishery (Figure 19). In some years fish less than 20 cm were discarded, whereas in other years few fish less than 30 cm were discarded. The kept portion of the catch was poorly estimated in 1989 and 1990, and the poor estimation accounts for the variation in the length composition of those years compared to the latter three years which show a smoother, unimodal distribution with the mode around 50 cm.

STOCK ABUNDANCE AND BIOMASS INDICES

Commercial LPUE

United States commercial LPUE (landings-per-unit-effort in metric tons landed per day fished) indices for white hake were calculated for each tonnage class for otter trawl trips that landed any white hake. Indices were also derived for trips that 'directed' toward white hake (white hake accounted for > 40% of the total landings for the trip, Table 11). Directed trips have always accounted for less than 10% of the total white hake landings and may not provide a very meaningful index of stock abundance.

Total and directed US LPUE indices show similar trends at the beginning of the time period, peaking in the late 1970s and declining through 1980 (Figure 20). After 1980, the trends diverge as the directed LPUE index continues to decline and the total LPUE index increases and remains relatively high but variable. The problems with changes in directivity and the reasons for the change (see section on Commercial Fishery) make the use of directed trips for an LPUE index inappropriate.

Fishing effort was standardized by applying two different General Linear Models to the LPUE data. The first was a six-factor model (year, quarter, area, tonnage class, depth, and species ratio) while the second omitted species ratio. These GLMs were applied to log LPUE data derived for all otter trawl trips taking white hake from 1975 through 1993 (Tables 12 and 13). The first model accounted for almost 40% of the total sum of squares, 8% more than the second which accounted for 32% of the total. All of the main effects were highly significant.

Standardized effort was calculated by multiplying the nominal effort in each cell by the product of the retransformed log coefficients for each factor (excluding year). The estimated standardized effort was then summed over all categories to give annual totals (Tables 14 and 15). Trends in the two standardized series are similar to the trends in the two nominal LPUE indices (Figure 21). The series produced by the first model (including species ratio) shows the same decline as in the nominal LPUE index derived from directed trips while the series resulting from the second model resembles the total nominal LPUE. Due to the same problems with directivity as noted above, the second model appears to be more realistic in describing the abundance of white hake over time.

The distribution pattern of weighted LPUE (sum pounds landed in a ten-minute square/ sum of days fished in that ten-minute square) in otter trawls exhibits an unusual trend (Figure 22). The highest LPUE values occur in the northeast portion of the Gulf of Maine with lower values of LPUE to the west. Sink gill net LPUE (Figure 23) increases with depth with the central portions of the Gulf of Maine having higher LPUE values than the inshore areas in the period 1989-1993.

Research Vessel Abundance and Biomass Indices

The NEFSC autumn bottom trawl survey has been in existence since 1963 (Azarovitz, 1981). Offshore areas from the Gulf of Maine to Southern New England are sampled, and, beginning in 1967, offshore areas in the Mid-Atlantic were sampled as well. The NEFSC spring bottom trawl survey began in 1968. The surveys have been conducted with the same gear and vessel as often as possible. The strata set used for white hake is the Gulf of Maine to Northern Georges Bank (offshore strata 21-30 and 33-40). Indices of abundance and biomass were calculated following the methods of Cochran (1977).

Stratified mean number per tow, weight per tow, and mean length from spring and autumn surveys are given in Table 16 and illustrated in Figure 24. The indices are especially variable in the spring survey. The autumn weight per tow index fluctuated around 5 kg/tow in the early 1960s and increased to approximately 12 kg/tow during the 1970s. Excluding the 1982 data point, the autumn mean weight per tow index has fluctuated around 10 kg/tow since 1983. Over the time period, the autumn abundance index increased relative to the biomass index indicating a gradual shift from larger to smaller fish during the 1970s and 1980s.

Length frequency histograms derived from the spring and autumn surveys are shown in Figure 25. Although the mode of the length composition remained at about 40 cm in almost all years, there were more white hake over 100 cm and fewer fish less than 20 cm in the 1970s compared to the 1980s.

STOCK PARAMETERS

Natural Mortality

Natural mortality (M) for most gadid stocks is assumed to be 0.2. Hoenig (1983) developed an empirical relationship between total mortality (Z) and longevity (T_{max}):

$$\ln Z = 1.46 - 1.01 \ln T_{max}$$

Assuming a maximum age of 20 years for white hake (the oldest fish in the samples used in section on total mortality was 18 years) this relationship estimates a Z of 0.2. In the absence of fishing mortality Z = M = 0.2.

Total Mortality

Estimates of instantaneous total mortality were derived from NEFSC spring survey catch per tow at age data (Table 17) for 1987-1989. Age at full recruitment to the survey was assumed to be 2. Therefore, an estimate was derived by taking the natural logarithm of pooled age 2+ to pooled age 3+. The estimate of Z for 1987-1988/1988-1989 is 1.32. If age at full recruitment is assumed to be 1 then ln(1+/2+) gives a Z of 0.91. More age data are needed to determine which assumption of age at full recruitment is more appropriate.

Maturity

Estimates of length at 50% maturity were taken from O'Brien et al. (1993). The estimate for females is 35.1 cm and the estimate for males is 32.7 cm. Estimates of age at 50% maturity are 1.4 years for both sexes (O'Brien et al. 1993).

Growth

The growth rate of white hake was estimated by fitting the von Bertalanffy growth equation to the age data from the 1987-1989 NEFSC spring surveys and the 1987 NEFSC autumn survey, sexes combined. Fish from the autumn were considered to be a half year older than their spring counterparts. The results of the analysis are shown in Figure 26. The estimate for L_{inf} was 125.8 cm and k was estimated to be 0.153. These results seem driven by the female portion of the stock since Bohan and Burnett (pers. comm.) estimated L_{inf} for females and males to be 144 cm and 69 cm, respectively. No males have been found to be older than age 8 (Burnett et al., 1984).

ESTIMATES OF STOCK SIZE AND FISHING MORTALITY

DeLury Analysis

A modified DeLury model was employed to derive estimates of fishing mortality rates and stock sizes for white hake from 1985-1993. The model as formulated by Conser (1994) is

$$n_y = \left\{ n_{y-1} + \frac{r_{y-1}}{s_r} - q_n C_{y-1} \right\} e^{-M+\epsilon_y}$$

where:

- n_y = survey index of abundance for fully recruited fish in year y
- r_{y-1}, n_{y-1} = survey indices of abundance for recruits and fully recruited fish in year y-1
- s_r = selectivity of the recruits relative to the fully recruited fish
- q_n = catchability coefficient of fully recruited fish
- C_{y-1} = catch in number during survey year y-1
- M = natural mortality
- ϵ_y = process error.

Estimates of n, r, and q were obtained by minimizing the difference between the observed and the predicted values in a nonlinear least squares objective function

(Conser 1994). Indices of abundance and mean weight for recruits and fully recruited fish from the NEFSC autumn survey, and the commercial catch in weight and number were used to fit the model (Table 18). Recruits were defined as all white hake between 29 and 43 cm and fully-recruited fish were defined as all fish greater than or equal to 44 cm. This was determined by comparing the length frequency compositions from the commercial fishery (Figure 16), sea sampling data (Figures 18 and 19) and research vessel surveys (Figure 25). Length at 50% recruitment to the fishery was 46 cm and, therefore, taking discards into account, the maximum length selected for recruits was 43 cm. Natural mortality was set at 0.2 and selectivity of the recruits relative to the fully recruited fish in the NEFSC survey was set equal to 1.0. Partial recruitment of recruits over the year was assumed to be linear (Figure 27) yielding an average partial recruitment of recruits to the commercial fishery of 0.50. Process error residuals were weighted to be twice the measurement error.

The uncertainty associated with the estimated parameters was evaluated using a bootstrap procedure (Conser 1994). Standard errors, coefficients of variation, and percent bias of the nonlinear least square (NLLS) estimates were derived from 200 bootstrap iterations. All NLLS estimates were corrected for bias.

The full results of the model are presented in Appendix A and the bootstrap results in Appendix B. The bias-corrected estimates of fishing mortality, stock sizes, and stock biomass are given in Table 19. Fishing mortality on the fully-recruited fish peaked in 1988 at 0.56, and declined to a low of 0.34 the following year (Figure 28). Fishing mortality has increased in the last four years and is currently estimated to be 0.42. Stock biomass of fully-recruited fish (Figure 29) has fluctuated without trend around 12,000 mt since 1985. The number of recruits has also fluctuated without trend and corresponds to the trend in fully-recruited biomass in the following year (Figure 29). Levels of recruitment in 1993 and 1994 appear to be approximately half that of 1992 (Table 19).

Surplus Production Analysis

A surplus production model was employed to derive estimates of catchability, maximum sustainable yield (MSY) for the stock, and annual estimates of biomass. The model was formulated by Conser (1994) as the difference in positive production due to recruitment and somatic growth and the negative production due to natural mortality:

$$P_Y = \frac{aB_Y}{1 + \frac{B_Y}{K}} - MB_Y$$

where:

a is the parameter of the Beverton-Holt function, representing the maximum instantaneous rate of positive production

B_y is the exploited stock biomass at the beginning of year y

K is the parameter of the Beverton-Holt function, representing the threshold stock biomass above which density dependent effects dominate and

M is the instantaneous rate of natural mortality.

The model was reparameterized using:

$$a = (\alpha'+1)M \quad \text{and} \quad K = B_{max} / \alpha'$$

yielding:

$$P_y = \alpha' M B_y \frac{1 - \frac{B_y}{B_{max}}}{1 + \alpha' \frac{B_y}{B_{max}}}$$

where α' is a unitless measure of the resilience of the stock and B_{max} is the exploitable virgin stock biomass.

Estimates of stock biomass and catchability were obtained by minimizing the difference between the observed and predicted values in a nonlinear least squares objective function (Conser 1994).

Annual biomass indices from the survey (Table 19) and the catch biomass as estimated by the DeLury model (Table 20) were used to fit the production model. Biomass indices were estimated from indices of abundance and mean weight of recruits and fully recruited fish in the NEFSC autumn survey from 1985-1993. The natural mortality estimate was 0.2 and the index of virgin biomass was set at 50,000 g.

The stock resiliency parameter is generally bounded between 1 and 10 for marine species (Shepherd 1987). Marine mammals can be considered to be least resilient with an α' at about 1 and species that are highly resilient, perhaps with a refuge for the brood stock, would have an α' of about 10. Given the life history pattern of white hake, α' was set at 7.

The uncertainty associated with the estimated parameters was evaluated using a bootstrap procedure (Conser 1994). Standard errors, coefficients of variation, and percent bias of the nonlinear least square (NLLS) estimates were derived from 200 bootstrap iterations. All NLLS estimates were corrected for bias.

The full results of the model are presented in Appendix C and the bootstrap results are given in Appendix D. The bias-corrected estimates of stock biomass, surplus production, and model parameters are given in Table 20. MSY was estimated to be 7,700 mt requiring a stock biomass of 21,000 mt (Figure 30). According to the surplus production curve, this stock of white hake is currently being fished slightly above MSY and the stock biomass is below that needed to support this level. The value of K corresponding to the values of α' and B_{max} is 11,500 tons. Current levels of biomass are above this threshold, so the stock is not recruitment overfished as density-dependent effects are still operating.

BIOLOGICAL REFERENCE POINTS

Yield and Spawning Stock Biomass per recruit

Yield-per-recruit, total stock biomass per recruit, and spawning stock biomass per recruit calculations were performed using the Thompson and Bell (1934) method. Mean weights at age were derived by taking lengths-at-age from the Von Bertalanffy equation described above and applying the NEFSC survey length-weight equation described above. This most likely underestimates weight-at-age in the catch for the first few ages. The maturity ogive was taken from O'Brien et al. (1993). The partial recruitment vector was extrapolated, assuming L_{50} at age 2 and full recruitment at age 4. This partial recruitment pattern takes into account more of the discards than the Modified DeLury and the Shepherd Production Models described above. Input data and results of the yield and SSB per recruit analyses are presented in Table 21 and are illustrated in Figure 31. The yield per recruit analyses indicate that $F_{0.1}$ = 0.13, F_{max} = 0.22 and $F_{20\%}$ = 0.33. All values are poorly estimated due to the uncertainties in the weight-at-age and the partial recruitment vector as noted above.

CONCLUSIONS

The Gulf of Maine to Mid-Atlantic white hake stock is currently at a moderate stock level and is at least fully exploited. Continued fishing at current levels of fishing mortality may possibly maintain the current stock level but any increase in fishing mortality may cause the stock to decline.

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Table 1. Total Landings (mt,live)[1] of white hake by country from the Gulf of Maine to Cape Hatteras (NAFO Subareas 5 and 6), 1964-1993.

	5Y[2]			5Z			6			Total			Total Subarea 5	Grand Total
	Canada	USA[3]	Other[4]	Canada	USA	Other[4]	Canada	USA	Other[4]	Canada	USA	Other	5	Total
1964	3	2129		26	772			4		29	2905	-	2930	2934
1965		2019			570			3		-	2593	-	2590	2593
1966		1127			408			2		-	1537	-	1535	1537
1967		797		16	312			<1		16	1109	-	1125	1125
1968	5	770		80	418			4		85	1193	-	1274	1278
1969	4	828		30	505	6		2		34	1335	6	1373	1375
1970	12	1201		34	590	222		5	58	46	1795	280	2058	2121
1971	18	1612		82	905	109		29	105	100	2546	214	2726	2860
1972	8	2146		32	764	159		14		40	2924	159	3109	3123
1973	17	2305		100	719	1		3	4	117	3027	5	3142	3149
1974	36	2868		196	768			3		232	3640	-	3869	3872
1975	17	2934		129	550			1		146	3485	-	3630	3631
1976		3378		195	539			3		195	3920	-	4112	4115
1977		4012		170	728	189		1	149	170	4740	338	5098	5248
1978	20	3843		135	837	1		4	28	155	4684	29	4836	4868
1979	102	2922		149	860	3		1	1	251	3782	4	4035	4037
1980	14	3382		291	982	1		2	1	305	4366	2	4670	4673
1981	21	4680		433	1233			4		454	5916	-	6366	6370
1982	352	5099		412	1070	1		4	1	764	6173	2	6934	6939
1983	441	5291		369	1111			2		810	6404	-	7212	7214
1984	479	5269		534	1467			8		1013	6744	-	7749	7757
1985	452	5901		501	1446			2		953	7349	-	8300	8302
1986	308	5055		648	1049			4		956	6107	-	7060	7063
1987		4402		555	1407			5		555	5814	-	6364	6369
1988		3171		534	1568			37		534	4776	-	5273	5310
1989		3471		583	1067			5		583	4543	-	5121	5126
1990		3804		547	1107			8		547	4920	-	5458	5467
1991		4309		552	1262			29		552	5600	-	6123	6152
1992		6335		1120	2058			45		1120	8438	-	9513	9558
1993	[5]	4432		1671	2997			32		1671	7461	-	9100	9132

[1]Canada and Other as reported to ICNAF/NAFO for 1964-1992. USA Landings derived from NEFSC Weighout files.
[2]NK Landings for SA5 assigned to Subarea 5Y
[3]US 5Y landings include 464 and 465
[4]Includes Japan, Spain, and USSR.
[5]Canadian 5Y landings for 93 moved to 4X.

Table 2. US landings (mt, lnd[1]), live weight (mt,live[2]), and calculated live weight (mt,calc live[3]) of white hake by market category.

Market Category

	Unclassified Dressed[4]			Small Round[5]			Small Gutted[6]			Unclassified Gutted[6]			Large Round[5]			Medium Round[5]		
	Lnd	Live	Calc. Live	Lnd	Live	Calc. Live	Lnd	Live	Calc. Live	Lnd	Live	Calc. Live	Lnd	Live	Calc. Live	Lnd	Live	Calc. Live
1964																		
1965																		
1966																		
1967																		
1968																		
1969																		
1970																		
1971																		
1972																		
1973	1921	2574	2574															
1974	2744	3676	3677															
1975	2619	2619	3510															
1976	2947	2947	3948															
1977	3559	3559	4770															
1978	3498	3498	4688										1	1	1	<1	<1	<1
1979	2822	2822	3782															
1980	3258	3258	4366															
1981	4410	5881	5910										3	3	3	1	1	1
1982	4314	5781	5781	13	17	13				8	10	9	4	4	4	2	2	2
1983	2934	3932	3932	1	2	1	2	3	2	7	10	8				1	1	1
1984	2422	3245	3245	8	10	8	4	5	4	38	50	43	<1	<1	<1	<1	<1	<1
1985	2781	2781	3727	3	3	3	15	20	17	54	72	61	1	1	1	1	1	1
1986	2780	2780	3725	<1	<1	<1	<1	<1	<1	22	28	25						
1987	1533	1533	2054	3	3	3				28	31	31	<1	<1	<1	<1	<1	<1
1988	550	732	737	3	3	3	3	3	3	40	46	46						
1989	809	1084	1084	1	1	1	<1	<1	<1	8	9	9				2	2	2
1990	706	947	947	2	2	2	<1	<1	<1	13	15	15	<1	<1	<1			
1991	923	1237	1237	<1	<1	<1				22	25	25	<1	<1	<1	<1	<1	<1
1992	1247	1672	1672	<1	<1	<1	1	2	2	48	54	54	1	1	1	2	2	2
1993	1442	1932	1932	1	1	1	10	12	12	28	32	32	2	2	2	3	3	3

	Large Dressed[4]			Medium Dressed[4]			Small Dressed[4]			Unclassified Round[5]			Total		
	Lnd	Live	Calc. Live	Lnd	Live	Calc. Live	Lnd	Live	Calc. Live	Lnd	Live	Calc. Live	Lnd	Live	Calc. Live
1964	1552	2079	2079	707	947	947							2258	3026	3026
1965	1533	2055	2055	484	648	648							2017	2702	2703
1966	790	1059	1059	403	540	540							1193	1598	1599
1967	511	685	685	424	569	569							935	1253	1253
1968	547	733	733	392	526	525							939	1258	1258
1969	594	796	796	428	574	573							1022	1370	1370
1970	772	1034	1034	603	808	807							1374	1842	1842
1971	1288	1726	1726	654	876	876							1942	2602	2602
1972	2045	2741	2741	189	253	253							2235	2994	2994
1973	283	379	379	70	93	93							2273	3046	3046
1974													2744	3676	3677
1975													2619	2619	3510
1976													2947	2947	3948
1977													3559	3559	4770
1978	<1	<1	<1	<1	<1	<1							3499	3499	4689
1979													2822	2822	3782
1980													3258	3258	4366
1981	2	3	3	<1	<1	<1							4416	5887	5917
1982	185	248	248	9	12	12	79	106	106				4614	6180	6174
1983	1215	1628	1628	75	100	100	548	734	734				4783	6409	6407
1984	1851	2480	2480	137	183	183	585	784	784				5043	6759	6747
1985	1821	2440	2440	332	445	445	503	674	674				5511	6437	7368
1986	1460	1957	1957	212	284	284	297	398	398				4772	5447	6390
1987	1355	1816	1816	228	306	306	1204	1614	1614				4352	5304	5825
1988	1111	1489	1489	365	489	489	1503	2015	2015				3575	4775	4780
1989	1519	2035	2035	213	285	285	844	1131	1131				3396	4548	4548
1990	1031	1382	1382	466	625	625	1456	1951	1951				3675	4922	4922
1991	924	1238	1238	566	758	758	1748	2342	2342	<1	<1	<1	4183	5600	5600
1992	1232	1650	1650	1064	1426	1426	2710	3631	3631	1	1	1	6306	8439	8439
1993	1387	1858	1858	1591	2132	2132	1110	1488	1488	2	2	2	5576	7461	7461

[1] Data Source - NEFSC Weighout Landed Pounds
[2] Data Source - NEFSC Weighout Live Pounds
[3] Data Source - NEFSC Weighout Landed Pounds * Appropriate Conversion Factor
[4] Conversion Factor = 1.34
[5] Conversion Factor = 1.00
[6] Conversion Factor = 1.13

Table 3. US commercial landings (mt,live) and the annual percentage of total landings of white hake by gear type, 1964-1993.

	Landings (mt,live)					Percentage of Annual Landings				
Year	Line Trawl	Bottom Otter Trawl	Sink Gill Net	Other[1] Gear	Total	Line Trawl	Bottom Otter Trawl	Sink Gill Net	Other[1] Gear	Total
1964	1146	1772	99	8	3026	37.9	58.6	3.3	0.3	100.0
1965	1511	1124	64	4	2703	55.9	41.6	2.4	0.2	100.0
1966	703	793	99	5	1599	43.9	49.6	6.2	0.3	100.0
1967	325	858	67	4	1253	25.9	68.5	5.3	0.3	100.0
1968	265	875	115	3	1259	21.1	69.5	9.2	0.2	100.0
1969	228	1037	103	2	1370	16.7	75.7	7.5	0.1	100.0
1970	201	1508	129	4	1842	10.9	81.9	7.0	0.2	100.0
1971	532	1943	118	9	2602	20.4	74.7	4.5	0.3	100.0
1972	833	1766	383	11	2994	27.8	59.0	12.8	0.4	100.0
1973	816	1803	421	6	3046	26.8	59.2	13.8	0.2	100.0
1974	624	1845	1198	10	3677	17.0	50.2	32.6	0.3	100.0
1975	972	1336	1201	2	3510	27.7	38.1	34.2	0.0	100.0
1976	527	1597	1818	6	3948	13.3	40.5	46.0	0.2	100.0
1977	350	2319	2091	10	4769	7.3	48.6	43.8	0.2	100.0
1978	297	2160	2213	19	4689	6.3	46.1	47.2	0.4	100.0
1979	192	2016	1556	19	3782	5.1	53.3	41.1	0.5	100.0
1980	72	2587	1680	28	4366	1.6	59.3	38.5	0.6	100.0
1981	108	3423	2376	11	5917	1.8	57.8	40.2	0.2	100.0
1982	95	3861	2201	18	6174	1.5	62.5	35.6	0.3	100.0
1983	59	4868	1394	85	6406	0.9	76.0	21.8	1.3	100.0
1984	5	5152	1486	104	6747	0.1	76.4	22.0	1.5	100.0
1985	20	5514	1417	417	7368	0.3	74.8	19.2	5.7	100.0
1986	19	4699	1162	510	6390	0.3	73.5	18.2	8.0	100.0
1987	36	4805	910	73	5825	0.6	82.5	15.6	1.3	100.0
1988	40	3650	1007	83	4780	0.8	76.4	21.1	1.7	100.0
1989	15	2552	1892	89	4548	0.3	56.1	41.6	2.0	100.0
1990	78	3280	1508	55	4922	1.6	66.6	30.6	1.1	100.0
1991	249	3548	1614	189	5600	4.4	63.3	28.8	3.4	100.0
1992	948	5190	2261	40	8438	11.2	61.5	26.8	0.5	100.0
1993	1203	4653	1588	16	7461	16.1	62.4	21.3	0.2	100.0

[1] Includes handline, Scottish seine, drift gill net, scallop dredge, Danish seine, pound net, floating trap net, longline, midwater trawl, lobster pots, fish pots, purse seine, troll line, common seine, diving gear, set gill net, harpoon, rakes, and trammel net.

Table 4. Landings (mt, live) and the annual percentage of landings of white hake by season, 1964-1993.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
						Month							
1964	150	127	127	168	112	224	745	419	394	249	211	101	3026
1965	83	105	88	39	26	153	763	584	408	186	148	121	2703
1966	37	40	68	48	30	94	92	596	234	169	108	84	1598
1967	56	29	50	23	22	33	68	266	282	244	115	65	1253
1968	38	52	51	23	28	67	104	332	242	175	82	66	1258
1969	55	44	19	25	34	69	82	278	269	220	164	112	1370
1970	57	54	52	41	116	160	186	244	259	332	197	144	1842
1971	83	39	41	44	99	180	184	458	422	445	422	187	2602
1972	123	65	57	46	151	187	384	649	446	507	214	166	2994
1973	124	54	68	79	147	193	316	581	417	482	324	261	3046
1974	175	51	87	148	164	194	356	531	577	644	422	327	3676
1975	106	74	65	100	234	297	465	733	505	312	427	193	3510
1976	97	148	153	128	133	317	758	576	671	366	384	219	3948
1977	120	93	199	146	196	284	685	852	645	665	612	272	4769
1978	106	147	114	131	172	271	370	1084	863	761	480	190	4689
1979	102	34	78	106	232	322	642	964	433	379	308	182	3782
1980	109	108	106	102	131	442	720	860	636	553	405	195	4366
1981	196	86	126	116	129	437	903	1375	798	649	766	336	5917
1982	174	180	194	134	190	462	1139	1280	809	693	571	349	6174
1983	408	237	284	211	334	630	817	1015	745	744	577	406	6406
1984	425	228	221	208	341	537	770	1209	964	934	549	362	6747
1985	273	231	299	345	362	708	1102	1030	1115	825	633	445	7368
1986	309	276	288	443	466	711	1051	855	723	623	373	272	6390
1987	135	188	224	163	270	725	1004	938	805	696	411	267	5825
1988	184	100	132	166	289	646	682	761	844	503	314	159	4780
1989	149	132	130	137	204	598	796	807	603	540	291	161	4548
1990	157	112	172	135	271	595	812	916	635	617	318	181	4921
1991	163	162	90	114	457	554	846	1126	871	624	345	247	5600
1992	277	247	294	283	344	832	1487	1756	1203	802	595	321	8438
1993	272	213	274	307	532	1000	1319	1232	790	744	514	266	7461
						Percentage of total							
1964	5.0	4.2	4.2	5.6	3.7	7.4	24.6	13.8	13.0	8.2	7.0	3.3	100.0
1965	3.1	3.9	3.3	1.4	0.9	5.7	28.2	21.6	15.1	6.9	5.5	4.5	100.0
1966	2.3	2.5	4.3	3.0	1.9	5.9	5.7	37.3	14.6	10.6	6.8	5.2	100.0
1967	4.4	2.3	4.0	1.9	1.8	2.6	5.4	21.3	22.5	19.5	9.2	5.2	100.0
1968	3.0	4.1	4.1	1.9	2.2	5.3	8.2	26.4	19.2	13.9	6.5	5.3	100.0
1969	4.0	3.2	1.4	1.8	2.5	5.0	6.0	20.3	19.6	16.0	11.9	8.1	100.0
1970	3.1	3.0	2.8	2.2	6.3	8.7	10.1	13.2	14.1	18.0	10.7	7.8	100.0
1971	3.2	1.5	1.6	1.7	3.8	6.9	7.1	17.6	16.2	17.1	16.2	7.2	100.0
1972	4.1	2.2	1.9	1.5	5.1	6.2	12.8	21.7	14.9	16.9	7.2	5.5	100.0
1973	4.1	1.8	2.2	2.6	4.8	6.3	10.4	19.1	13.7	15.8	10.6	8.6	100.0
1974	4.8	1.4	2.4	4.0	4.5	5.3	9.7	14.4	15.7	17.5	11.6	8.9	100.0
1975	3.0	2.1	1.8	2.8	6.7	8.4	13.2	20.9	14.4	8.9	12.2	5.5	100.0
1976	2.4	3.7	3.9	3.2	3.4	8.0	19.2	14.6	17.0	9.3	9.7	5.5	100.0
1977	2.5	2.0	4.2	3.1	4.1	6.0	14.4	17.9	13.5	13.9	12.8	5.7	100.0
1978	2.3	3.1	2.4	2.8	3.7	5.8	7.9	23.1	18.4	16.2	10.2	4.1	100.0
1979	2.7	0.9	2.1	2.8	6.1	8.5	17.0	25.5	11.4	10.0	8.1	4.8	100.0
1980	2.5	2.5	2.4	2.3	3.0	10.1	16.5	19.7	14.6	12.7	9.3	4.5	100.0
1981	3.3	1.5	2.1	2.0	2.2	7.4	15.3	23.2	13.5	11.0	12.9	5.7	100.0
1982	2.8	2.9	3.1	2.2	3.1	7.5	18.5	20.7	13.1	11.2	9.3	5.6	100.0
1983	6.4	3.7	4.4	3.3	5.2	9.8	12.7	15.8	11.6	11.6	9.0	6.3	100.0
1984	6.3	3.4	3.3	3.1	5.1	8.0	11.4	17.9	14.3	13.8	8.1	5.4	100.0
1985	3.7	3.1	4.1	4.7	4.9	9.6	15.0	14.0	15.1	11.2	8.6	6.0	100.0
1986	4.8	4.3	4.5	6.9	7.3	11.1	16.4	13.4	11.3	9.8	5.8	4.3	100.0
1987	2.3	3.2	3.8	2.8	4.6	12.4	17.2	16.1	13.8	11.9	7.1	4.6	100.0
1988	3.8	2.1	2.8	3.5	6.1	13.5	14.3	15.9	17.7	10.5	6.6	3.3	100.0
1989	3.3	2.9	2.9	3.0	4.5	13.1	17.5	17.8	13.3	11.9	6.4	3.5	100.0
1990	3.2	2.3	3.5	2.7	5.5	12.1	16.5	18.6	12.9	12.5	6.5	3.7	100.0
1991	2.9	2.9	1.6	2.0	8.2	9.9	15.1	20.1	15.6	11.1	6.2	4.4	100.0
1992	3.3	2.9	3.5	3.4	4.1	9.9	17.6	20.8	14.3	9.5	7.1	3.8	100.0
1993	3.6	2.9	3.7	4.1	7.1	13.4	17.7	16.5	10.6	10.0	6.9	3.6	100.0

Table 5. Total US Landings (mt,live) and the annual percentage of landings of white hake by state, 1964-1993.

	Landings (mt, live)				Percentage of total			
Year	Maine	Mass.	Others[1]	Total	Maine	Mass.	Others[1]	Total
1964	1531	1475	20	3026	50.6	48.7	0.7	100.0
1965	1746	937	19	2703	64.6	34.7	0.7	100.0
1966	915	657	26	1599	57.3	41.1	1.6	100.0
1967	641	595	18	1253	51.1	47.5	1.4	100.0
1968	570	641	48	1259	45.2	50.9	3.8	100.0
1969	475	852	43	1370	34.7	62.2	3.1	100.0
1970	640	1133	69	1842	34.8	61.5	3.7	100.0
1971	883	1616	103	2602	33.9	62.1	4.0	100.0
1972	1338	1599	58	2994	44.7	53.4	1.9	100.0
1973	1269	1714	64	3047	41.6	56.2	2.1	100.0
1974	1714	1932	31	3676	46.6	52.6	0.8	100.0
1975	2068	1424	18	3510	58.9	40.6	0.5	100.0
1976	2506	1426	17	3948	63.5	36.1	0.4	100.0
1977	2968	1767	35	4769	62.2	37.0	0.7	100.0
1978	3047	1623	19	4689	65.0	34.6	0.4	100.0
1979	2404	1366	12	3782	63.6	36.1	0.3	100.0
1980	2729	1594	44	4366	62.5	36.5	1.0	100.0
1981	3756	2024	137	5917	63.5	34.2	2.3	100.0
1982	4253	1795	127	6174	68.9	29.1	2.1	100.0
1983	4292	1871	244	6406	67.0	29.2	3.8	100.0
1984	3877	2446	425	6747	57.5	36.2	6.3	100.0
1985	3707	3376	285	7368	50.3	45.8	3.9	100.0
1986	3230	2880	280	6389	50.5	45.1	4.4	100.0
1987	3255	2255	315	5825	55.9	38.7	5.4	100.0
1988	2699	1898	183	4780	56.5	39.7	3.8	100.0
1989	3128	1322	97	4548	68.8	29.1	2.1	100.0
1990	2746	2105	70	4922	55.8	42.8	1.4	100.0
1991	3280	2118	202	5600	58.6	37.8	3.6	100.0
1992	5357	2518	564	8438	63.5	29.8	6.7	100.0
1993	5042	2064	355	7461	67.6	27.7	4.8	100.0

[1]Others include NH,RI,NY,NJ,VA

Table 6. US Landings (mt,live) and the annual percentage of total landings of white hake by tonnage class[1], 1964-1993.

Year	Tonnage Class (TC)					Percentage of total				
	2	3	4	Others[2]	Total	2	3	4	Others[2]	Total
1964	450	1084	258	1234	3026	14.9	35.8	8.5	40.8	100.0
1965	312	590	228	1573	2703	11.5	21.8	8.4	58.2	100.0
1966	280	445	145	728	1599	17.5	27.9	9.1	45.6	100.0
1967	206	437	150	459	1253	16.5	34.9	12.0	36.6	100.0
1968	300	457	185	317	1259	23.8	36.3	14.7	25.2	100.0
1969	286	555	239	290	1370	20.9	40.5	17.4	21.2	100.0
1970	520	748	323	251	1842	28.2	40.6	17.5	13.6	100.0
1971	600	1114	367	521	2602	23.1	42.8	14.1	20.0	100.0
1972	738	1002	343	912	2995	24.6	33.5	11.4	30.5	100.0
1973	933	922	298	893	3046	30.6	30.3	9.8	29.3	100.0
1974	1339	907	347	1084	3676	36.4	24.7	9.4	29.5	100.0
1975	1304	609	271	1327	3510	37.1	17.3	7.7	37.8	100.0
1976	1587	845	299	1217	3948	40.2	21.4	7.6	30.8	100.0
1977	2363	1020	503	883	4769	49.5	21.4	10.5	18.5	100.0
1978	2161	1087	535	906	4689	46.1	23.2	11.4	19.3	100.0
1979	1687	1055	469	571	3782	44.6	27.9	12.4	15.1	100.0
1980	1809	1143	730	685	4366	41.4	26.2	16.7	15.7	100.0
1981	2346	1492	1348	731	5917	39.6	25.2	22.8	12.4	100.0
1982	2626	1828	1310	411	6174	42.5	29.6	21.2	6.7	100.0
1983	1964	2405	1798	240	6407	30.7	37.5	28.1	3.7	100.0
1984	1966	2746	1625	411	6748	29.1	40.7	24.1	6.1	100.0
1985	1882	2987	2199	299	7367	25.5	40.5	29.8	4.1	100.0
1986	1189	2512	2223	465	6389	18.6	39.3	34.8	7.3	100.0
1987	1078	2556	1876	315	5825	18.5	43.9	32.2	5.4	100.0
1988	1114	1755	1684	227	4780	23.3	36.7	35.2	4.7	100.0
1989	1535	1525	1193	295	4548	33.8	33.5	26.2	6.5	100.0
1990	1330	1727	1672	192	4921	27.0	35.1	34.0	3.9	100.0
1991	1749	1948	1636	268	5601	31.2	34.8	29.2	4.8	100.0
1992	2666	2933	2354	486	8439	31.6	34.8	27.9	5.8	100.0
1993	1995	2563	2704	199	7461	26.7	34.4	36.2	2.7	100.0

[1]TC2 = 5-50 GRT, TC3 = 51-150 GRT, TC4 = 151-500 GRT.
[2]Undertonnage vessels

Table 7. Landings (mt,live) of white hake by statistical area.

Year	Statistical Areas																		Total
	3[1]	4[2]	511	512	513	514	515	521	522	525	526	537	538	539	561	562	5[3]	6[4]	
1964	0	185	339	984	303	318	122	420	247	1	15	5	0	1	63	22	0	4	3026
1965	0	121	160	1433	228	156	32	146	320	6	6	15	0	2	70	6	0	3	2703
1966	0	89	33	758	182	116	12	146	158	4	11	23	0	2	58	6	1	2	1599
1967	0	167	141	406	153	53	19	130	95	3	9	11	0	2	55	7	2	0	1253
1968	0	79	96	332	243	76	11	199	98	9	15	17	1	6	63	8	4	4	1258
1969	0	46	24	289	372	102	30	282	108	5	23	32	0	1	44	9	0	2	1370
1970	0	75	20	276	573	190	114	274	179	7	32	42	0	3	46	6	0	5	1842
1971	0	70	54	574	588	277	105	490	279	9	24	43	1	3	45	12	0	29	2602
1972	0	86	60	829	828	314	99	390	222	21	17	18	0	2	50	44	0	14	2994
1973	0	33	38	584	1009	472	190	449	164	6	24	44	0	2	21	11	0	3	3047
1974	0	50	63	493	1567	550	182	525	178	3	13	7	0	3	18	21	0	3	3676
1975	0	48	37	744	1614	262	254	370	123	5	6	4	0	3	22	18	0	1	3510
1976	0	71	20	830	1822	272	392	404	96	5	6	4	0	1	9	15	0	3	3949
1977	0	132	28	538	2428	531	385	349	303	10	5	5	0	0	35	20	0	1	4769
1978	0	40	35	1345	1743	351	334	365	360	4	4	18	2	0	70	14	0	4	4689
1979	0	16	342	957	1035	277	295	408	348	3	5	4	0	2	81	8	0	1	3782
1980	0	51	86	821	1775	253	396	465	372	7	9	15	0	6	98	9	0	2	4366
1981	0	185	59	1360	2258	149	669	306	485	10	7	14	0	1	355	52	3	4	5917
1982	0	196	299	2056	1422	285	842	409	345	21	11	20	4	3	240	17	0	4	6174
1983	0	243	427	1600	1464	264	1295	353	386	9	6	15	0	10	298	35	0	2	6407
1984	0	276	354	1215	1716	319	1392	600	475	11	12	33	0	4	292	39	0	8	6747
1985	19	72	425	1293	1642	439	2031	699	449	24	14	31	0	6	182	40	0	2	7368
1986	278	181	648	1341	1103	261	1525	434	342	60	19	22	0	2	157	13	0	4	6390
1987	8	76	345	965	1194	345	1479	574	509	17	26	33	1	2	206	38	0	5	5825
1988	4	23	308	755	854	322	910	740	490	12	30	23	0	3	248	23	0	37	4780
1989	6	33	209	1151	897	185	996	343	514	5	15	10	0	1	151	27	0	5	4548
1990	2	140	242	1090	1031	206	1095	394	330	15	10	25	0	4	287	44	0	8	4922
1991	0	24	191	1350	1138	243	1364	289	437	47	15	55	0	3	367	50	0	29	5600
1992	0	6	416	1945	1596	282	2090	513	939	127	52	117	0	2	268	35	6	45	8438
1993	0	0	222	1154	1063	218	1774	389	1839	211	38	77	0	4	393	45	0	32	7461
Mean	11	94	191	982	1128	270	681	395	373	23	16	26	0	3	143	23	1	9	4367
Percent	0.2	2.1	4.4	22.5	25.8	6.2	15.6	9.0	8.5	0.5	0.4	0.6	0.0	0.1	3.3	0.5	0.0	0.2	100.0

[1]Includes SA 3
[2]Includes SA 4
[3]Includes SA 500,510,520,533,etc
[4]Includes SA 600,611,etc

Table 8. Summary of the landings (mt,live) and number of trips (trp) by percentage white hake of total landings. The percentage of each category is also given.

	<10%		10-20%		20-30%		30-40%		40-50%		50-60%		60-70%		70-80%		80-90%		90-100%		Total	
	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp
1975	1112	14380	755	2000	321	601	194	232	327	340	257	196	104	83	100	35	238	92	101	28	3510	17987
1976	1375	14822	678	2000	323	530	389	467	243	354	288	197	213	110	91	55	187	70	161	66	3948	18671
1977	1697	15979	871	2277	592	1042	454	689	424	447	418	308	157	77	60	21	18	12	78	11	4770	20863
1978	2061	16689	805	1938	433	810	383	370	234	148	232	154	146	76	232	50	99	38	6	23	4631	20296
1979	1826	19870	582	1531	294	419	288	317	377	389	200	162	131	80	58	44	24	17	1	1	3782	22830
1980	2184	22132	847	2249	483	1032	233	315	361	373	86	91	82	62	23	23	5	6	62	33	4366	26316
1981	1730	17319	1188	2271	665	887	473	487	298	232	336	297	428	289	553	247	226	103	18	8	5917	22140
1982	2056	18673	1162	2325	766	943	652	569	413	265	423	273	433	269	231	85	32	9	7	2	6174	23413
1983	1852	16888	1511	2589	1009	1158	729	553	521	276	393	166	279	141	60	12	10	3	42	11	6407	21797
1984	1549	15065	1708	2644	1279	1350	884	658	702	491	380	253	189	79	40	19	10	6	5	1	6747	20566
1985	1475	16562	1768	2597	1470	1095	1176	790	804	385	348	169	220	84	87	51	3	4	17	4	7368	21741
1986	1295	16574	1387	2273	1056	848	1066	647	610	225	316	137	251	98	207	66	55	4	147	8	6390	20880
1987	1140	19906	1366	2606	1155	1170	968	595	587	302	373	147	153	56	59	9	6	3	17	2	5825	24796
1988	710	15289	864	1628	893	1043	795	627	590	420	484	251	235	142	122	52	53	19	36	11	4780	19482
1989	621	13808	688	1603	682	857	644	739	694	695	479	326	320	177	202	58	143	28	74	12	4548	18303
1990	814	13286	844	1416	685	665	702	606	425	208	650	437	480	211	231	107	61	35	29	9	4922	16980
1991	958	13769	1072	1758	1020	1297	764	669	673	593	333	286	234	74	223	93	96	31	227	14	5600	18584
1992	722	13165	1057	1924	1408	1335	1433	946	1155	665	914	565	809	382	699	225	161	65	81	22	8438	19294
1993	602	11847	854	1524	1180	889	1309	727	1164	612	725	347	727	271	458	169	283	44	159	60	7461	16490

Percentage of total

	<10%		10-20%		20-30%		30-40%		40-50%		50-60%		60-70%		70-80%		80-90%		90-100%		Total	
	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp	mt	trp
1975	31.7	79.9	21.5	11.1	9.2	3.3	5.5	1.3	9.3	1.9	7.3	1.1	3.0	0.5	2.8	0.2	6.8	0.5	2.9	0.2	100.0	100.0
1976	34.8	79.4	17.2	10.7	8.2	2.8	9.9	2.5	6.2	1.9	7.3	1.1	5.4	0.6	2.3	0.3	4.7	0.4	4.1	0.4	100.0	100.0
1977	35.6	76.6	18.3	10.9	12.4	5.0	9.5	3.3	8.9	2.1	8.8	1.5	3.3	0.4	1.3	0.1	0.4	0.1	1.6	0.1	100.0	100.0
1978	44.5	82.2	17.4	9.5	9.3	4.0	8.3	1.8	5.1	0.7	5.0	0.8	3.1	0.4	5.0	0.2	2.1	0.2	0.1	0.1	100.0	100.0
1979	48.3	87.0	15.4	6.7	7.8	1.8	7.6	1.4	10.0	1.7	5.3	0.7	3.5	0.4	1.5	0.2	0.6	0.1	0.0	0.0	100.0	100.0
1980	50.0	84.1	19.4	8.5	11.1	3.9	5.3	1.2	8.3	1.4	2.0	0.3	1.9	0.2	0.5	0.1	0.1	0.0	1.4	0.1	100.0	100.0
1981	29.2	78.2	20.1	10.3	11.2	4.0	8.0	2.2	5.0	1.0	5.7	1.3	7.2	1.3	9.4	1.1	3.8	0.5	0.3	0.0	100.0	100.0
1982	33.3	79.8	18.8	9.9	12.4	4.0	10.6	2.4	6.7	1.1	6.8	1.2	7.0	1.1	3.7	0.4	0.5	0.0	0.1	0.0	100.0	100.0
1983	28.9	77.5	23.6	11.9	15.8	5.3	11.4	2.5	8.1	1.3	6.1	0.8	4.3	0.6	0.9	0.1	0.2	0.0	0.7	0.1	100.0	100.0
1984	23.0	73.3	25.3	12.9	19.0	6.6	13.1	3.2	10.4	2.4	5.6	1.2	2.8	0.4	0.6	0.1	0.2	0.0	0.1	0.0	100.0	100.0
1985	20.0	76.2	24.0	11.9	20.0	5.0	16.0	3.6	10.9	1.8	4.7	0.8	3.0	0.4	1.2	0.2	0.0	0.0	0.2	0.0	100.0	100.0
1986	20.3	79.4	21.7	10.9	16.5	4.1	16.7	3.1	9.5	1.1	4.9	0.7	3.9	0.5	3.2	0.3	0.9	0.0	2.3	0.0	100.0	100.0
1987	19.6	80.3	23.4	10.5	19.8	4.7	16.6	2.4	10.1	1.2	6.4	0.6	2.6	0.2	1.0	0.0	0.1	0.0	0.3	0.0	100.0	100.0
1988	14.8	78.5	18.1	8.4	18.7	5.4	16.6	3.2	12.3	2.2	10.1	1.3	4.9	0.7	2.6	0.3	1.1	0.1	0.7	0.1	100.0	100.0
1989	13.7	75.4	15.1	8.8	15.0	4.7	14.2	4.0	15.3	3.8	10.5	1.8	7.0	1.0	4.4	0.3	3.1	0.2	1.6	0.1	100.0	100.0
1990	16.5	78.2	17.2	8.3	13.9	3.9	14.3	3.6	8.6	1.2	13.2	2.6	9.8	1.2	4.7	0.6	1.2	0.2	0.6	0.1	100.0	100.0
1991	17.1	74.1	19.1	9.5	18.2	7.0	13.6	3.6	12.0	3.2	6.0	1.5	4.2	0.4	4.0	0.5	1.7	0.2	4.1	0.1	100.0	100.0
1992	8.6	68.2	12.5	10.0	16.7	6.9	17.0	4.9	13.7	3.4	10.8	2.9	9.6	2.0	8.3	1.2	1.9	0.3	1.0	0.1	100.0	100.0
1993	8.1	71.8	11.4	9.2	15.8	5.4	17.5	4.4	15.6	3.7	9.7	2.1	9.7	1.6	6.1	1.0	3.8	0.3	2.1	0.4	100.0	100.0

Table 9. Summary of US commercial white hake landings (mt), number of length samples (n), and number of fish measured (len) by market category and quarter from the Gulf of Maine to the Mid-Atlantic (SA 464,465 511-515,521-526,533-539,611-626) for all gear types, 1985-1993.

		small					medium					large					unclassified					All	Sampling Intensity mt/
Year		Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Total	sample
1985	mt	129	162	235	167	694	63	78	181	124	446	237	433	1135	623	2428	367	737	1690	988	3782	7349	272
	N	2	4	3	-	9	-	-	-	-	-	-	5	5	3	13	-	1	3	1	5	27	
	#fish	233	323	317	-	873	-	-	-	-	-	-	632	519	271	1422	-	101	293	104	498	2793	
1986	mt	59	134	105	100	398	86	89	55	54	284	274	422	835	417	1948	455	752	1578	694	3478	6107	235
	N	1	2	3	1	7	1	2	-	2	5	1	3	1	1	6	2	2	3	1	8	26	
	#fish	102	156	338	101	697	94	227	-	229	550	122	317	125	96	660	215	206	292	106	819	2726	
1987	mt	98	300	641	576	1616	13	49	122	123	306	171	326	943	372	1813	262	482	1035	301	2080	5814	194
	N	-	2	4	5	11	-	2	1	1	4	-	1	6	3	10	2	1	1	1	5	30	
	#fish	-	240	291	507	1038	-	203	91	109	403	-	111	518	236	865	218	140	112	125	595	2901	
1988	mt	181	549	893	397	2020	26	82	262	120	489	136	330	695	325	1486	73	137	437	134	782	4776	165
	N	5	6	3	5	19	1	1	1	-	3	1	2	1	-	4	1	1	-	1	3	29	
	#fish	558	764	240	478	2040	100	92	105	-	297	121	214	85	-	420	112	100	-	41	253	3010	
1989	mt	148	221	404	358	1132	41	54	124	68	287	187	472	903	470	2032	33	190	774	96	1092	4542	349
	N	1	1	2	2	6	-	-	1	-	1	-	-	2	2	4	1	-	1	-	2	13	
	#fish	91	94	213	195	593	-	-	103	-	103	-	-	206	204	410	100	-	106	-	206	1312	
1990	mt	207	410	885	450	1953	43	108	303	171	625	167	298	596	320	1381	24	182	580	176	962	4920	234
	N	3	4	4	2	13	-	-	2	1	3	2	-	1	1	4	-	-	1	-	1	21	
	#fish	309	408	399	151	1267	-	-	302	99	401	214	-	101	103	418	-	-	101	-	101	2187	
1991	mt	150	366	1215	612	2342	88	160	381	129	758	126	241	533	338	1238	52	358	714	138	1262	5601	156
	N	1	5	8	4	18	2	1	1	1	5	4	1	1	4	10	-	2	1	-	3	36	
	#fish	50	471	765	350	1636	204	100	102	100	506	375	99	96	433	1003	-	207	94	-	301	3446	
1992	mt	424	626	1735	848	3633	102	202	765	358	1428	231	351	699	371	1651	60	280	1246	140	1726	8438	211
	N	4	4	8	3	19	1	4	3	3	11	2	2	3	-	7	1	-	2	-	3	40	
	#fish	329	432	655	240	1656	80	388	266	317	1051	297	194	325	-	816	97	-	237	-	334	3857	
1993	mt	331	502	453	214	1500	161	397	1117	461	2135	173	476	795	416	1860	94	463	975	433	1965	7461	191
	N	2	5	4	1	12	2	3	2	1	8	2	3	7	2	14	-	2	2	1	5	39	
	#fish	150	504	275	50	979	184	309	196	95	784	199	262	676	175	1312	-	214	196	97	507	3582	

Table 10. Summary of Domestic Sea Sampling number of length samples (n), number of trips sampled (trips), number of fish measured (len), and number of age samples taken (age) by gear type, quarter, and catch disposition, 1989-1993.

Sink Gill Net

		Q1		Q2		Q3		Q4		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
1989	n	-	-	-	-	14	1	3	-	17	1
	trips	-	-	-	-	12	1	2	-	14	1
	len	-	-	-	-	416	2	50	-	466	2
	age	-	-	-	-	3	-	3	-	6	-
1990	n	2	-	6	-	16	-	1	1	25	1
	trips	1	-	5	-	7	-	1	1	14	1
	len	2	-	204	-	1093	-	104	32	1403	32
	age	2	-	28	-	76	-	-	-	106	-
1991	n	-	-	66	8	206	6	55	2	327	16
	trips	-	-	21	1	68	5	21	2	110	8
	len	-	-	2527	135	8636	26	1339	4	12502	165
	age	-	-	155	49	297	12	57	4	509	65
1992	n	2	-	65	1	239	3	83	1	389	5
	trips	1	-	33	1	132	3	49	1	215	5
	len	2	-	1617	1	7560	3	880	1	10059	5
	age	2	-	59	-	208	3	70	-	339	3
1993	n	7	-	45	1	141	4	116	6	309	11
	trips	5	-	21	1	71	4	52	5	149	10
	len	35	-	1241	1	3348	6	636	6	5260	13
	age	5	-	25	1	164	-	15	3	209	4

Otter Trawl

		Q1		Q2		Q3		Q4		Total	
		Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc	Kept	Disc
1989	n	1	3	6	16	4	47	-	5	11	71
	trips	1	2	3	6	3	15	-	4	7	27
	len	15	20	108	696	154	1578	-	157	277	2451
	age	-	-	-	7	16	93	-	20	16	120
1990	n	3	2	4	1	1	2	-	4	8	9
	trips	1	2	1	1	1	2	-	3	3	8
	len	41	8	28	8	138	91	-	221	207	328
	age	7	-	12	7	-	-	-	-	19	7
1991	n	1	-	-	1	11	2	3	1	15	4
	trips	1	-	-	1	2	1	1	1	4	3
	len	1	-	-	180	409	43	4	2	414	225
	age	-	-	-	-	-	-	-	2	-	2
1992	n	6	-	1	-	1	1	1	-	9	1
	trips	5	-	1	-	1	1	1	-	8	1
	len	150	-	78	-	3	86	56	-	287	86
	age	31	-	16	-	-	13	-	-	47	13
1993	n	12	-	23	10	3	1	25	1	63	12
	trips	2	-	6	3	1	1	3	1	12	5
	len	253	-	428	51	79	14	578	30	1338	95
	age	2	-	-	21	15	-	2	-	19	21

Table 11. US Commercial landings (mt), days fished (df), and landings per day fished (mt/df) by vessel tonnage class, of white hake for otter trawl trips catching white hake, 1975-1993. Data are also provided for otter trawl trips in which white hake comprised 40% or more of the total trip catch by weight.

	Class 2			Class 3			Class 4			Totals		
	mt	df	mt/df	mt	df	mt/df	mt	df	mt/df	mt	df	mt/df[1]
						ALL TRIPS						
1975	339	1970	0.17	582	2951	0.20	267	1257	0.21	1188	6178	0.19
1976	426	2256	0.19	834	2814	0.30	291	1272	0.23	1551	6342	0.25
1977	744	2572	0.29	986	3627	0.27	493	1307	0.38	2222	7506	0.30
1978	554	2876	0.19	1028	3969	0.26	530	1480	0.36	2112	8325	0.27
1979	527	3403	0.15	990	4581	0.22	467	1801	0.26	1983	9785	0.21
1980	675	3877	0.17	1088	5063	0.21	723	2380	0.30	2486	11320	0.23
1981	610	2718	0.22	1417	4896	0.29	1344	2790	0.48	3371	10404	0.35
1982	705	3415	0.21	1753	6413	0.27	1304	3771	0.35	3763	13599	0.29
1983	740	2964	0.25	2240	6391	0.35	1792	4362	0.41	4772	13717	0.36
1984	783	2895	0.27	2648	7645	0.35	1620	4623	0.35	5051	15163	0.34
1985	658	2398	0.27	2614	8716	0.30	2146	4923	0.44	5417	16037	0.35
1986	294	1796	0.16	1929	7975	0.24	2219	5459	0.41	4442	15230	0.32
1987	404	1933	0.21	2384	8504	0.28	1915	5448	0.35	4704	15885	0.30
1988	290	1517	0.19	1595	7018	0.23	1732	5156	0.34	3617	13691	0.28
1989	191	1340	0.14	1112	6168	0.18	1174	4516	0.26	2476	12024	0.22
1990	291	1614	0.18	1262	5965	0.21	1698	4533	0.37	3251	12112	0.29
1991	438	2242	0.20	1396	7413	0.19	1678	5088	0.33	3513	14743	0.26
1992	652	2584	0.25	2232	8731	0.26	2263	5532	0.41	5148	16847	0.32
1993	381	2116	0.18	1933	9199	0.21	2290	5031	0.46	4604	16346	0.33
						40% TRIPS						
1975	31	11	2.85	17	10	1.68	1	<1	2.50	50	21	2.43
1976	36	17	2.08	50	9	5.63				86	26	4.16
1977	14	6	2.47	13	4	3.00	64	5	11.98	91	15	9.20
1978	16	8	1.96	6	1	4.83	28	2	13.14	49	11	8.59
1979	7	5	1.35	27	5	5.04	3	1	5.00	37	11	4.35
1980	9	6	1.60	15	5	2.94	12	3	4.96	37	14	3.30
1981	36	29	1.26	132	42	3.18	80	24	3.39	249	95	2.97
1982	32	17	1.83	86	40	2.14	20	6	3.34	137	63	2.24
1983	116	52	2.24	129	53	2.42	61	22	2.78	306	127	2.42
1984	154	118	1.31	103	46	2.24	19	13	1.49	276	177	1.67
1985	102	71	1.43	120	71	1.70	99	46	2.14	322	237	1.75
1986	8	5	1.54	112	85	1.32	185	118	1.58	305	208	1.48
1987	44	33	1.32	169	127	1.33	103	75	1.38	316	235	1.34
1988	39	29	1.34	215	185	1.16	65	56	1.15	319	270	1.18
1989	14	7	2.17	24	23	1.04	59	37	1.59	97	67	1.54
1990	13	16	0.80	259	173	1.50	282	117	2.41	553	306	1.95
1991	54	50	1.09	174	125	1.40	264	59	4.46	492	234	3.01
1992	253	155	1.63	457	324	1.41	105	117	0.89	815	596	1.41
1993	75	59	1.25	148	146	1.02	117	90	1.30	339	295	1.17

[1]Total mt/df was derived by weighting individual tonnage class mt/df values by the percentage of total landings accounted for by each vessel class and summing over the three vessel class categories.

Table 12. White hake effort (days fished) standardization. GLM1 - run with perc (spratio) as a factor. Standard: Year = 75; Area = 515; Qtr = 3; TC = 3; Depth = 3; Perc = 1;

GENERAL LINEAR MODEL 1

Dependent Variable :LNCPUEDF

Source	DF	Sum of Squares	Mean Square	F Value	PR > 1	R-Square	CV
Model	35	35715.2	1020.4	755.16	0.0001	0.39287	-57.2
Error	40845	55193.3	1.4				
Corrected Total	40880	90908.5					

Source	DF	Type I SS	Mean Square	F Value	PR > F
Year	18	2287.8	127.1	94.06	0.0001
Area	7	16980.2	2425.7	1795.13	0.0001
Qtr	3	2857.3	952.4	704.83	0.0001
TC	2	2481.9	1240.9	918.34	0.0001
Depthcd	3	4290.0	1430.0	1058.25	0.0001
Perc	2	6818.0	3409.0	2522.79	0.0001

Source	DF	Type III SS	Mean Square	F Value	PR > F
Year	18	4209.0	233.8	173.04	0.0001
Area	7	4100.1	585.7	433.46	0.0001
Qtr	3	2385.8	795.3	588.53	0.0001
TC	2	1973.4	986.7	730.20	0.0001
Depthcd	3	3240.4	1080.1	799.33	0.0001
Perc	2	6818.0	3409.0	2522.79	0.0001

Parameter		Estimate	T for H_0 : Coefficient	Pr > |T| Parameter = 0	Std Error of Estimate	Re-Transformed Estimate
Intercept		-1.19749 B	-33.71	0.0001	0.035521	
Area	511	0.24591 B	5.08	0.0001	0.048435	1.278787
	512	0.19857 B	7.31	0.0001	0.027166	1.219660
	513	-0.36810 B	-17.10	0.0001	0.021531	0.692047
	514	-0.40340 B	-16.16	0.0001	0.024966	0.668042
	515	0.00000 B	-	-	-	1.000000
	522[1]	-0.42458 B	-22.95	0.0001	0.018498	0.654045
	525[2]	-1.30959 B	-41.42	0.0001	0.031621	0.269929
	530[3]	-1.18096 B	-36.83	0.0001	0.032066	0.306984
Quarter	1	-0.59101 B	-33.83	0.0001	0.017470	0.553766
	2	-0.44795 B	-27.99	0.0001	0.016002	0.638937
	3	0.00000 B	-	-	-	1.000000
	4	-0.02833 B	-1.82	0.0689	0.015576	0.972064
TC	2	-0.17661 B	-9.86	0.0001	0.017914	0.838108
	3	0.00000 B	-	-	-	1.000000
	4	0.50076 B	35.24	0.0001	0.014211	1.649977
Depthcd	1	-0.63664 B	-24.19	0.0001	0.026313	0.529069
	2	-0.48254 B	-30.91	0.0001	0.015612	0.617214
	3	0.00000 B	-	-	-	1.000000
	4[4]	0.44870 B	26.69	0.0001	0.016814	1.566278
Perc	1	0.00000 B	-	-	-	1.000000
	2	1.51047 B	67.09	0.0001	0.022515	4.528869
	3	2.16107 B	27.32	0.0001	0.079103	8.680384

[1]Includes 521,522,523(561).
[2]Includes 524(562) 525,526.
[3]Includes 537,538,539.
[4]Includes depthcd 4-7.

Table 13. White hake effort (days fished) standardization. GLM2 - run without perc (spratio) as a factor. Standard: Year = 75; Area = 515[1]; Qtr = 3; TC = 3[2]; Depth = 3[3];

GENERAL LINEAR MODEL 2

Dependent Variable :LNCPUEDF

Source	DF	Sum of Squares	Mean Square	F Value	PR > 1	R-Square	CV
Model	33	28901.4	875.8	875.80	0.0001	0.31789	-60.7
Error	40849	62013.7	1.5				
Corrected Total	40882	90915.0					

Source	DF	Type I SS	Mean Square	F Value	PR > F
Year	18	2288.3	127.1	83.74	0.0001
Area	7	16983.1	2426.2	1598.13	0.0001
Qtr	3	2857.6	952.5	627.44	0.0001
TC	2	2480.5	1240.2	816.96	0.0001
Depthcd	3	4291.9	1430.6	942.38	0.0001

Source	DF	Type III SS	Mean Square	F Value	PR > F
Year	18	3275.4	182.0	119.86	0.0001
Area	7	6014.6	859.2	565.98	0.0001
Qtr	3	3734.1	1244.7	819.90	0.0001
TC	2	1912.5	956.2	629.89	0.0001
Depthcd	3	4291.9	1430.6	942.38	0.0001

Parameter		Estimate	T for H_0 : Coefficient	Pr > |T| Parameter = 0	Std Error of Estimate	Re-Transformed Estimate
Intercept		-1.04707 B	-27.86	0.0001	0.037581	
Area	511	0.52850 B	10.33	0.0001	0.051146	1.696388
	512	0.52509 B	18.50	0.0001	0.028377	1.690606
	513	-0.39135 B	-17.15	0.0001	0.022818	0.676145
	514	-0.42839 B	-16.19	0.0001	0.026456	0.651552
	515	0.00000 B	-	-	-	1.000000
	522[1]	-0.44661 B	-22.79	0.0001	0.019598	0.639795
	525[2]	-1.35401 B	-40.41	0.0001	0.033506	0.258204
	530[3]	-1.24666 B	-36.70	0.0001	0.033971	0.287464
Quarter	1	-0.75242 B	-40.98	0.0001	0.018359	0.471223
	2	-0.56311 B	-33.37	0.0001	0.016874	0.569437
	3	0.00000 B	-	-	-	1.000000
	4	-0.07127 B	-4.32	0.0001	0.016496	0.931209
TC	2	-0.15654 B	-8.25	0.0001	0.018985	0.855100
	3	0.00000 B	-	-	-	1.000000
	4	0.49821 B	33.08	0.0001	0.015062	1.645776
Depthcd	1	-0.67720 B	-24.29	0.0001	0.027883	0.508037
	2	-0.53709 B	-32.50	0.0001	0.016527	0.584449
	3	0.00000 B	-	-	-	1.000000
	4[4]	0.54435 B	30.65	0.0001	0.017761	1.723495

[1]Includes 521,522,523(561).
[2]Includes 524(562) 525,526.
[3]Includes 537,538,539.
[4]Includes depthcd 4-7.

Table 14. Nominal and standardized (GLM1) white hake landings (mt), effort (days fished) and landings per day fished (LPUE) for the otter trawl fleet.

	Landings	Nominal		Standardized	
Year	(mt)	Effort	LPUE	Effort	LPUE
1975	660	2698	0.245	1693	0.390
1976	737	2324	0.317	1514	0.487
1977	841	2616	0.322	1566	0.537
1978	896	2728	0.317	1796	0.499
1979	882	3682	0.239	2675	0.330
1980	1008	4276	0.236	3201	0.315
1981	1404	3817	0.368	4342	0.323
1982	1804	5483	0.329	6611	0.273
1983	2292	6196	0.370	7320	0.313
1984	2424	6772	0.358	7700	0.315
1985	3375	8713	0.387	11712	0.288
1986	2791	8284	0.337	12205	0.229
1987	2841	8849	0.321	13549	0.210
1988	2460	8188	0.300	12318	0.199
1989	1313	6267	0.209	6679	0.197
1990	1771	6435	0.275	8245	0.215
1991	1935	7055	0.274	8650	0.224
1992	2675	7988	0.335	13396	0.200
1993	2455	7849	0.313	10092	0.243

Table 15. Nominal and standardized (GLM2) white hake landings (mt), effort (days fished) and landings per day fished (LPUE) for the otter trawl fleet.

	Landings	Nominal		Standardized	
Year	(mt)	Effort	LPUE	Effort	LPUE
1975	660	2698	0.245	1504	0.439
1976	737	2324	0.317	1355	0.544
1977	842	2616	0.322	1378	0.611
1978	896	2728	0.317	1596	0.562
1979	882	3682	0.239	2392	0.369
1980	1008	4276	0.236	3014	0.335
1981	1404	3817	0.368	3200	0.439
1982	1804	5483	0.329	5066	0.356
1983	2292	6196	0.370	5563	0.412
1984	2424	6772	0.358	6086	0.398
1985	3375	8713	0.387	8424	0.401
1986	2791	8284	0.337	8534	0.327
1987	2841	8849	0.321	7772	0.366
1988	2460	8188	0.300	6817	0.361
1989	1313	6267	0.209	4809	0.273
1990	1771	6435	0.275	5190	0.341
1991	1935	7055	0.274	5571	0.347
1992	2675	7988	0.335	6210	0.431
1993	2455	7849	0.313	6036	0.407

Table 16. Stratified mean catch per tow in numbers and weight (kg) for white hake from NEFSC offshore spring and autumn research vessel bottom trawl surveys (strata 21-30,33-40), 1963-1994[1,2,3].

Year	Spring			Autumn		
	No/Tow	Wt/Tow	Length	No/Tow	Wt/Tow	Length
1963				5.00	6.31	46.16
1964				1.77	4.14	56.31
1965				4.39	6.86	50.41
1966				6.79	7.67	45.12
1967				3.92	3.64	42.63
1968	1.60	1.74	44.08	4.24	4.54	44.93
1969	3.76	5.09	46.28	9.24	13.09	46.79
1970	5.84	11.86	52.95	8.05	12.82	51.32
1971	3.31	5.14	51.26	10.38	12.10	43.61
1972	10.18	12.66	47.32	12.52	13.10	45.23
1973	9.24	12.22	49.90	9.05	13.46	51.72
1974	8.08	13.99	55.03	5.35	11.00	54.47
1975	9.32	11.22	44.73	5.28	7.23	48.55
1976	9.98	17.01	52.74	6.04	10.56	54.66
1977	6.13	11.01	55.52	9.78	13.74	47.81
1978	3.22	6.14	51.84	7.87	12.54	50.21
1979	5.26	4.97	43.02	5.62	10.31	53.14
1980	10.38	13.96	49.70	10.86	16.66	48.83
1981	17.09	19.92	45.94	8.70	12.16	49.87
1982	6.06	8.91	51.00	1.96	2.11	46.75
1983	3.23	3.12	43.72	8.22	10.79	48.77
1984	2.75	4.17	51.42	5.32	8.23	51.94
1985	4.33	5.38	48.53	9.37	9.74	42.94
1986	8.24	5.61	39.97	14.42	11.56	41.92
1987	7.15	6.44	45.27	7.59	9.62	49.15
1988	4.52	3.69	41.87	8.12	9.88	46.08
1989	3.65	3.22	43.00	11.76	9.23	40.53
1990	11.11	18.37	53.29	13.09	10.58	41.49
1991	8.42	6.14	41.57	13.22	12.20	44.58
1992	7.59	7.11	45.09	10.16	11.24	47.75
1993	7.93	6.84	45.07	11.35	11.66	45.21
1994	4.59	3.17	40.13			

[1]During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No adjustments were made because no significant difference was found between the two types of doors for white hake (NEFSC 1991).

[2]Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments were made because no informationis available at this time.

[3]During some years the Delaware II was used in place of the Albatross IV. No adjustments were made because no significant difference was found between the two vessels for white hake (NEFSC 1991).

Table 17. Stratified mean number per tow at age of white hake in the NEFSC spring and autumn bottom trawl surveys (Strata 21-30,33-40), 1982 and 1987-1989. Also shown at the bottom of the page are the plus groups used in deriving the estimates of instantaneous total mortality.

	Age Group															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total
Spring																
1982	0.00	1.04	2.63	0.63	1.06	0.26	0.05	0.07	0.04	0.00	0.00	0.01	0.01	0.00	0.00	5.80
1983	NOT AGED															
1984	NOT AGED															
1985	NOT AGED															
1986	NOT AGED															
1987	0.00	1.13	3.24	2.05	0.35	0.13	0.11	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.01	7.06
1988	0.00	1.77	1.26	1.02	0.22	0.09	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.37
1989	0.00	1.44	1.21	0.28	0.46	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.43
Autumn																
1982	0.13	0.74	0.41	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.41
1983	NOT AGED															
1984	NOT AGED															
1985	NOT AGED															
1986	NOT AGED															
1987	0.72	1.56	3.81	0.94	0.15	0.14	0.03	0.03	0.00	0.05	0.00	0.02	0.02	0.02	0.00	7.49

	AGE								LN (1+/2+)	LN(2+/3+)
Year	0+	1+	2+	3+	4+	5+	6+	Time Period	Z	Z
Spring										
1982	5.80	5.80	4.76	2.13	1.50	0.44	0.18			
1983										
1984										
1985										
1986										
1987	7.06	7.06	5.93	2.69	0.64	0.29	0.16	1987-88/88-89	0.91	1.39
1988	4.37	4.37	2.60	1.34	0.32	0.10	0.01			
1989	3.43	3.43	1.99	0.78	0.50	0.04	0.02			
Autumn										
1982	1.41	1.28	0.54	0.13	0.05	0.00	0.00			
1983										
1984										
1985										
1986										
1987	7.49	6.77	5.21	1.40	0.46	0.31	0.17			

Table 18. Input parameters for the Modified-DeLury and the Shepherd Stock Production Models. Natural mortality was assumed to be 0.2. The selectivity of the recruits to the survey gear was assumed to be equal to that of the fully-recruited animals. Partial recruitment of the recruits was assumed linear for the year. The index of virgin biomass was set at 50,000g.

	Indices of Abundance		Mean Wt (g)		Index of	Total Catch	
	Recruits	Fully-Recruited	Recruits	Fully-Recruited	Exploited Biomass (g)	Millions	1000 mt
1985	1.245	3.743	454.5	2032.4	7890.1	3.496013	8.304
1986	2.824	4.051	374.0	2109.1	9071.9	2.349630	7.065
1987	7.538	5.046	459.3	1579.2	9699.7	2.832091	6.371
1988	2.116	5.016	424.3	1775.4	9354.4	4.004625	5.312
1989	4.178	3.506	431.0	2002.5	7921.1	2.201709	5.127
1990	4.214	4.367	429.9	1657.8	8145.6	3.357205	5.469
1991	5.458	5.370	398.5	1552.6	9425.0	4.110854	6.154
1992	6.545	5.760	425.1	1609.8	10663.8	5.631835	9.561
1993	3.162	6.574	427.5	1491.9	10483.5	5.296829	9.135
1994	3.577	6.112	404.1	1591.9			

Table 19. Bias-corrected results of the Modified-DeLury Model for white hake.

	Fishing Mortality			Stock Sizes (Millions)			Stock Biomass (000s MT)		
	Recruits	Fully-Recruited	Exploited	Recruits	Fully-Recruited	Exploited	Recruits	Fully-Recruited	Exploited
1985	0.1982	0.3965	0.3562	1.923	7.331	8.292	0.874	14.90	15.34
1986	0.1508	0.3016	0.2359	4.291	5.214	7.360	1.605	11.00	11.80
1987	0.2516	0.5032	0.3544	8.807	6.065	11.008	4.045	9.58	11.60
1988	0.2775	0.5550	0.4852	2.913	8.573	10.030	1.236	15.22	15.84
1989	0.1703	0.3406	0.2561	5.730	5.729	8.594	2.470	11.47	12.71
1990	0.1881	0.3761	0.2911	6.081	7.234	10.274	2.614	11.99	13.30
1991	0.2094	0.4188	0.3185	7.632	8.072	11.888	3.041	12.53	14.05
1992	0.2255	0.4510	0.3384	9.568	9.279	14.063	4.067	14.94	16.97
1993	0.2091	0.4182	0.3584	4.691	10.890	13.236	2.006	16.24	17.25
1994				5.327	8.716	11.380	2.153	13.58	14.95

Table 20. Bias-corrected results of the Surplus Production model (given in 000s mt).

	Stock	Surplus Production	
Year	Biomass	"Observed"	"Estimated"
1985	13.56	8.957	7.256
1986	14.22	7.831	7.338
1987	14.98	5.949	7.436
1988	14.56	4.242	7.384
1989	13.49	5.524	7.239
1990	13.89	7.233	7.296
1991	15.65	8.168	7.482
1992	17.67	8.650	7.618
1993	16.75		7.583

B_{max}	80.460
B_{msy}	21.017
K	11.494
MSY	7.685
P_at_K	6.897

Table 21. Yield and spawning stock biomass per recruit analyses for white hake.

PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
Run Date: 19-10-1994; Time: 12:51:34.50
Proportion of F before spawning: .0000
Proportion of M before spawning: .0000
Natural Mortality is Constant at: .200
Initial age is: 1; Last age is: 15
Last age is a PLUS group;

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.2000	1.0000	.3300	.191	.191
2	.5000	1.0000	.7400	.642	.642
3	.7000	1.0000	.9400	1.385	1.385
4	1.0000	1.0000	.9900	2.375	2.375
5	1.0000	1.0000	1.0000	3.543	3.543
6	1.0000	1.0000	1.0000	4.818	4.818
7	1.0000	1.0000	1.0000	6.140	6.140
8	1.0000	1.0000	1.0000	7.457	7.457
9	1.0000	1.0000	1.0000	8.733	8.733
10	1.0000	1.0000	1.0000	9.941	9.941
11	1.0000	1.0000	1.0000	11.066	11.066
12	1.0000	1.0000	1.0000	12.099	12.099
13	1.0000	1.0000	1.0000	13.037	13.037
14	1.0000	1.0000	1.0000	13.880	13.880
15+	1.0000	1.0000	1.0000	14.634	14.634

Summary of Yield per Recruit Analysis for: WHITE HAKE
Slope of the Yield/Recruit Curve at F=0.00: --> 20.5491
F level at slope=1/10 of the above slope (F0.1): -----> .132
Yield/Recruit corresponding to F0.1: -----> 1.0807
F level to produce Maximum Yield/Recruit (Fmax): -----> .220
Yield/Recruit corresponding to Fmax: -----> 1.1520
F level at 20 % of Max Spawning Potential (F20): -----> .328
SSB/Recruit corresponding to F20: --------> 4.6060

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.00	.00000	.00000	5.5167	23.3687	4.5881	23.0353	100.00
	.10	.25084	.98949	4.2684	12.1070	3.3474	11.7818	51.15
F0.1	.13	.30040	1.08072	4.0223	10.2525	3.1038	9.9299	43.11
	.20	.38008	1.14960	3.6275	7.5902	2.7139	7.2727	31.57
Fmax	.22	.39898	1.15200	3.5340	7.0207	2.6218	6.7046	29.11
	.30	.46038	1.12468	3.2309	5.3453	2.3242	5.0349	21.86
F20%	.33	.47803	1.10746	3.1439	4.9144	2.2392	4.6060	20.00
	.40	.51601	1.05762	2.9572	4.0651	2.0572	3.7615	16.33
	.50	.55737	.98594	2.7546	3.2608	1.8609	2.9635	12.86
	.60	.58968	.91972	2.5968	2.7178	1.7092	2.4265	10.53
	.70	.61586	.86107	2.4695	2.3305	1.5878	2.0448	8.88
	.80	.63766	.80976	2.3638	2.0420	1.4877	1.7615	7.65
	.90	.65622	.76488	2.2742	1.8195	1.4034	1.5440	6.70
	1.00	.67229	.72549	2.1969	1.6430	1.3312	1.3723	5.96
	1.10	.68641	.69071	2.1291	1.4997	1.2685	1.2335	5.35
	1.20	.69894	.65983	2.0692	1.3810	1.2133	1.1191	4.86
	1.30	.71019	.63224	2.0156	1.2812	1.1644	1.0234	4.44
	1.40	.72036	.60744	1.9672	1.1961	1.1205	.9421	4.09
	1.50	.72962	.58504	1.9233	1.1225	1.0809	.8723	3.79
	1.60	.73811	.56470	1.8832	1.0584	1.0449	.8117	3.52
	1.70	.74593	.54615	1.8464	1.0020	1.0121	.7586	3.29
	1.80	.75316	.52916	1.8124	.9519	.9821	.7118	3.09
	1.90	.75989	.51354	1.7809	.9072	.9543	.6702	2.91
	2.00	.76616	.49913	1.7516	.8670	.9287	.6330	2.75

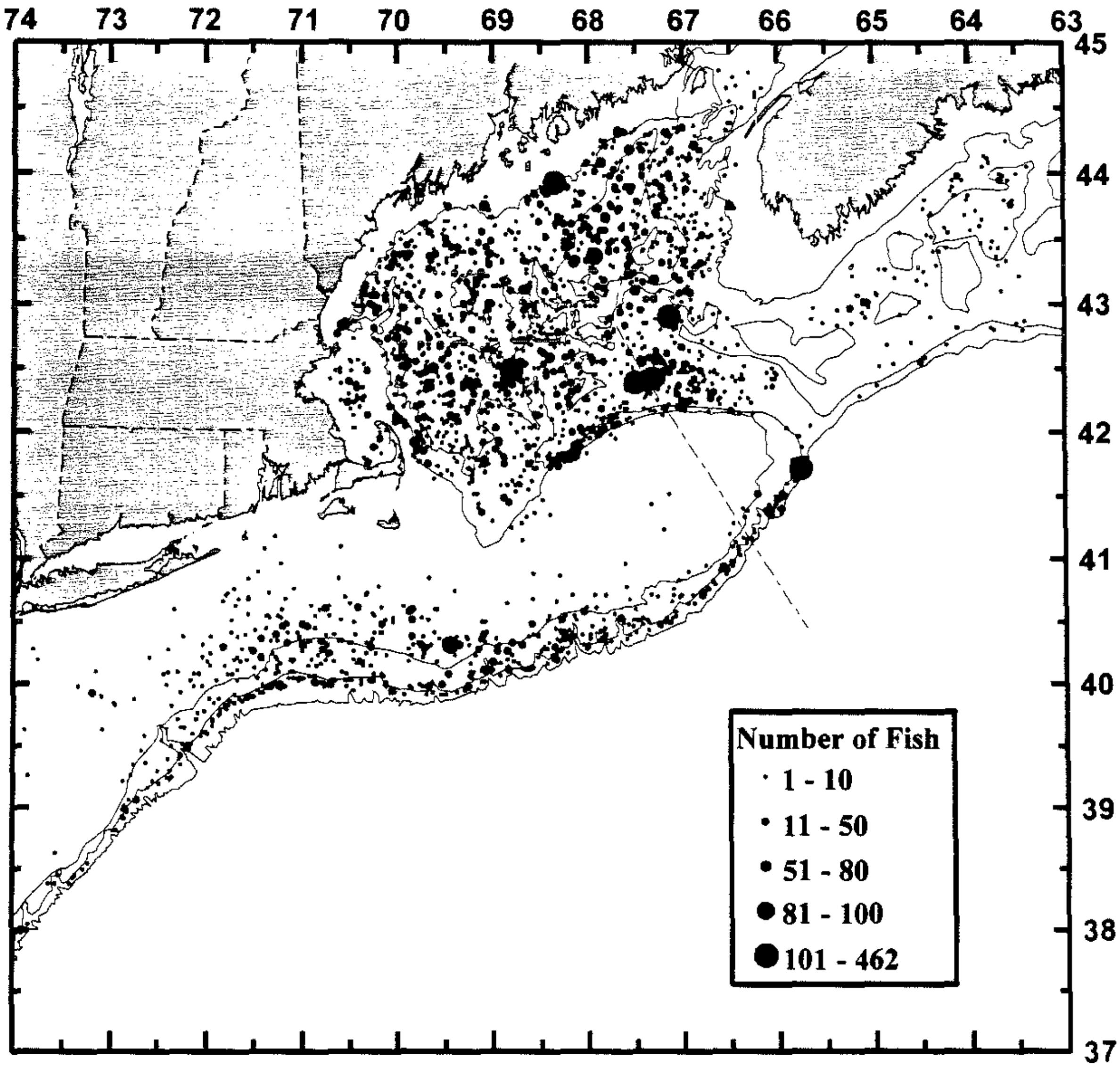


Figure 1. Distribution of white hake in the NEFSC spring surveys, 1968-1994.

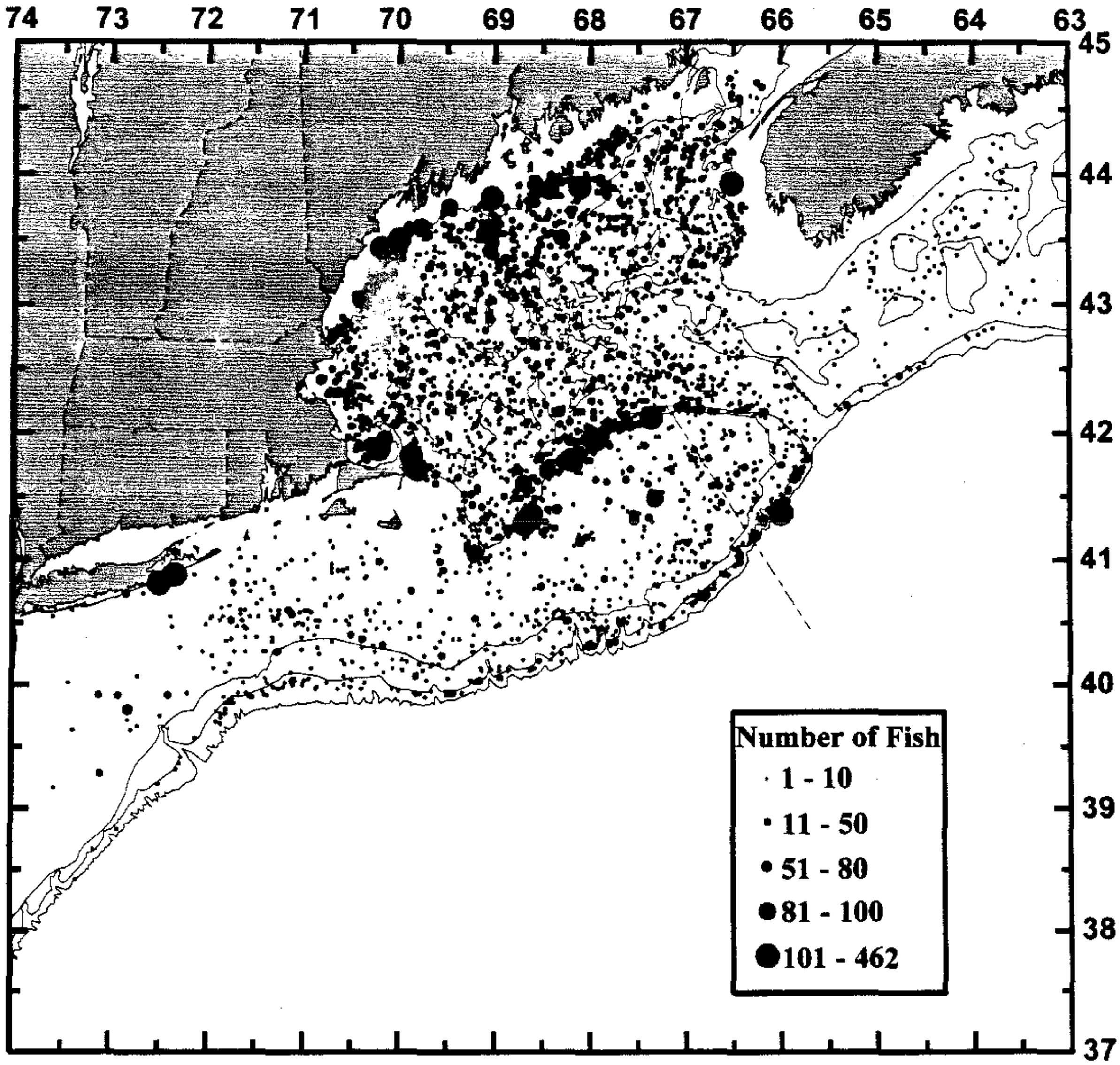


Figure 2. Distribution of white hake in the NEFSC autumn surveys, 1963-1993.

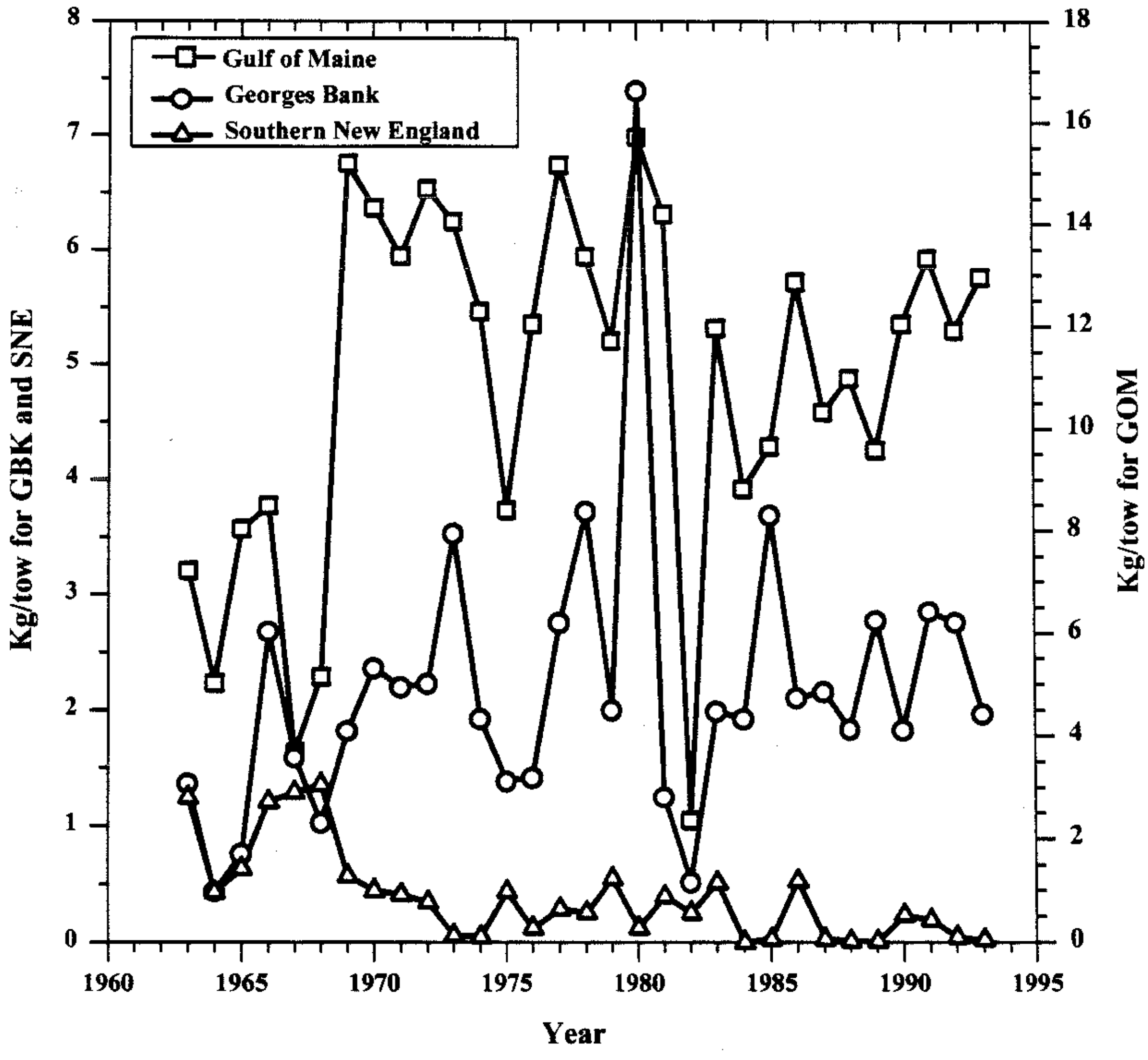


Figure 3. NEFSC autumn bottom trawl survey biomass indices from three regions: Gulf of Maine (GOM, Strata 26-30, 33-40), Georges Bank (GBK, Strata 13-25) and Southern New England (SNE, Strata 1-12), 1963-1993.

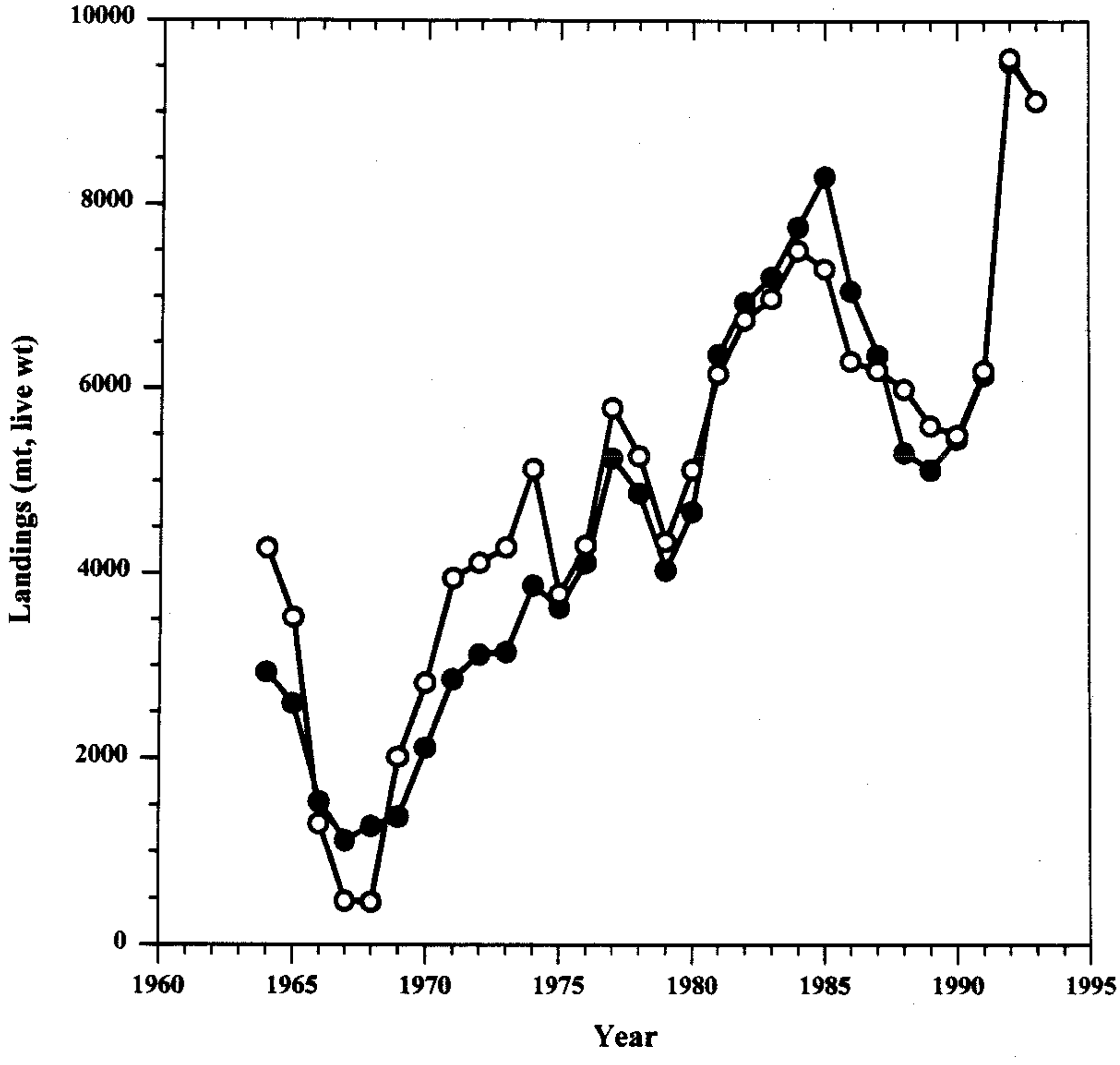


Figure 4. Total landings of white hake from the Gulf of Maine to Mid-Atlantic region, 1964-1993. The open circles represent landings in live weight from NEFSC (1993) while the solid circles represent corrected live weight landings.

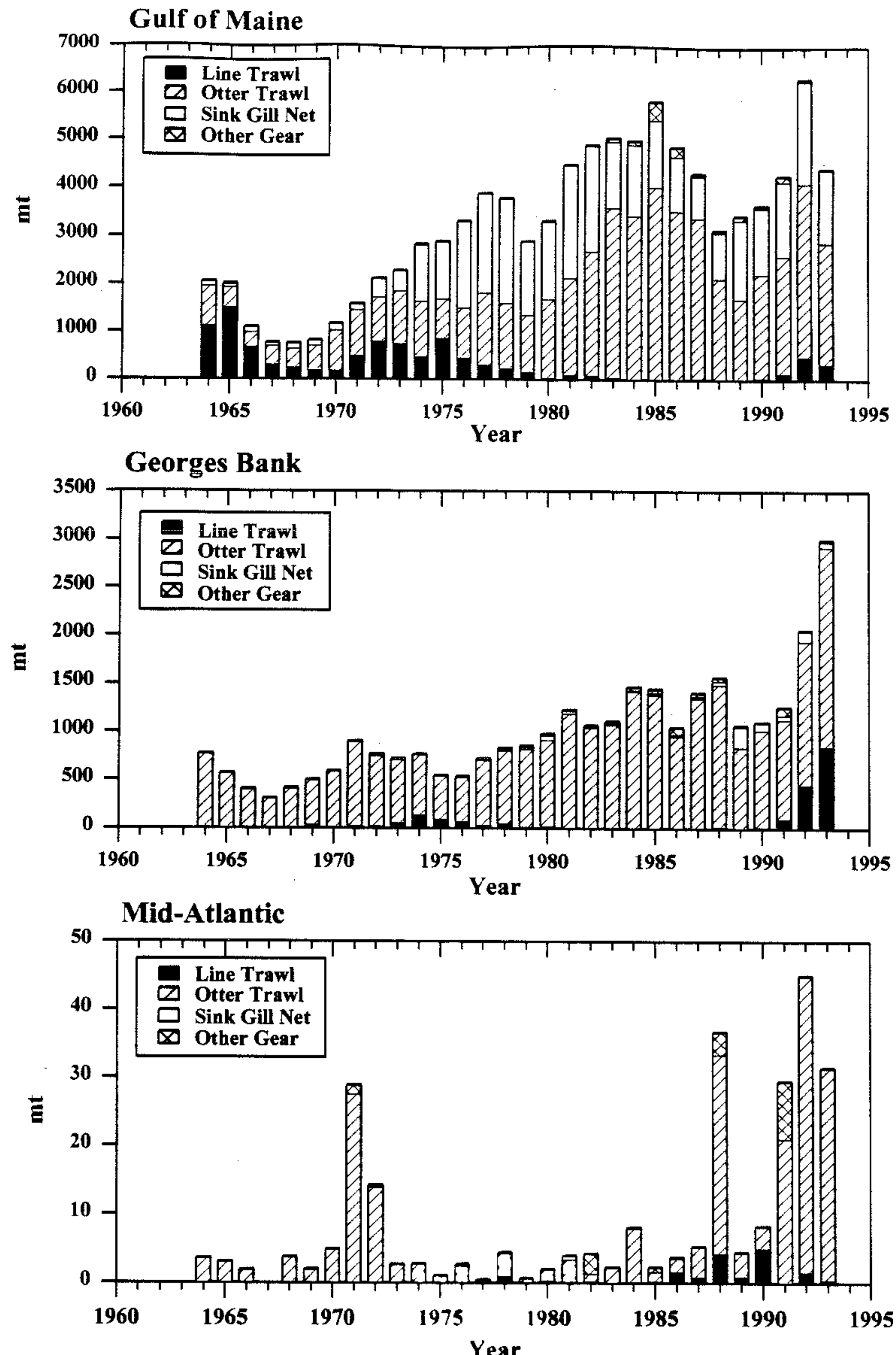


Figure 5. Landings of white hake (mt, live weight) by quarter in three areas: Gulf of Maine (SA 511-515,464-465), Georges Bank (SA 520-562), and the Mid-Atlantic (SA >= 600).

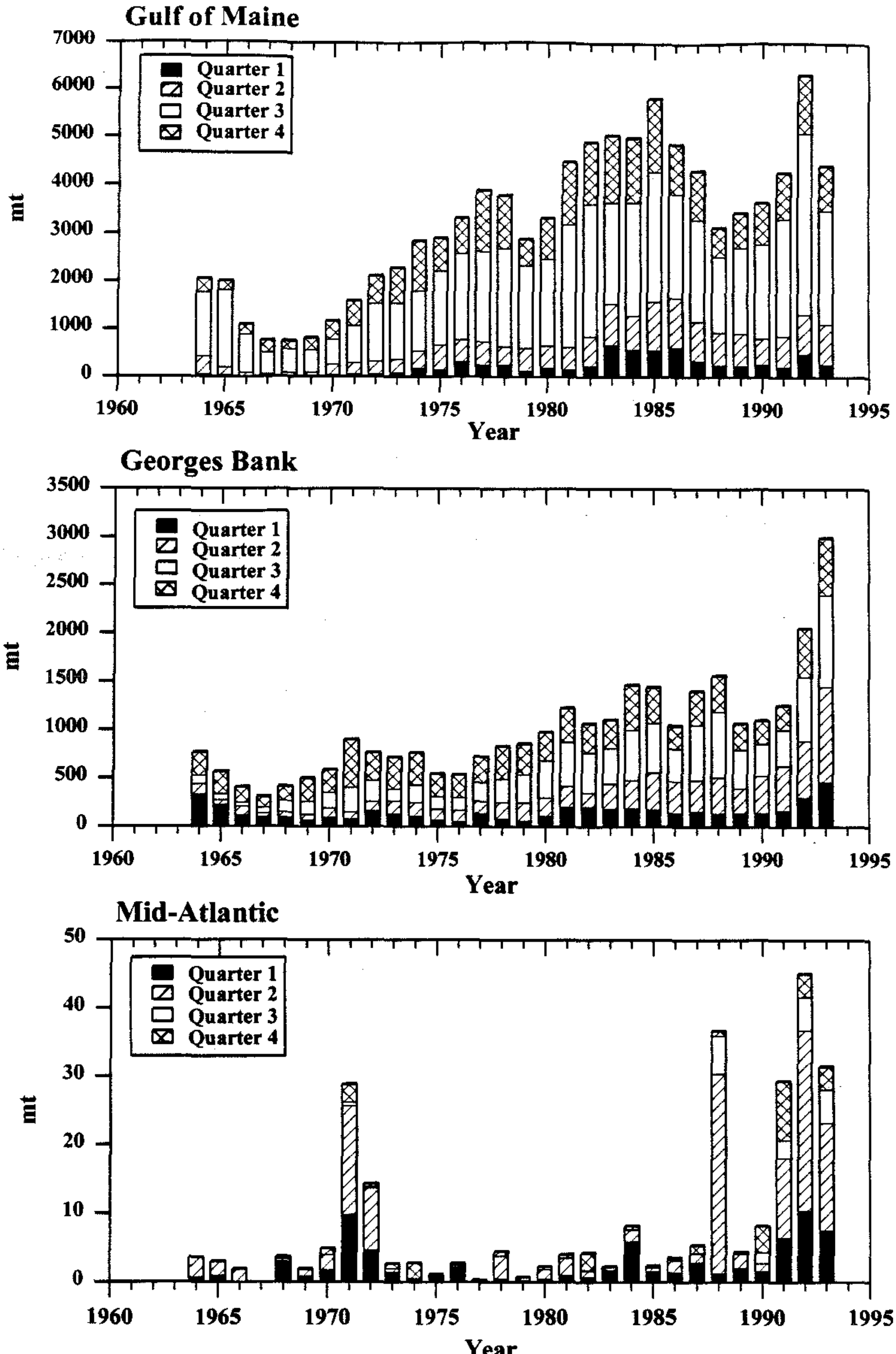


Figure 6. Landings of white hake (mt, live weight) by quarter in three areas: Gulf of Maine (SA 511-515,464-465), Georges Bank (SA 520-562), and the Mid-Atlantic (SA >= 600).

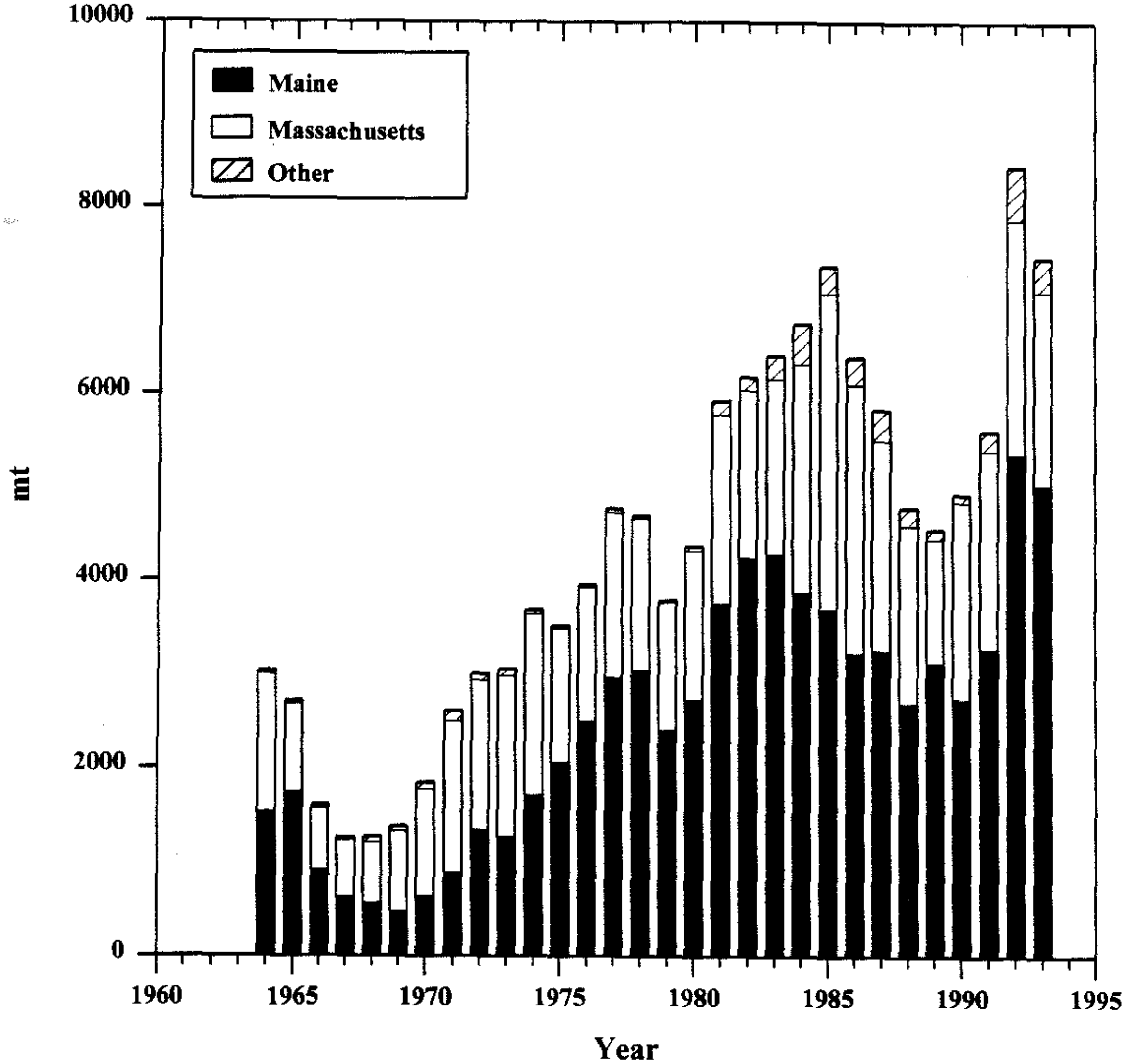


Figure 7. Commercial landings (mt, live weight) of white hake in Maine, Massachusetts, and other states.

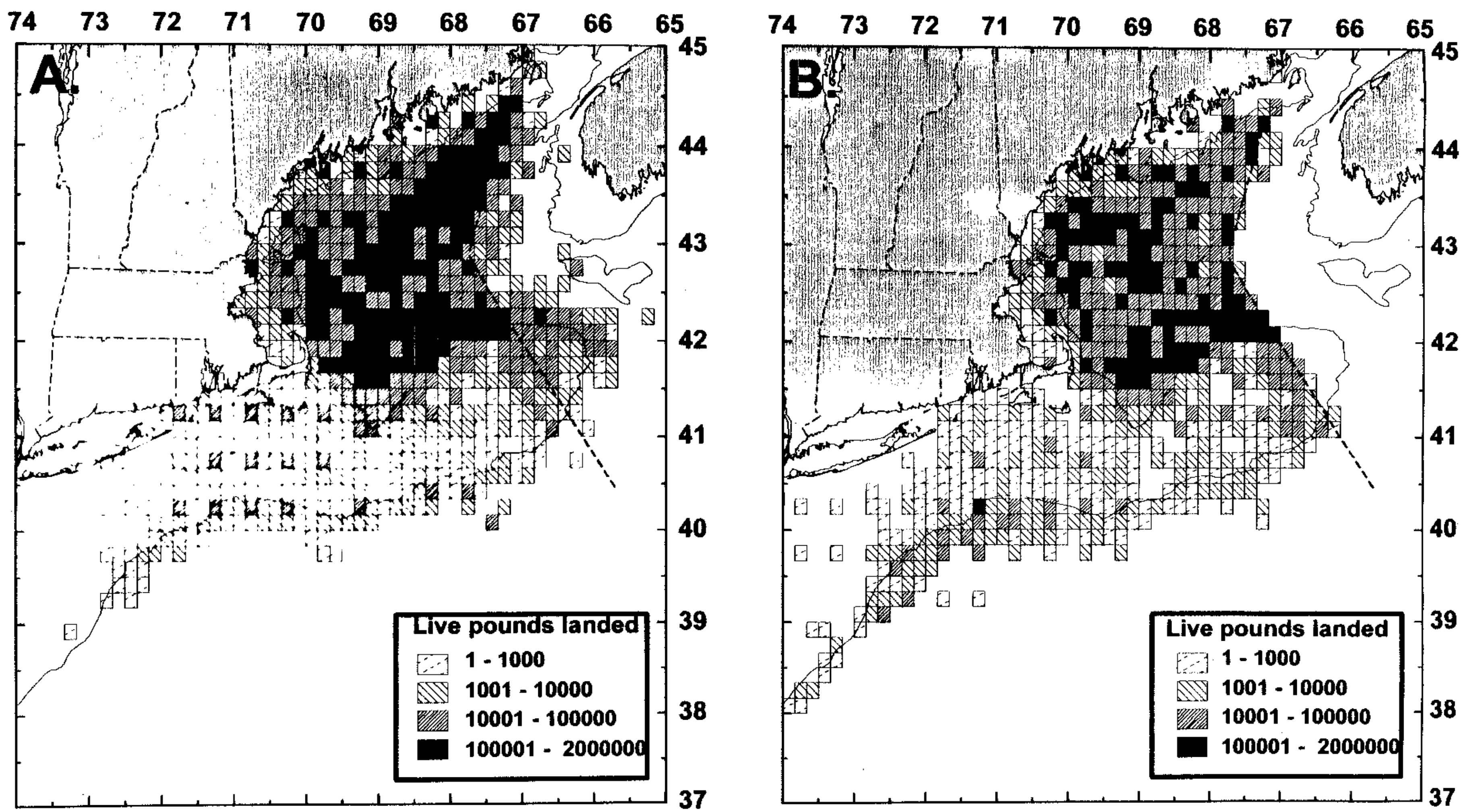


Figure 8. Distribution of white hake landings in the otter trawl fishery during two time periods: A. 1983-1987; B. 1989-1993.

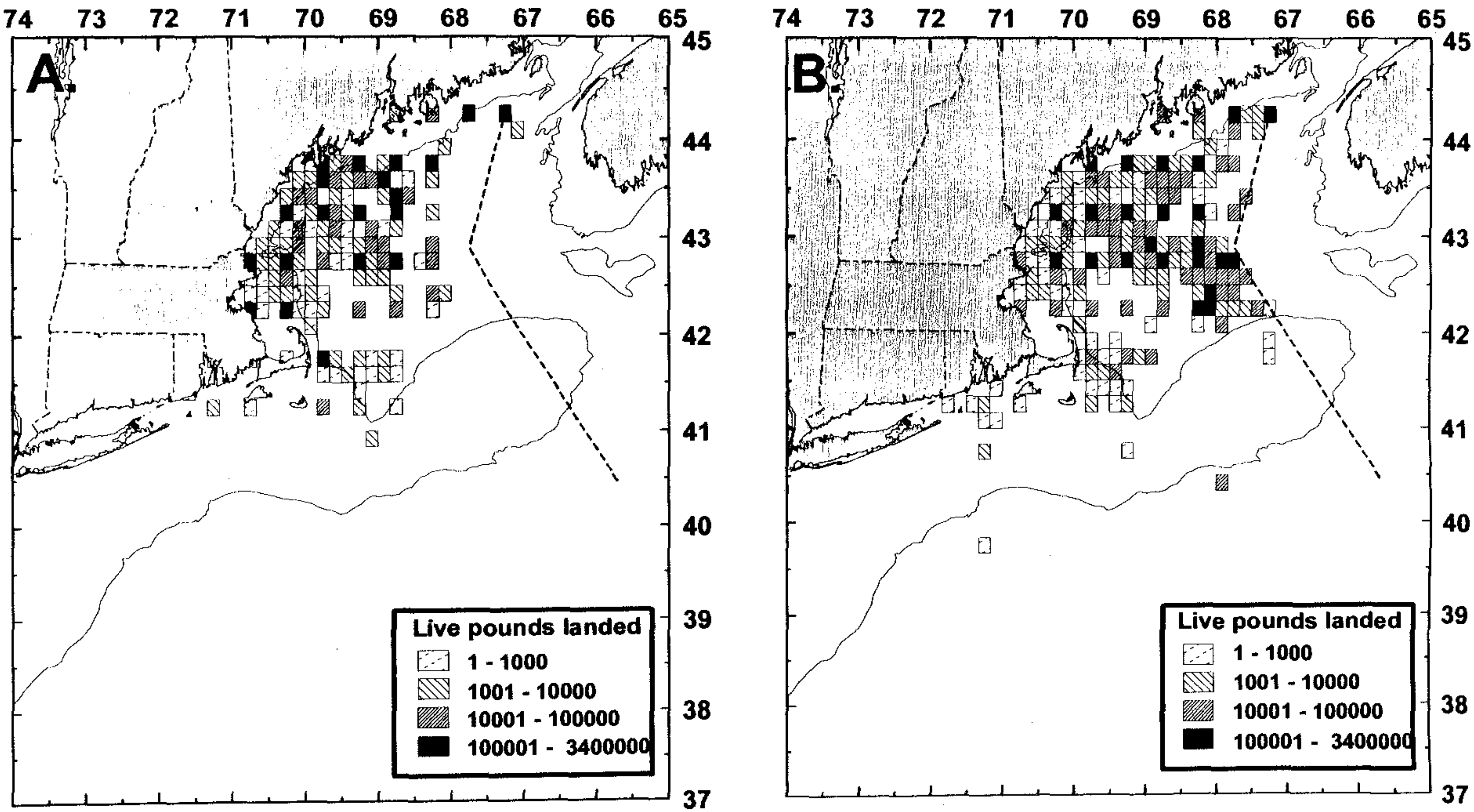


Figure 9. Distribution of white hake landings per unit effort (LPUE) in the sink gill net fishery during two time periods: A. 1983-1987; B. 1989-1993.

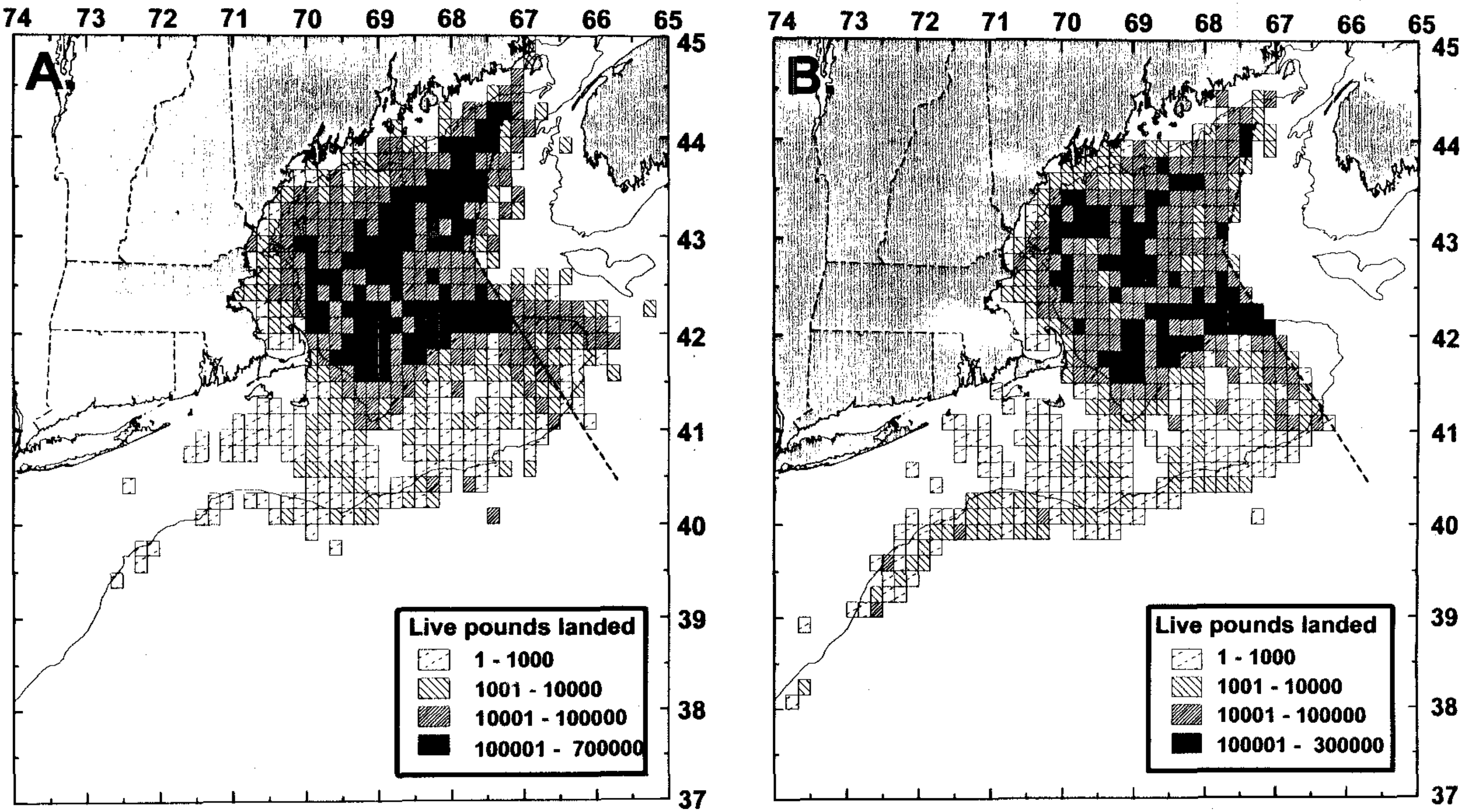


Figure 10. Distribution of white hake landings in the large mesh (>= 5.5 in) otter trawl fishery during two time periods: A. 1983-1987; B. 1989-1993.

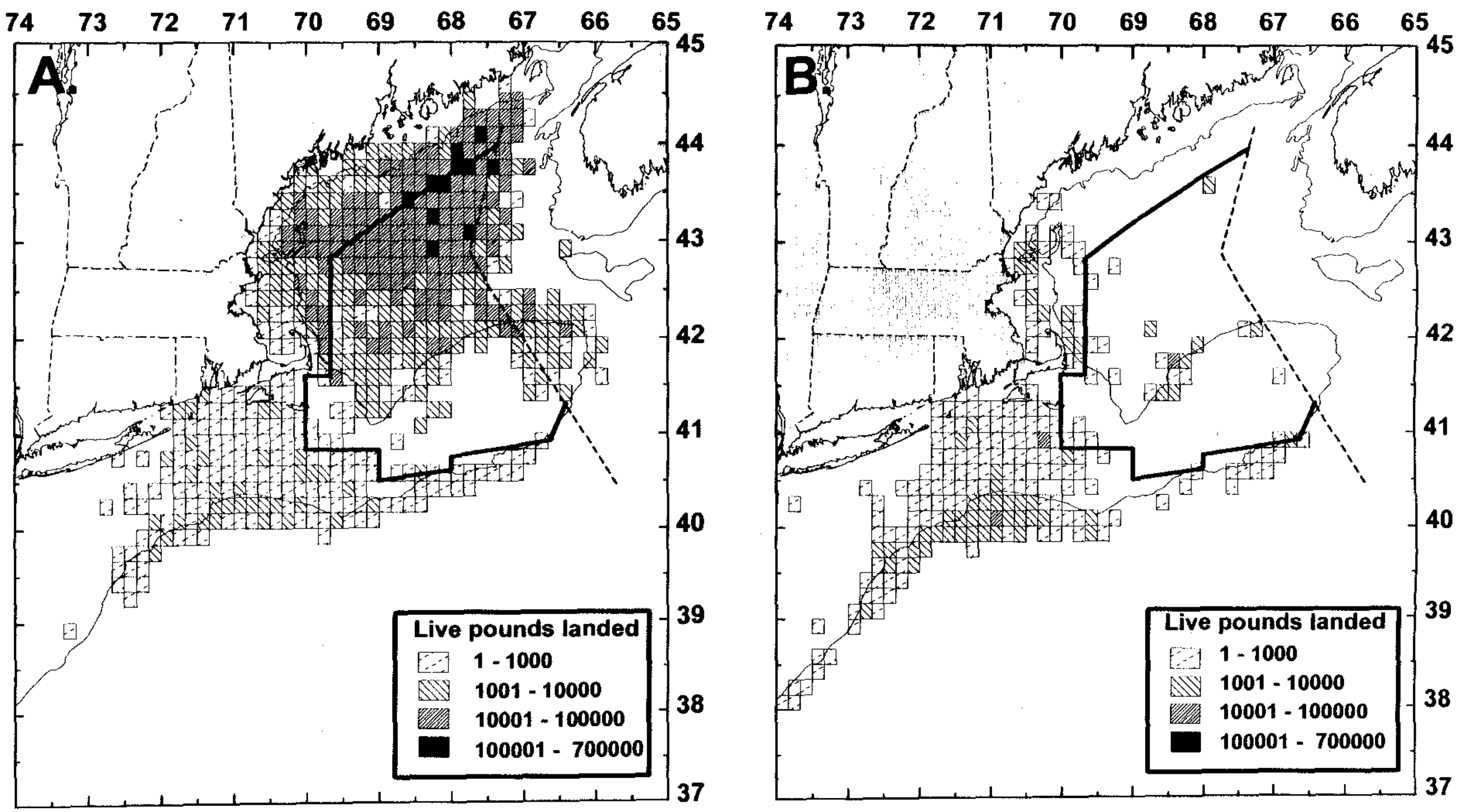


Figure 11. Distribution of white hake landings in the small mesh (< 5.5 in) otter trawl fishery during two time periods: A. 1983-1987; B. 1989-1993.

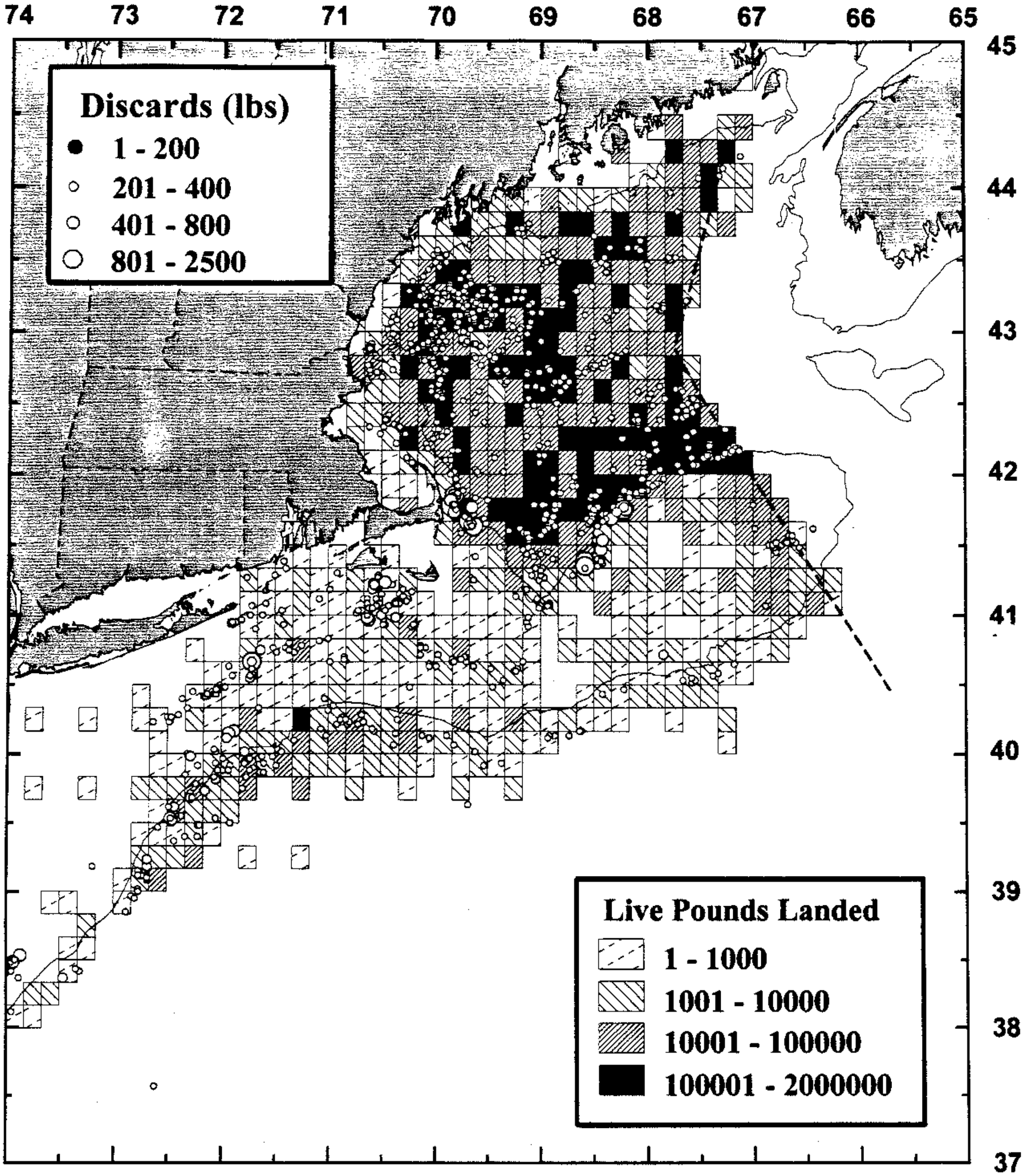


Figure 12. Distribution of white hake landings and discards in the otter trawl fishery during 1989-1993.

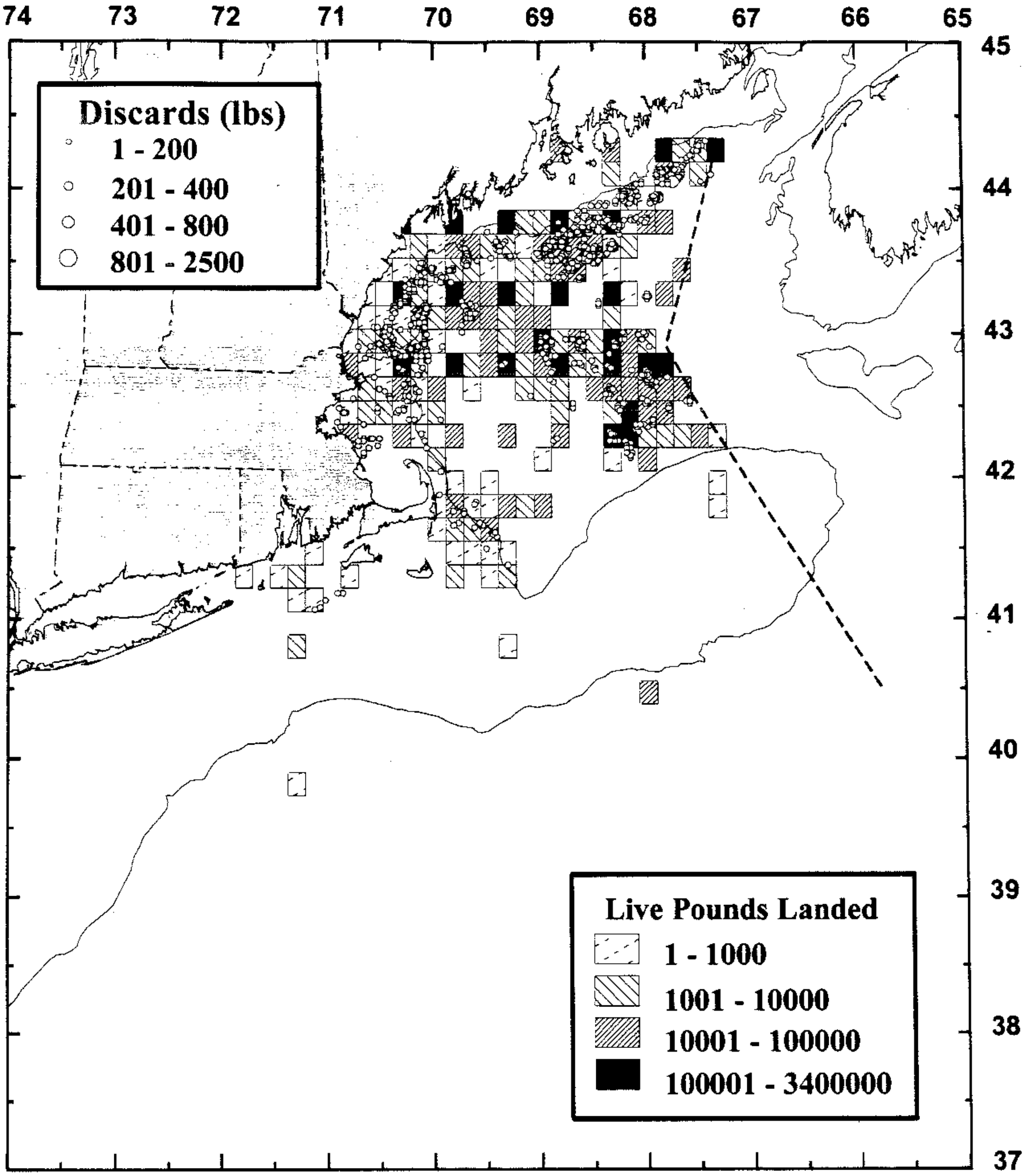


Figure 13. Distribution of white hake landings and discards in the sink gill net fishery during 1989-1993.

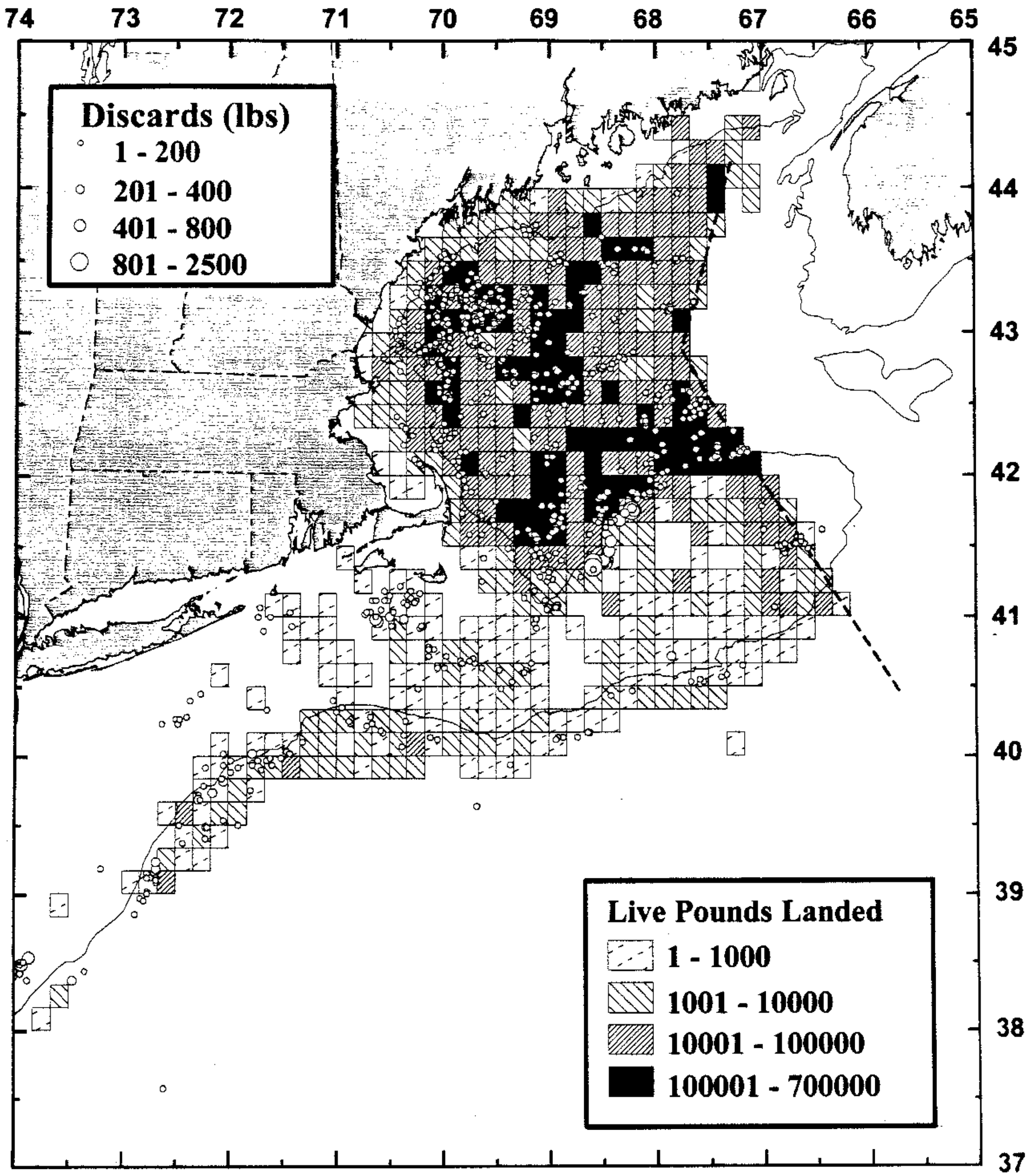


Figure 14. Distribution of white hake landings and discards in the large mesh (>= 5.5 in.) otter trawl fishery during 1989-1993.

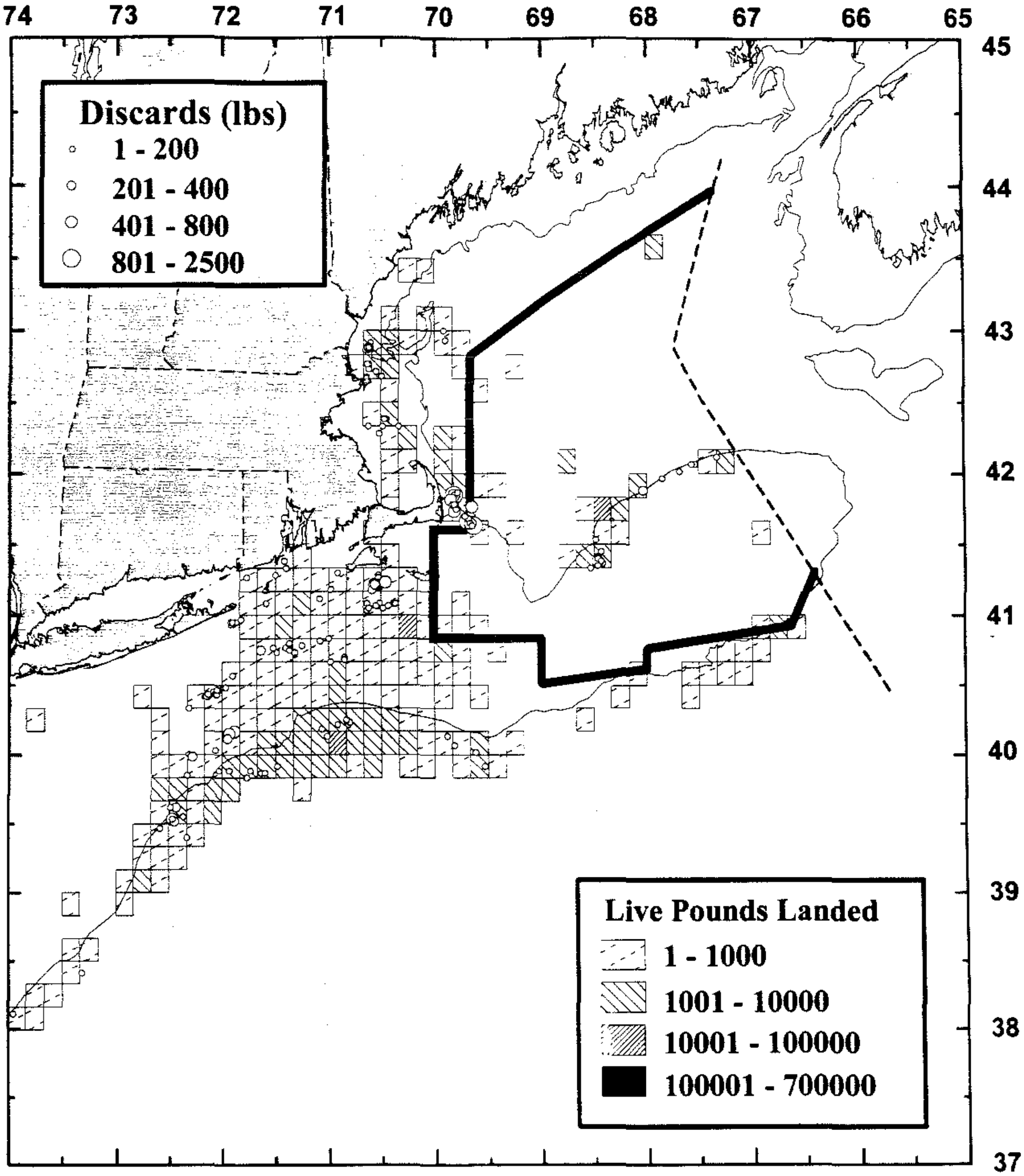


Figure 15. Distribution of white hake landings and discards in the small mesh (< 5.5 in.) otter trawl fishery during 1989-1993.

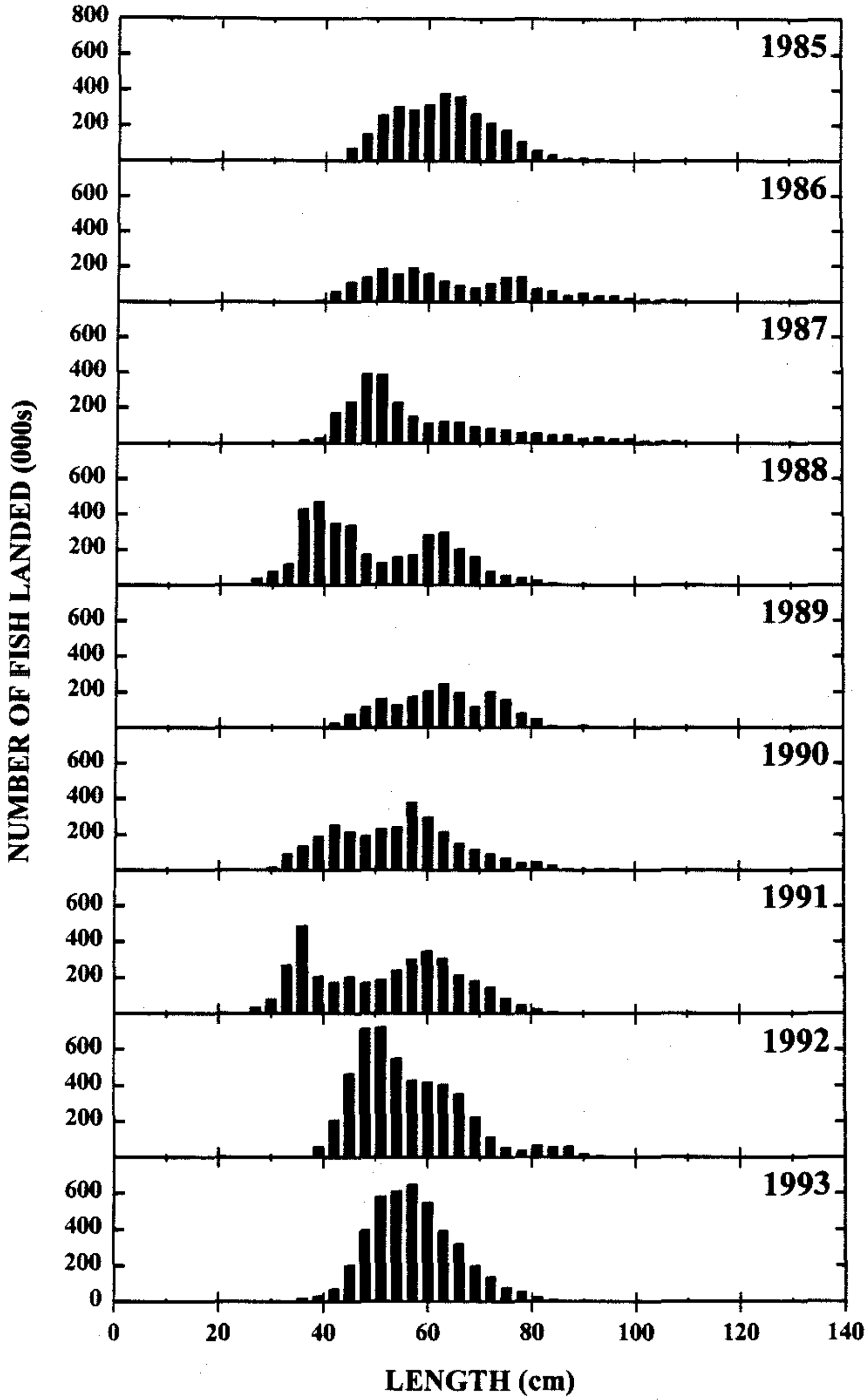


Figure 16. Commercial length composition of white hake landings for all gear types, 1985-1993.

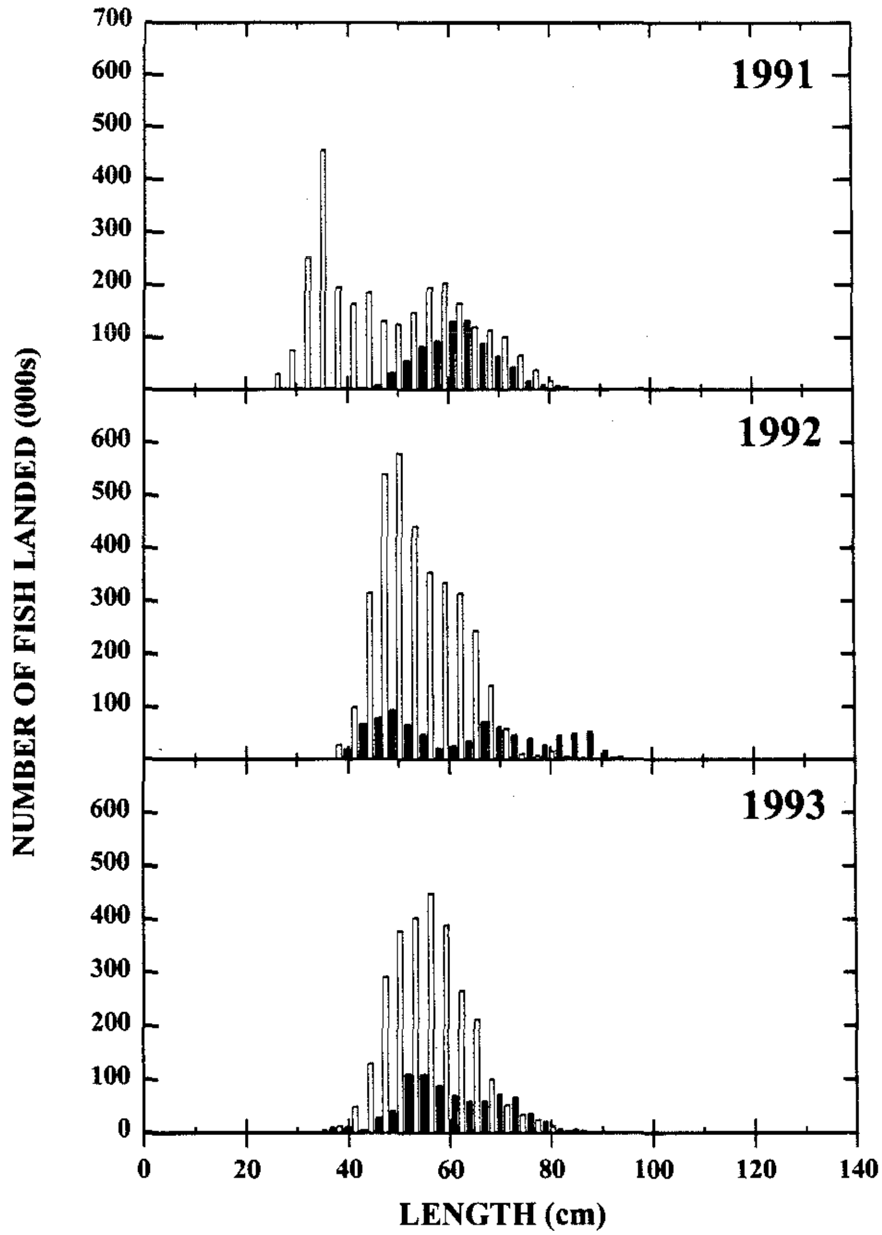


Figure 17. Commercial length composition of white hake landings in the otter trawl fishery (open bars) and in the sink gill net fishery (solid bars), 1991-1993.

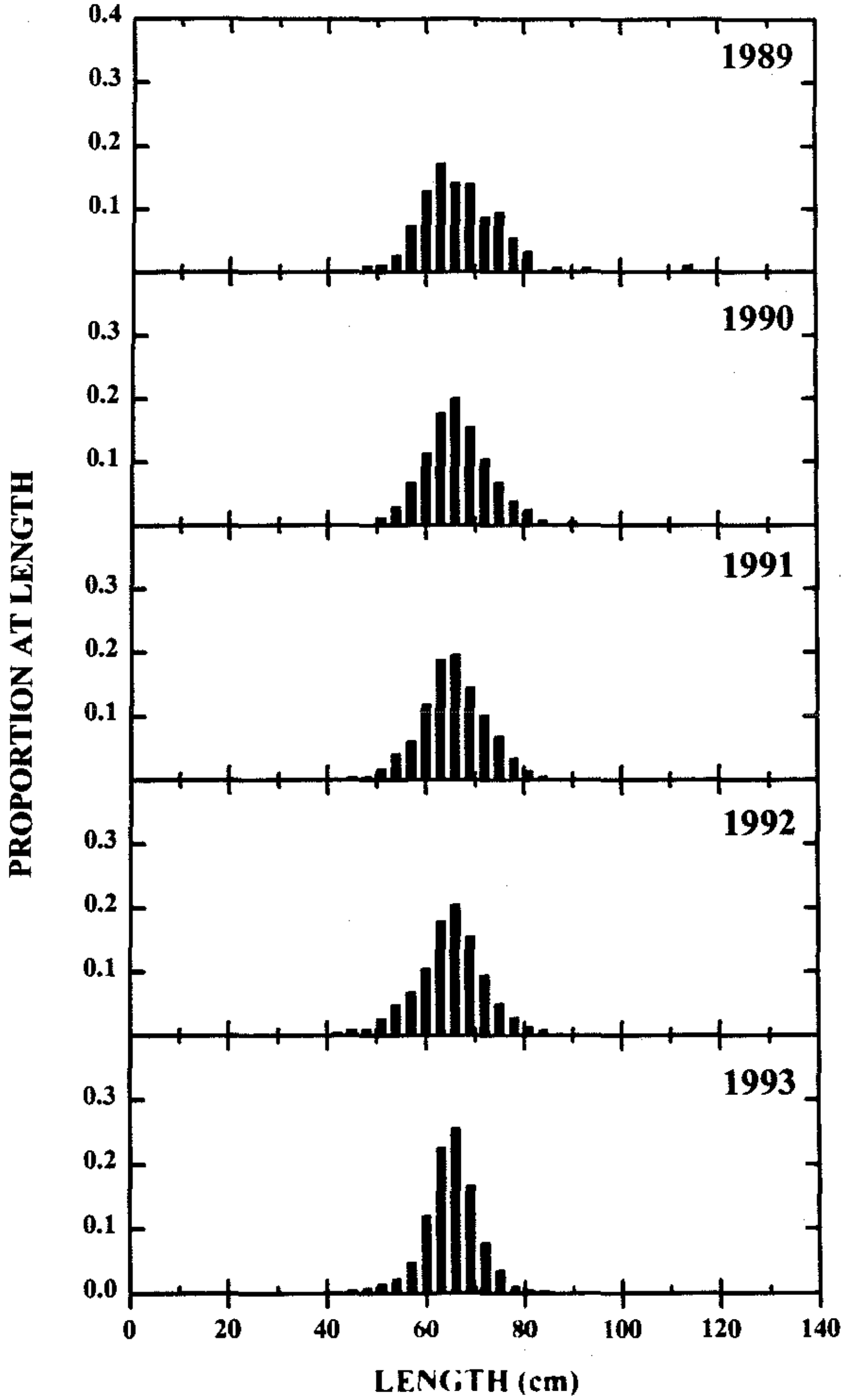


Figure 18. Length composition of sea sampled sink gill net trips, 1989-1993.

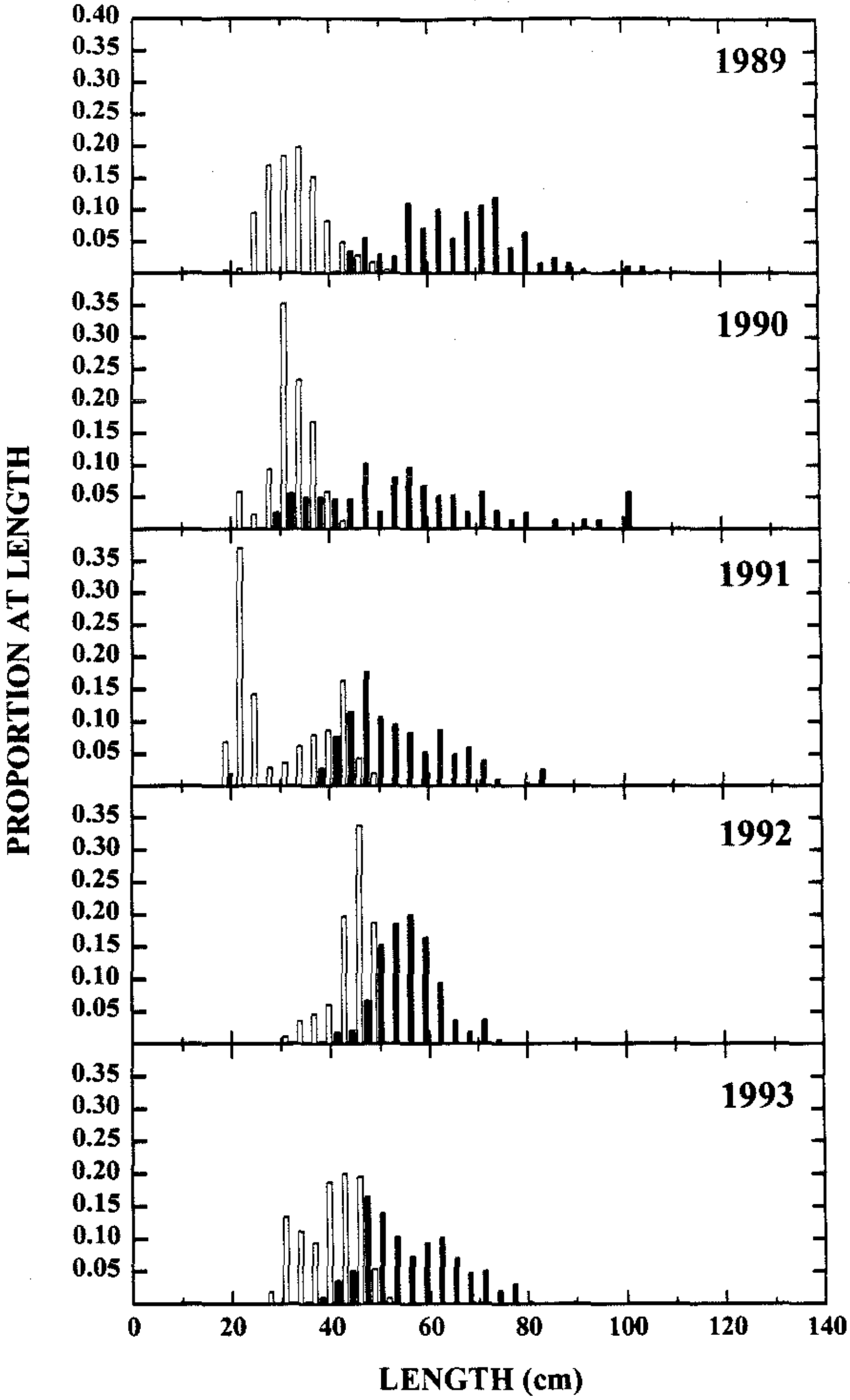


Figure 19. Length composition of discarded (open bars) and landed (solid bars) white hake from sea sampled otter trawl trips, 1989-1993.

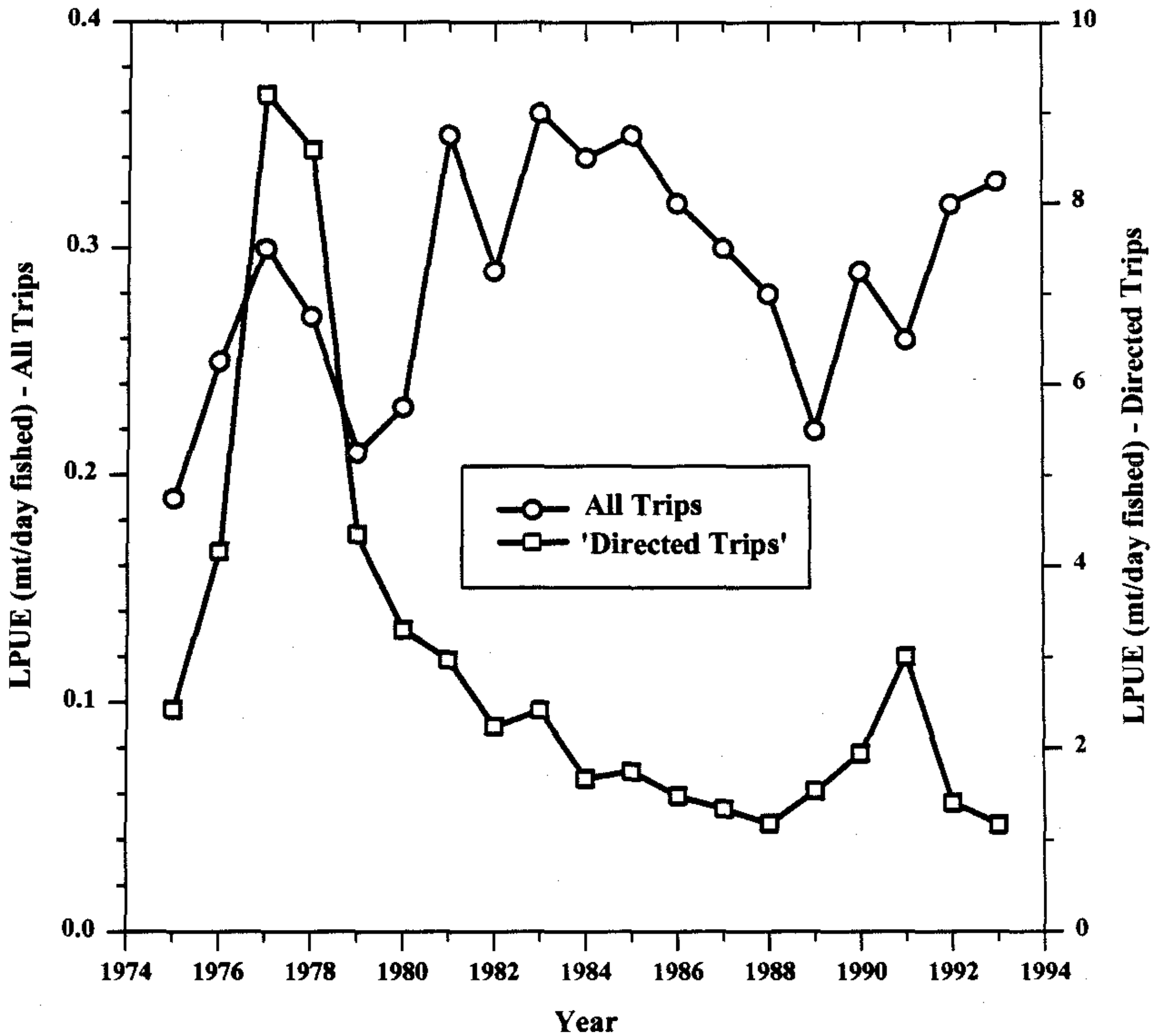


Figure 20. Nominal landings per day fished (LPUE) of white hake from all trips and 'directed trips' (trips in which white hake comprised 40% or more of the total trip catch).

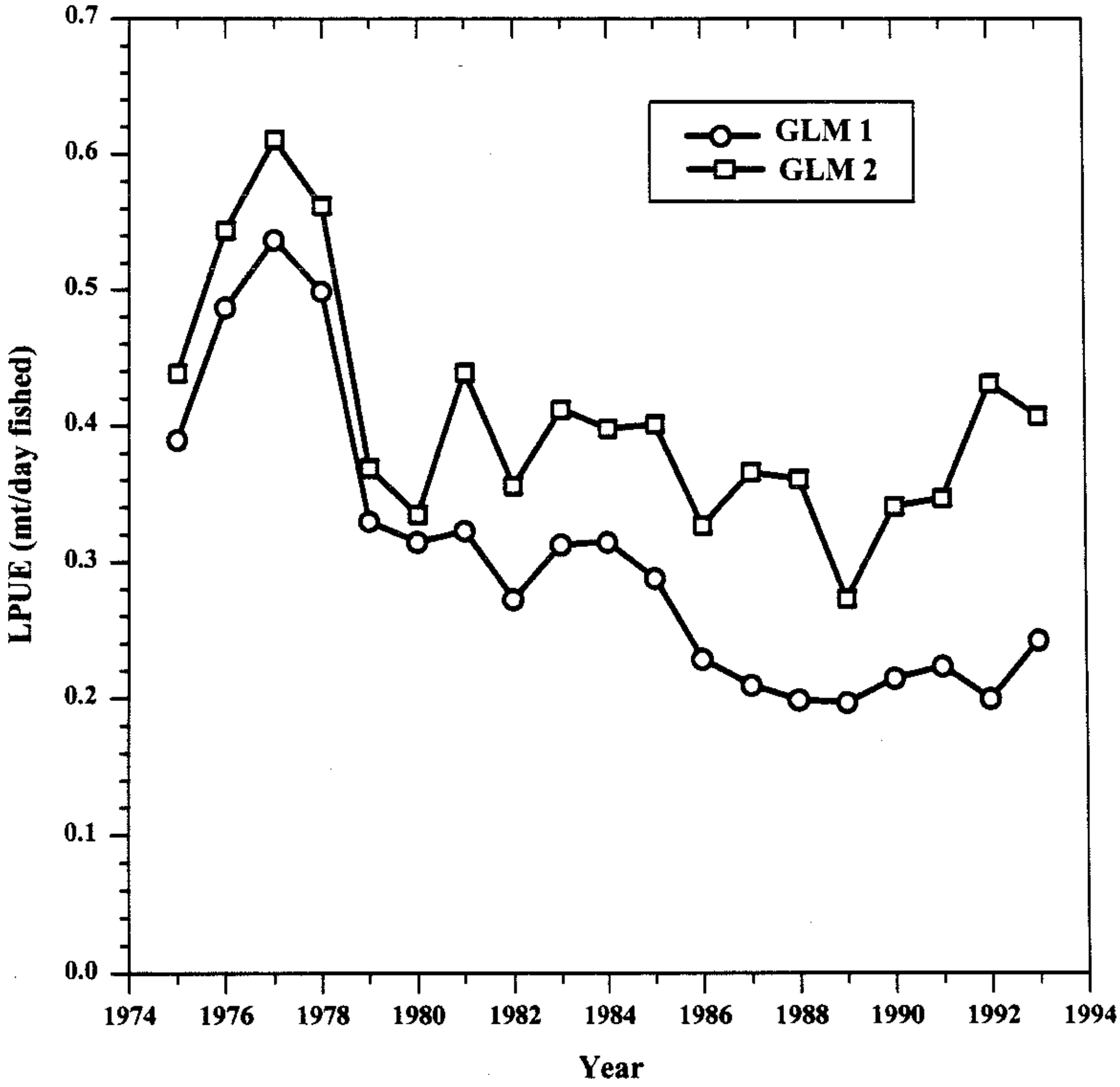


Figure 21. Standardized landings per day fished (LPUE) of white hake using two general linear models (GLM): GLM1 (year, quarter, area, tonnage class, depth, species ratio); and GLM2 (year, quarter, area, tonnage class, and depth).

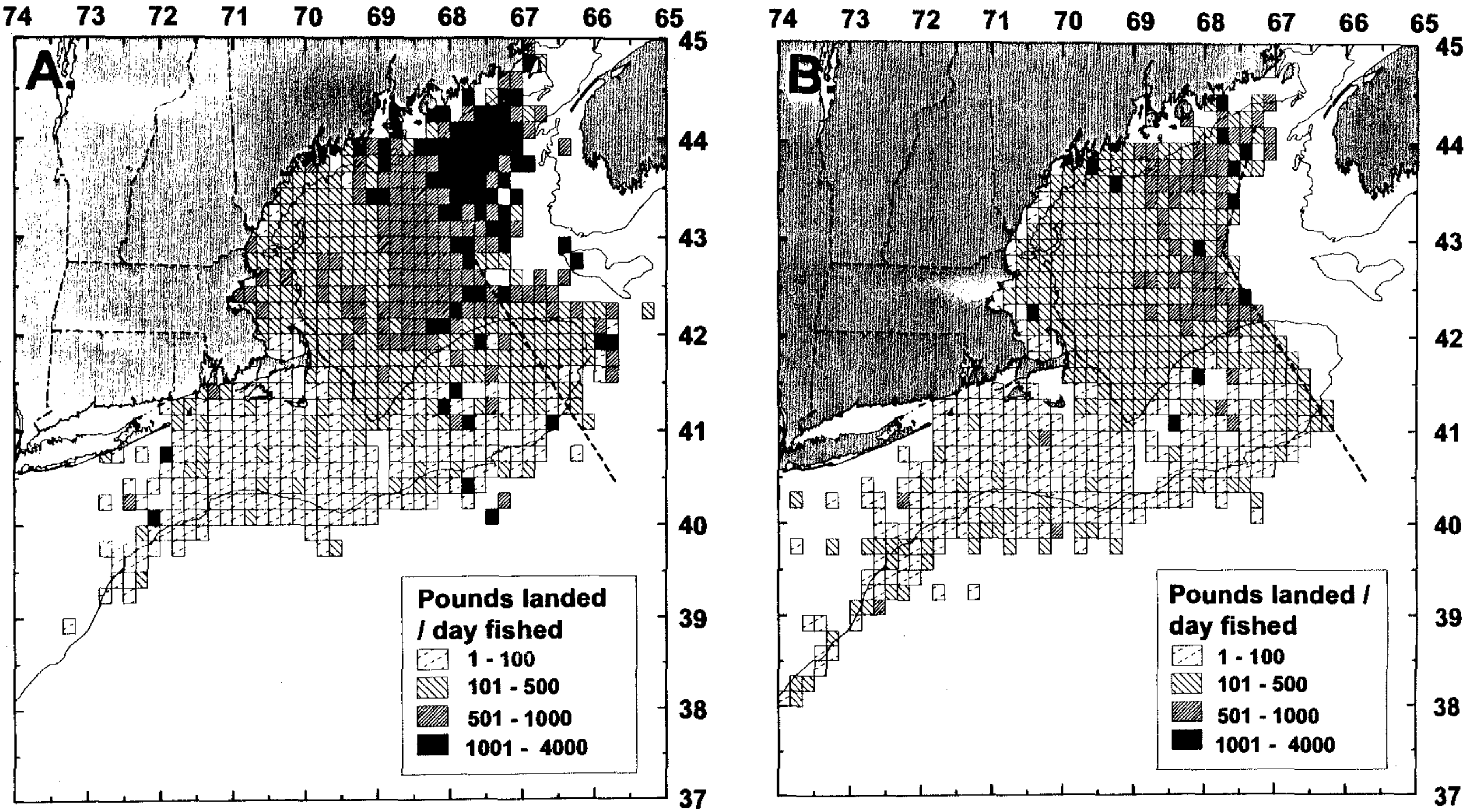


Figure 22. Distribution of white hake landings per unit effort (LPUE) in the otter trawl fishery during two time periods: A. 1983-1987; B. 1989-1993.

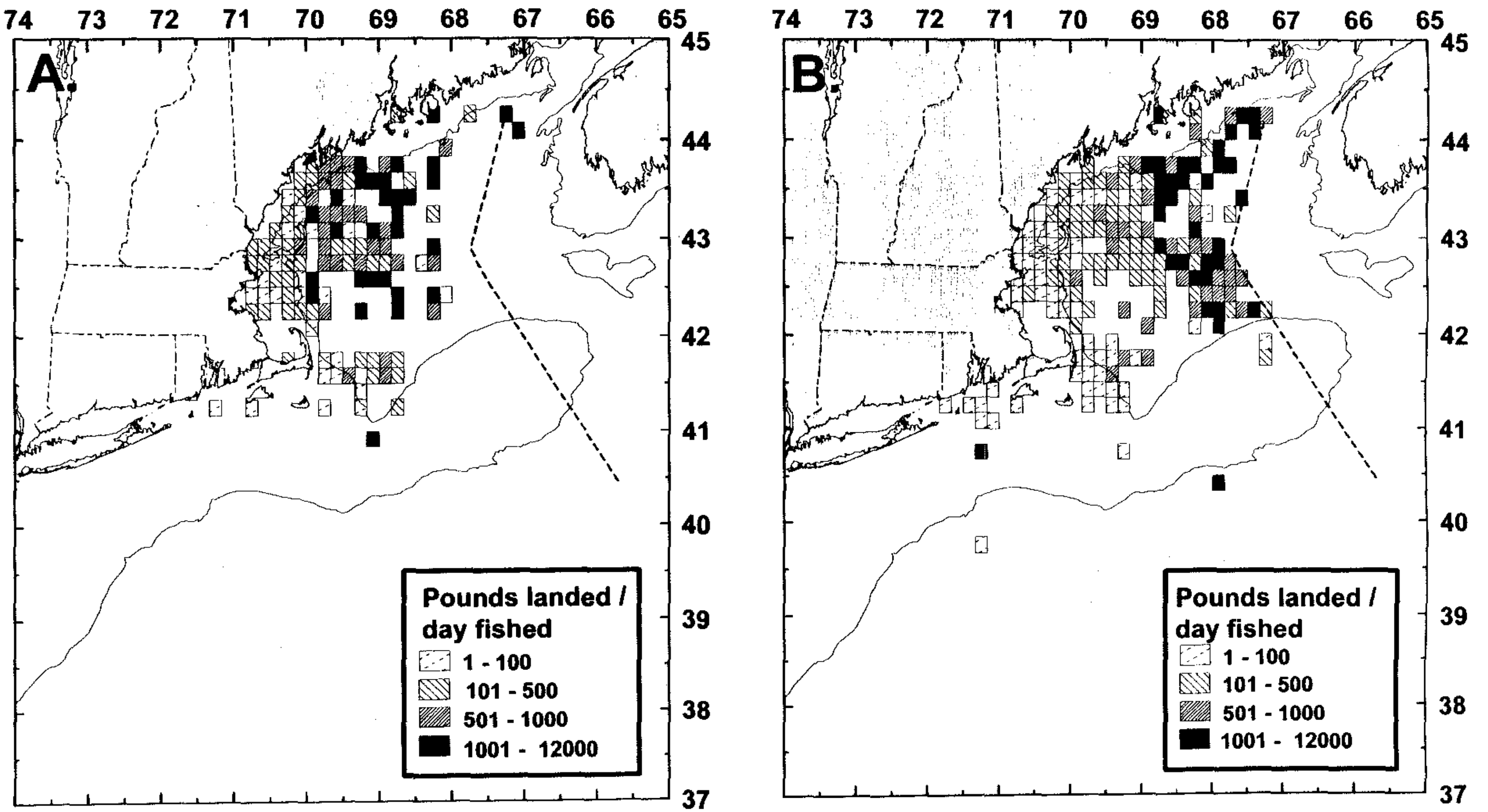
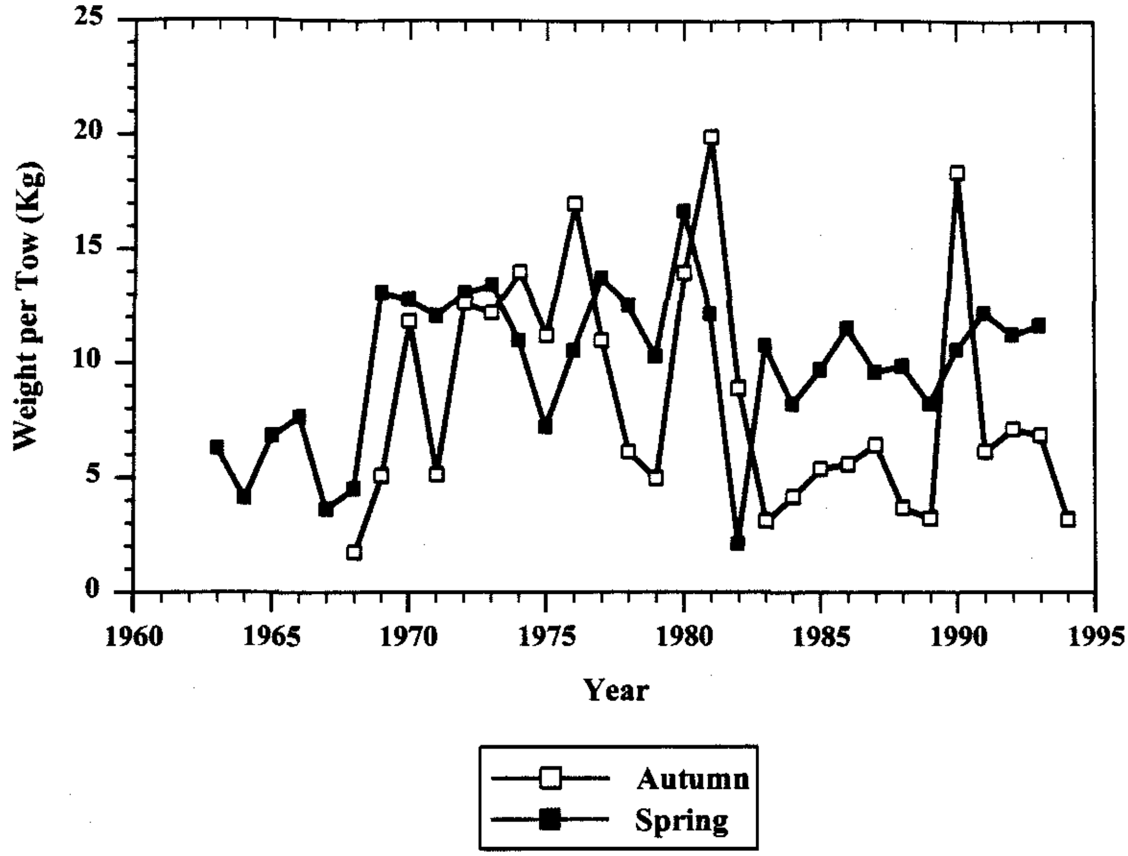


Figure 23. Distribution of white hake landings per unit effort (LPUE) in the sink gill net fishery during two time periods: A. 1983-1987; B. 1989-1993.



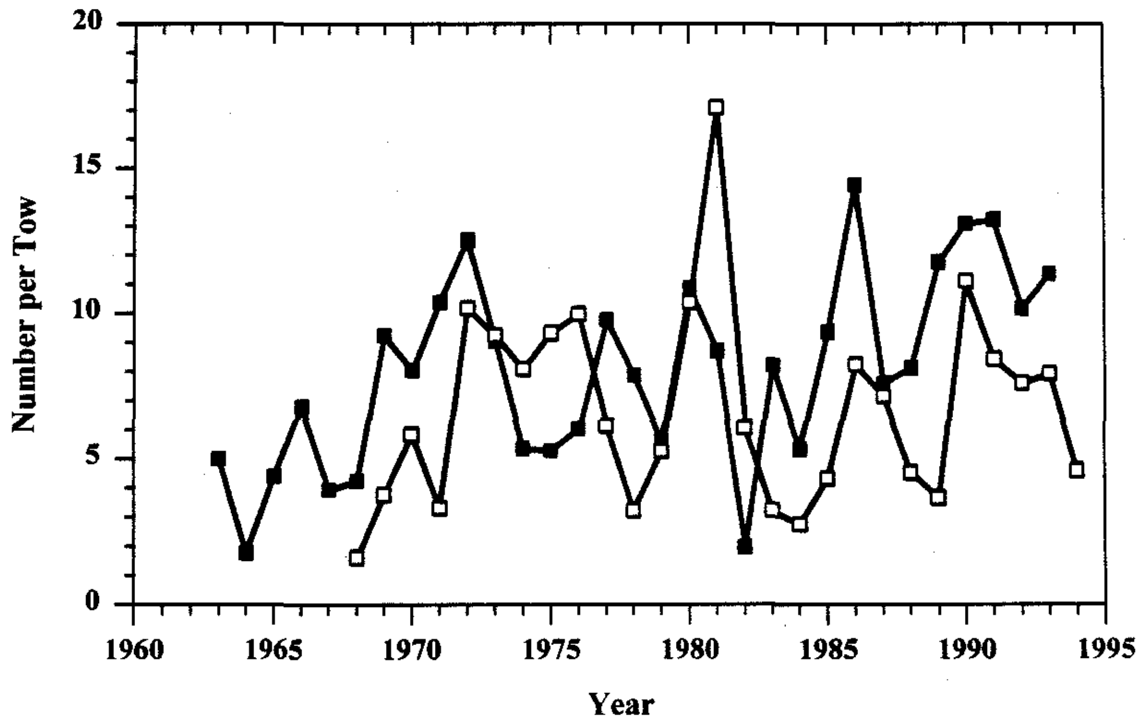


Figure 24. White hake indices of biomass (top panel) and abundance (bottom panel) from the NEFSC bottom trawl spring (solid line) and autumn (dashed line) surveys in the Gulf of Maine to Northern Georges Bank region (offshore strata 21-30, 33-40).

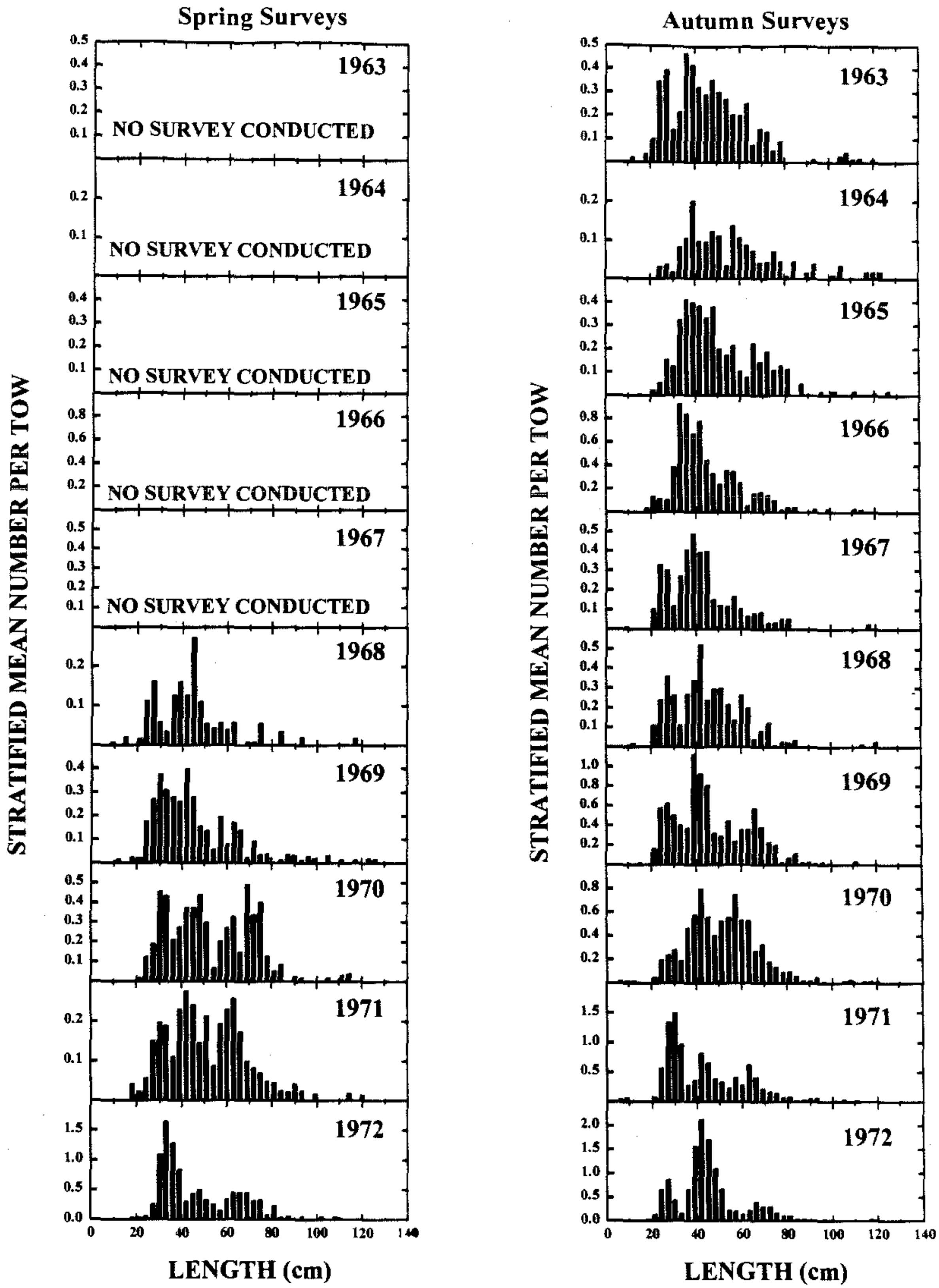


Figure 25. Length composition of white hake from the NEFSC bottom trawl surveys in the Gulf of Maine to northern Georges Bank region, 1963-1994.

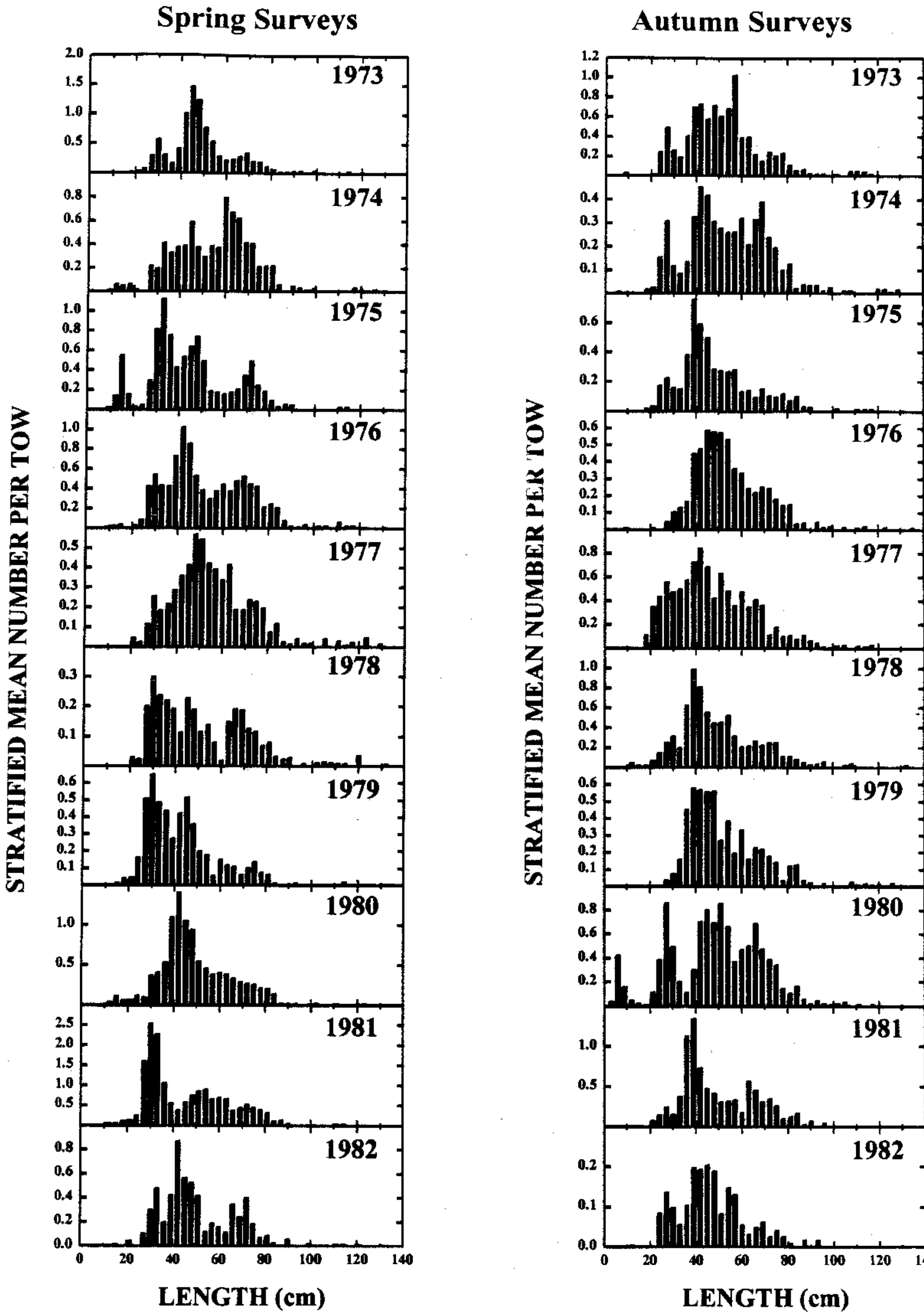
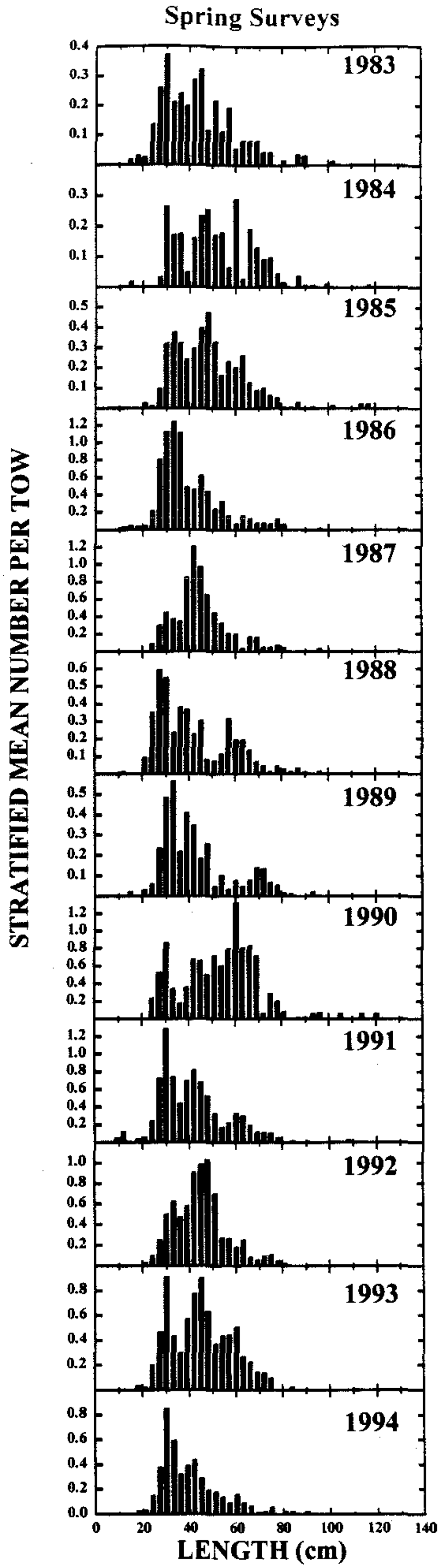


Figure 25. cont.



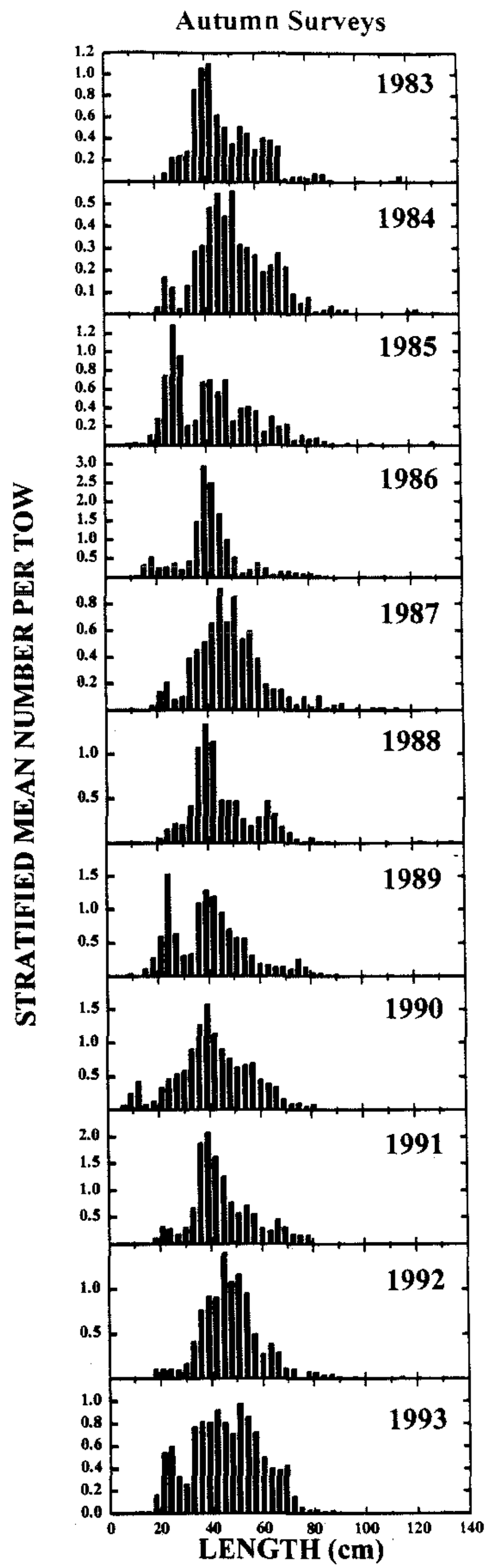


Figure 25. cont.

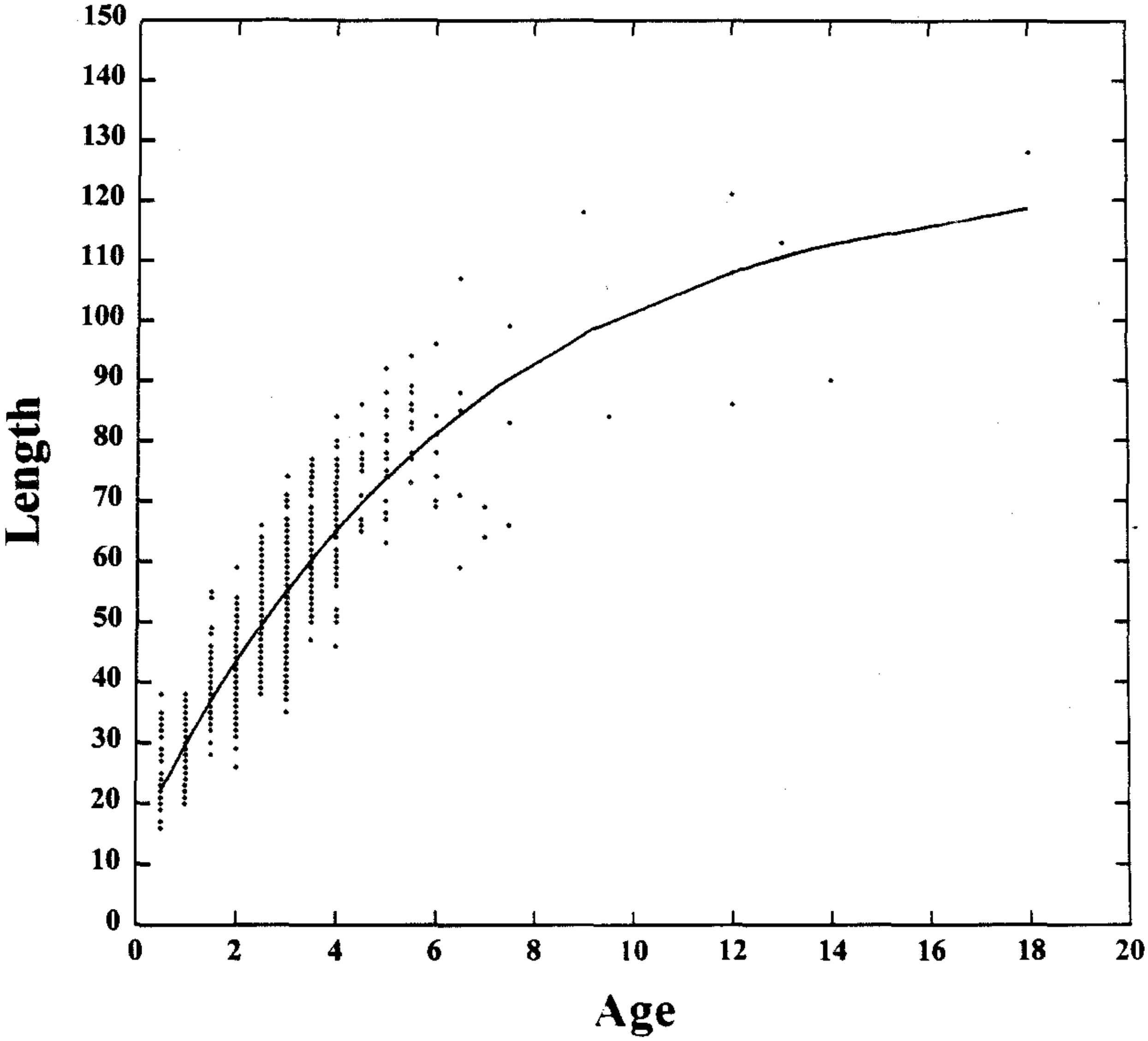


Figure 26. Von Bertalanffy growth curve for white hake, sexes combined.

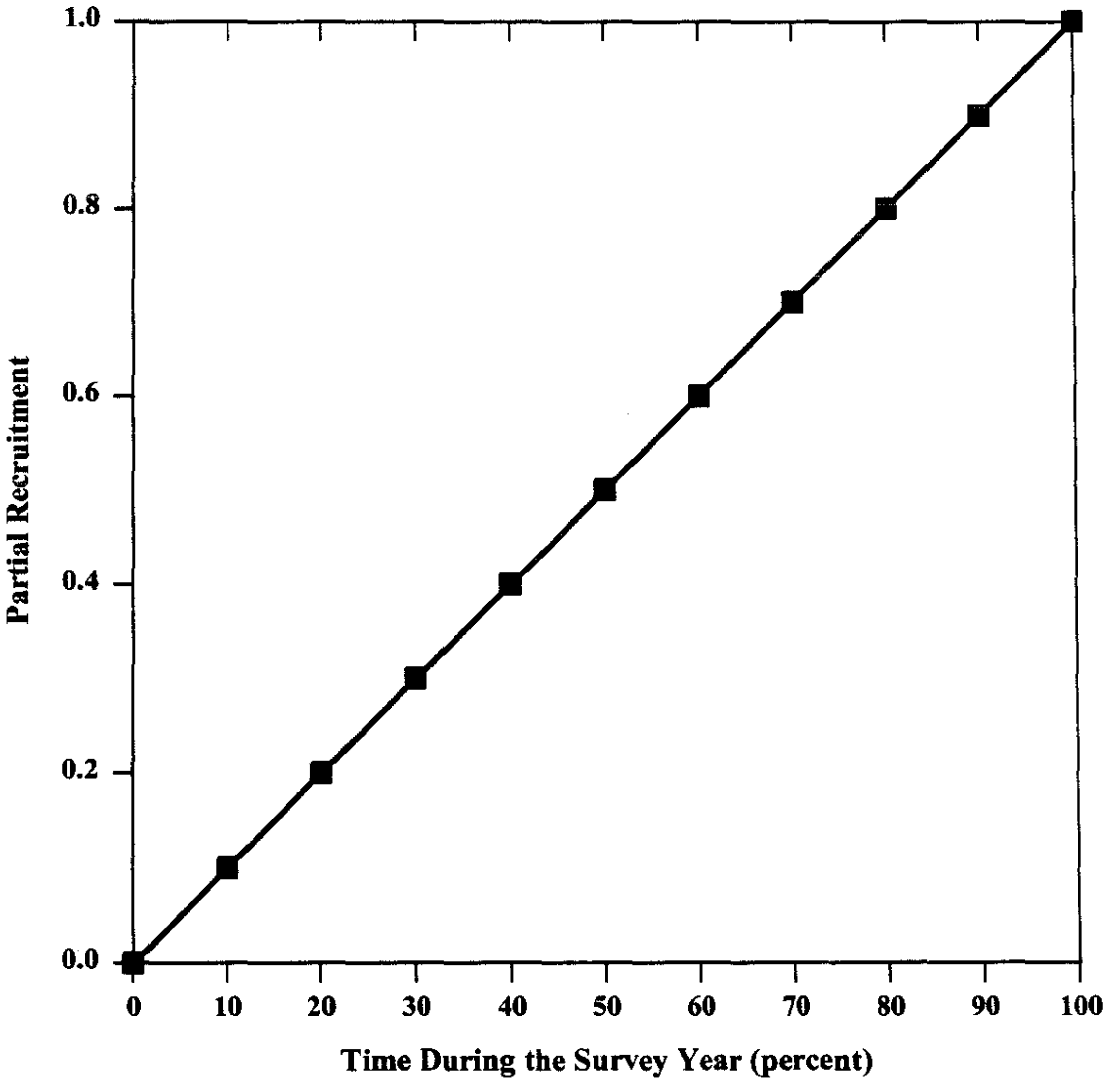


Figure 27. Partial recruitment of white hake to the commercial fishery during the year as used in the Modified DeLury model.

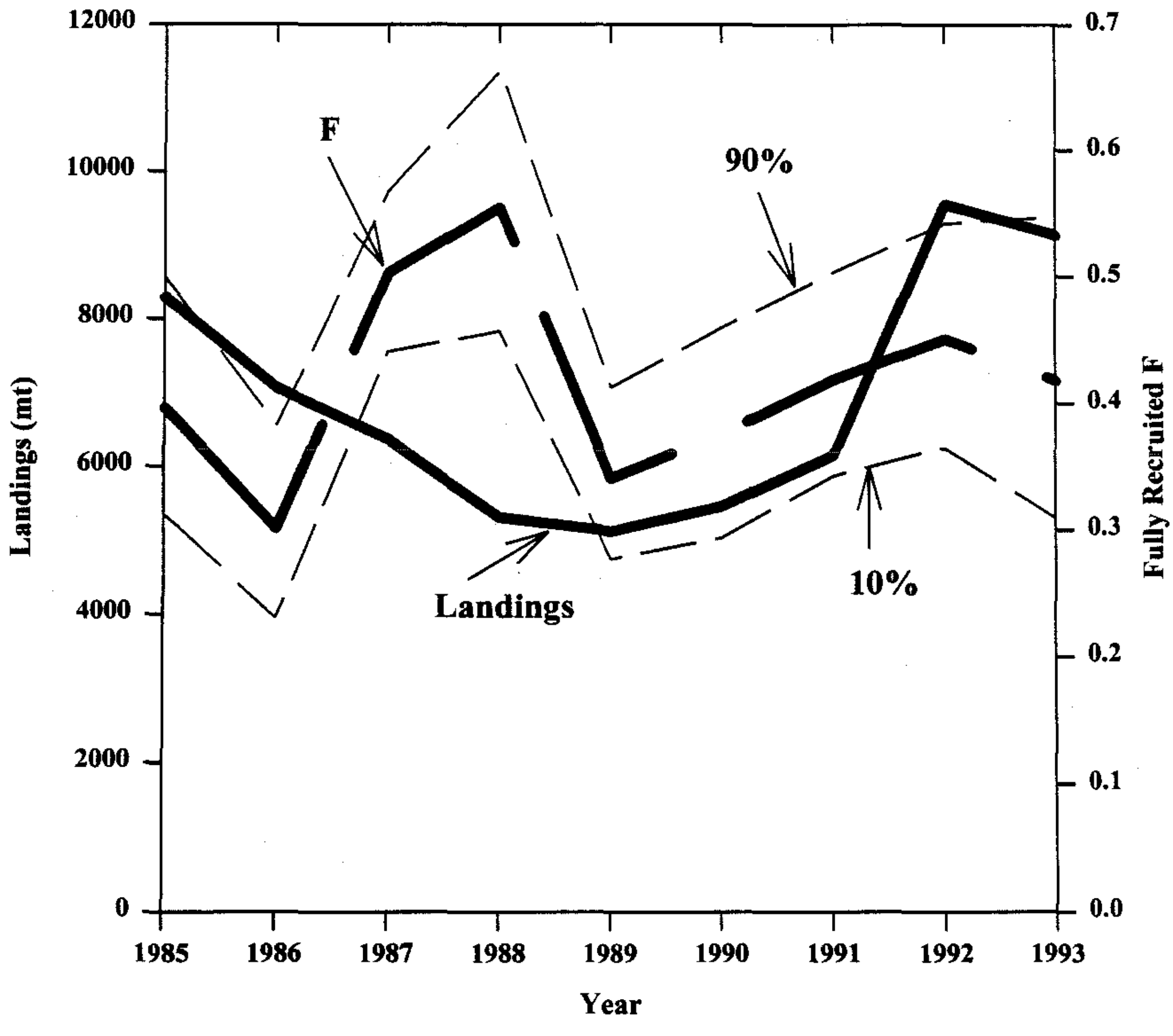


Figure 28. Trends in white hake commercial landings in mt and fishing mortality estimated from the Modified DeLury model. The 80% confidence limits for fishing mortality are also presented.

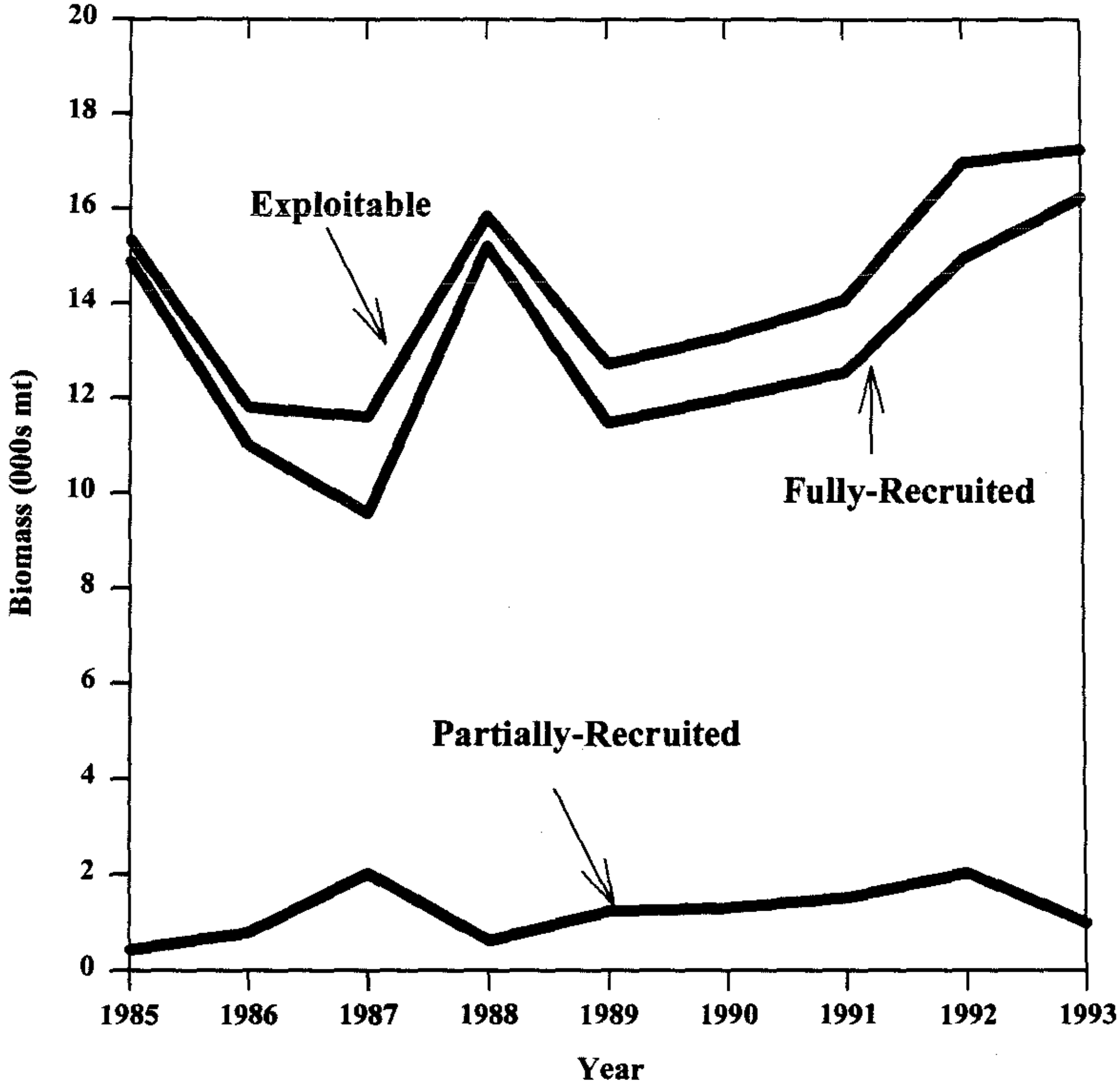


Figure 29. Trends in white hake fully-recruited biomass and recruitment biomass from the Modified DeLury model.

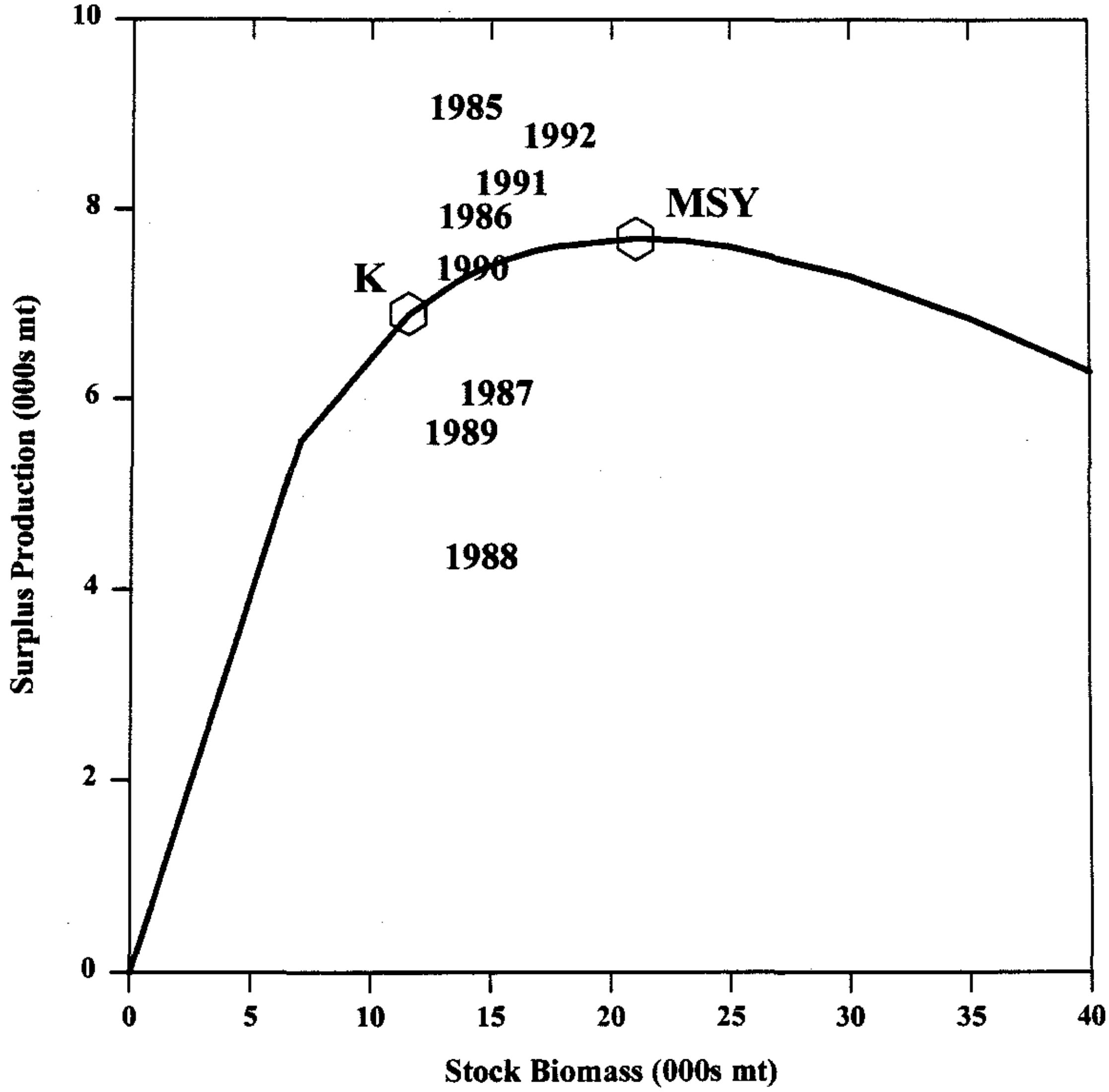


Figure 30. Surplus production curve for white hake showing observed production values in relation to MSY and K.

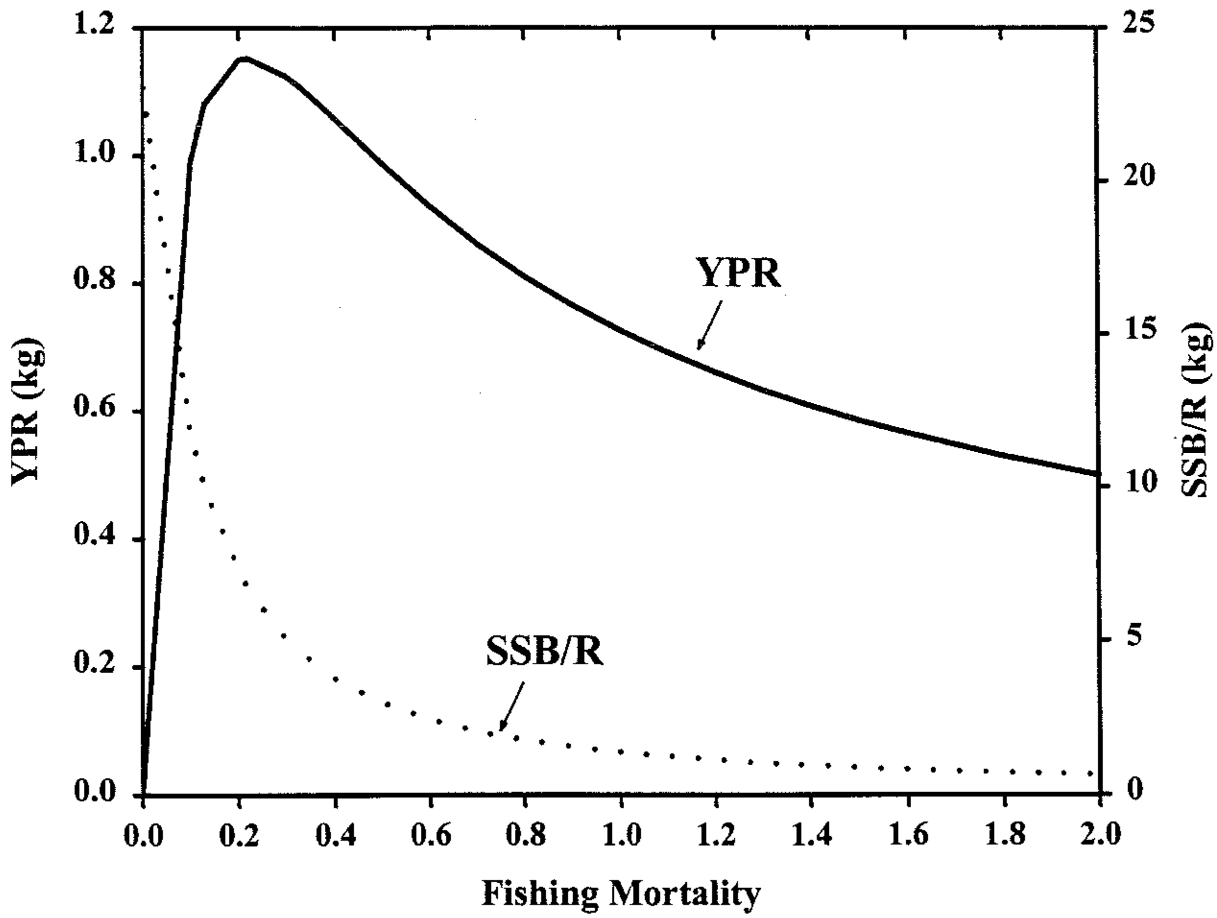


Figure 31. Yield and spawning stock biomass per recruit of white hake.

Appendix A. Results of the Modified DeLury Analysis.

APPENDIX A. RESULTS OF THE MODIFIED DELURY ANALYSIS   Run Number 28   1994 10 19 12 2 50
White Hake
Gulf of Maine Stock
Using indices of abundance from the NMFS Autumn Survey
Prepared for SARC 19 -- October 1994
Sizeclass 1 = Recruits   Sizeclasses 2+ = Fully-recruited hake

Definitions

Survey Year	The period between successive NEFSC Autumn research surveys e.g. the autumn survey in year t is lagged forward to Jan. of year t+1
Fully-recruited	All white hake greater than or equal to 44 cm at the beginning of the survey year (Oct 1).
Recruits	All white hake 29 to 43 cm at the beginning of the survey year whose length will be greater than or equal to 44 cm by the end of the survey year.

INPUT PARAMETERS AND OPTIONS SELECTED

Input data and options were taken from workspace variables.
Data used in fitting the model:

Natural mortality is 0.2

SURVEY YEAR	-- INDICES OF ABUNDANCE -- RECRUITS	FULLY-RECRUITED	TOTAL CATCH (millions)
1985	1.2450	3.7430	3.496013
1986	2.8240	4.0510	2.349630
1987	7.5380	5.0460	2.832091
1988	2.1160	5.0160	4.004625
1989	4.1780	3.5060	2.201709
1990	4.2140	4.3670	3.357205
1991	5.4580	5.3700	4.110854
1992	6.5450	5.7600	5.631835
1993	3.1620	6.5740	5.296829
1994	3.5770	6.1120	

Indices of abundance are from the NEFSC Autumn survey. They are assumed to be proportional to stock numbers on October 1st. The survey catches are classified into recruits and fully-recruited white hake (weight in g) based on the definitons given at the beginning of this output.

Note that the recruit abundance index for the last year is NOT used in the least squares estimation. It is, however, used in conjunction with the least squares estimate of q_n and the selectivity of the recruits to calculate recruit population size in 1994 (see RESULTS section).

MEAN WEIGHT (g) AT THE BEGINNING OF SURVEY YEAR

SURVEY YEAR	RECRUITS	FULLY-RECRUITED
1985	454.5	2032.4
1986	374.0	2109.1
1987	459.3	1579.2
1988	424.3	1775.4
1989	431.0	2002.5
1990	429.9	1657.8
1991	398.5	1552.6
1992	425.1	1609.8
1993	427.5	1491.9
1994	404.1	1591.9

SELECTIVITY OF RECRUITS TO THE SURVEY GEAR

Selectivity of the recruits (relative to the fully-recruited animals) to the survey gear is set at 1

PARTIAL RECRUITMENT (OF RECRUITS) TO THE COMMERCIAL FISHERY

Partial recruitment (PR) of the recruits to the commercial fishery is a function of month of the survey year (SY). As animals grow in size, partial recruitment increases, eventually reaching 1.0 at the end of each survey year. The PR function may vary over years due to changes in regulations and/or unusually small (or large) mean size of the recruits. The following table gives the input PR functions for each survey year. The rows of the table represent the percent of the SY completed, e.g. 0 represents the beginning of the SY (Oct 1) and 100 (**) represents the end of the SY (Sept 30). The annual average partial recruitment (shown after this table) results from integrating the annual PR functions with respect to time.

PARTIAL RECRUITMENT DURING EACH SURVEY YEAR

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
**	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

AVERAGE PARTIAL RECRUITMENT OF RECRUITS TO THE COMMERCIAL FISHERY

Survey Year	Average Partial Recruitment
1985	0.500
1986	0.500
1987	0.500
1988	0.500
1989	0.500
1990	0.500
1991	0.500
1992	0.500
1993	0.500
1994	0.500

OTHER INPUT DATA AND OPTIONS

Measurement error in the abundance indices for both the recruits and the fully-recruited ages is assumed to be lognormally distributed. Process error is assumed to follow a lognormal distribution.

Initial estimates of parameters for the Marquardt algorithm
and lower and upper bounds on the parameter estimates:

	Parameter	Initial Est	Lower Bnd	Upper Bnd
1	n 2+ 1985	3.7430000E0	1.0000000E-10	1.0000000E6
2	n 2+ 1986	4.0510000E0	1.0000000E-10	1.0000000E6
3	n 2+ 1987	5.0460000E0	1.0000000E-10	1.0000000E6
4	n 2+ 1988	5.0160000E0	1.0000000E-10	1.0000000E6
5	n 2+ 1989	3.5060000E0	1.0000000E-10	1.0000000E6
6	n 2+ 1990	4.3670000E0	1.0000000E-10	1.0000000E6
7	n 2+ 1991	5.3700000E0	1.0000000E-10	1.0000000E6
8	n 2+ 1992	5.7600000E0	1.0000000E-10	1.0000000E6
9	n 2+ 1993	6.5740000E0	1.0000000E-10	1.0000000E6
10	n 2+ 1994	6.1120000E0	1.0000000E-10	1.0000000E6
11	r 1 1985	1.2450000E0	1.0000000E-10	1.0000000E6
12	r 1 1986	2.8240000E0	1.0000000E-10	1.0000000E6
13	r 1 1987	7.5380000E0	1.0000000E-10	1.0000000E6
14	r 1 1988	2.1160000E0	1.0000000E-10	1.0000000E6
15	r 1 1989	4.1780000E0	1.0000000E-10	1.0000000E6
16	r 1 1990	4.2140000E0	1.0000000E-10	1.0000000E6
17	r 1 1991	5.4580000E0	1.0000000E-10	1.0000000E6
18	r 1 1992	6.5450000E0	1.0000000E-10	1.0000000E6
19	r 1 1993	3.1620000E0	1.0000000E-10	1.0000000E6
20	Surv q_n	1.0000000E0	1.0000000E-10	1.0000000E6

BEGIN MARQUARDT ALGORITHM

```
LAMBDA      1.00000E-2
RSS         8.82649E0
NPHI        8.82649E0

par
   3.74300E0       4.05100E0       5.04600E0       5.01600E0       3.50600E0       4.
      36700E0       5.37000E0       5.76000E0       6.57400E0       6.11200E0       1
      .24500E0       2.82400E0       7.53800E0       2.11600E0       4.17800E0
      4.21400E0       5.45800E0       6.54500E0       3.16200E0       1.00000E0

LAMBDA      1.00000E-3
RSS         9.29063E-1
NPHI        9.29063E-1

par
   4.55103E0       3.83358E0       3.94917E0       5.64698E0       3.77320E0       4.
      75242E0       5.28241E0       6.05974E0       7.11563E0       5.65194E0       1
      .33712E0       2.89246E0       5.52259E0       1.92020E0       3.87939E0
      4.19358E0       5.33388E0       6.72542E0       3.33211E0       7.77761E-1

LAMBDA      1.00000E-4
RSS         3.98578E-1
NPHI        3.98578E-1

par
   5.07603E0       3.42899E0       3.89898E0       5.76005E0       3.81163E0       4.
      82850E0       5.31709E0       6.14262E0       7.16135E0       5.57004E0       1
      .36434E0       2.94647E0       5.80829E0       1.97389E0       3.86153E0
      4.14027E0       5.26065E0       6.64225E0       3.32045E0       7.25286E-1

LAMBDA      1.00000E-5
RSS         3.97646E-1
NPHI        3.97646E-1

par
   5.09672E0       3.39794E0       3.90562E0       5.78695E0       3.82001E0       4.
      83536E0       5.31983E0       6.14457E0       7.15237E0       5.55401E0       1
      .35314E0       2.97888E0       5.83884E0       1.97995E0       3.86694E0
      4.14353E0       5.26726E0       6.64003E0       3.31740E0       7.26175E-1
```

```
LAMBDA        1.00000E-5
RSS           3.97644E-1
NPHI          3.97644E-1

par
  5.09713E0      3.39792E0      3.90739E0      5.78709E0      3.82068E0      4.
    83574E0      5.32022E0      6.14491E0      7.15292E0      5.55527E0      1
    .35189E0      2.98055E0      5.83692E0      1.98004E0      3.86653E0
    4.14307E0      5.26655E0      6.63924E0      3.31733E0      7.25929E-1
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN 0.00001

RESULTS
-------
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

SUM OF SQUARES ..............        0.397644
ORTHOGONALITY OFFSET.........        0.001852
MEAN SQUARE RESIDUALS .......        0.049705
```

	PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
1	n 2+ 1985	5.09713E0	7.92469E-1	6.43196E0	0.16
2	n 2+ 1986	3.39792E0	5.61320E-1	6.05344E0	0.17
3	n 2+ 1987	3.90739E0	5.97231E-1	6.54251E0	0.15
4	n 2+ 1988	5.78709E0	7.29253E-1	7.93564E0	0.13
5	n 2+ 1989	3.82068E0	5.98682E-1	6.38182E0	0.16
6	n 2+ 1990	4.83574E0	6.83916E-1	7.07066E0	0.14
7	n 2+ 1991	5.32022E0	7.72275E-1	6.88902E0	0.15
8	n 2+ 1992	6.14491E0	8.97017E-1	6.85039E0	0.15
9	n 2+ 1993	7.15292E0	9.79870E-1	7.29986E0	0.14
10	n 2+ 1994	5.55527E0	9.90611E-1	5.60793E0	0.18
11	r 1 1985	1.35189E0	2.97275E-1	4.54760E0	0.22
12	r 1 1986	2.98055E0	6.02212E-1	4.94935E0	0.20
13	r 1 1987	5.83692E0	1.07901E0	5.40953E0	0.18
14	r 1 1988	1.98004E0	4.29650E-1	4.60851E0	0.22
15	r 1 1989	3.86653E0	7.71403E-1	5.01233E0	0.20
16	r 1 1990	4.14307E0	8.35200E-1	4.96058E0	0.20
17	r 1 1991	5.26655E0	1.04568E0	5.03650E0	0.20
18	r 1 1992	6.63924E0	1.28396E0	5.17091E0	0.19
19	r 1 1993	3.31733E0	7.08119E-1	4.68471E0	0.21
20	Surv q_n	7.25929E-1	1.19262E-1	6.08685E0	0.16

```
CORRELATION BETWEEN PARAMETERS ESTIMATED (SYMBOLIC FORM)

 1 n 2+ 1985 * + . . . . . . . . . . . . . . . . . +
 2 n 2+ 1986 + * + . . . . . . . . . . . . . . . . .
 3 n 2+ 1987 . + * . . . . . . . . + . . . . . . . .
 4 n 2+ 1988 . . . * + . . . . . . . + . . . . . . .
 5 n 2+ 1989 . . . + * . . . . . . . . . . . . . . .
 6 n 2+ 1990 . . . . . * . . . . . . . . + . . . . .
 7 n 2+ 1991 . . . . . . * . . . . . . . . + . . . .
 8 n 2+ 1992 . . . . . . . * . . . . . . . . + . . .
 9 n 2+ 1993 . . . . . . . . * + . . . . . . . + . .
10 n 2+ 1994 . . . . . . . . + * . . . . . . . . . -
11 r 1  1985 . . . . . . . . . . * . . . . . . . . .
12 r 1  1986 . . + . . . . . . . . * . . . . . . . .
13 r 1  1987 . . . + . . . . . . . . * . . . . . . .
14 r 1  1988 . . . . . . . . . . . . . * . . . . . .
15 r 1  1989 . . . . . + . . . . . . . . * . . . . .
16 r 1  1990 . . . . . . + . . . . . . . . * . . . .
17 r 1  1991 . . . . . . . + . . . . . . . . * . . .
18 r 1  1992 . . . . . . . . + . . . . . . . . * . .
19 r 1  1993 . . . . . . . . . . . . . . . . . . * .
20 Surv q_n  + . . . . . . . . - . . . . . . . . . *

SYMBOLS:  =  LARGE NEGATIVE CORRELATION     whenever  -1 <= r <   L
          -  MODERATE NEGATIVE CORRELATION  whenever  -L <= r <   M
          .  SMALL CORRELATION              whenever  -M <= r <= +M
          +  MODERATE POSITIVE CORRELATION  whenever  +M <  r <= +L
          *  LARGE POSITIVE CORRELATION     whenever  +L <  r <= +1

Where r is the estimated correlation, M is 0.4 and L is 0.8
```

SURVEY YEAR	STOCK SIZE ESTIMATES (millions at start of yr) RECRUITS	FULLY-RECRUITED	Z on sizes 1+	F on size 1	F on sizes 2+
1985	1.862	7.022	0.64	0.25	0.49
1986	4.106	4.681	0.49	0.19	0.38
1987	8.041	5.383	0.52	0.23	0.46
1988	2.728	7.972	0.71	0.29	0.58
1989	5.326	5.263	0.46	0.18	0.35
1990	5.707	6.661	0.52	0.21	0.42
1991	7.255	7.329	0.54	0.23	0.46
1992	9.146	8.465	0.58	0.26	0.51
1993	4.570	9.853	0.63	0.26	0.52
1994	4.927	7.653			

RECRUITS = SIZECLASS 1
FULLY-RECRUITED = SIZECLASS 2+

Note that the recruit population estimate for the last year (1994) is NOT a least squares estimate. It is calculated from the observed survey index, the least squares estimate of q, and the calculated selectivity.

SURVEY YEAR	---- BIOMASS ESTIMATES (start of year - 1000 mt) ---- RECRUITS	FULLY-RECRUITED	TOTAL BIOMASS	EXPLOITED BIOMASS	CATCH BIOMASS DURING SURVEY YEAR (1000 mt)
1985	0.846	14.271	15.117	14.694	8.304
1986	1.536	9.872	11.408	10.640	7.065
1987	3.693	8.500	12.193	10.347	6.371
1988	1.157	14.153	15.311	14.732	5.312
1989	2.296	10.539	12.835	11.687	5.127
1990	2.454	11.043	13.497	12.270	5.469
1991	2.891	11.379	14.270	12.824	6.154
1992	3.888	13.627	17.515	15.571	9.561
1993	1.954	14.700	16.654	15.677	9.135
1994	1.991	12.182	14.173	13.178	

SURVEY YEAR	--------------- 1000 Metric Tons ------------- EXPLOITED BIOMASS	DELTA B	CATCH	SURPLUS PRODUCTION	PROD-BIOMASS RATIO
1985	14.694	-4.054	8.304	4.251	0.2893
1986	10.640	-0.293	7.065	6.772	0.6364
1987	10.347	4.385	6.371	10.756	1.0396
1988	14.732	-3.045	5.312	2.267	0.1539
1989	11.687	0.583	5.127	5.710	0.4886
1990	12.270	0.554	5.469	6.023	0.4908
1991	12.824	2.746	6.154	8.900	0.6940
1992	15.571	0.106	9.561	9.667	0.6209
1993	15.677	-2.499	9.135	6.635	0.4232
1994	13.178				

SUMMARY OF RESIDUALS FROM THE FITTED MODEL

MEASUREMENT ERROR -- Fully-recruited index with lognormal errors

ERROR TERM	OBSERVED	PREDICTED	WEIGHT	RESIDUAL	STD RES	%SS
n 2+ 1985	3.7430	5.0971	1.0000	-0.3088	-1.3850	24.0
n 2+ 1986	4.0510	3.3979	1.0000	0.1758	0.7885	7.8
n 2+ 1987	5.0460	3.9074	1.0000	0.2557	1.1470	16.4
n 2+ 1988	5.0160	5.7871	1.0000	-0.1430	-0.6414	5.1
n 2+ 1989	3.5060	3.8207	1.0000	-0.0860	-0.3855	1.9
n 2+ 1990	4.3670	4.8357	1.0000	-0.1020	-0.4573	2.6
n 2+ 1991	5.3700	5.3202	1.0000	0.0093	0.0418	0.0
n 2+ 1992	5.7600	6.1449	1.0000	-0.0647	-0.2901	1.1
n 2+ 1993	6.5740	7.1529	1.0000	-0.0844	-0.3786	1.8
n 2+ 1994	6.1120	5.5553	1.0000	0.0955	0.4284	2.3
SUM				-0.2524	-1.1323	63.0

MEASUREMENT ERROR -- Recruit index with lognormal errors

ERROR TERM	OBSERVED	PREDICTED	WEIGHT	RESIDUAL	STD RES	%SS
r 1 1985	1.2450	1.3519	1.0000	-0.0824	-0.3694	1.7
r 1 1986	2.8240	2.9806	1.0000	-0.0540	-0.2420	0.7
r 1 1987	7.5380	5.8369	1.0000	0.2558	1.1472	16.4
r 1 1988	2.1160	1.9800	1.0000	0.0664	0.2979	1.1
r 1 1989	4.1780	3.8665	1.0000	0.0775	0.3475	1.5
r 1 1990	4.2140	4.1431	1.0000	0.0170	0.0761	0.1
r 1 1991	5.4580	5.2666	1.0000	0.0357	0.1602	0.3
r 1 1992	6.5450	6.6392	1.0000	-0.0143	-0.0641	0.1
r 1 1993	3.1620	3.3173	1.0000	-0.0480	-0.2151	0.6
SUM				0.2537	1.1382	22.5

PROCESS ERROR -- DeLury equation with lognormal errors

ERROR TERM	PREDICTED	CALCULATED	WEIGHT	RESIDUAL	STD RES	%SS
n 2+ 1986	3.3979	3.2022	2.0000	0.1187	0.5322	3.5
n 2+ 1987	3.9074	3.8258	2.0000	0.0422	0.1894	0.4
n 2+ 1988	5.7871	6.2947	2.0000	-0.1682	-0.7543	7.1
n 2+ 1989	3.8207	3.9791	2.0000	-0.0812	-0.3644	1.7
n 2+ 1990	4.8357	4.9852	2.0000	-0.0609	-0.2731	0.9
n 2+ 1991	5.3202	5.3559	2.0000	-0.0134	-0.0600	0.0
n 2+ 1992	6.1449	6.2245	2.0000	-0.0257	-0.1154	0.2
n 2+ 1993	7.1529	7.1195	2.0000	0.0094	0.0419	0.0
n 2+ 1994	5.5553	5.4242	2.0000	0.0478	0.2142	0.6
SUM				-0.1314	-0.5894	14.5

28 residual error terms
20 parameters estimated
8 degrees of freedom

Time stamp at end of run 1994 10 19 12 2 59

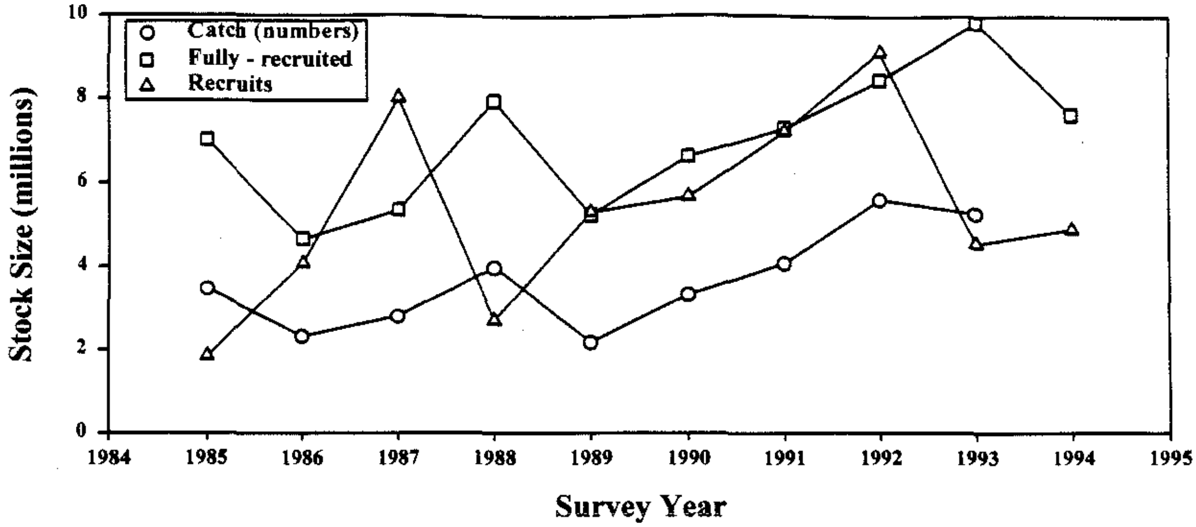


Figure A1a. Catches in numbers, fully-recruited stock sizes and recruited stock sizes as estimated from the modified DeLury model.

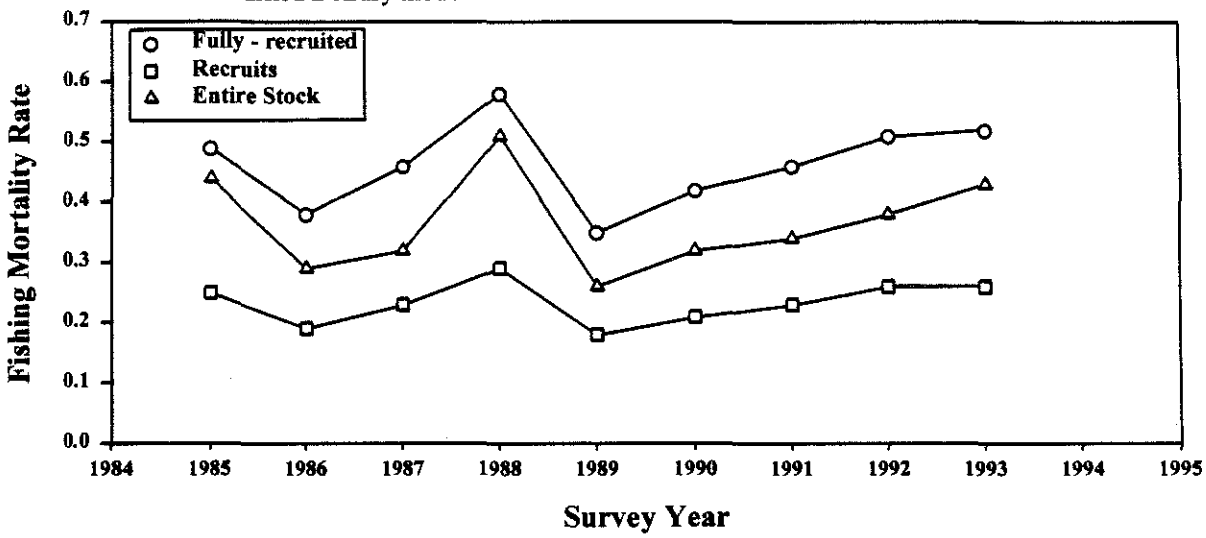


Figure A1b. Fishing mortality rates for fully-recruited, recruits, and entire stock as estimated from the modified DeLury model.

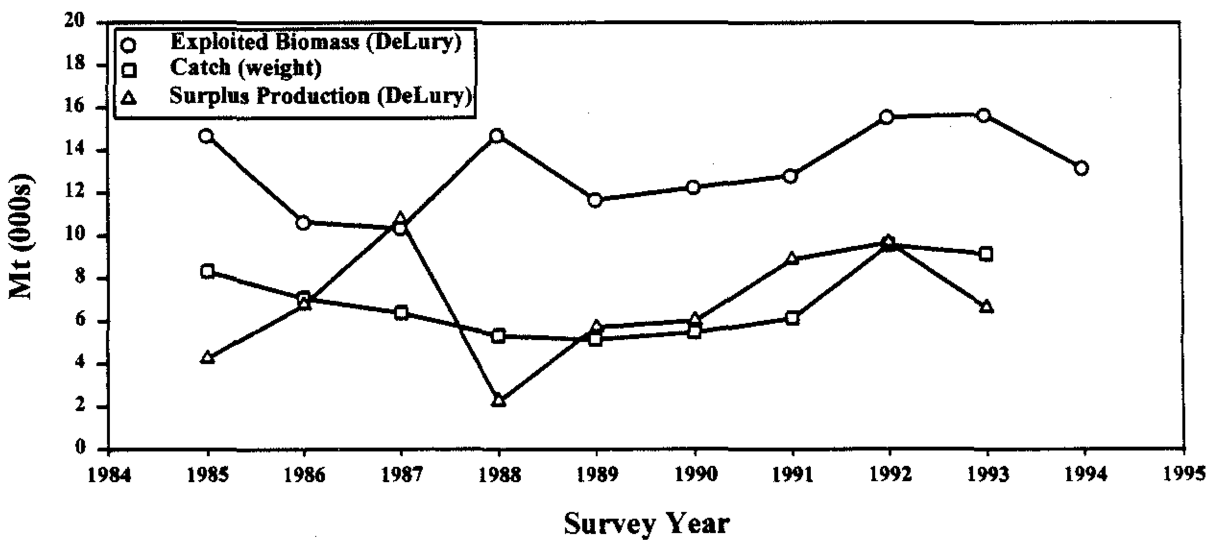


Figure A1c. Biomass estimates for exploited, catch, and surplus production as estimated from the modified DeLury model.

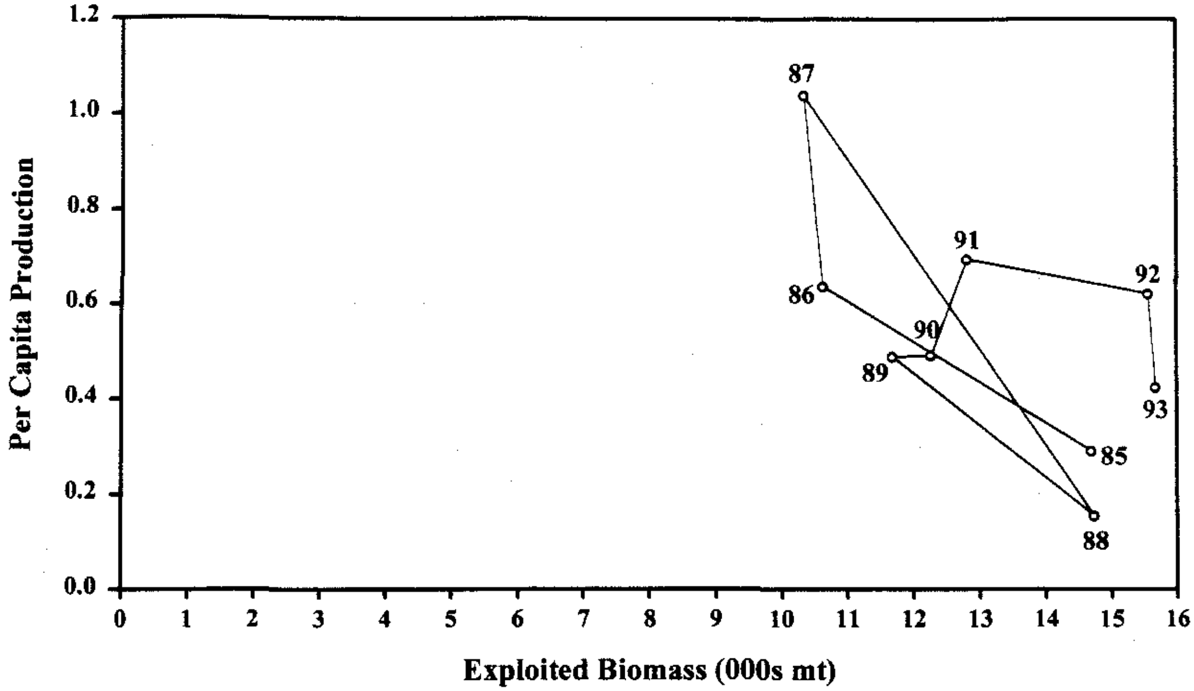


Figure A2a. Per capita production versus exploited biomass from the modified DeLury model.

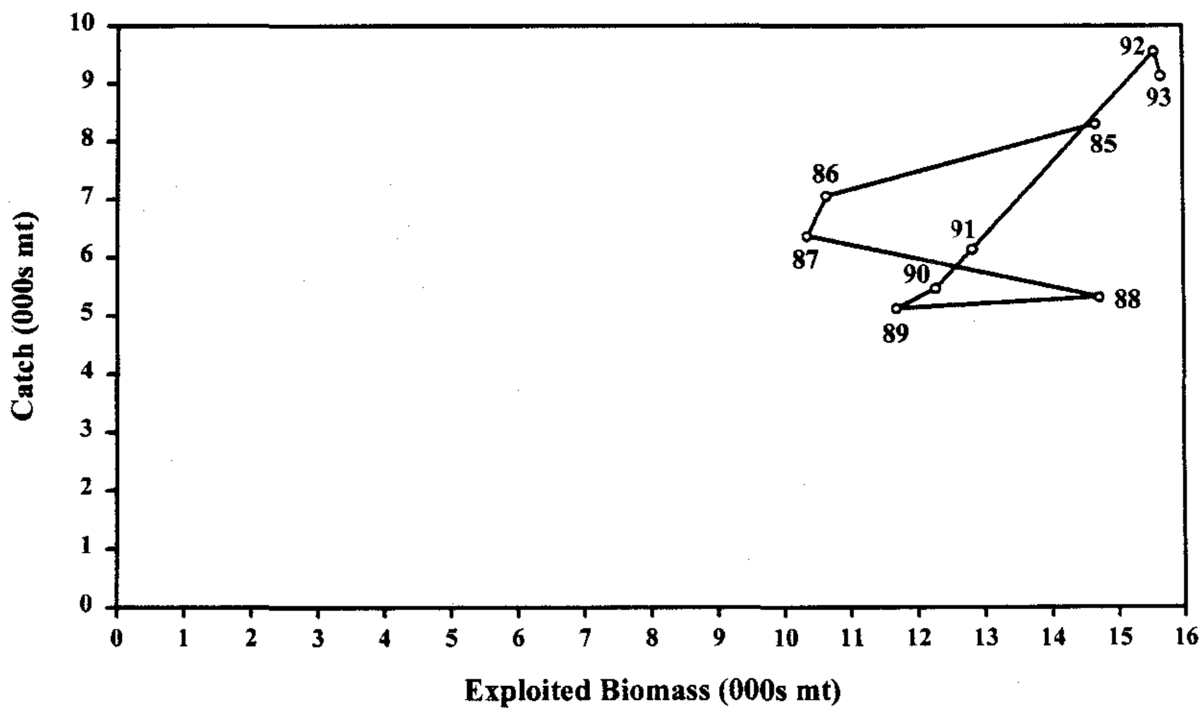


Figure A2b. Catch streams versus exploited biomass from the modified DeLury model.

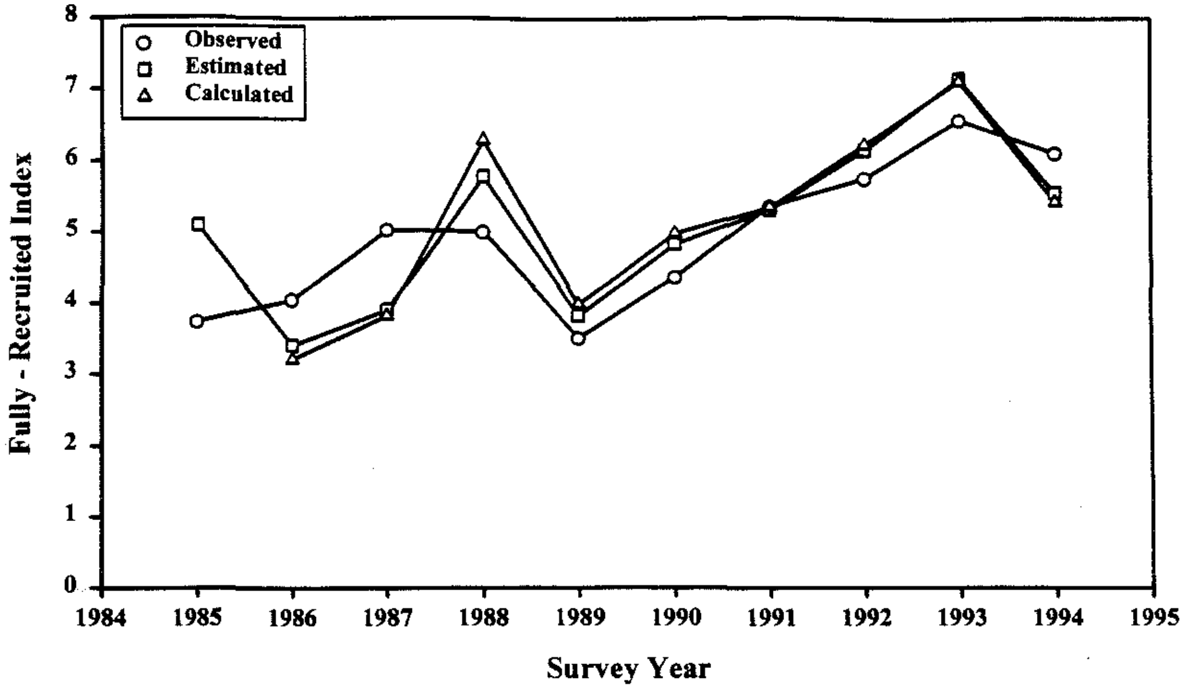


Figure A3a. Observed, estimated, and calculated indices of abundance for fully - recruited white hake from the modified DeLury model.

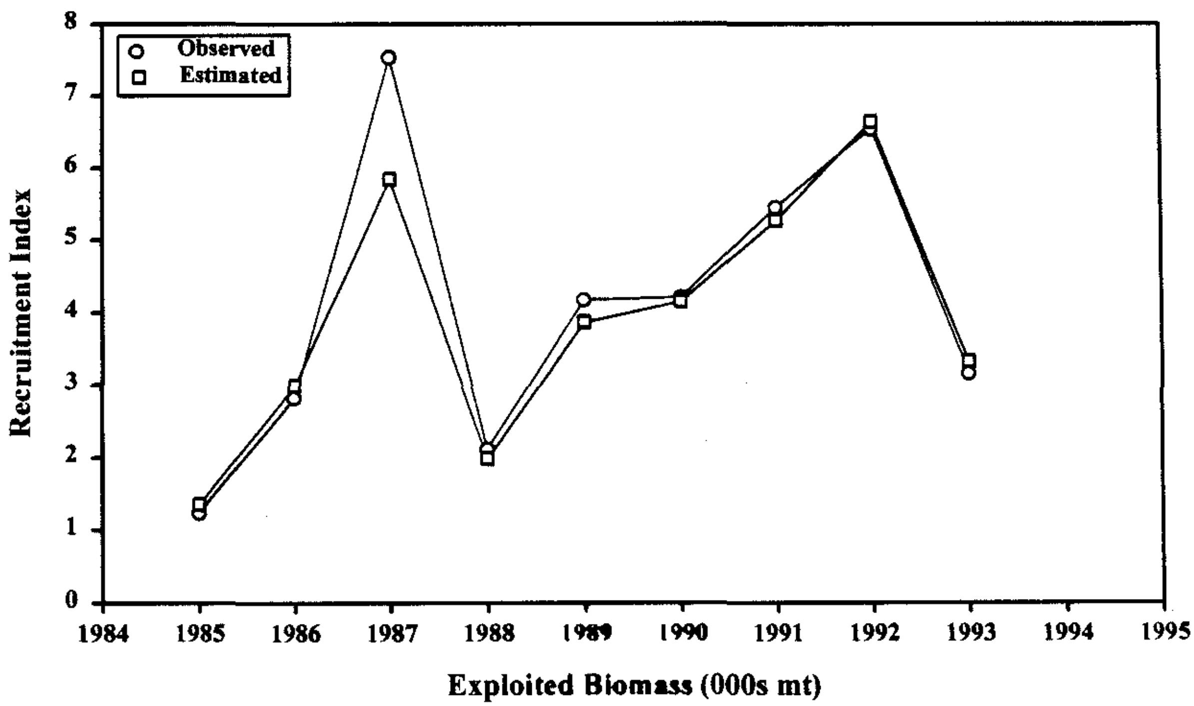


Figure A3b. Observed and estimated indices of abundance for white hake recruits from the modified DeLury model.

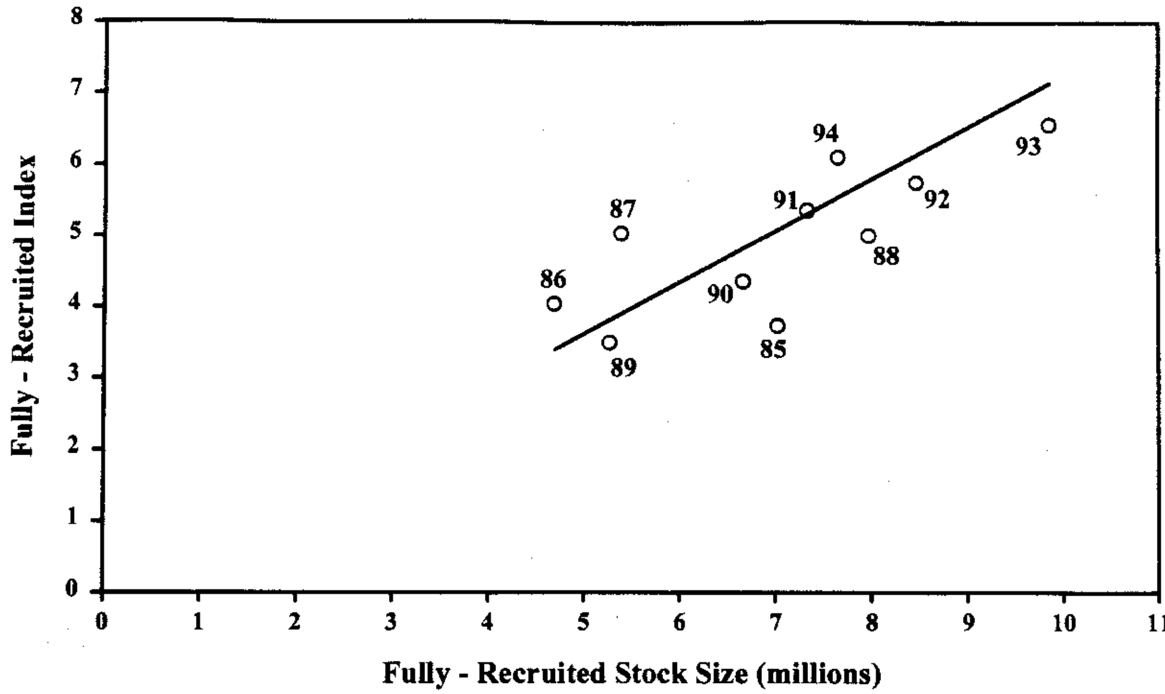


Figure A4a. The relationship between observed and estimated indices of abundance and estimated stock sizes for fully - recruited white hake from the modified DeLury model.

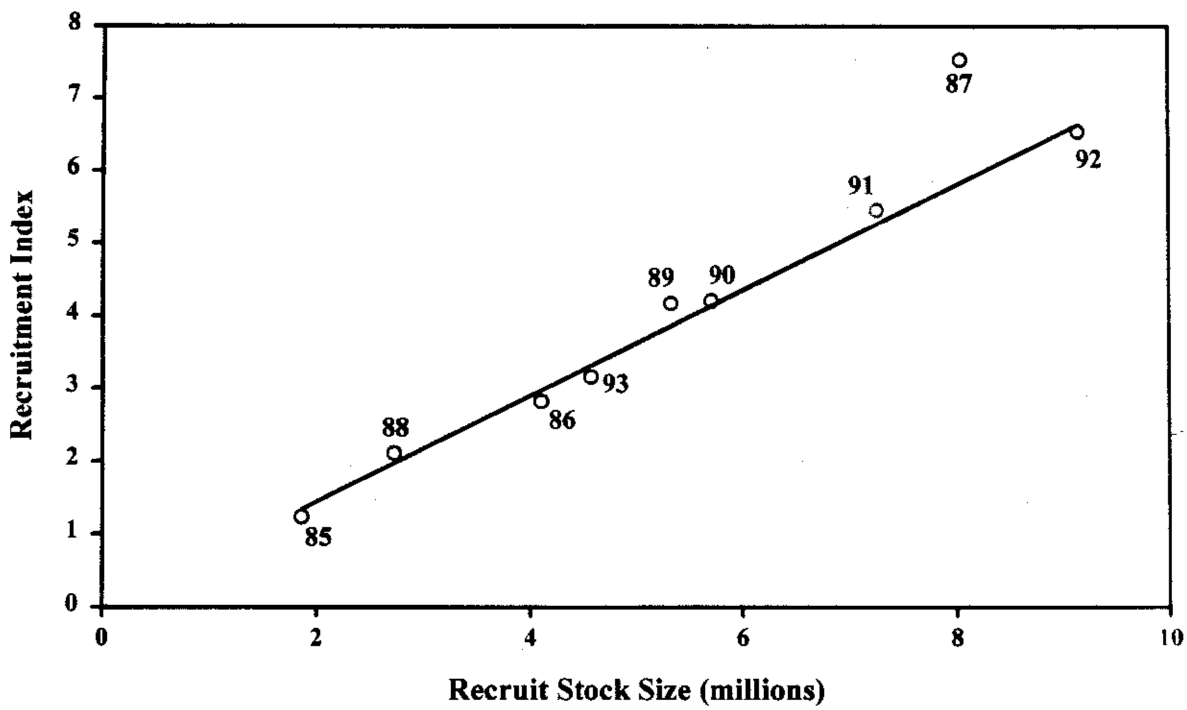


Figure A4b. The relationship between observed and estimated indices of abundance and estimated stock sizes for white hake recruits from the modified DeLury model.

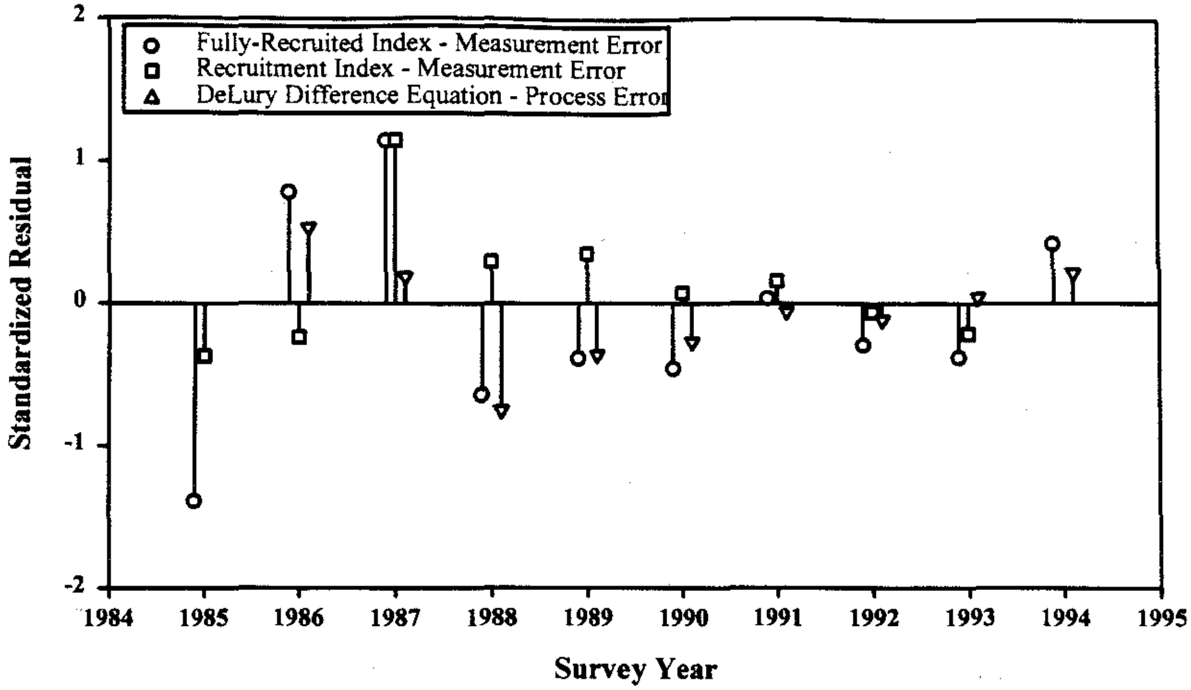


Figure A5a. Standardized residuals by year from the modified DeLury model.

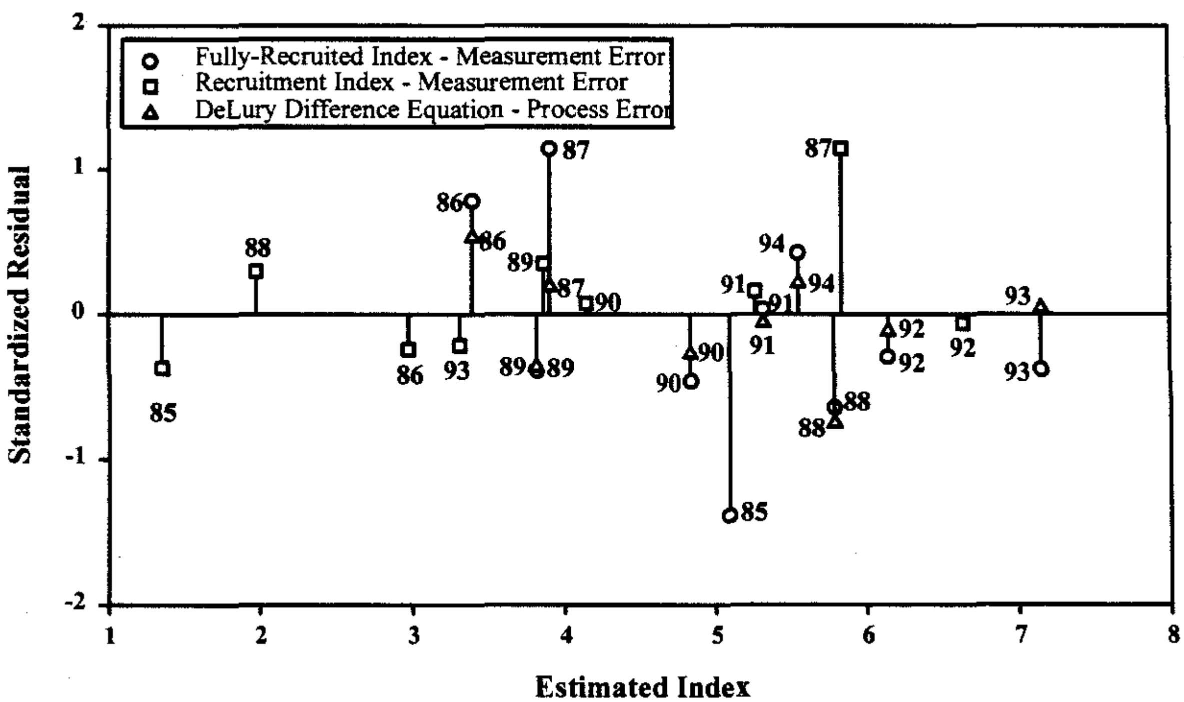


Figure A5b. Standardized residuals by index from the modified DeLury model.

Appendix B. Results of the Bootstrapped Modified DeLury.

APPENDIX B. RESULTS OF THE BOOTSTRAPPED MODIFIED DELURY
BOOTSTRAP RESULTS FOR RUN NUMBER 28 1994 10 19 12 10 7
White Hake
Gulf of Maine Stock
Using indices of abundance from the NMFS Autumn Survey
Prepared for SARC 19 -- October 1994
Sizeclass 1 = Recruits Sizeclasses 2+ = Fully-recruited hake

Definitions

Survey Year	The period between successive NEFSC Autumn research surveys e.g. the autumn survey in year t is lagged forward to Jan. of year t+1
Fully-recruited	All white hake greater than or equal to 44 cm at the beginning of the survey year (Oct 1).
Recruits	All white hake 29 to 43 cm at the beginning of the survey year whose length will be greater than or equal to 44 cm by the end of the survey year.

BOOTSTRAP TYPE : LOB
BOOTSTRAP CLASS: parametric conditional
SEED FOR THE RANDOM NUMBER GENERATOR: 74747

NUMBER OF MEASUREMENT ERROR RESIDUALS: fully-recr index 10
NUMBER OF MEASUREMENT ERROR RESIDUALS: recruit index 9
NUMBER OF PROCESS ERROR RESIDUALS: 9

MAIN LOOP LIMIT IN MARQUARDT ALGORITHM: 50
NUMBER OF BOOTSTRAP REPLICATIONS ATTEMPTED: 200
NUMBER FOR WHICH NLLS CONVERGED: 200
Results from the converged replications are used for computing the statistics that follow. Other replications are ignored.

This bootstrap run finished running at timestamp: 1994 10 19 12 8 4 550
This bootstrap run was started at timestamp: 1994 10 19 12 3 11 190

BOOTSTRAP OUTPUT VARIABLE: n_hat
Predicted indices of abundance for the fully-recruited animals for years
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994

PARAMETER	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
n 2+ 1985	5.097E0	4.867E0	6.055E-1	0.12
n 2+ 1986	3.398E0	3.513E0	4.155E-1	0.12
n 2+ 1987	3.907E0	4.103E0	3.443E-1	0.09
n 2+ 1988	5.787E0	5.750E0	4.535E-1	0.08
n 2+ 1989	3.821E0	3.864E0	4.176E-1	0.11
n 2+ 1990	4.836E0	4.872E0	4.142E-1	0.09
n 2+ 1991	5.320E0	5.450E0	4.812E-1	0.09
n 2+ 1992	6.145E0	6.256E0	5.321E-1	0.09
n 2+ 1993	7.153E0	7.347E0	5.823E-1	0.08
n 2+ 1994	5.555E0	5.928E0	6.055E-1	0.11

PARAMETER		PERCENTILES					
	MIN	10	25	MEDIAN	75	90	MAX
n 2+ 1985	3.424E0	4.056E0	4.444E0	4.902E0	5.265E0	5.649E0	6.571E0
n 2+ 1986	2.459E0	2.978E0	3.268E0	3.514E0	3.769E0	4.097E0	4.492E0
n 2+ 1987	3.013E0	3.649E0	3.859E0	4.124E0	4.353E0	4.564E0	5.017E0
n 2+ 1988	4.736E0	5.166E0	5.411E0	5.747E0	6.073E0	6.354E0	7.155E0
n 2+ 1989	2.856E0	3.340E0	3.570E0	3.878E0	4.134E0	4.404E0	5.011E0
n 2+ 1990	3.836E0	4.326E0	4.610E0	4.840E0	5.141E0	5.445E0	5.879E0
n 2+ 1991	4.124E0	4.775E0	5.156E0	5.458E0	5.794E0	6.021E0	6.742E0
n 2+ 1992	4.896E0	5.504E0	5.937E0	6.311E0	6.648E0	6.898E0	7.476E0
n 2+ 1993	5.719E0	6.585E0	6.951E0	7.359E0	7.741E0	7.996E0	8.980E0
n 2+ 1994	4.358E0	5.110E0	5.514E0	5.919E0	6.364E0	6.696E0	7.625E0

BOOTSTRAP OUTPUT VARIABLE: r_hat
Predicted indices of abundance for the recruits for years
1985 1986 1987 1988 1989 1990 1991 1992 1993

PARAMETER		NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
r 1	1985	1.352E0	1.280E0	1.429E-1	0.11
r 1	1986	2.981E0	2.861E0	3.082E-1	0.10
r 1	1987	5.837E0	5.912E0	5.028E-1	0.09
r 1	1988	1.980E0	1.951E0	2.004E-1	0.10
r 1	1989	3.867E0	3.838E0	3.956E-1	0.10
r 1	1990	4.143E0	4.063E0	4.312E-1	0.10
r 1	1991	5.267E0	5.086E0	5.667E-1	0.11
r 1	1992	6.639E0	6.364E0	7.031E-1	0.11
r 1	1993	3.317E0	3.116E0	3.670E-1	0.11

PARAMETER		MIN	PERCENTILES 10	25	MEDIAN	75	90	MAX
r 1	1985	9.371E-1	1.112E0	1.169E0	1.278E0	1.381E0	1.470E0	1.649E0
r 1	1986	2.168E0	2.487E0	2.635E0	2.859E0	3.062E0	3.228E0	3.918E0
r 1	1987	4.344E0	5.280E0	5.574E0	5.905E0	6.253E0	6.538E0	7.519E0
r 1	1988	1.473E0	1.697E0	1.815E0	1.939E0	2.085E0	2.201E0	2.560E0
r 1	1989	2.798E0	3.350E0	3.579E0	3.836E0	4.070E0	4.361E0	5.292E0
r 1	1990	3.068E0	3.554E0	3.774E0	4.019E0	4.372E0	4.628E0	5.486E0
r 1	1991	3.583E0	4.417E0	4.696E0	5.044E0	5.451E0	5.914E0	6.720E0
r 1	1992	4.774E0	5.470E0	5.854E0	6.300E0	6.808E0	7.310E0	8.233E0
r 1	1993	2.334E0	2.699E0	2.801E0	3.091E0	3.349E0	3.624E0	4.183E0

BOOTSTRAP OUTPUT VARIABLE: q_hat
Catchability of the fully-recruited animals to the survey gear

PARAMETER	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
Surv q_n	7.259E-1	6.575E-1	5.883E-2	0.08

PARAMETER	MIN	PERCENTILES 10	25	MEDIAN	75	90	MAX
Surv q_n	4.791E-1	5.811E-1	6.194E-1	6.560E-1	7.008E-1	7.337E-1	8.005E-1

BOOTSTRAP OUTPUT VARIABLE: n_calculated
Calculated indices of abundance for the fully-recruited group
(using the DeLury difference equation) for years:
1986 1987 1988 1989 1990 1991 1992 1993 1994

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1986	3.202E0	3.151E0	4.137E-1	0.13
1987	3.826E0	3.954E0	3.243E-1	0.08
1988	6.295E0	6.675E0	4.336E-1	0.07
1989	3.979E0	4.149E0	4.130E-1	0.10
1990	4.985E0	5.120E0	4.206E-1	0.08
1991	5.356E0	5.508E0	4.602E-1	0.09
1992	6.224E0	6.413E0	5.097E-1	0.08
1993	7.120E0	7.301E0	5.619E-1	0.08
1994	5.424E0	5.715E0	5.823E-1	0.11

SURVEY YEAR	MIN	PERCENTILES 10	25	MEDIAN	75	90	MAX
1986	2.094E0	2.616E0	2.881E0	3.146E0	3.437E0	3.679E0	4.065E0
1987	2.959E0	3.520E0	3.724E0	3.984E0	4.172E0	4.381E0	4.698E0
1988	5.619E0	6.166E0	6.340E0	6.685E0	7.004E0	7.190E0	7.822E0
1989	3.152E0	3.643E0	3.816E0	4.153E0	4.410E0	4.671E0	5.372E0
1990	4.199E0	4.551E0	4.854E0	5.084E0	5.395E0	5.701E0	6.350E0
1991	4.342E0	4.916E0	5.222E0	5.507E0	5.819E0	6.087E0	6.742E0
1992	4.984E0	5.702E0	6.064E0	6.446E0	6.737E0	7.029E0	7.542E0
1993	5.781E0	6.573E0	6.986E0	7.294E0	7.688E0	7.975E0	8.714E0
1994	4.121E0	4.884E0	5.346E0	5.715E0	6.123E0	6.473E0	7.368E0

BOOTSTRAP OUTPUT VARIABLE: R_0
Population size (in number) of the recruits at the beginning of survey

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	1.862E0	1.923E0	2.251E-1	0.12
1986	4.106E0	4.291E0	4.630E-1	0.11
1987	8.041E0	8.807E0	6.529E-1	0.08
1988	2.728E0	2.913E0	3.081E-1	0.11
1989	5.326E0	5.730E0	5.496E-1	0.10
1990	5.707E0	6.081E0	5.597E-1	0.10
1991	7.255E0	7.632E0	7.280E-1	0.10
1992	9.146E0	9.568E0	8.404E-1	0.09
1993	4.570E0	4.691E0	5.223E-1	0.11
1994	4.927E0	5.327E0	3.414E-1	0.07

SURVEY		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	1.418E0	1.637E0	1.754E0	1.903E0	2.082E0	2.232E0	2.563E0
1986	3.219E0	3.681E0	3.977E0	4.252E0	4.598E0	4.879E0	5.756E0
1987	7.130E0	7.965E0	8.360E0	8.800E0	9.195E0	9.630E0	1.105E1
1988	2.153E0	2.571E0	2.681E0	2.868E0	3.112E0	3.358E0	3.809E0
1989	4.451E0	5.093E0	5.312E0	5.701E0	6.055E0	6.408E0	7.758E0
1990	4.743E0	5.350E0	5.703E0	6.114E0	6.431E0	6.772E0	7.968E0
1991	5.649E0	6.809E0	7.100E0	7.547E0	8.171E0	8.634E0	9.561E0
1992	7.001E0	8.591E0	9.021E0	9.542E0	1.002E1	1.073E1	1.193E1
1993	3.433E0	4.035E0	4.334E0	4.673E0	5.009E0	5.413E0	6.122E0
1994	4.615E0	4.908E0	5.069E0	5.310E0	5.529E0	5.781E0	6.606E0

BOOTSTRAP OUTPUT VARIABLE: N_0
Popn size (in number) of the fully-recruited animals at the beginning of survey years 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	7.022E0	7.331E0	6.438E-1	0.09
1986	4.681E0	5.214E0	5.499E-1	0.12
1987	5.383E0	6.065E0	5.748E-1	0.11
1988	7.972E0	8.573E0	7.791E-1	0.10
1989	5.263E0	5.729E0	7.519E-1	0.14
1990	6.661E0	7.234E0	8.152E-1	0.12
1991	7.329E0	8.072E0	9.015E-1	0.12
1992	8.465E0	9.279E0	9.921E-1	0.12
1993	9.853E0	1.089E1	1.085E0	0.11
1994	7.653E0	8.716E0	1.104E0	0.14

SURVEY		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	5.860E0	6.494E0	6.891E0	7.371E0	7.778E0	8.134E0	8.945E0
1986	3.857E0	4.400E0	4.882E0	5.212E0	5.595E0	5.957E0	6.483E0
1987	4.604E0	5.301E0	5.665E0	6.036E0	6.456E0	6.828E0	7.772E0
1988	6.604E0	7.596E0	7.972E0	8.565E0	9.112E0	9.605E0	1.075E1
1989	4.041E0	4.743E0	5.221E0	5.702E0	6.184E0	6.692E0	8.222E0
1990	5.489E0	6.220E0	6.678E0	7.208E0	7.788E0	8.214E0	9.992E0
1991	6.070E0	6.903E0	7.491E0	8.049E0	8.658E0	9.159E0	1.111E1
1992	6.828E0	8.045E0	8.627E0	9.193E0	1.000E1	1.061E1	1.225E1
1993	8.232E0	9.445E0	1.017E1	1.081E1	1.150E1	1.229E1	1.420E1
1994	6.018E0	7.308E0	7.977E0	8.725E0	9.440E0	1.002E1	1.268E1

BOOTSTRAP OUTPUT VARIABLE: F_R
Fishing mortality rate on the recruits during survey years
1985 1986 1987 1988 1989 1990 1991 1992 1993

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	0.2462	0.1982	0.0355	0.14
1986	0.1892	0.1508	0.0297	0.16
1987	0.2292	0.2516	0.0238	0.10
1988	0.2919	0.2775	0.0397	0.14

1989	0.1760	0.1703	0.0249	0.14
1990	0.2102	0.1881	0.0313	0.15
1991	0.2289	0.2094	0.0312	0.14
1992	0.2571	0.2255	0.0329	0.13
1993	0.2577	0.2091	0.0453	0.18

SURVEY		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	0.1213	0.1563	0.1728	0.1964	0.2174	0.2499	0.3043
1986	0.0741	0.1153	0.1302	0.1498	0.1685	0.1912	0.2489
1987	0.1967	0.2203	0.2349	0.2517	0.2690	0.2838	0.3091
1988	0.1868	0.2284	0.2498	0.2741	0.3057	0.3319	0.4024
1989	0.1050	0.1386	0.1541	0.1691	0.1865	0.2063	0.2270
1990	0.1115	0.1471	0.1657	0.1868	0.2099	0.2299	0.2801
1991	0.1399	0.1714	0.1860	0.2063	0.2294	0.2518	0.2926
1992	0.1396	0.1824	0.2007	0.2235	0.2488	0.2713	0.3260
1993	0.1028	0.1547	0.1781	0.2039	0.2368	0.2738	0.3521

BOOTSTRAP OUTPUT VARIABLE: F_N
Fishing mortality rate on the fully-recruited animals during survey yrs
1985 1986 1987 1988 1989 1990 1991 1992 1993

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	0.4924	0.3965	0.0711	0.14
1986	0.3785	0.3016	0.0593	0.16
1987	0.4583	0.5032	0.0477	0.10
1988	0.5839	0.5550	0.0795	0.14
1989	0.3521	0.3406	0.0498	0.14
1990	0.4203	0.3761	0.0625	0.15
1991	0.4579	0.4188	0.0624	0.14
1992	0.5142	0.4510	0.0658	0.13
1993	0.5154	0.4182	0.0906	0.18

SURVEY		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	0.2426	0.3126	0.3457	0.3929	0.4348	0.4999	0.6086
1986	0.1482	0.2305	0.2604	0.2995	0.3371	0.3824	0.4977
1987	0.3935	0.4406	0.4698	0.5033	0.5381	0.5676	0.6181
1988	0.3736	0.4568	0.4996	0.5482	0.6115	0.6637	0.8047
1989	0.2100	0.2772	0.3082	0.3383	0.3731	0.4125	0.4541
1990	0.2230	0.2941	0.3314	0.3736	0.4199	0.4597	0.5603
1991	0.2797	0.3427	0.3721	0.4125	0.4588	0.5035	0.5853
1992	0.2793	0.3647	0.4015	0.4471	0.4975	0.5425	0.6520
1993	0.2056	0.3095	0.3562	0.4077	0.4736	0.5476	0.7042

BOOTSTRAP OUTPUT VARIABLE: F_RN
Fishing mortality rate for all animals of recruitment size and larger
i.e. recruits plus the fully-recruited group during survey years
1985 1986 1987 1988 1989 1990 1991 1992 1993

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	0.4408	0.3562	0.0604	0.14
1986	0.2901	0.2359	0.0431	0.15
1987	0.3211	0.3544	0.0329	0.10
1988	0.5095	0.4852	0.0674	0.13
1989	0.2635	0.2561	0.0358	0.14
1990	0.3234	0.2911	0.0468	0.14
1991	0.3440	0.3185	0.0449	0.13
1992	0.3807	0.3384	0.0458	0.12
1993	0.4338	0.3584	0.0729	0.17

SURVEY		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	0.2216	0.2856	0.3119	0.3496	0.3893	0.4477	0.5336
1986	0.1272	0.1751	0.2067	0.2353	0.2654	0.2920	0.3767
1987	0.2707	0.3112	0.3315	0.3553	0.3781	0.3992	0.4312
1988	0.3255	0.4010	0.4365	0.4825	0.5315	0.5771	0.6790

1989	0.1622	0.2104	0.2303	0.2538	0.2792	0.3030	0.3600
1990	0.1828	0.2322	0.2579	0.2877	0.3199	0.3558	0.4329
1991	0.2239	0.2652	0.2857	0.3176	0.3479	0.3788	0.4589
1992	0.2143	0.2836	0.3038	0.3366	0.3683	0.3993	0.4831
1993	0.1838	0.2708	0.3078	0.3510	0.4017	0.4540	0.5840

BOOTSTRAP OUTPUT VARIABLE: F_RN_bar
Average fishing mortality rate for all animals of recruitment size and larger
i.e. recruits plus the fully-recruited group during survey years
Average fishing mortality rates on the fully-recruited animals
1st Row: F in 1993
2nd Row: Average F for 1992 1993
3rd Row: Average F for 1991 1992 1993

YEAR(S)	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1993 0	0.4338	0.3584	0.0729	0.17
1992 93	0.4072	0.3484	0.0566	0.14
1991 93	0.3862	0.3384	0.0478	0.12

YEAR(S)		PERCENTILES					
	MIN	10	25	MEDIAN	75	90	MAX
1993 0	0.1838	0.2708	0.3078	0.3510	0.4017	0.4540	0.5840
1992 93	0.2161	0.2846	0.3072	0.3439	0.3863	0.4284	0.5208
1991 93	0.2258	0.2838	0.3035	0.3336	0.3686	0.4077	0.5002

BOOTSTRAP OUTPUT VARIABLE: F_N_bar
Average fishing mortality rates on the fully-recruited animals
1st Row: F in 1993
2nd Row: Average F for 1992 1993
3rd Row: Average F for 1991 1992 1993

YEAR(S)	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1993 0	0.5154	0.4182	0.0906	0.18
1992 93	0.5148	0.4346	0.0759	0.15
1991 93	0.4958	0.4293	0.0664	0.13

YEAR(S)		PERCENTILES					
	MIN	10	25	MEDIAN	75	90	MAX
1993 0	0.2056	0.3095	0.3562	0.4077	0.4736	0.5476	0.7042
1992 93	0.2583	0.3490	0.3842	0.4290	0.4835	0.5451	0.6781
1991 93	0.2768	0.3531	0.3835	0.4211	0.4713	0.5287	0.6472

BOOTSTRAP OUTPUT VARIABLE: B_R_0
Population biomass of the recruits at the beginning of survey
years 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	8.464E-1	8.738E-1	1.023E-1	0.12
1986	1.536E0	1.605E0	1.731E-1	0.11
1987	3.693E0	4.045E0	2.999E-1	0.08
1988	1.157E0	1.236E0	1.307E-1	0.11
1989	2.296E0	2.470E0	2.369E-1	0.10
1990	2.454E0	2.614E0	2.406E-1	0.10
1991	2.891E0	3.041E0	2.901E-1	0.10
1992	3.888E0	4.067E0	3.573E-1	0.09
1993	1.954E0	2.006E0	2.233E-1	0.11
1994	1.991E0	2.153E0	1.380E-1	0.07

SURVEY ------------- PERCENTILES -------------------

YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	6.446E-1	7.441E-1	7.974E-1	8.649E-1	9.462E-1	1.014E0	1.165E0
1986	1.204E0	1.377E0	1.487E0	1.590E0	1.720E0	1.825E0	2.153E0
1987	3.275E0	3.658E0	3.840E0	4.042E0	4.223E0	4.423E0	5.074E0
1988	9.136E-1	1.091E0	1.138E0	1.217E0	1.321E0	1.425E0	1.616E0
1989	1.918E0	2.195E0	2.289E0	2.457E0	2.610E0	2.762E0	3.344E0
1990	2.039E0	2.300E0	2.452E0	2.629E0	2.765E0	2.911E0	3.426E0
1991	2.251E0	2.713E0	2.829E0	3.007E0	3.256E0	3.441E0	3.810E0
1992	2.976E0	3.652E0	3.835E0	4.056E0	4.261E0	4.560E0	5.073E0
1993	1.468E0	1.725E0	1.853E0	1.998E0	2.141E0	2.314E0	2.617E0
1994	1.865E0	1.983E0	2.048E0	2.146E0	2.234E0	2.336E0	2.669E0

BOOTSTRAP OUTPUT VARIABLE: B_N_0
Population biomass of the fully-recruited animals at the beginning of survey years 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	1.427E1	1.490E1	1.309E0	0.09
1986	9.872E0	1.100E1	1.160E0	0.12
1987	8.500E0	9.578E0	9.077E-1	0.11
1988	1.415E1	1.522E1	1.383E0	0.10
1989	1.054E1	1.147E1	1.506E0	0.14
1990	1.104E1	1.199E1	1.351E0	0.12
1991	1.138E1	1.253E1	1.400E0	0.12
1992	1.363E1	1.494E1	1.597E0	0.12
1993	1.470E1	1.624E1	1.618E0	0.11
1994	1.218E1	1.388E1	1.757E0	0.14

SURVEY		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	1.191E1	1.320E1	1.401E1	1.498E1	1.581E1	1.653E1	1.818E1
1986	8.134E0	9.281E0	1.030E1	1.099E1	1.180E1	1.256E1	1.367E1
1987	7.271E0	8.372E0	8.947E0	9.533E0	1.019E1	1.078E1	1.227E1
1988	1.172E1	1.349E1	1.415E1	1.521E1	1.618E1	1.705E1	1.909E1
1989	8.092E0	9.498E0	1.045E1	1.142E1	1.238E1	1.340E1	1.646E1
1990	9.100E0	1.031E1	1.107E1	1.195E1	1.291E1	1.362E1	1.656E1
1991	9.425E0	1.072E1	1.163E1	1.250E1	1.344E1	1.422E1	1.725E1
1992	1.099E1	1.295E1	1.389E1	1.480E1	1.610E1	1.708E1	1.973E1
1993	1.228E1	1.409E1	1.518E1	1.613E1	1.715E1	1.834E1	2.119E1
1994	9.580E0	1.163E1	1.270E1	1.389E1	1.503E1	1.595E1	2.019E1

BOOTSTRAP OUTPUT VARIABLE: B_RN_0_expl
Exploited biomass at the beginning of survey years
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	1.469E1	1.534E1	1.303E0	0.09
1986	1.064E1	1.180E1	1.153E0	0.11
1987	1.035E1	1.160E1	9.444E-1	0.09
1988	1.473E1	1.584E1	1.403E0	0.10
1989	1.169E1	1.271E1	1.536E0	0.13
1990	1.227E1	1.330E1	1.386E0	0.11
1991	1.282E1	1.405E1	1.423E0	0.11
1992	1.557E1	1.697E1	1.616E0	0.10
1993	1.568E1	1.725E1	1.649E0	0.11
1994	1.318E1	1.495E1	1.813E0	0.14

SURVEY		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	1.230E1	1.361E1	1.448E1	1.539E1	1.625E1	1.700E1	1.859E1
1986	8.974E0	1.011E1	1.111E1	1.181E1	1.256E1	1.332E1	1.450E1
1987	9.262E0	1.037E1	1.100E1	1.158E1	1.226E1	1.273E1	1.453E1

1988	1.233E1	1.407E1	1.473E1	1.582E1	1.678E1	1.769E1	1.982E1
1989	9.355E0	1.074E1	1.166E1	1.265E1	1.361E1	1.466E1	1.782E1
1990	1.054E1	1.157E1	1.232E1	1.325E1	1.425E1	1.501E1	1.806E1
1991	1.081E1	1.221E1	1.306E1	1.400E1	1.496E1	1.576E1	1.884E1
1992	1.288E1	1.501E1	1.593E1	1.678E1	1.804E1	1.911E1	2.214E1
1993	1.330E1	1.503E1	1.616E1	1.714E1	1.824E1	1.933E1	2.250E1
1994	1.051E1	1.263E1	1.370E1	1.496E1	1.614E1	1.709E1	2.146E1

BOOTSTRAP OUTPUT VARIABLE: P
Surplus production (from expl biomass & catch vectors)

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	4.251E0	4.768E0	5.278E-1	0.12
1986	6.772E0	6.865E0	8.121E-1	0.12
1987	1.076E1	1.061E1	8.903E-1	0.08
1988	2.267E0	2.180E0	5.356E-1	0.24
1989	5.710E0	5.719E0	8.046E-1	0.14
1990	6.023E0	6.224E0	6.814E-1	0.11
1991	8.900E0	9.070E0	8.961E-1	0.10
1992	9.667E0	9.835E0	1.016E0	0.11
1993	6.635E0	6.841E0	6.914E-1	0.10

SURVEY		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	3.55E0	4.09E0	4.40E0	4.77E0	5.08E0	5.48E0	6.19E0
1986	4.80E0	5.80E0	6.37E0	6.80E0	7.39E0	7.86E0	9.76E0
1987	8.46E0	9.51E0	9.99E0	1.06E1	1.12E1	1.18E1	1.39E1
1988	1.13E0	1.50E0	1.78E0	2.16E0	2.51E0	2.92E0	3.63E0
1989	3.42E0	4.59E0	5.21E0	5.72E0	6.24E0	6.67E0	8.44E0
1990	4.84E0	5.37E0	5.70E0	6.15E0	6.71E0	7.12E0	8.81E0
1991	6.72E0	7.97E0	8.43E0	9.02E0	9.73E0	1.03E1	1.12E1
1992	7.22E0	8.69E0	9.15E0	9.82E0	1.05E1	1.12E1	1.26E1
1993	5.31E0	5.97E0	6.38E0	6.75E0	7.26E0	7.89E0	8.76E0

BOOTSTRAP OUTPUT VARIABLE: PB_ratio
Per capita production (from P & expl biomass vectors)

SURVEY YEAR	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1985	2.893E-1	3.089E-1	5.489E-2	0.19
1986	6.364E-1	5.511E-1	1.622E-1	0.25
1987	1.040E0	8.688E-1	1.462E-1	0.14
1988	1.539E-1	1.334E-1	4.252E-2	0.28
1989	4.886E-1	4.268E-1	1.325E-1	0.27
1990	4.908E-1	4.547E-1	9.782E-2	0.20
1991	6.940E-1	6.228E-1	1.294E-1	0.19
1992	6.209E-1	5.601E-1	1.227E-1	0.20
1993	4.232E-1	3.849E-1	7.189E-2	0.17

SURVEY		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	1.98E-1	2.42E-1	2.68E-1	3.05E-1	3.39E-1	3.86E-1	4.55E-1
1986	2.24E-1	3.62E-1	4.47E-1	5.35E-1	6.31E-1	7.73E-1	1.18E0
1987	5.14E-1	6.84E-1	7.68E-1	8.68E-1	9.62E-1	1.04E0	1.36E0
1988	4.66E-2	7.92E-2	1.04E-1	1.30E-1	1.58E-1	1.93E-1	2.57E-1
1989	1.21E-1	2.54E-1	3.38E-1	4.16E-1	5.06E-1	6.08E-1	8.67E-1
1990	2.46E-1	3.41E-1	3.84E-1	4.47E-1	5.07E-1	5.91E-1	8.09E-1
1991	3.23E-1	4.74E-1	5.23E-1	6.13E-1	6.92E-1	7.99E-1	9.90E-1
1992	2.90E-1	4.21E-1	4.67E-1	5.41E-1	6.43E-1	7.34E-1	8.89E-1
1993	2.31E-1	2.98E-1	3.31E-1	3.79E-1	4.35E-1	4.75E-1	6.58E-1

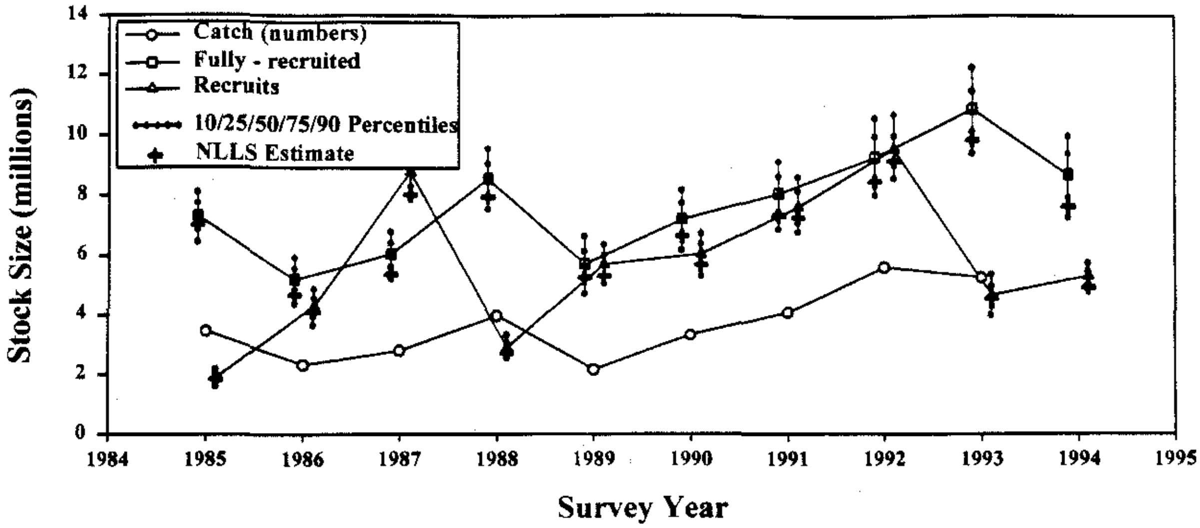


Figure B1a. Catches in numbers, bootstrapped fully-recruited stock sizes and bootstrapped recruited stock sizes as estimated from the modified DeLury model. The NLLS estimate and percentiles are also shown.

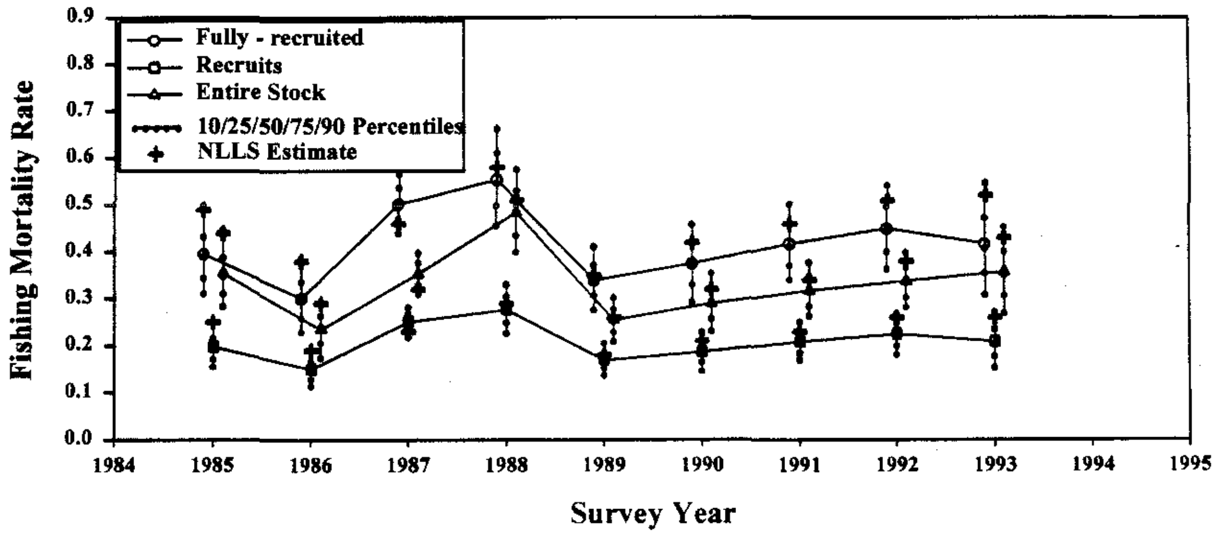


Figure B1b. Bootstrapped fishing mortality rates for fully-recruited, recruits, and entire stock as estimated from the modified DeLury model.

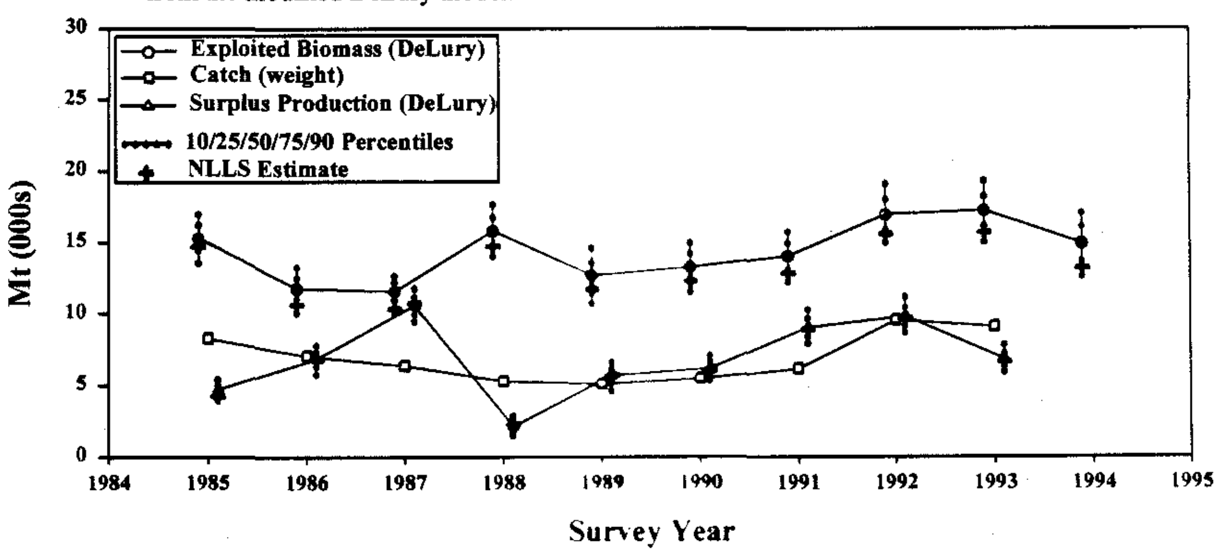


Figure B1c. Bootstrapped biomass estimates for exploited, catch, and surplus production as estimated from the modified DeLury model.

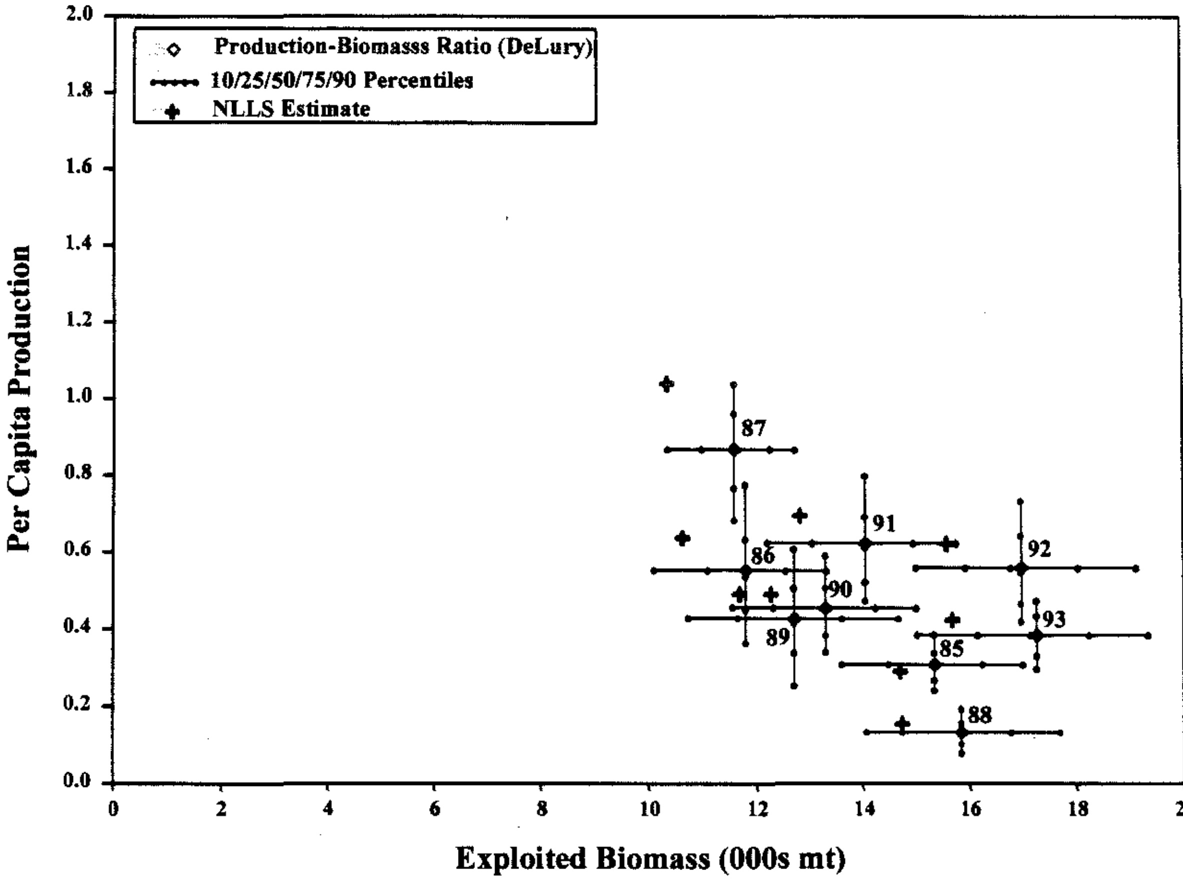


Figure B2. Bootstrapped per capita production as estimated from the modified DeLury model. The NLLS estimate and percentiles are also shown.

Appendix C. Statistical Framework for the Shepherd Stock-Production Model.

APPENDIX C. STATISTICAL FRAMEWORK FOR THE SHEPHERD STOCK-PRODUCTION MODEL
See Conser et al. (1992)
Run Number 35 1994 10 19 12 25 18
Model MP_q

INPUT PARAMETERS AND OPTIONS SELECTED

Data used in fitting the model:

YEAR	INDEX OF EXPLOITED BIOMASS (beginning of year)	CATCH (1000 mt)
1985	7890.10	8.304
1986	9071.90	7.065
1987	9699.70	6.371
1988	9354.40	5.312
1989	7921.10	5.127
1990	8145.60	5.469
1991	9425.00	6.154
1992	10663.80	9.561
1993	10483.40	9.135

Indices of abundance are from the NEFSC Autumn survey. They are assumed to be proportional to stock numbers on October 1st. The survey catches are classified into recruits and fully-recruited based on the definitons given at the beginning of this output.

Annual biomass index was then obtained from
I(r)*prbar*wbar(r) + I(n)*wbar(n)
where I(r) is the survey index of abundance (in number) for recruits
I(n) is the survey index of abundance (in number) for fully-recruited
prbar is the average partial recruitment (of recruits)
(prbar = 0.5 for all years here)
wbar(r) is the mean wt of recruitsat the beginning of the survey yr
wbar(n) is the mean wt of fully recr'ed at the beginning of the survey yr

Survey Year 1994 is not used since SY1994 landings are not yet available.

The landings (in 1000 MT) for Survey Years 1985-93 were taken from the SARC19 DeLury run.

The natural mortality parameter (M) is fixed at 0.2

The stock resilience parameter (alpha_prime) is fixed at 7

The index of virgin biomass (b_max) is fixed at 50000

Measurement error in biomass indices is assumed to be lognormally distributed.
Process error is assumed to follow a lognormal distribution.

Initial estimates of parameters for the Marquardt algorithm and lower and upper bounds on the parameter estimates:

	Parameter	Initial Est	Lower Bnd	Upper Bnd
1	b 1985	7.8901000E3	1.0000000E-10	1.0000000E8
2	b 1986	9.0719000E3	1.0000000E-10	1.0000000E8
3	b 1987	9.6997000E3	1.0000000E-10	1.0000000E8
4	b 1988	9.3544000E3	1.0000000E-10	1.0000000E8
5	b 1989	7.9211000E3	1.0000000E-10	1.0000000E8
6	b 1990	8.1456000E3	1.0000000E-10	1.0000000E8
7	b 1991	9.4250000E3	1.0000000E-10	1.0000000E8
8	b 1992	1.0663800E4	1.0000000E-10	1.0000000E8
9	b 1993	1.0483400E4	1.0000000E-10	1.0000000E8
10	q	1.0000000E0	1.0000000E-10	1.0000000E8

BEGIN MARQUARDT ALGORITHM

```
------------------------

LAMBDA        1.00000E-2
RSS           5.95498E-1
NPHI          5.95498E-1

par
  7.89010E3     9.07190E3     9.69970E3     9.35440E3     7.92110E3     8.
     14560E3     9.42500E3     1.06638E4     1.04834E4     1.00000E0


LAMBDA        1.00000E-3
RSS           9.92751E-2
NPHI          9.92751E-2

par
  8.42260E3     8.43067E3     8.92910E3     8.96195E3     8.65281E3     8.
     83695E3     9.66119E3     1.06280E4     9.98303E3     7.64334E2


LAMBDA        1.00000E-4
RSS           4.44235E-2
NPHI          4.44235E-2

par
  8.73449E3     8.62900E3     8.79909E3     8.60972E3     8.39154E3     8.
     82099E3     9.82957E3     1.09293E4     1.00339E4     6.47627E2


LAMBDA        1.00000E-5
RSS           4.42770E-2
NPHI          4.42770E-2

par
  8.72483E3     8.60013E3     8.79857E3     8.64305E3     8.42308E3     8.
     83485E3     9.82616E3     1.09152E4     9.97868E3     6.42347E2


LAMBDA        1.00000E-5
RSS           4.42770E-2
NPHI          4.42770E-2

par
  8.72175E3     8.59955E3     8.80020E3     8.64613E3     8.42519E3     8.
     83541E3     9.82560E3     1.09140E4     9.97954E3     6.42086E2
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN 0.00001


RESULTS
-------
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

SUM OF SQUARES ..............          0.044277
ORTHOGONALITY OFFSET.........          0.003254
MEAN SQUARE RESIDUALS .......          0.006325
```

	PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
1	b 1985	8.72175E3	7.77862E2	1.12125E1	0.09
2	b 1986	8.59955E3	6.64950E2	1.29326E1	0.08
3	b 1987	8.80020E3	6.67610E2	1.31816E1	0.08
4	b 1988	8.64613E3	6.61370E2	1.30731E1	0.08
5	b 1989	8.42519E3	6.38859E2	1.31879E1	0.08
6	b 1990	8.83541E3	6.66879E2	1.32489E1	0.08
7	b 1991	9.82560E3	7.38284E2	1.33087E1	0.08
8	b 1992	1.09140E4	8.06890E2	1.35260E1	0.07
9	b 1993	9.97954E3	9.64514E2	1.03467E1	0.10
10	q	6.42086E2	6.26285E1	1.02523E1	0.10

CORRELATION BETWEEN PARAMETERS ESTIMATED

■	1	2	3	4	5	6	7	8	9	10
1 ■	1.00	0.48	0.19	0.06	0.02	0.01	0.01	0.01	-0.14	0.43
2 ■	0.48	1.00	0.42	0.16	0.06	0.03	0.01	0.01	-0.05	0.17
3 ■	0.19	0.42	1.00	0.40	0.16	0.06	0.02	0.01	0.00	0.02
4 ■	0.06	0.16	0.40	1.00	0.39	0.15	0.05	0.02	0.02	-0.04
5 ■	0.02	0.06	0.16	0.39	1.00	0.38	0.14	0.05	0.03	-0.01
6 ■	0.01	0.03	0.06	0.15	0.38	1.00	0.38	0.14	0.06	0.01
7 ■	0.01	0.01	0.02	0.05	0.14	0.38	1.00	0.38	0.17	0.02
8 ■	0.01	0.01	0.01	0.02	0.05	0.14	0.38	1.00	0.46	0.01
9 ■	-0.14	-0.05	0.00	0.02	0.03	0.06	0.17	0.46	1.00	-0.32
10 ■	0.43	0.17	0.02	-0.04	-0.01	0.01	0.02	0.01	-0.32	1.00

CORRELATION BETWEEN PARAMETERS ESTIMATED (SYMBOLIC FORM)

```
 1 b 1985    * + . . . . . . . +
 2 b 1986    + * + . . . . . . .
 3 b 1987    . + * + . . . . . .
 4 b 1988    . . + * . . . . . .
 5 b 1989    . . . . * . . . . .
 6 b 1990    . . . . . * . . . .
 7 b 1991    . . . . . . * . . .
 8 b 1992    . . . . . . . * + .
 9 b 1993    . . . . . . . + * .
10 q         + . . . . . . . . *
```

SYMBOLS:				
	=	LARGE NEGATIVE CORRELATION	whenever	-1 <= r < -L
	-	MODERATE NEGATIVE CORRELATION	whenever	-L <= r < -M
	.	SMALL CORRELATION	whenever	-M <= r <= +M
	+	MODERATE POSITIVE CORRELATION	whenever	+M < r <= +L
	*	LARGE POSITIVE CORRELATION	whenever	+L < r <= +1

Where r is the estimated correlation, M is 0.4 and L is 0.8

MEASUREMENT ERROR -- Biomass index with lognormal errors

ERROR TERM	OBSERVED	PREDICTED	WEIGHT	RESIDUAL	STD RES	%SS
b 1985	7890.1	8721.8	0.7071	-0.0709	-0.8910	11.3
b 1986	9071.9	8599.5	0.7071	0.0378	0.4754	3.2
b 1987	9699.7	8800.2	0.7071	0.0688	0.8653	10.7
b 1988	9354.4	8646.1	0.7071	0.0557	0.7000	7.0
b 1989	7921.1	8425.2	0.7071	-0.0436	-0.5485	4.3
b 1990	8145.6	8835.4	0.7071	-0.0575	-0.7227	7.5
b 1991	9425.0	9825.6	0.7071	-0.0294	-0.3701	2.0
b 1992	10663.8	10914.0	0.7071	-0.0164	-0.2062	0.6
b 1993	10483.4	9979.5	0.7071	0.0348	0.4379	2.7
SUM				-0.0207	-0.2598	49.3

PROCESS ERROR -- Stock-production equation with lognormal errors

ERROR TERM	PREDICTED	CALCULATED	WEIGHT	RESIDUAL	STD RES	%SS
b 1986	8599.5	7928.5	0.7071	0.0574	0.7223	7.5
b 1987	8800.2	8586.3	0.7071	0.0174	0.2187	0.7
b 1988	8646.1	9257.7	0.7071	-0.0483	-0.6077	5.3
b 1989	8425.2	9764.5	0.7071	-0.1043	-1.3116	24.6
b 1990	8835.4	9633.1	0.7071	-0.0611	-0.7686	8.4
b 1991	9825.6	9876.3	0.7071	-0.0036	-0.0458	0.0
b 1992	10914.0	10526.8	0.7071	0.0255	0.3211	1.5
b 1993	9979.5	9499.9	0.7071	0.0348	0.4380	2.7
SUM				-0.0822	-1.0335	50.7

17 residual error terms
10 parameters estimated
7 degrees of freedom

YEAR	CATCH	BIOMASS	DELTA B	-- "observed" --		--- estimated --	
	(wt)			PROD	P/B	PROD	P/B
1985	8.304	13.583	-0.190	8.114	0.5973	7.069	0.5204
1986	7.065	13.393	0.312	7.377	0.5508	7.044	0.5260
1987	6.371	13.706	-0.240	6.131	0.4473	7.084	0.5168
1988	5.312	13.466	-0.344	4.968	0.3689	7.054	0.5238
1989	5.127	13.122	0.639	5.766	0.4394	7.008	0.5341

1990	5.469	13.760	1.542	7.011	0.5095	7.090	0.5153
1991	6.154	15.303	1.695	7.849	0.5129	7.246	0.4735
1992	9.561	16.998	-1.455	8.106	0.4769	7.359	0.4329
1993	9.135	15.542				7.265	0.4675

SUMMARY

```
Model used:  MP_q
q_hat       =   642.086
alpha_prime =     7.000
b_max       =   50000.000

B_max  =    77.871
B_msy  =    20.340
K      =    11.124

MSY    =     7.438
P(K)   =     6.675
```

Time stamp at end of run 1994 10 19 12 25 23

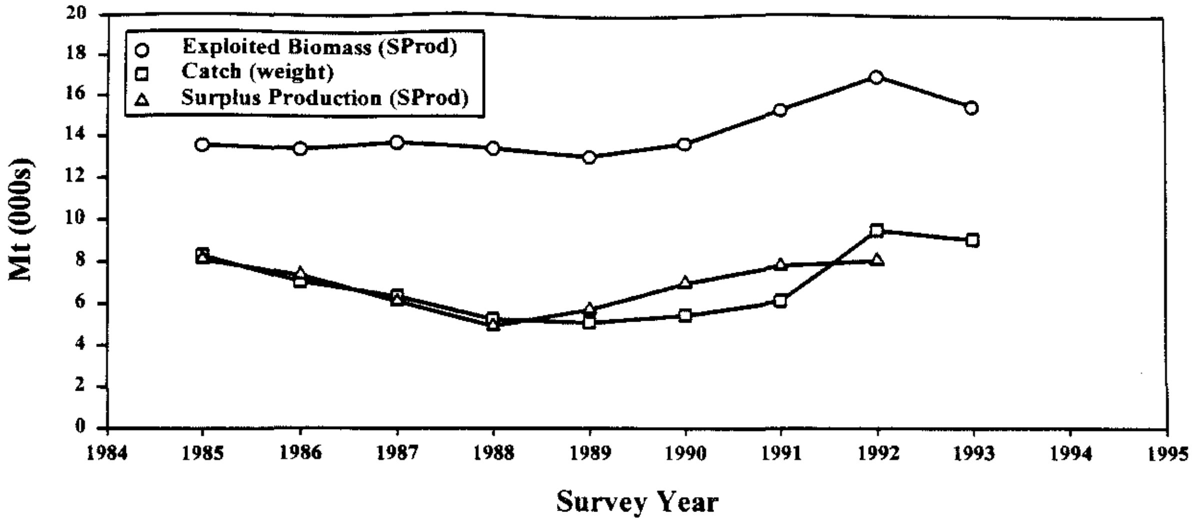


Figure C1. Biomass estimates for exploited white hake and for surplus production estimated from the surplus production model.

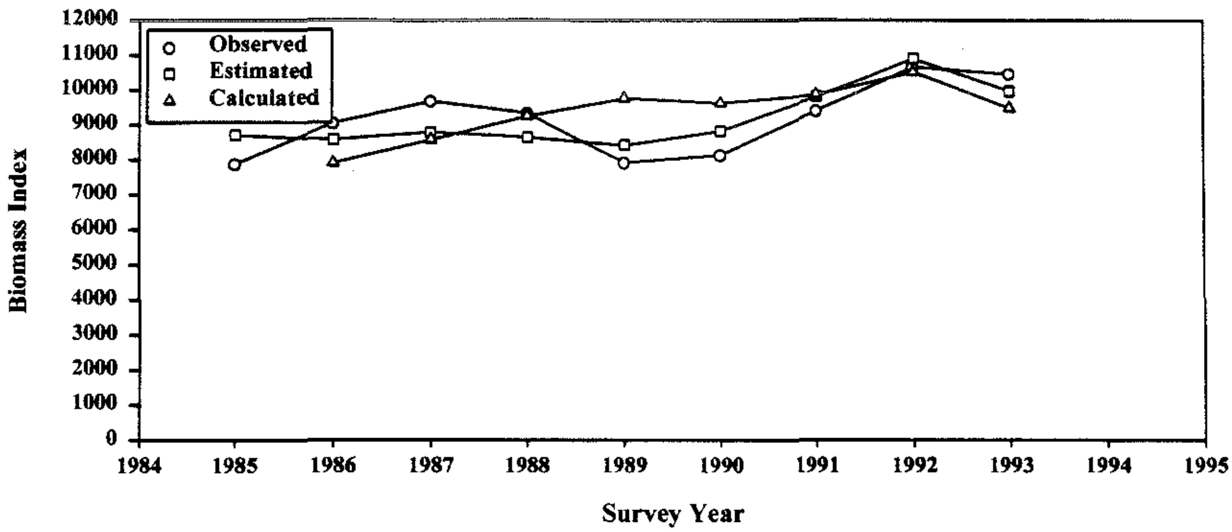


Figure C2. Observed, estimated, and calculated indices of biomass for white hake estimated from the surplus production model.

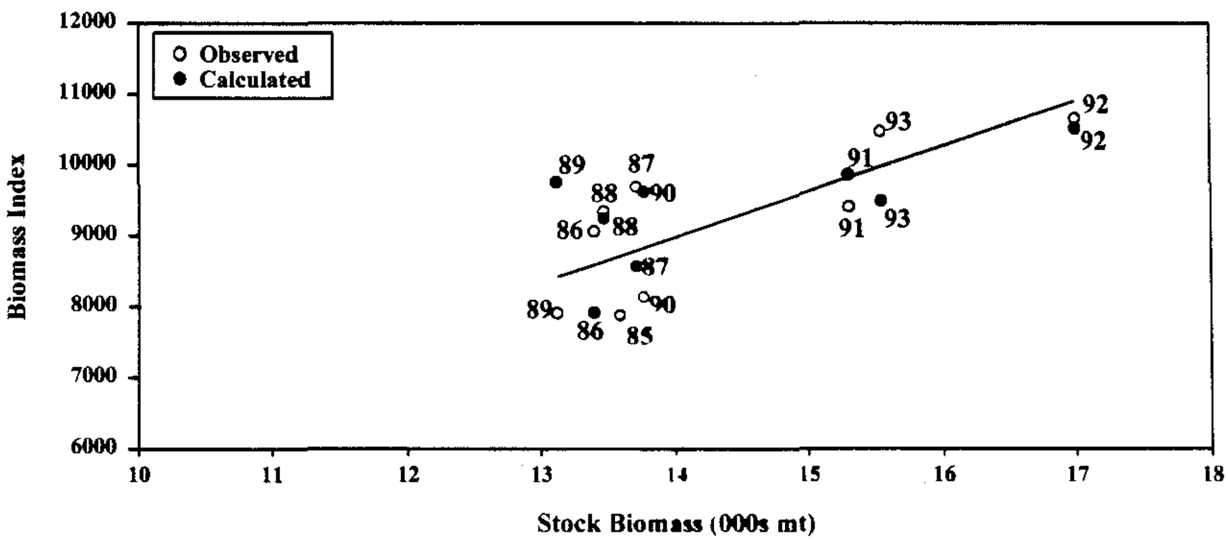


Figure C3. The relationship between observed and estimated indices of biomass and estimated stock biomass for white hake estimated from the surplus production model.

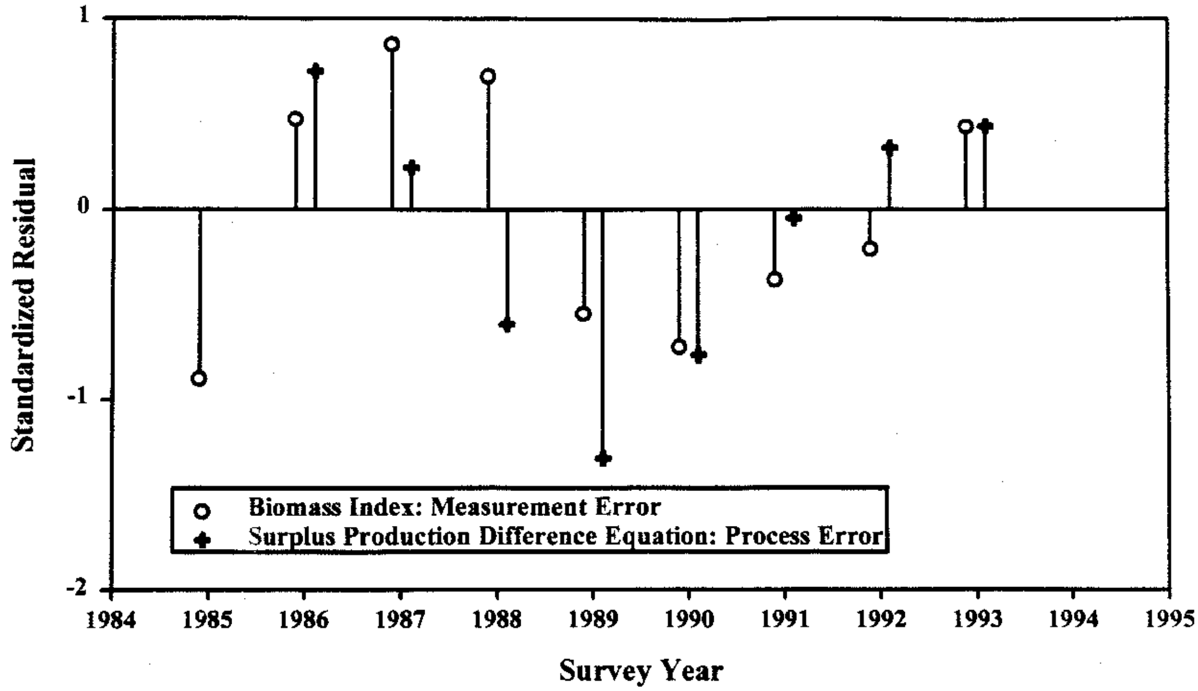


Figure C4a. Standardized residuals by year from the surplus production model.

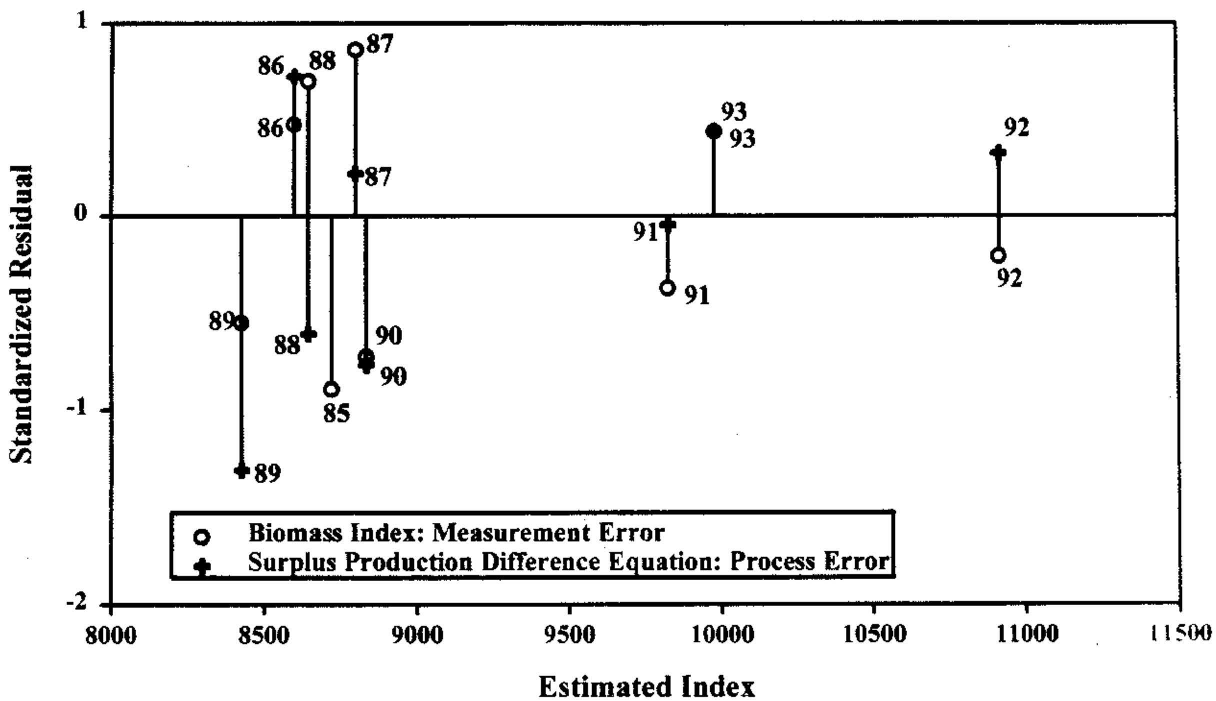


Figure C4b. Standardized residuals by index from the surplus production model.

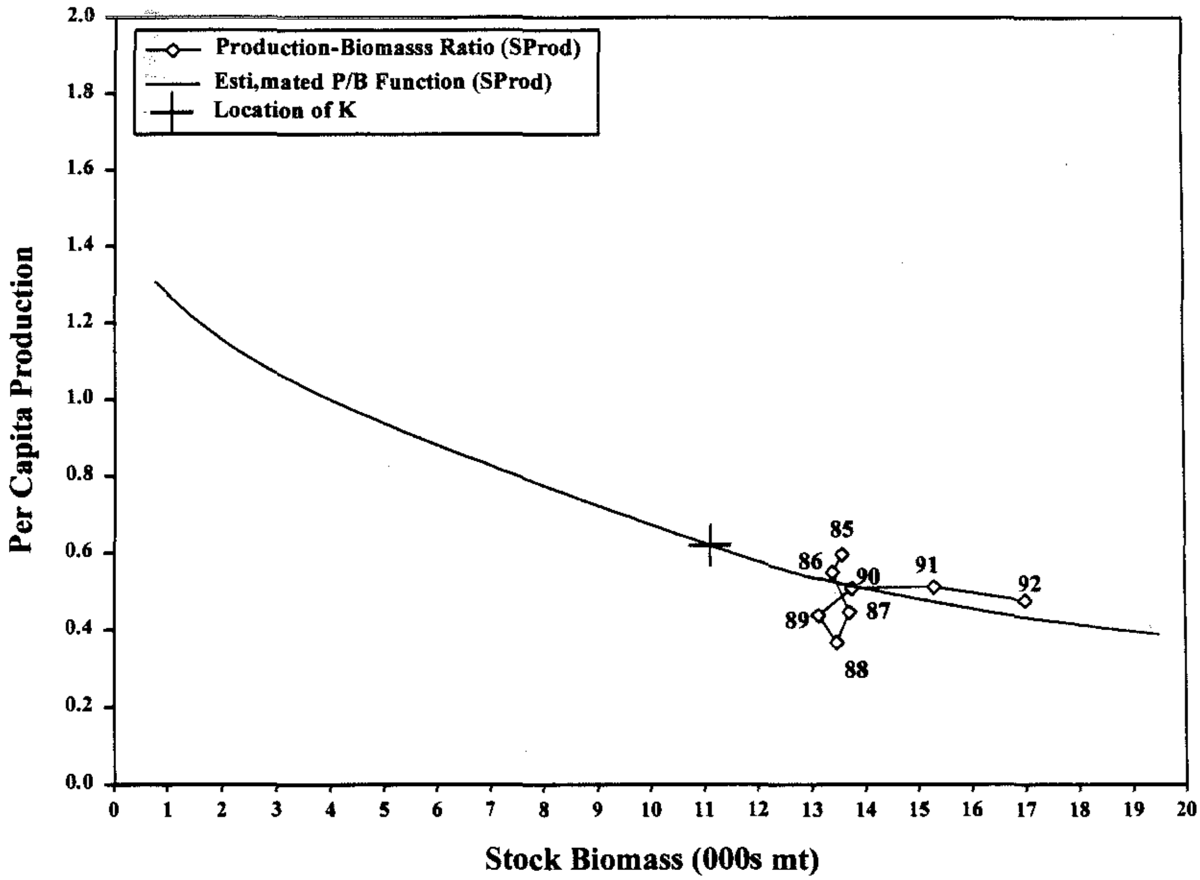


Figure C5. Per capita production versus stock biomass from the surplus production model.

Appendix D. Results of the Bootstrapped Surplus Production Model.

APPENDIX D. RESULTS OF THE BOOTSTRAPPED SURPLUS PRODUCTION MODEL
BOOTSTRAP RESULTS FOR RUN NUMBER 35 1994 10 19 12 54 53
White Hake
Gulf of Maine Stock
Using indices of abundance from the NMFS Autumn Survey
Prepared for SARC 19 -- October 1994
Sizeclass 1 = Recruits Sizeclasses 2+ = Fully-recruited white hake

Definitions

Survey Year	The period between successive NEFSC Autumn research surveys e.g. the autumn index in year t is lagged forward to Jan, t+1
Fully-recruited	All white hake greater than or equal to 44 at the beginning of the survey year (Oct 1).
Recruits	All white hake greater than 29 and less than or equal to 43 at the beginning of the survey year whose length will be greater than or equal to 44 cm by the end of the survey year (Sept 30)

BOOTSTRAP TYPE : SWF
BOOTSTRAP CLASS: parametric conditional
SEED FOR THE RANDOM NUMBER GENERATOR: 74747

NUMBER OF MEASUREMENT ERROR RESIDUALS: biomass index 9
NUMBER OF PROCESS ERROR RESIDUALS: equation error 8

MAIN LOOP LIMIT IN MARQUARDT ALGORITHM: 50
NUMBER OF BOOTSTRAP REPLICATIONS ATTEMPTED: 200
NUMBER FOR WHICH NLLS CONVERGED: 200
Results from the converged replications are used for computing the statistics that follow. Other replications are ignored.

This bootstrap run finished running at timestamp: 1994 10 19 12 53
This bootstrap run was started at timestamp: 1994 10 19 12 51

BOOTSTRAP OUTPUT VARIABLE: b_hat
Predicted indices of exploited biomass at the beginning of the year

PARAMETER	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
b 1985	8.722E3	8.394E3	5.170E2	0.06
b 1986	8.600E3	8.841E3	4.940E2	0.06
b 1987	8.800E3	9.340E3	4.895E2	0.06
b 1988	8.646E3	9.074E3	4.847E2	0.06
b 1989	8.425E3	8.381E3	4.646E2	0.06
b 1990	8.835E3	8.615E3	5.219E2	0.06
b 1991	9.826E3	9.720E3	5.807E2	0.06
b 1992	1.091E4	1.099E4	6.692E2	0.06
b 1993	9.980E3	1.046E4	7.837E2	0.08

PARAMETER	MIN	PERCENTILES 10	25	MEDIAN	75	90	MAX
b 1985	7.062E3	7.701E3	8.043E3	8.428E3	8.739E3	9.069E3	9.636E3
b 1986	7.584E3	8.205E3	8.484E3	8.833E3	9.193E3	9.468E3	1.025E4
b 1987	8.319E3	8.717E3	8.982E3	9.350E3	9.647E3	9.979E3	1.086E4
b 1988	7.992E3	8.487E3	8.791E3	9.006E3	9.343E3	9.748E3	1.067E4
b 1989	7.109E3	7.830E3	8.041E3	8.358E3	8.666E3	9.010E3	9.560E3
b 1990	7.361E3	7.921E3	8.272E3	8.611E3	8.972E3	9.233E3	1.022E4
b 1991	8.430E3	8.956E3	9.313E3	9.746E3	1.002E4	1.048E4	1.166E4
b 1992	9.346E3	1.016E4	1.054E4	1.094E4	1.145E4	1.184E4	1.332E4
b 1993	8.503E3	9.500E3	9.935E3	1.044E4	1.098E4	1.149E4	1.284E4

BOOTSTRAP OUTPUT VARIABLE: b_calculated
Forward-calculated biomass index (from the difference equation)

PARAMETER	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
1986	7.929E3	7.757E3	4.357E2	0.05
1987	8.586E3	9.026E3	4.802E2	0.06
1988	9.258E3	1.002E4	5.242E2	0.06
1989	9.764E3	1.038E4	5.538E2	0.06
1990	9.633E3	9.704E3	5.457E2	0.06
1991	9.876E3	9.760E3	5.878E2	0.06
1992	1.053E4	1.056E4	6.425E2	0.06
1993	9.500E3	9.799E3	7.563E2	0.08

PARAMETER		PERCENTILES					
	MIN	10	25	MEDIAN	75	90	MAX
1986	6.697E3	7.192E3	7.464E3	7.772E3	8.066E3	8.323E3	8.958E3
1987	7.811E3	8.396E3	8.664E3	9.009E3	9.336E3	9.652E3	1.036E4
1988	8.966E3	9.407E3	9.630E3	1.001E4	1.036E4	1.071E4	1.151E4
1989	9.087E3	9.723E3	1.004E4	1.031E4	1.072E4	1.110E4	1.217E4
1990	8.238E3	9.058E3	9.342E3	9.676E3	1.007E4	1.043E4	1.102E4
1991	8.148E3	9.005E3	9.402E3	9.756E3	1.016E4	1.049E4	1.165E4
1992	9.075E3	9.689E3	1.014E4	1.058E4	1.093E4	1.136E4	1.251E4
1993	8.106E3	8.843E3	9.266E3	9.760E3	1.031E4	1.078E4	1.217E4

BOOTSTRAP OUTPUT VARIABLE: q_hat
Catchability (with respect to the exploited biomass index)

PARAMETER	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
q_hat	6.421E2	6.193E2	2.182E1	0.03

PARAMETER		PERCENTILES					
	MIN	10	25	MEDIAN	75	90	MAX
q_hat	5.647E2	5.920E2	6.049E2	6.196E2	6.346E2	6.464E2	6.936E2

BOOTSTRAP OUTPUT VARIABLE: p_hat
Index of production -- a function of biomass at the start of the year
(see Conser et al. 1992; Equation 9)

YEAR	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
1985	4.539E3	4.505E3	5.882E1	0.01
1986	4.523E3	4.561E3	6.987E1	0.02
1987	4.548E3	4.625E3	6.995E1	0.02
1988	4.529E3	4.593E3	6.927E1	0.02
1989	4.500E3	4.499E3	6.295E1	0.01
1990	4.553E3	4.532E3	5.864E1	0.01
1991	4.653E3	4.649E3	4.639E1	0.01
1992	4.725E3	4.735E3	3.503E1	0.01
1993	4.665E3	4.717E3	7.591E1	0.02

		PERCENTILES					
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	4.32E3	4.42E3	4.47E3	4.51E3	4.55E3	4.58E3	4.62E3
1986	4.35E3	4.47E3	4.51E3	4.57E3	4.61E3	4.65E3	4.72E3
1987	4.46E3	4.53E3	4.58E3	4.63E3	4.67E3	4.71E3	4.80E3
1988	4.41E3	4.50E3	4.55E3	4.59E3	4.64E3	4.69E3	4.78E3
1989	4.29E3	4.42E3	4.45E3	4.50E3	4.54E3	4.58E3	4.63E3
1990	4.37E3	4.45E3	4.50E3	4.54E3	4.57E3	4.60E3	4.67E3
1991	4.52E3	4.58E3	4.62E3	4.66E3	4.68E3	4.71E3	4.75E3
1992	4.61E3	4.69E3	4.71E3	4.74E3	4.76E3	4.78E3	4.80E3
1993	4.47E3	4.62E3	4.67E3	4.73E3	4.77E3	4.81E3	4.87E3

BOOTSTRAP OUTPUT VARIABLE: B
Expoited biomass at the beginning of the year

YEAR	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
1985	1.358E1	1.356E1	4.750E-1	0.03
1986	1.339E1	1.422E1	5.785E-1	0.04
1987	1.371E1	1.498E1	6.991E-1	0.05
1988	1.347E1	1.456E1	7.961E-1	0.06
1989	1.312E1	1.349E1	8.365E-1	0.06
1990	1.376E1	1.389E1	8.906E-1	0.06
1991	1.530E1	1.565E1	1.008E0	0.07
1992	1.700E1	1.767E1	1.199E0	0.07
1993	1.554E1	1.675E1	1.496E0	0.10

		--------------	PERCENTILES	--------------------			
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	1.248E1	1.294E1	1.324E1	1.356E1	1.389E1	1.415E1	1.503E1
1986	1.287E1	1.351E1	1.382E1	1.419E1	1.457E1	1.504E1	1.575E1
1987	1.326E1	1.414E1	1.451E1	1.495E1	1.537E1	1.596E1	1.707E1
1988	1.261E1	1.352E1	1.400E1	1.456E1	1.501E1	1.555E1	1.703E1
1989	1.158E1	1.242E1	1.290E1	1.351E1	1.401E1	1.469E1	1.568E1
1990	1.140E1	1.276E1	1.327E1	1.384E1	1.449E1	1.510E1	1.695E1
1991	1.323E1	1.432E1	1.504E1	1.555E1	1.639E1	1.689E1	1.890E1
1992	1.500E1	1.613E1	1.678E1	1.756E1	1.841E1	1.934E1	2.107E1
1993	1.276E1	1.504E1	1.568E1	1.669E1	1.772E1	1.879E1	2.037E1

BOOTSTRAP OUTPUT VARIABLE: P_obs
"Observed" surplus production over the course of the year

YEAR	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
1985	8.114E0	8.957E0	4.370E-1	0.05
1986	7.377E0	7.831E0	5.221E-1	0.07
1987	6.131E0	5.949E0	5.355E-1	0.09
1988	4.968E0	4.242E0	5.819E-1	0.12
1989	5.766E0	5.524E0	6.265E-1	0.11
1990	7.011E0	7.233E0	7.034E-1	0.10
1991	7.849E0	8.168E0	7.630E-1	0.10
1992	8.106E0	8.650E0	6.974E-1	0.09

		--------------	PERCENTILES	--------------------			
YEAR	MIN	10	25	MEDIAN	75	90	MAX
1985	7.97E0	8.37E0	8.69E0	8.94E0	9.23E0	9.52E0	1.01E1
1986	6.55E0	7.21E0	7.47E0	7.82E0	8.17E0	8.48E0	9.55E0
1987	4.61E0	5.23E0	5.59E0	5.94E0	6.35E0	6.61E0	7.18E0
1988	2.27E0	3.51E0	3.86E0	4.20E0	4.65E0	4.94E0	5.88E0
1989	3.79E0	4.70E0	5.09E0	5.51E0	5.93E0	6.34E0	7.23E0
1990	4.91E0	6.30E0	6.83E0	7.20E0	7.72E0	8.12E0	9.33E0
1991	5.99E0	7.14E0	7.63E0	8.15E0	8.66E0	9.21E0	1.01E1
1992	6.80E0	7.74E0	8.21E0	8.65E0	9.09E0	9.55E0	1.07E1

BOOTSTRAP OUTPUT VARIABLE: PB_ratio_obs
"Observed" surplus production - biomass ratio during the year

YEAR	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
1985	5.973E-1	6.593E-1	4.000E-2	0.07
1986	5.508E-1	5.493E-1	5.309E-2	0.10
1987	4.473E-1	3.847E-1	5.582E-2	0.12
1988	3.689E-1	2.749E-1	6.170E-2	0.17
1989	4.394E-1	4.048E-1	6.526E-2	0.15
1990	5.095E-1	5.183E-1	6.602E-2	0.13
1991	5.129E-1	5.196E-1	6.471E-2	0.13
1992	4.769E-1	4.888E-1	4.836E-2	0.10

YEAR	MIN	PERCENTILES 10	25	MEDIAN	75	90	MAX
1985	5.61E-1	6.05E-1	6.34E-1	6.60E-1	6.86E-1	7.15E-1	7.62E-1
1986	4.17E-1	4.84E-1	5.12E-1	5.42E-1	5.85E-1	6.26E-1	7.02E-1
1987	2.32E-1	3.09E-1	3.51E-1	3.84E-1	4.21E-1	4.57E-1	5.39E-1
1988	9.73E-2	2.01E-1	2.34E-1	2.77E-1	3.17E-1	3.53E-1	4.15E-1
1989	2.32E-1	3.17E-1	3.64E-1	4.04E-1	4.44E-1	4.90E-1	6.08E-1
1990	3.01E-1	4.39E-1	4.69E-1	5.19E-1	5.65E-1	6.06E-1	7.19E-1
1991	3.33E-1	4.41E-1	4.79E-1	5.14E-1	5.57E-1	6.05E-1	7.08E-1
1992	3.39E-1	4.26E-1	4.56E-1	4.92E-1	5.26E-1	5.47E-1	5.81E-1

BOOTSTRAP OUTPUT VARIABLE: P_est
Estimated surplus production during over the course of the year

YEAR	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
1985	7.069E0	7.256E0	1.591E-1	0.02
1986	7.044E0	7.338E0	1.738E-1	0.02
1987	7.084E0	7.436E0	2.062E-1	0.03
1988	7.054E0	7.384E0	2.342E-1	0.03
1989	7.008E0	7.239E0	2.471E-1	0.04
1990	7.090E0	7.296E0	2.397E-1	0.03
1991	7.246E0	7.482E0	2.430E-1	0.03
1992	7.359E0	7.618E0	2.453E-1	0.03
1993	7.265E0	7.583E0	3.057E-1	0.04

YEAR	MIN	PERCENTILES 10	25	MEDIAN	75	90	MAX
1985	6.72E0	7.08E0	7.15E0	7.26E0	7.37E0	7.46E0	7.67E0
1986	6.81E0	7.15E0	7.21E0	7.32E0	7.44E0	7.57E0	7.85E0
1987	6.77E0	7.20E0	7.30E0	7.42E0	7.57E0	7.71E0	8.17E0
1988	6.61E0	7.10E0	7.23E0	7.38E0	7.54E0	7.68E0	8.16E0
1989	6.53E0	6.94E0	7.06E0	7.22E0	7.41E0	7.55E0	7.92E0
1990	6.67E0	7.02E0	7.13E0	7.29E0	7.47E0	7.61E0	7.94E0
1991	6.79E0	7.21E0	7.31E0	7.47E0	7.65E0	7.79E0	8.12E0
1992	6.84E0	7.32E0	7.46E0	7.60E0	7.77E0	7.95E0	8.28E0
1993	6.56E0	7.25E0	7.38E0	7.57E0	7.78E0	7.98E0	8.33E0

BOOTSTRAP OUTPUT VARIABLE: PB_ratio_est
Estimated surplus production - biomass ratio during the year

YEAR	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
1985	5.204E-1	5.342E-1	2.268E-2	0.04
1986	5.260E-1	5.139E-1	2.358E-2	0.04
1987	5.168E-1	4.910E-1	2.347E-2	0.05
1988	5.238E-1	5.029E-1	2.324E-2	0.04
1989	5.341E-1	5.355E-1	2.179E-2	0.04
1990	5.153E-1	5.243E-1	2.278E-2	0.04
1991	4.735E-1	4.769E-1	2.268E-2	0.05
1992	4.329E-1	4.295E-1	2.352E-2	0.05
1993	4.675E-1	4.469E-1	3.243E-2	0.07

YEAR	MIN	PERCENTILES 10	25	MEDIAN	75	90	MAX
1985	4.83E-1	5.05E-1	5.19E-1	5.32E-1	5.49E-1	5.65E-1	5.97E-1
1986	4.52E-1	4.85E-1	4.97E-1	5.14E-1	5.31E-1	5.45E-1	5.78E-1
1987	4.24E-1	4.61E-1	4.76E-1	4.90E-1	5.08E-1	5.22E-1	5.43E-1
1988	4.32E-1	4.71E-1	4.89E-1	5.06E-1	5.16E-1	5.32E-1	5.59E-1
1989	4.84E-1	5.07E-1	5.22E-1	5.36E-1	5.51E-1	5.62E-1	6.00E-1
1990	4.60E-1	4.98E-1	5.08E-1	5.24E-1	5.39E-1	5.55E-1	5.83E-1
1991	4.08E-1	4.47E-1	4.65E-1	4.75E-1	4.92E-1	5.07E-1	5.31E-1
1992	3.56E-1	4.00E-1	4.13E-1	4.30E-1	4.45E-1	4.59E-1	4.92E-1
1993	3.59E-1	4.05E-1	4.25E-1	4.46E-1	4.67E-1	4.87E-1	5.37E-1

BOOTSTRAP OUTPUT VARIABLE: B_max
Exploitable virgin stock biomass

PARAMETER	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
B_max	77.871	80.460	2.479	0.03

PARAMETER	MIN	10	25	MEDIAN	75	90	MAX
B_max	72.818	77.432	78.692	80.340	82.042	83.603	87.108

BOOTSTRAP OUTPUT VARIABLE: B_msy
Stock biomass level at which MSY can be taken

PARAMETER	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
B_msy	20.340	21.017	0.648	0.03

PARAMETER	MIN	10	25	MEDIAN	75	90	MAX
B_msy	19.020	20.226	20.555	20.985	21.430	21.837	22.753

BOOTSTRAP OUTPUT VARIABLE: K
Stock biomass level above which density dependent effects dominate

PARAMETER	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
K	11.124	11.494	0.354	0.03

PARAMETER	MIN	10	25	MEDIAN	75	90	MAX
K	10.403	11.062	11.242	11.477	11.720	11.943	12.444

BOOTSTRAP OUTPUT VARIABLE: MSY
Maximum sustainable yield

PARAMETER	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
MSY	7.438	7.685	0.237	0.03

PARAMETER	MIN	10	25	MEDIAN	75	90	MAX
MSY	6.955	7.396	7.516	7.674	7.836	7.986	8.320

BOOTSTRAP OUTPUT VARIABLE: P_at_K
Expected surplus production when B=K

PARAMETER	SPROD ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR SPROD EST
P_at_K	6.675	6.897	0.213	0.03

PARAMETER	MIN	10	25	MEDIAN	75	90	MAX
P_at_K	6.242	6.637	6.745	6.886	7.032	7.166	7.466

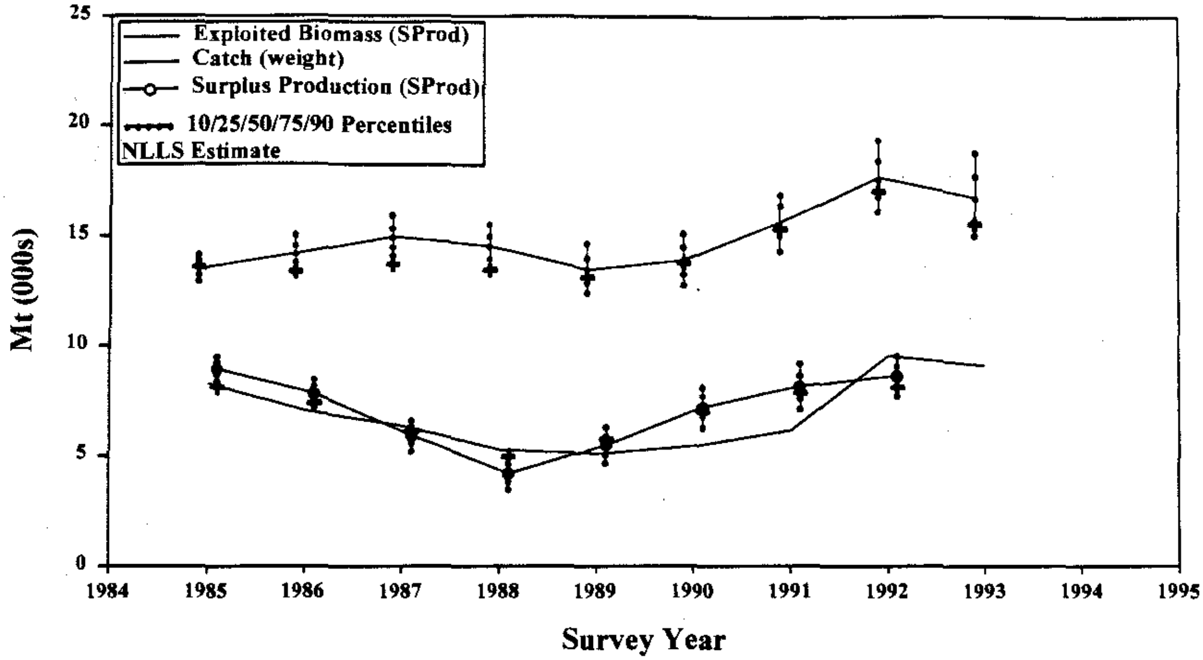


Figure D1. Bootstrapped biomass estimates for exploited, catch, and surplus production as estimated from the surplus production model.

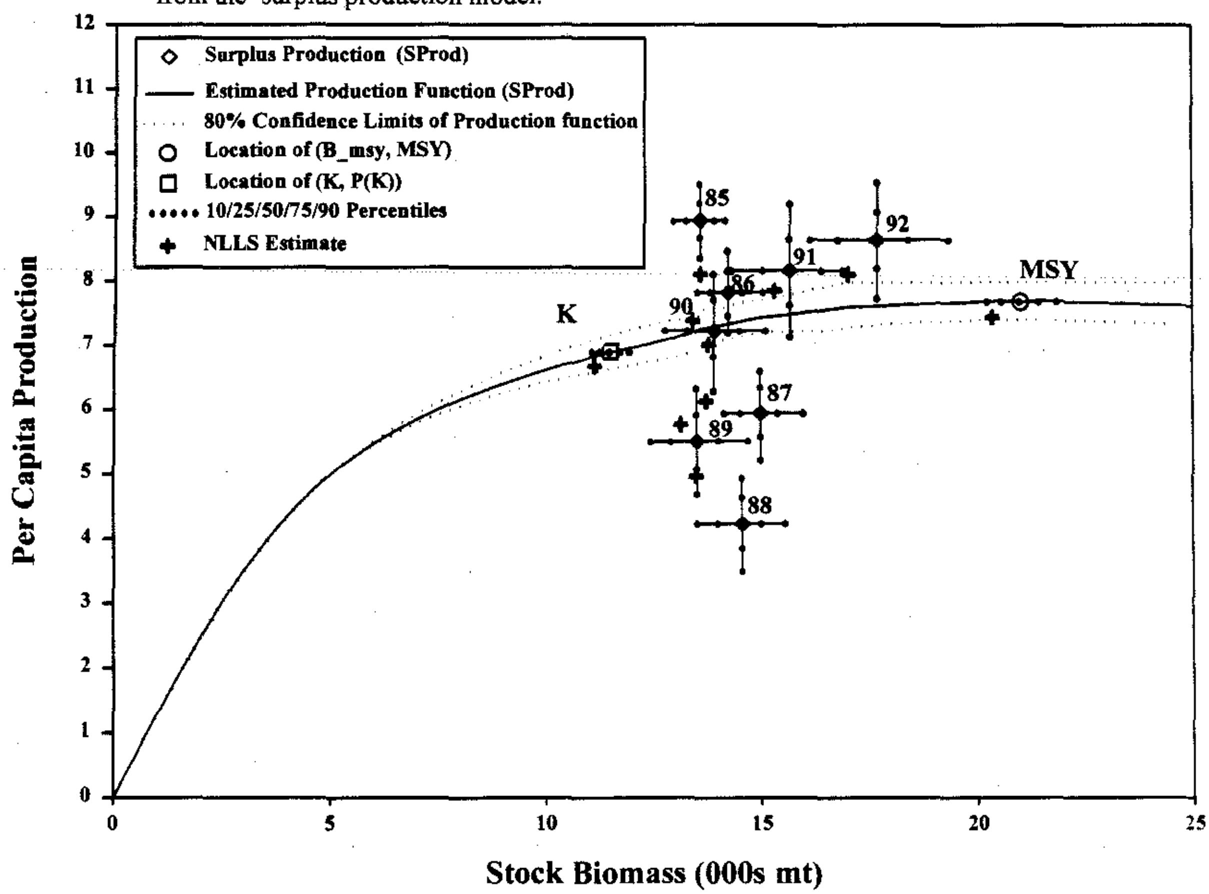


Figure D2. Bootstrapped surplus production curve with bootstrapped estimates of K, MSY and surplus production as estimated from the surplus production model. The NLLS estimate and percentiles are also shown.