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Stock Assessment of Longfin Inshore Squid, *Loligo pealeii*

by

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ABSTRACT

Length-based virtual population analysis, seasonal dynamic pool models, and a quarterly surplus production analysis indicate that the *loligo pealeii* stock is approaching an overfished state, and overfishing is occurring. The production model indicates that current biomass is less than the biomass that can produce maximum sustainable yield (B_{MSY}) and near the biomass threshold of 50% B_{MSY}. There is high probability that fishing mortality (F) in 1998 exceeded MSY levels. However, the production model also indicates that the stock has the ability to quickly rebuild from low stock sizes. Length-based analyses indicate that fully-recruited F in 1998 was greater than than F_{max}, and stock biomass is among the lowest in the assessment time series (1987-1998). Recent survey indices of recruitment are below average. Stochastic projections suggest that F should be reduced to rebuild stock biomass to B_{MSY}.

INTRODUCTION

Life History

Stock assessment and management of *Loligo pealeii* are highly dependent on basic biological information, because recent findings have recast our perception its life history. The "longfin inshore squid" schools in waters of the continental shelf and slope, from Canada to the Caribbean (Cohen 1976). Within its range of commercial exploitation (Southern Georges Bank to Cape Hatteras) the population is considered to be a unit stock (NEFC 1986). However, heterogeneous subpopulations may exist (NEFSC 1996). Verrill (1882) reported different morphotypes from Vineyard Sound samples, but differences were likely caused by extremely variable rates of growth and maturation within the population. Genetic variation was extremely low among samples from NEFSC surveys, but allele frequencies were different at one locus among samples from Georges Bank, Cape Cod, and Cape Hatteras (Garthwaite et al. 1989). South of Cape Hatteras, the geographic distribution of *L. pealeii* overlaps with that of a congener, *L. plei*, which is morphometrically similar (Cohen 1976). *L. pealeii* migrate seasonally. They move offshore during late autumn to overwinter in warmer waters along the edge of the continental shelf and move inshore during the spring and early summer (Summers 1969; Serchuk and Rathjen 1974).

L. pealeii are sexually dimorphic with males growing faster and to larger sizes than females. Some males grow to more than 40 cm dorsal-mantle length (ML), although most squid harvested in the commercial fishery are less than 30 cm ML (Tibbetts 1975; NEFC 1986, 1990; McKiernan and Pierce 1995). Recent research indicates that *L. pealeii* live for less than one year, grow rapidly, and spawn year-round (Brodziak and Macy 1994, Macy 1994). Ageing studies show that growth is essentially exponential, size at age is extremely variable, and squid hatched in summer grow more rapidly than those hatched in winter (Macy 1994, Brodziak and Macy 1996). Age data indicates that major hatching periods are in summer-fall and early winter (Macy 1998). Age and growth information from 353 individuals indicated that size at age is extremely variable, but growth of summer-hatched individuals is faster and less variable than winter-hatched individuals (Brodziak and Macy 1996). New age data, based on 212 additional observations, generally confirm the earlier conclusions, but also show that length at age varies significantly within seasons (Macy 1998). The samples analyzed by Brodziak and Macy (1996) and Macy (1998) were taken opportunistically from the fishery with limited geographic and temporal coverage. Therefore, the limited information on age and growth may not represent the population.

Size at sexual maturity is extremely variable, but generally occurs at about 15 cm ML and 6 months of age in the waters of southern New England and the mid Atlantic Bight (Macy 1982, 1998; NEFSC 1996). *L. pealeii* mature at larger size in the northern extent of the range (Dawe et al. 1990). Similar to the limitations of available information on age and growth, maturity data reported by Macy (1982, 1998) have restricted spatio-temporal coverage. For example, hatch dates were distributed throughout the year, but no mature females were sampled in the fall, presumably because they spawn outside the sampled area (Macy 1998).

A NEFSC study was initiated in fall of 1997 to investigate geographic and seasonal patterns of growth and maturity (Hatfield and Cadrin 1999). Large portions of juvenile squid in the fall survey are produced by known areas of inshore, summer spawning. Similarly large portions of juveniles in winter and spring surveys implies significant winter spawning activity. To locate areas and times of spawning activity, 50 individuals were sampled in each of three geographic regions (Gulf of Maine, Georges Bank-southern New England, and mid-Atlantic Bight; a fourth region, south of Cape Hatteras was added later) and five depth zones (1 to 26 m, 27 to 55 m, 56 to 110 m, 111 to 185 m, >185 m) from five research surveys (NEFSC fall, winter, and spring, Massachusetts, and Connecticut) and sampled for morphometric maturity (Macy 1982). Statoliths were subsampled according to a uniform design described by Dawe and Natsukari (1991; three per cm per sex per maturity stage). A total of 2,274 individuals were processed, and 915 statoliths were collected. Cooperative work with University of Rhode Island has commenced to age statoliths from NEFSC samples, but data are presently unavailable. Results on size at maturity from recent field sampling (Hatfield and Cadrin 1999) is similar to previous information (NEFSC 1996 and Macy 1998). Overall, few mature individuals were sampled. Spawning observations during late spring and early summer were in the well-documented spawning grounds of inshore southern New England in spring. During the fall NEFSC and Massachusetts surveys, spawning was observed in Cape Cod Bay and off Chesapeake Bay. Minimal spawning activity was observed from winter survey samples. A large portion of mature observations from the spring survey (45%) were from stations south of Cape Hatteras. This finding confirms earlier reports of substantial spawning of *L. pealeii* off the southeast U.S. (Whitaker 1978). Opportunistic commercial samples from early winter were also processed to bridge the temporal gap in survey coverage, but no mature squid were found. It appears that more extensive sampling is required to understand geographic and seasonal spawning patterns.

Reproductive dynamics of *L. pealeii* are also being studied at the Marine Biological Laboratory (MBL). A high frequency of alternative mating behavior has been observed in field and culture studies (Hanlon 1996, Hanlon et al. 1997). As an alternative to side-to-side copulation, which involves placement of spermatophores into the female mantle cavity by large males, smaller 'sneaker' males have been observed in head-to-head copulation, which involves storage of spermatophores in the female buccal receptacle. Nearly all females arriving inshore in the spring and early summer have stored spermatophores, presumably from offshore copulation (Hanlon 1996, Hanlon et al. 1997). Multiple spawning of individual females has been observed in culture, and spawning can last for over a month (Hanlon 1998, Maxwell et al. 1999). Preliminary data on fecundity indicate little relationship to size or age (Maxwell et al. 1999). Data on sex ratios over time suggest that demographics can change substantially within a season (M. Maxwell, MBL, personal communication).

Environmental effects on growth and productivity have been studied in culture and in the field. As an extension to the analysis of temperature effects on survey catches of *L. pealeii* reported by Brodziak and Hendrickson (1999), correlation analyses indicate that survey indices of biomass and abundance are positively related to sea surface and bottom water temperatures, and some temperature variations have lagged effects on abundance, suggesting that temperature affects early life history stages (Hatfield et al. 1998). Culture experiments show that small *L. pealeii* grow significantly faster at 20° C than at 15°C (Hatfield et al., in prep.).

Brodziak (1998) identified the need to consider trophic dynamics and community-level interactions with *L. pealeii*. Diet observations from NEFSC surveys indicate that the primary finfish predators are bluefish, monkfish, fourspot flounder, and spiny dogfish (J. Link, pers. comm.). Estimates of total consumption by predatory fish (Overholtz et al. 1999) and marine mammals (Kenney et al. 1995) are significant in comparison to fishery yields.

Recently collected data on *L. pealeii* biology confirms that rates of growth and maturity are extremely variable, and the few available samples may not adequately represent the population or the fishery. Opportunistic samples may be biased, but structured sampling designs require an extremely large number of observations to represent temporal and geographic patterns. Boyle and Boletzky (1996) concluded that useful generalizations about squid populations are difficult, because of short lifespans, little generational overlap, rapid growth, early maturity, and extensive migrations.

The Fishery

The Northwest Atlantic *L. pealeii* squid fishery began in the late 1800s as a source of bait, and annual squid landings from Maine to North Carolina (including *Illex illecebrosus* landings) averaged approximately 2,000 mt per year from 1928 to 1966 (Lange 1980). A directed foreign fishery for *L. pealeii* developed in 1967, and catches were used for human consumption. During the 1970s and early 1980s, the foreign fleet generally fished on the edge of the continental shelf in the winter, and the domestic fleet generally fished inshore in spring and summer (Lange et al. 1984). Annual landings increased to a peak of 37,600 mt in 1973 (Table 1). Foreign catches were gradually restricted, and in 1987, foreign fishing effort ceased. As the distant water fishery came to an end, the domestic fishery expanded to include an offshore, winter component.

Management History

From 1974 to 1977, the International Commission for the Northwest Atlantic Fisheries managed the Northwest Atlantic *L. pealeii* resource by regulating total allowable catch (TAC). A TAC of 44,000 mt was allowed in 1976 and 1977 (Lange and Sissenwine 1980). In 1978, management of the U.S. *L. pealeii* stock shifted to the Mid-Atlantic Fishery Management Council. The *L. pealeii* fishery is currently managed under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan (MAFMC 1998).

In 1996, management targets were reevaluated to reflect recent research on its life history, and domestic annual harvest was limited to 21,000 mt (Brodziak 1998). The current overfishing definition is the fishing mortality rate (F) which produces maximum yield per recruit (F_{max}), and the F target is $F_{50\%}$ (the F that preserves 50% of the unfished spawning potential) (MAFMC 1997). In 1998, an overfishing definition was proposed that was based on F_{max} as a proxy for the level which will produce maximum sustainable yield (F_{MSY}), a minimum biomass threshold of half the level which can produce MSY (B_{MSY} = 80,000 mt and 1/2 B_{MSY} = 40,000 mt, as indexed by the combined spring and fall NEFSC survey swept-area biomass), and a target F of 75% F_{MSY} (MAFMC 1998).

Assessment Background

Stock abundance and biomass of *L. pealeii* have been monitored by area-swept methods using bottom trawls for over 30 years. Estimates of stock size have varied widely from different approaches (Edwards 1968, Summers 1969, Serchuk and Rathjen 1974, Ikeda and Nagasaki 1975, Tibbetts 1975, Lange and Sissenwine 1983, Lange 1984, NEFSC 1996, Brodziak 1998).

Annual assessment reports based on survey and catch trends concluded that the stock was fluctuating around the long-term average and catches were sustainable during the 1970s and early 1980s (Serchuk and Rathjen 1974, Tibbets 1975, Lange and Sissenwine 1977, Lange 1984). Regular status of stocks reports stated that the *L. pealeii* stock was underexploited and at high levels of abundance from 1989 to 1993 (NEFC 1989, NEFSC 1993). In 1994, the stock was determined to be at a medium level of abundance and full-exploited (NEFSC 1994a), and that status continued through the most recent determination (Cadrin 1998).

Historical attempts to model abundance and F were generally conditional on obsolete life history paradigms involving a multi-year life span. For example, Ikeda and Nagasaki (1975) and Lange et al (1984) performed cohort analysis of length modes, assuming a three-year lifespan. Historical estimates of biological reference points based on dynamic pool models (Sissenwine and Tibbetts 1977, Lange 1981, Lange and Sissenwine 1983) and stock-recruit analyses (Lange 1984, Lange et al. 1984) also assumed a multi-year life cycle. A Collie-Sissenwine model was applied to the *L. pealeii* fishery, but results were sensitive to the assumed natural mortality rate (NEFSC 1992). Brodziak and Rosenberg (1993) developed an extended Leslie-DeLury model to estimate abundance and exploitation rate based on catch per unit effort (CPUE) data from the inshore Massachusetts fishery, but migrations to and from adjacent areas made interpretations difficult.

The most recent stock assessments of *L. pealeii* have continued area-swept estimates of biomass and revised dynamic pool approaches with updated information on growth, maturity, and natural mortality (NEFSC 1994b, 1996). Previous assessments did not successfully estimate fully-recruited F for comparison to dynamic pool reference points. Status determination was based on ratios of catch to area-swept biomass, assuming no seasonal growth or recruitment and equal catchability of spring and summer surveys (NEFSC 1996, Brodziak 1998).

DATA AND ASSESSMENT

Landings

Annual landings were estimated from northeast dealer weighout and canvass data (Burns et al. 1983). Annual landings from 1982 to 1987 were revised to include prorated unspecified squid landings (which include *I. illecebrosus*). Unspecified landings were prorated according to the relative proportions of *L. pealeii* and *I. illecebrosus* by month and 2-digit statistical reporting area. Some landings of *L. plei* may be included in *Loligo* catches south of Cape Hatteras, because landings are categorized to genus, not species. There is substantial uncertainty in the estimates of foreign landings and historical domestic landings. There was no observer coverage of distant water fleets before 1978, and observer coverage was low in the early 1980s (P. Gerrior, personal communication). The relative proportion of total landings from unspecified squid landings was substantial in some years (e.g., 20% in 1983), but has been generally low since 1985 (<5%; with the exception of 1996, when 10% of total landings estimates were from unspecified records). Differences between dealer weighout and canvass data were also substantial until the early 1980s, but annual differences have been less than 2% of the total since 1987. Accuracy of landings estimates has improved as a result of better reporting of landings by species and prohibitions on foreign fishing.

Estimated landings increased rapidly in the 1960s and early 1970s to a peak of 38,000 mt in 1973, with nearly all landings from distant water fleets (Table 1, Figure 1). During the 1980s, domestic landings replaced foreign landings. Landings in 1998 were approximately equal to average annual landings from 1967 to 1998 (18,400 mt), with most landings taken in the first quarter.

Landings are predominately taken by small-mesh otter trawlers, but substantial landings are taken from inshore fish traps. Since 1989, most landings were taken from the winter fishery (first and fourth quarters; Table 2, Figure 2). Most landings in recent years were taken during winter months along the edge of the continental shelf from the Mid-Atlantic Bight (statistical areas, 613, 616, 622) to southern New England waters (area 537; Table 3, Figure 3).

Size distribution of landings was sampled in every quarter, from 1987 to the third quarter of 1998, but samples were not distributed across all months, nor were all market categories sampled (Table 4a). Approximately 80% of all landings from 1987 to 1998 were landed as 'unclassified', with variable proportions of specific market categories (Table 4b). Catch at length was estimated using quarterly samples by market category where available. Landings from unsampled categories were characterized by samples from adjacent categories (i.e., 'large' were pooled with 'extra large'; 'small' were pooled with 'boogers'; 'medium' were pooled with 'unclassified'). When adjacent categories were not available, landings were characterized by 'unclassified' samples. Sample lengths were expanded to quarterly landings using predicted sample weights (Lange and Johnson 1981).

Estimated catch at length generally indicates an increase in catch from small, partially-recruited recruited sizes (approximately 9 to12 cm ML) to a mode at approximately 13 to 15 cm ML and a gradual decrease in catch at length greater than 13 cm ML (Figure 4). Most landings range from 10 to 20 cm ML, with variable portions of large individuals (>25 cm ML). This pattern is similar to those reported in previous assessments (Tibbetts 1975; NEFC 1986, 1990, McKiernan and Pierce 1995).

Discarded Catch

The previous stock assessment recommended that more data was needed on the magnitude and composition of discards (NEFSC 1996, Brodziak 1998). The magnitude of *L. pealeii* discards appears to be relatively low. Analysis of data from 22 directed trips in Nantucket and Vineyard Sounds from 1989 to 1993 indicated that the magnitude of *L. pealeii* discards were negligible (McKiernan and Pierce 1995). Information from observed trips that caught *L. pealeii* (1989 to 1998 NEFSC and Massachusetts observer data) suggests that the magnitude of discards varies by time, fishing gear, and target species. Determining directed trips is difficult from observer databases because target species are not coded (NEFSC 1996), and traditional directed trips land a mix of other species (e.g., silver hake). Data from observed otter trawl trips that caught *L. pealeii* were analyzed in two categories: those that landed *L. pealeii* (producing an average discard:kept ratio of 6%; Table 5), and those that discarded all *L. pealeii* (10 mt of observed discard from 207 trips, averaging approximately 50 kg/trip). Discarded catch from other fishing gear also appears to be relatively low in magnitude: 78 observed scallop trips caught *L. pealeii* and discarded 500 kg (averaging 6 kg/trip); five observed gillnet trips caught *L. pealeii* and discarded 2 kg (averaging less than 1 kg/trip). These discard observations are not randomly sampled and may not represent the entire directed fishery or bycatch fisheries (NEFSC 1996).

Observed lengths of discarded *L. pealeii* are generally small (mode <10 cm ML in most years; Figure 5). However, some discard samples also include substantial portions of large individuals, presumably from trips that are not landing *L. pealeii.*

Commercial CPUE

Generalized linear models (GLMs) of catch rates in domestic fisheries for *L. pealeii* were developed in the previous stock assessment (Figure 6; NEFSC 1996, Brodziak 1998). Port interview data from 1982 to 1993 were partitioned into two seasons: winter (October-March) and summer (April-September). The two GLMs included statistical area, vessel size, and month as main effects. The standardized CPUE series could not be updated for this assessment, because port interview data are not available from 1994-1998. A quarterly series of CPUE was derived from the standardization coefficients for statistical area and vessel size reported in the last stock assessment (NEFSC 1996, Brodziak 1998). Quarterly CPUE estimates for 1987 to 1993 were from dealer weighout and interview data, and estimates for from 1994 to 1998 were from vessel logbook data. Quarterly CPUE generally increased in the late 1980s, generally decreased from 1988 to 1991, and fluctuated without trend in the 1990s (Figure 6). There is no apparent seasonal periodicity in CPUE. However, effort statistics from logbook data may be unreliable and may not be comparable to interview data (NEFSC 1997, Mayo 1998).

Research Surveys

Geographic patterns in survey catches show that *L. pealeii* are distributed over the entire continental shelf (from inshore to offshore) in the fall, are concentrated at the edge of the continental shelf (and likely outside the surveyed area) in winter and spring, and are concentrated inshore in the summer (Figure 7; Summers 1967, 1969; Mercer 1969a, 1969b, 1970; Serchuk and Rathjen 1974; Vovk 1978; Whitaker 1980). Catches in the mid-Atlantic Bight are significantly greater than those in more northern strata during all seasons (Hatfield and Cadrin 1999). Some catches of *L. plei* may be included in *Loligo* survey catches off Cape Hatters, because data are categorized to genus, not species.

Many studies found day/night differences in *L. pealeii* survey catches (Sissenwine and Bowman 1978, Serchuk and Rathjen 1974, Tibbetts 1975, Sissenwine and Tibbetts 1977, Brodziak and Hendrickson 1999). The most recent *L. pealeii* stock assessment used diel correction factors for prerecruits ($\leq$ 8 cm ML) and recruits (>8 cm ML) derived by generalized linear model (GLM) of NEFSC fall survey data with cruise, stratum, and time zone main effects (NEFSC 1996, Brodziak and Hendrickson 1999). The previous stock assessment applied fall diel corrections to spring survey data. Brodziak and Hendrickson's (1999) methods were applied to winter and spring survey data to derive seasonal correction factors. All correction factors for spring and winter surveys were statistically significant, but diel differences were substantially less for spring, and nighttime catches of large *L. pealeii* by the winter survey were slightly greater than daytime catches. Survey indices of abundance and biomass were revised and updated using season-specific diel corrections, excluding short tows, and reducing the strata set for the winter survey to regularly sampled strata (Table 6, Figure 8).

A comparison of length frequencies from recent surveys (i.e., those sampled since the last assessment, NEFSC 1996) and previous surveys indicates that size distributions are similar (Figure 9a). Approximately 80% of *L. pealeii* sampled by the fall survey are prerecruits ($\leq$ 8 cm ML). There are relatively fewer small *L. pealeii* sampled by the winter survey (approximately 60% prerecruits) and the spring survey (65% prerecruits). Survey length modes range from three to six cm ML (i.e., the most frequent size sampled is generally 3 to 6 cm ML, and frequency decreases at greater sizes), suggesting that 6 cm squid are fully recruited to the survey gear. Size distributions from offshore, deep stations were larger than those from inshore, shallow stations (Hatfield and Cadrin 1999; Figure 9b).

L. pealeii are also sampled by state surveys. The Massachusetts spring survey (Howe 1989) samples an aggregation of *L. pealeii* in Nantucket Sound, Vineyard Sound and Buzzards Bay (statistical area 538, Figure 3), where the inshore spring fishery operates. The Massachusetts survey index generally increased in the 1980s and decreased in the 1990s (Table 7, Figure 10).

The previous stock assessment of *L. pealeii* reported a significant negative relationship between winter effort and summer catch rates (NEFSC 1996, Brodziak 1998). Unfortunately, the series of interview effort used in the analysis cannot be updated because of the switch to logbook-based effort estimates, described above. However, the relationship between the winter and summer fisheries for *L. pealeii* was examined using the Massachusetts survey biomass index and offshore removals (yield during the previous fourth and first quarters). The relationship was negative (Figure 10; $r = -0.41$), but was only marginally significant ($P = 0.095$), suggesting a weak relationship between offshore removals and subsequent biomass available for the inshore fishery or low power of detection.

In summary, survey biomass indices suggest some long-term patterns in stock biomass. Biomass appears to have increased in the 1960s and early 1970s, decreased in the late 1970s, slightly increased in the early 1980s, and decreased in the late 1980s and early 1990s.

<u>Estimates of Relative Exploitation</u> - Descriptive approach.

Ratios of landings to survey biomass indices were calculated to investigate patterns of relative exploitation rate (NEFSC 1996). Ratios were based on seasonal surveys and the corresponding quarterly landings. Patterns in relative exploitation indices were inconsistent among surveys, but the fall and winter indices suggest that exploitation rate was high in 1998 (Figure 11).

<u>Estimates of Stock Size and Fishing Mortality</u> - Length-based approach.

Length-based virtual population analysis (LVPA) was used to estimate abundance and mortality from average monthly catch at size, by season. Visual inspection of commercial length samples (Figure 4), suggests that information on mortality rate can be indicated from the rate of decrease in catch as size increases if a general growth rate is assumed. LVPA is a modification of Jones' (1974, 1981) length-based cohort analysis, which uses Pope's (1972) approximate solution to the catch equation:

$$N_{t+\Delta t} = (N_t \, e^{-0.5M\Delta t} - C_t) \, e^{-0.5M\Delta t} \qquad (1)$$

where abundance of a size class at the end of a time period ($N_{t+\Delta t}$) can be estimated from abundance at the beginning of the period (N_t) decreased by a half-period of natural mortality ($e^{0.5M\Delta t}$), catch at mid-period (C_t), and another half year of M on the survivors from the fishery. Monthly M was assumed to be 0.3 (NEFSC 1996). The period (Δt) is the predicted time to grow from one size class to the next, in months. A sequential population analysis with variable time periods was performed using an iterative search algorithm (Sims 1982) for a more exact solution of F, given $N_{t+\Delta t}$, $M\Delta t$, and C_t in a modified catch equation:

$$C_t = (1-e^{-Z\Delta t})\, N_{t+\Delta t}e^{-Z\Delta t}\, F_{\Delta t}/Z_{\Delta t} \qquad (2)$$

and

$$N_t = N_{t+\Delta t}e^{-Z\Delta t} \qquad (3)$$

where Z is total mortality (F+M). Monthly F was derived as $F_{\Delta t}/\Delta t$. Therefore, a size distribution of landings (catch at a sequence of length classes) was used to approximate catch at a sequence of time intervals.

Jones (1974) used vonBertalanffy growth parameters to estimate Δt, but any continuous growth function can be used (Cadrin and Estrella 1996). The seasonal, pooled-sex Schnute growth functions for *L. pealeii* reported by Brodziak and Macy (1996, Figure 12) were used to derive Δt for successive two-cm ML size classes (Appendix A). The preliminary growth estimates reported in Macy (1998, Figure 12) were not used, because they are simple power functions, which may not be appropriate for squid, and they are grouped by sample date, rather than hatch date. Growth of *L. pealeii* is sexually dimorphic, but separate-sex analyses are not possible, because sex is not identified in commercial length samples. Seasonal growth models were used for corresponding seasonal catches: growth of individuals hatched from November to May was used to analyze summer catch (April to September), and growth of individuals hatched from June to October was used to analyze winter catch (October to May, labeled as the calendar year in January).

Length-based VPA assumes stationary recruitment, because a single-month length frequency, which comprises several cohorts, is used to approximate abundance of a single cohort over time. This approximation assumes that all size classes in the catch were equally abundant at the time of recruitment to the fishery. Somerton and Kobayashi (1991) proposed that catch at length should be averaged over successive periods to reduce bias from disequilibria. Catch at length was averaged over six month periods to derive an average monthly catch for each fishing season (summer: April to September; winter: October to May) in an attempt to integrate variable recruitment within a season.

Backward sequential population analysis requires an assumption about abundance at the oldest age (or largest size class for LVPA). Abundance of the largest size class was estimated from observed catch and F (using equation 2), and F was approximated as a log catch ratio:

$$F_t = Ln\ (C_{7+}/C_{8+}) - M \tag{5}$$

Catch at ages-7+ and age-8+ months were based on predicted size at age (Brodziak and Macy 1996, Figure 12). Catch at age 7+ was approximated from catch of 13+ cm ML for the winter fishery (summer hatched) and 16+ cm ML for the summer fishery (winter hatched). Catch at age 8+ was approximated from catch of 19+ cm ML for the winter fishery (summer hatched) and 20+ cm ML for the summer fishery (winter hatched).

Results of LVPA indicate that stock biomass fluctuated around a seasonal average of 7,700 mt, but generally decreased since 1991 (Figure 13). Four of the five most recent biomass estimates are among the lowest in the series (approximately 2,900 mt; Figure 13). Biomass estimates are substantially less than the area-swept estimates from the fall survey (Figure 7). The pattern of F at size from LVPA and predicted age at size from Brodziak and Macy (1996) indicates that 19 to 24 cm ML squid are fully-recruited to the fishery. A size of 19 cm ML corresponds to approximately age-8 months in the winter fishery and approximately age-7.5 months in the summer fishery (Table 8). Estimates of fully-recruited F (19 to 24 cm ML) averaged 1.6 over the entire time series, but were consistently lower in summer than in winter (the summer average was 1.0, and the winter average was 2.2), and generally increased since 1991 within seasons.

Results of length-based sequential population analysis are extremely sensitive to assumed growth rates (Jones 1986, Lai and Gallucci 1988, Cadrin and Estrella 1996). Sensitivity analyses were performed on summer 1998 data (average F of 19 to 24 cm ML was 1.09), using the range of M estimates reported in the last assessment (0.26 to 0.34, NEFSC 1996), a range of relative change in Δt of 50% to 150% of the deterministic estimates, and a range of relative change in terminal F values of 50% to 150% of the assumed values. Results confirm that F estimates are extremely sensitive to assumed Δt (F estimates ranged from 0.7 to 1.8), moderately sensitive to terminal F (F estimates ranged 0.8 to 1.2), and relatively robust to the assumed value of M (F estimates ranged 1.0 to 1.2; Figure 14).

Uncertainty of biomass and F estimates from LVPA were approximated using Monte Carlo methods similar to the approach used by Lai and Gallucci (1988). Relative variation from deterministic estimates of Δt were assumed to be normally distributed with a mean of 1 (no difference than the deterministic estimate) and a standard deviation of 0.1 (based on 10% relative standard error of growth in ML per month, Brodziak and Macy 1996). The level of M was assumed to vary normally (mean = 0.3, standard deviation = 0.04, based on alternative estimates of 0.26, 0.30, and 0.34, NEFSC 1996). The value of terminal F was assumed to vary normally (mean = 0.6, standard deviation = 0.15, based on variation among length samples). Results suggest that the 80% confidence interval of F is 0.94 to 1.24 (CV=11%) and the 80% confidence interval of stock biomass is 2,240 to 2,540 mt (CV=5%, Figure 15). These estimates are conditional on the assumed level and distribution of variance of input data and the assumption of no error in catch at length. The true variance of estimates is likely to be greater than indicated by these Monte Carlo results, because growth and mortality estimates were for pooled-sexes, length samples may not represent the fishery, and the variance in M and growth is probably underestimated.

There are several theoretical and practical problems with applying length-based assessment methods to squid. In a review of cephalopod stock assessment methods, Pierce and Guerra (1994) reported that results from length-based analyses are highly questionable given the extreme variability of growth rates. Another problem with length-based determinations of mortality is movement of squid in and out of fishing areas. Hatfield and Rodhouse (1994) found that commercial size frequencies provided misleading information on size structure of the *L. gahi* population. Jackson et al. (1997) observed similar biases and concluded that catch at size approaches should be abandoned for *Lolliguncula brevis*. Apparent signals in mortality from *Loligo pealeii* commercial length data may reflect rates of migration to and from fishing grounds. For example, the high estimates of F may result from a net emigration of large squid (Caddy 1991). Low sampling intensity and incomplete sampling of all market categories may also bias length-based estimates.

<u>Biological Reference Points</u> - Dynamic pool approach.

Thompson and Bell (1934) dynamic pool models were used to derive F_{max}, $F_{0.1}$ (the F at which increase in yield per unit F is decreased to 10% of the initial increase in yield from F=0 to F>0), and $F_{50\%}$ (the F that decreases mature biomass per recruit to half that of an unfished cohort). The previous assessment, which used seasonal size at age data from Brodziak and Macy (1996), preliminary maturity at age data based on proportion developing and mature (stages 3 and 4, Macy 1982), and assumed a 9 cm ML length at full recruitment, indicated that $F_{0.1}$=0.22, F_{max}=0.36, $F_{50\%}$=0.14 for summer-hatched squid; and $F_{0.1}$=0.23, F_{max}=0.38, $F_{50\%}$=0.13 for winter-hatched squid (NEFSC 1996, Brodziak 1998).

Despite variability in LVPA results, it appears that the size of full-recruitment is somewhat larger than 9 cm ML and the largest squid may be partially recruited. Dynamic pool models were revised using the seasonal fishing mortality patterns at age indicated by LVPA (Table 8), and revised estimates of maturity (stage-4) at weight data (Hatfield and Cadrin 1999). Results (in monthly fishing mortality rates) indicate that summer-hatched/winter fishery $F_{0.1}$=0.61,

F_{max}=1.24, $F_{50\%}$=0.34; winter-hatched/summer fishery $F_{0.1}$=0.39, F_{max}=0.66, $F_{50\%}$=0.21 (Table 9, Figure 16).

Uncertainty in yield per recruit estimates was assessed using Monte Carlo methods. Similar to the approach used by Restrepo and Fox (1988), uncertainty in growth and natural mortality were used to assess uncertainty in F_{max} and yield per recruit at several levels of F for the Thompson-Bell model. Relative variation from deterministic estimates of weight at age were assumed to be normally distributed with a mean of 1 (no difference than the deterministic estimate) and standard deviations of 0.20 and 0.25 for summer-hatched and winter-hatched, respectively (based on a relative standard errors of growth in g per month, Brodziak and Macy 1996). Partial recruitment (PR) was assumed to be determined by the stochastic estimate of weight at age (R^2>0.98 for both summer and winter-hatched logistic relationships between the ascending portion of PR and mean weight, Table 9). The level of M was assumed to vary normally (mean = 0.3, standard deviation = 0.04, based on alternative estimates of 0.26, 0.30, and 0.34, NEFSC 1996). Results indicate that the 80% confidence interval of F_{max} is 0.88 to 1.55 (CV=21%) for summer-hatched and 0.50 to 0.71 (CV=14%) for winter-hatched (Figure 17). Similar to Monte Carlo results for LVPA, confidence intervals for dynamic pool model estimates are conditional on the assumed level and distribution of simulated errors; true variance of estimates is probably greater than reported here.

Reported estimates of long-term potential yield (LTPY), which were derived for each seasonal cohort by applying an average area-swept survey recruitment value ($\leq$8 cm ML) to the yield-per-recruit at F_{max}, were 18,000 mt for summer-hatched squid and 3,000 mt for winter-hatched squid (NEFSC 1996, Brodziak 1998). However, the reported estimates implicitly assume that survey catchabilities were equal for the spring and fall surveys. Attempts to derive proxies for biomass reference points using average area-swept recruitment with estimates of biomass-per-recruit were considered to be unrealistically high, because the B_{MSY} proxy was substantially greater than all area-swept biomass observations from 1968 to 1997 (Applegate et al. 1998). This discrepancy suggests that area-swept survey recruitment observations ($\leq$ 8 cm ML) do not represent cohort size at month-0. The observed ages reported in Brodziak and Macy (1996) indicate that 8 cm *L. pealeii* are older than five months, and swept-area abundance of ≤ 8 cm ML individuals is likely to include several monthly cohorts thereby overestimating the average level of monthly recruitment (see Figure 12). Estimates of LTPY were not attempted for the present assessment, because reliable estimates of average monthly cohort size are not available.

<u>Estimates of Stock Size, Fishing Mortality, and Reference Points</u> - Biomass dynamics approach. Recent advances in life history information of *L. pealeii* suggest that there is a great deal of natural variability and statistical uncertainty in estimates of growth and natural mortality. Therefore, estimates of abundance and fishing mortality or biological reference points from demographic models (i.e., length-based or age-based) have a great deal of uncertainty. Surplus production models can be useful in situations where information on age structure is unavailable or unreliable, and provide an alternative perspective for stock assessment. Production models can also provide guidance on maximum sustainable yield (MSY), the biomass which could produce MSY (B_{MSY}), and fishing mortality at MSY (F_{MSY}). A study group on squid stock assessment concluded that production models are the best prospect for determining stock status (ICES 1988). Production models have provided the basis of management advice for *L. vulgaris* and *L. forbesi* (Bravo de Laguna 1989).

The previous *L. pealeii* assessment recommended investigation of a seasonal stock production model (NEFSC 1996). A production model of quarterly landings and biomass indices was explored to estimate stock biomass, fishing mortality, and maximum sustainable yield reference points. A nonequilibrium surplus production model incorporating covariates (ASPIC; Prager 1994, 1995) was applied to quarterly catch (1987 to 1998) and biomass indices. Data on the fishery prior to 1987 were excluded because of uncertainty in foreign and domestic catches (Table 1). The production model assumes logistic population growth, in which the change in stock biomass over time (dB_t/dt) is a quadratic function of biomass (B):

$$dB_t/dt = rB_t - (r/K)B^2_t \tag{5}$$

where r is the intrinsic rate of population growth, and K is carrying capacity. For a fished stock, the rate of change is also a function of catch biomass (Y):

$$dB_t/dt = rB_t - (r/K)B_t^2 - Y_t \tag{6}$$

Maximum sustainable yield reference points can be calculated from the production model parameters:

$$\text{MSY} = K\,r\,/\,4 \tag{7}$$
$$B_{MSY} = K\,/\,2 \tag{8}$$
$$F_{MSY} = r\,/\,2 \tag{9}$$

Initial biomass (expressed as a ratio to B_{MSY}: $B1R$), r, MSY, and catchability coefficients for each biomass index (q_i) were estimated using nonlinear least squares of survey residuals (Prager 1994).

Potential biomass indices for *L. pealeii* are standardized CPUE, NEFSC spring, fall and winter surveys, and the Massachusetts spring survey. Several combinations of biomass indices were attempted for alternative production analyses and are reported as sensitivity analyses. The most acceptable configuration tuned biomass estimates to NEFSC spring and fall survey indices and the two seasonal CPUE series based on interview data. A small portion of total variance in the biomass indices was explained by the model ($R^2 = 0.0$ to 0.3), but model residuals appear to be randomly distributed (Appendix B).

The production model suggests that MSY is 4,900 mt per quarter (19,600 mt per year; Appendix B, Figure 18). Performance of ASPIC on simulated data indicates that ratios to MSY reference points (Bratio: B_t/B_{MSY} and Fratio: F_t/F_{MSY}) are generally more reliable than absolute estimates of biomass or F, particularly when the observed dynamic range is limited (Prager et al. 1996, NRC 1998, Prager 1998). Estimates of absolute biomass from ASPIC (Appendix B) are generally lower than area-swept biomass estimates from the fall survey (i.e., $q_{fall} > 1$), but greater than those from LVPA. The range of *L. pealeii* biomass estimates represents 44% of the potential dynamic range (0 to K). Therefore, in lieu of reliable information on absolute levels of stock biomass, ratios to MSY conditions (i.e., Bratio = B_t/B_{MSY}; Fratio = F_t/F_{MSY}) should be used for assessing trends in biomass and F.

The production model indicates that stock biomass fluctuated around B_{MSY} from the late 1980s to the early 1990s, decreased to low levels in the late 1990s, and was approximately 60% of B_{MSY} at the beginning of 1999 (Figure 19). Fishing mortality was generally greater in winter than in summer.

Survey residuals were randomly resampled 500 times to derive probability distributions of parameter estimates and derived variables. Variance of estimates was evaluated using bias-corrected bootstrap percentiles (Manly 1997). Bootstrap results suggest that MSY is well estimated (the relative interquartile range was 7%). Biological reference points, other model parameters , and current F and biomass ratios were estimated with moderate precision (IQRs were 44% to 60%; Appendix B). The most recent Fratio (fourth quarter of 1998) was 1.7 with an 80% confidence limit of 1.1 to 3.0 (Figure 20), and the most recent Bratio (January, 1999) was 0.57 with an 80% confidence limit of 0.27 to 0.94. Therefore, despite low precision in estimates of current biomass and F, the model indicates that there is approximately 90% chance that F is greater than F_{MSY} and biomass is less than B_{MSY}. However, a relatively large portion of bootstrap trials (approximately 10%) were replaced for lack of convergence.

Stochastic, 3-year projections of ASPIC results were performed assuming status quo F (estimated as seasonal averages from 1994 to 1998) in 1999. Three alternative F scenarios were forecasted for 2000-2001: status quo F, the Amendment 8 overfishing definition (F_{MSY}), and target F (75% F_{MSY}). Projected biomass was extremely variable, particularly for the status quo projection. At $F_{94\text{-}98}$, biomass is projected to fluctuate at slightly less than 50% B_{MSY} (Figure 21a), yielding approximately 4,000 mt per quarter (16,000 mt per year; Figure 21b). At F_{MSY}, the stock is projected to increase, with quarterly yield increasing to more than 4,000 mt per quarter (17,800 mt per year), but with low probability of attaining B_{MSY} by the year 2002 (Figure 21). At 75% F_{MSY}, the stock is projected to increase more rapidly, with quarterly yield increasing to more than 4,000 mt per quarter (17,000 mt per year), and high probability of attaining B_{MSY} by the year 2002 (Figure 21).

Results from alternative production analyses show that the winter survey series, the Massachusetts survey series, and CPUE estimates derived from logbook data do not fit the model well (Table 10). The winter and Massachusetts surveys may sample an unrepresentative geographic portion of total stock area, and logbook effort may not be reliable (as demonstrated by other stock assessments; NEFSC 1997, Mayo 1998). Despite poor statistical fit, estimates of MSY from runs 4T, 3S, and 3M are similar to those from models with good fit (runs 3T and 2S; approximately 5,000 mt), and all alternative analyses indicated that current biomass was low relative to B_{MSY}, and current F is high relative to F_{MSY}. Mean square error and bootstrap variance for run 2S was slightly greater than the results for run 3T. Run 2C was considered to be the most reliable, because it did not assume equal catchability of winter and summer fishing effort.

A second set of alternative ASPIC analyses were conducted to investigate sensitivity of estimates to values of survey catchability, because the model estimate of q_{fall} (2.4) is unrealistically high. Three alternative model solutions were performed with catchability for the fall survey set at 1.0, 0.9, and 0.8 to assume complete sampling efficiency during daytime, 90% efficiency, and 80% efficiency, respectively. Setting q_{fall} to lower than 0.8 resulted in unstable solutions. As expected, estimates of biomass, MSY and B_{MSY} are inversely proportional to the assumed value of q_{fall}, but the perception of current stock status worsens as q_{fall} decreases (i.e., B_{1999}/B_{MSY} decreases and F_{1998}/F_{MSY} increases; Table 11). Model variance is greater when q_{fall} is removed from the estimation, and increases from the as the assumed value of q_{fall} decreases. For example, 15% of bootstrap trials did not converge, and the 80% confidence interval of MSY was 4,620 mt to 47,220 mt (IQR=288%) when q_{fall} was assumed to be 1.0. Results from these alternative analyses suggest that the best ASPIC solution (Appendix B) may underestimate MSY and may be overly optimistic with respect to current stock conditions.

The previous stock assessment of *L. pealeii* further recommended that season-specific production functions should be investigated, because growth of summer-hatched squid was greater than growth of winter-hatched squid, and apparent biomass is consistently greater from the fall survey than the spring survey (NEFSC 1996, Brodziak 1998). It is possible that ASPIC explained a small portion of total variance in observed biomass indices because it assumed constant production parameters. A model building exercise was conducted to test for changes in production parameters using an approach described by Fournier (1999). The parameters $B1$, r, K, and q_i were set at the estimated values for a 'second phase' of estimation to evaluate the effect of an additional parameter that accounts for seasonal change in r. The parameter r was assumed to vary over time according to a time vector of quantities r_t consisting of an overall mean r and a set of deviations (δ_t) from the mean, where t is a quarter-year time step (1 to 4):

$$r_t = r + \delta_t \qquad \text{where } {}^t\textstyle\sum \delta_t = 0 \tag{10}$$

A regular pattern of δ_t was assumed:

$$\delta_t = s \cdot \cos\,(t \cdot \pi/2) \tag{11}$$

and

$$r_t = r + s \cdot \cos\,(t \cdot \pi/2) \tag{12}$$

where s is the maximum absolute seasonal deviation from r. This assumes that r_t is at the greatest value ($r + s$) during the fourth quarter (i.e., during the fall survey of summer-hatched individuals); r_t is at the lowest value ($r - s$) during the second quarter (i.e., during the spring survey of winter-hatched individuals); and r_t is average ($r + 0$) during the first and third quarters (Figure 22).

The parameter s was estimated by minimizing lognormal residuals (ϵ) of a discrete-time approximation of equation 6:

$$B_{t+1} = B_t + r_t B_t - (r_t/K)B_t^2 - Y_t + e^{\epsilon} \tag{13}$$

Residual sum of squares was minimized at a solution of $s = 0.0017$ (Figure 23), which implies that $r_t = 0.516$ in the spring and 0.519 in the fall, and MSY is only slightly greater in the fall (5,040 mt) than in the spring (5,010 mt). The estimated biomass trajectory from the seasonal production model was nearly identical to the estimates in Appendix B (Figure 24). However, the reduction in mean square error was insignificant (P=0.53, F-test, Sokal and Rohlf 1995), and adding the parameter was not a significant improvement to the model.

Another production parameter that may vary seasonally is the carrying capacity (K), because the available resources and density dependent effects may change as squid move from inshore, summer habitats to offshore, winter habitats. A parameter k, the maximum absolute deviation from K, was also tested using second stage estimation:

$$K_t = K + k \cdot \cos(t \cdot \pi/2) \tag{14}$$

Similar to the results for s, the estimated value of k was relatively small (<2,000 mt), and adding the parameter did not result in a significant improvement to the model. Estimating both s and k simultaneously was also attempted, but solutions were similar to those from separate estimations (Figure 25). Less restrictive patterns of seasonal deviations than the simple cosine amplitude parameter were unsuccessful, because converged solutions could not be found. More complicated models included adding four parameters (i.e., δ_{spring}, δ_{summer}, δ_{fall}, δ_{winter}) and adding two parameters for amplitude (s) and phase (c, where $\delta_t = s \cdot \cos[(t+c) \cdot \pi/2]$) were attempted but could not converge on a solution.

Presumably, if population growth was substantially greater in the fall than in the spring, the revised models would explain a significantly greater portion of variance in biomass indices. It appears that resolution in biomass indices is not sufficient to detect a significant seasonal difference in productivity. Perhaps the disparate components of production (e.g., natural mortality rate, reproductive rate) offset seasonal differences in individual growth rate and geographic ranges. However, results of second stage estimations are conditional on the accuracy of results from the first stage (Appendix B). A more fruitful extension of the simple production model may be to incorporate response to trends in predator biomass.

DISCUSSION

Although advances have been made in understanding the life history of *Loligo pealeii*, data on age and growth are extremely variable. Length-based population estimates may not be reliable, because they are sensitive to differences in assumed growth rates. The surplus production model could only explain a small portion of variance in biomass indices, and survey catchability estimates from the model are probably unrealistic. Sensitivity analyses assuming lower catchability indicate that production model results may be overly optimistic. Estimates of F may also be biased high due to stock outside the shelf and to the south (outside the range of the survey). However, the NEFSC fall, winter and spring survey data, estimated trends and ratios (such as B/Bmsy) from the surplus production model runs, and trends from length based virtual population analyses all indicate declines in stock size across broad geographic areas since 1990. Massachusetts survey data indicate low abundance locally since 1991. The decline in abundance, together with relatively stable catches, likely resulted in increased exploitation rates after 1990.

There may be some biological basis for the dome-shaped PR used in the yield and spawning biomass per recruit model. Possible reasons included net avoidance, behavioral changes with size, distribution differences, and reduced fishing effort in spawning areas (e.g., many inshore trawling closures and winter refuges in southern or deep waters).

Predation is an important component of squid mortality that was not explicitly considered. The variation in predation may account for some of the variability in the model results. The impact of predation should be considered when developing management advice. Predation may be highly density dependent. Therefore, models with compensatory assumptions, such as ASPIC, may be appropriate.

An implication of the apparent seasonal complexity of reproductive dynamics is that effort should be distributed throughout the year. Spawning occurs year round and removing too much biomass during one period could have negative impacts on the life cycles. *L. pealeii* are a continuous rather than time segregated population. In the last 5-7 years, the survey indices have suggested low recruitment. Improving recruitment should be an objective of management. Managers may want to consider a management approach which optimizes escapement to ensure continued recruitment.

The current overfishing definitions may be inappropriate. Estimates of F_{max} may be poor proxies for F_{MSY}, because F_{max} is poorly determined and the approach ignores a stock recruit relationship. The associated risk of overfishing may be unacceptable. Additive swept-area estimates may be a poor proxy for B_{MSY}. The apparent resilience of this stock suggests that the stock can rebuild from low stock sizes at low to moderate F, and a target F of zero at 50% B_{MSY} may be overly conservative.

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Table 1. Estimates of *Loligo pealei* annual landings (thousand mt). Estimates for 1982-1998 are from dealer weighout records and include prorated unspecified squid landings.

Year	U.S.	Foreign	Total
1963	1.294	0.000	1.294
1964	0.576	0.002	0.578
1965	0.709	0.099	0.808
1966	0.772	0.226	0.998
1967	0.547	1.130	1.677
1968	1.084	2.327	3.411
1969	0.899	8.643	9.542
1970	0.653	16.732	17.385
1971	0.727	17.442	18.169
1972	0.725	29.009	29.734
1973	1.105	36.508	37.613
1974	2.274	32.576	34.850
1975	1.621	32.180	33.801
1976	3.602	21.682	25.284
1977	1.088	15.586	16.674
1978	1.291	9.355	10.646
1979	4.252	13.068	17.320
1980	3.996	19.750	23.746
1981	2.316	20.212	22.528
1982	2.848	15.805	18.653
1983	10.867	11.720	22.587
1984	7.689	11.031	18.720
1985	6.899	6.549	13.448
1986	11.525	4.598	16.123
1987	10.367	0.002	10.369
1988	18.593	0.003	18.596
1989	23.733	0.005	23.738
1990	15.399	0.000	15.399
1991	20.299	0.000	20.299
1992	19.018	0.000	19.018
1993	23.020	0.000	23.020
1994	23.480	0.000	23.480
1995	18.880	0.000	18.880
1996	12.026	0.000	12.026
1997	16.308	0.000	16.308
1998	18.385	0.000	18.385
average	8.024	9.062	17.086

Table 2. Estimates of *Loligo pealei* quarterly landings (thousand mt) from dealer weighout records, including prorated unspecified squid landings.

	quarter					quarter				
year	1	2	3	4	sum	1	2	3	4	sum
1987	2.505	4.265	1.815	1.782	10.367	24%	41%	18%	17%	100%
1988	3.404	7.589	3.451	4.149	18.593	18%	41%	19%	22%	100%
1989	9.838	6.919	1.164	5.812	23.733	41%	29%	5%	24%	100%
1990	4.538	3.847	2.933	4.081	15.399	29%	25%	19%	27%	100%
1991	2.877	6.297	3.443	7.682	20.299	14%	31%	17%	38%	100%
1992	7.211	3.531	2.061	6.214	19.018	38%	19%	11%	33%	100%
1993	11.438	4.736	1.725	5.121	23.02	50%	21%	7%	22%	100%
1994	4.762	2.285	6.603	9.830	23.48	20%	10%	28%	42%	100%
1995	5.815	3.820	3.933	5.312	18.88	31%	20%	21%	28%	100%
1996	5.201	4.648	1.019	1.158	12.026	43%	39%	8%	10%	100%
1997	3.347	2.961	2.753	7.248	16.308	21%	18%	17%	44%	100%
1998	10.479	1.976	1.099	4.831	18.385	57%	11%	6%	26%	100%
average	5.951	4.406	2.667	5.268	18.292	32%	25%	15%	28%	

Table 3. Geographic distribution of *Loligo pealei* quarterly landings from dealer weighout records and logbook data.

1994			quarter		
area	1	2	3	4	sum
52	2%	0%	0%	0%	2%
53	4%	4%	15%	9%	32%
61	9%	2%	12%	18%	41%
62	5%	2%	1%	11%	19%
63	0%	2%	1%	3%	6%
sum	20%	10%	28%	42%	100%

1995			quarter		
area	1	2	3	4	sum
52	3%	2%	0%	0%	5%
53	7%	8%	6%	3%	24%
61	12%	6%	9%	9%	37%
62	9%	4%	5%	14%	31%
63	0%	0%	0%	2%	3%
sum	31%	20%	21%	28%	100%

1996			quarter		
area	1	2	3	4	sum
52	12%	1%	0%	0%	13%
53	22%	1%	0%	0%	23%
61	42%	0%	0%	0%	43%
62	18%	0%	0%	0%	19%
63	1%	0%	0%	0%	2%
sum	97%	2%	0%	1%	100%

1997			quarter		
area	1	2	3	4	sum
52	0%	1%	0%	0%	1%
53	3%	10%	2%	8%	24%
61	7%	6%	11%	27%	51%
62	10%	1%	3%	6%	20%
63	0%	0%	0%	3%	4%
sum	21%	18%	17%	44%	100%

1998			quarter		
area	1	2	3	4	sum
52	5%	0%	0%	8%	13%
53	13%	2%	1%	6%	23%
61	23%	3%	3%	6%	35%
62	15%	5%	1%	2%	23%
63	0%	0%	0%	4%	5%
sum	57%	11%	6%	26%	100%

Table 4a. Samples of *Loligo pealeii* catch at length (number of lengths measured).

		market category						
		8010	8011	8012	8013	8014	8015	
year	quarter	unclassified	large	small	medium	booger	extra large	sum
1987	1	518	49					567
	2	1063						1063
	3	310						310
	4	558						558
1988	1	510						510
	2	1665						1665
	3	519						519
	4	459						459
1989	1	892						892
	2	1682						1682
	3	763						763
	4	1118						1118
1990	1	1331						1331
	2	1760	50					1810
	3	658	52					710
	4	1154	50					1204
1991	1	756	152					908
	2	1214	50					1264
	3	600	50					650
	4	1056						1056
1992	1	954						954
	2	929	50					979
	3	975						975
	4	994						994
1993	1	968						968
	2	584	151					735
	3	351						351
	4	815						815
1994	1	766						766
	2	638		50				688
	3	1034	212	119	253			1618
	4	1024	104	167	68		32	1395
1995	1	1020	731	315	481			2547
	2	555	275					830
	3	542						542
	4	253	94					347
1996	1	1588	315					1903
	2	388	50					438
	3	636	111					747
	4	2509	757					3266
1997	1	3082	770	836				4688
	2	2603	198	100	100	100		3101
	3	1451	591	100				2142
	4	1823	206	100		100		2229
1998	1	3533	1344	106				4983
	2	998	199					1197
	3	414						414
sum		50013	6611	1893	902	200	32	59651

Table 4b. Proportion of *L. pealei* quarterly landings by market category.

		market category						
		8010	8011	8012	8013	8014	8015	
year	quarter	unclass.	large	small	medium	booger	extra large	sum
1987	1	0.94	0.04	0.02	0.00	0.00	0.00	1.00
	2	0.95	0.04	0.01	0.00	0.00	0.00	1.00
	3	0.98	0.02	0.00	0.00	0.00	0.00	1.00
	4	0.95	0.01	0.04	0.00	0.00	0.00	1.00
1988	1	0.83	0.05	0.12	0.00	0.00	0.00	1.00
	2	0.97	0.02	0.00	0.00	0.00	0.00	1.00
	3	0.83	0.02	0.15	0.00	0.00	0.00	1.00
	4	0.67	0.06	0.27	0.00	0.00	0.00	1.00
1989	1	0.66	0.05	0.29	0.00	0.00	0.00	1.00
	2	0.93	0.03	0.05	0.00	0.00	0.00	1.00
	3	0.89	0.02	0.08	0.00	0.00	0.00	1.00
	4	0.80	0.04	0.16	0.00	0.00	0.00	1.00
1990	1	0.89	0.05	0.03	0.03	0.00	0.00	1.00
	2	0.92	0.04	0.01	0.02	0.00	0.01	1.00
	3	0.93	0.03	0.02	0.00	0.01	0.00	1.00
	4	0.84	0.06	0.07	0.02	0.01	0.00	1.00
1991	1	0.89	0.06	0.02	0.01	0.02	0.00	1.00
	2	0.89	0.07	0.01	0.02	0.01	0.00	1.00
	3	0.97	0.03	0.00	0.00	0.00	0.00	1.00
	4	0.96	0.04	0.00	0.00	0.00	0.00	1.00
1992	1	0.97	0.03	0.00	0.00	0.00	0.00	1.00
	2	0.95	0.05	0.00	0.00	0.00	0.00	1.00
	3	0.97	0.03	0.00	0.00	0.00	0.00	1.00
	4	0.98	0.01	0.00	0.00	0.00	0.00	1.00
1993	1	0.95	0.02	0.01	0.02	0.00	0.00	1.00
	2	0.93	0.05	0.00	0.02	0.00	0.00	1.00
	3	0.96	0.02	0.00	0.02	0.00	0.00	1.00
	4	0.89	0.07	0.01	0.03	0.00	0.00	1.00
1994	1	0.81	0.09	0.04	0.02	0.04	0.00	1.00
	2	0.72	0.14	0.05	0.04	0.04	0.02	1.00
	3	0.84	0.05	0.05	0.05	0.01	0.00	1.00
	4	0.70	0.16	0.05	0.04	0.04	0.00	1.00
1995	1	0.57	0.10	0.10	0.07	0.15	0.00	1.00
	2	0.73	0.09	0.05	0.04	0.08	0.01	1.00
	3	0.54	0.11	0.11	0.22	0.02	0.00	1.00
	4	0.68	0.07	0.14	0.05	0.05	0.00	1.00
1996	1	0.63	0.08	0.15	0.08	0.06	0.00	1.00
	2	0.53	0.20	0.10	0.15	0.01	0.01	1.00
	3	0.74	0.20	0.01	0.01	0.04	0.00	1.00
	4	0.82	0.04	0.08	0.02	0.04	0.00	1.00
1997	1	0.72	0.06	0.14	0.03	0.05	0.00	1.00
	2	0.69	0.12	0.09	0.06	0.03	0.00	1.00
	3	0.69	0.11	0.11	0.04	0.05	0.00	1.00
	4	0.67	0.07	0.11	0.05	0.10	0.00	1.00
1998	1	0.60	0.07	0.15	0.07	0.11	0.00	1.00
	2	0.54	0.16	0.12	0.10	0.07	0.01	1.00
	3	0.76	0.13	0.04	0.02	0.05	0.00	1.00
	4	0.54	0.08	0.16	0.05	0.17	0.00	1.00
sum		0.80	0.06	0.07	0.03	0.03	0.00	1.00

Table 5. Observed trips, kept catch (kept mt), discarded catch (disc. mt), and discard ratios from all otter trawl trips that landed *Loligo pealeii.*

		quarter				
year		1	2	3	4	sum
1989	# trips	14	20	30	25	89
	mt kept	24.1	17.2	7.2	25.1	73.6
	mt disc	1.5	0.3	4.1	1.3	7.2
	ratio	0.06	0.02	0.57	0.05	0.10
1990	# trips	14	23	8	27	72
	mt kept	17.5	5.9	0.1	4.5	27.8
	mt disc	0.7	0.2	0.0	1.4	2.3
	ratio	0.04	0.03	0.35	0.32	0:08
1991	# trips	23	17	20	72	132
	mt kept	12.0	5.9	37.6	71.5	126.9
	mt disc	0.9	0.4	1.1	2.8	5.2
	ratio	0.07	0.07	0.03	0.04	0.04
1992	# trips	45	12	10	26	93
	mt kept	39.7	1.4	0.9	28.2	70.1
	mt disc	2.7	0.1	1.1	1.5	5.4
	ratio	0.07	0.06	1.21	0.05	0.08
1993	# trips	14	24	12	22	72
	mt kept	25.2	2.4	2.4	7.4	37.5
	mt disc	1.5	0.1	2.3	1.4	5.3
	ratio	0.06	0.03	0.97	0.19	0.14
1994	# trips	18	15	18	25	76
	mt kept	13.9	1.3	0.1	5.8	21.1
	mt disc	0.8	0.5	0.0	0.7	2.0
	ratio	0.06	0.35	0.26	0.12	0.10
1995	# trips	25	39	40	39	143
	mt kept	3.3	6.0	10.9	1.3	21.6
	mt disc	1.0	0.4	0.5	0.2	2.1
	ratio	0.30	0.06	0.05	0.16	0.10
1996	# trips	12	38	39	34	123
	mt kept	12.6	6.2	4.4	3.9	27.1
	mt disc	0.7	0.2	0.2	0.1	1.2
	ratio	0.05	0.03	0.05	0.02	0.04
1997	# trips	33	16	20	5	74
	mt kept	15.8	3.8	26.6	8.3	54.4
	mt disc	2.3	0.4	1.3	0.0	4.0
	ratio	0.15	0.09	0.05	0.00	0.07
1998	# trips	27	7	6	1	41
	mt kept	70.1	11.7	1.8	0.0	83.6
	mt disc	0.5	0.0	0.0	0.0	0.5
	ratio	0.01	0.00	0.00	0.00	0.01
sum	# trips	225	211	203	276	915
	mt kept	234.1	61.9	92.0	156.0	543.9
	mt disc	12.5	2.5	10.7	9.4	35.1
	ratio	0.05	0.04	0.12	0.06	0.06

Table 6. NEFSC survey estimates *Loligo pealeii* biomass (B in thousand mt), abundance (N in millions), abundance of precrecruits (prerec; ≤ 8 cm ML), and abundance of recruits (> 8 cm ML). Catch data are adjusted for season-specific diel differences and exclude short tows. Strata for spring and winter survey indices are 1-23, 25, 61-76, and strata for winter survey indices are 1-17, 61-76. Fall plus following spring biomass for annual assessment of stock biomass relative to the Amendment #8 B_{MSY} proxy (80,000 mt).

year	fall B	fall N	fall prerec	fall recruit	winter B	winter N	winter prerec	winter recruit	spring B	spring N	spring prerec	spring recruit	fall + spring B
1967	20.9	917	747	171	----	----	----	----	----	----	----	----	----
1968	35.2	1155	807	348	----	----	----	----	6.5	130	42	88	27.5
1969	45.6	1542	1098	444	----	----	----	----	4.3	67	11	56	39.5
1970	21.2	723	504	218	----	----	----	----	3.7	120	81	39	49.2
1971	14.8	936	784	153	----	----	----	----	6.8	156	94	62	28.0
1972	40.8	2143	1804	340	----	----	----	----	12.5	302	176	126	27.3
1973	60.9	2502	1880	622	----	----	----	----	11.6	194	91	103	52.4
1974	51.2	2129	1668	461	----	----	----	----	17.5	1043	890	153	78.4
1975	72.7	4261	3640	620	----	----	----	----	18.0	744	571	173	69.2
1976	64.9	3220	2604	616	----	----	----	----	23.2	967	760	207	96.0
1977	52.2	2909	2440	468	----	----	----	----	3.8	82	45	37	68.7
1978	25.8	1078	788	290	----	----	----	----	5.8	236	179	57	58.0
1979	26.1	1658	1449	208	----	----	----	----	9.8	495	417	78	35.6
1980	48.7	5850	5369	481	----	----	----	----	7.6	249	181	68	33.8
1981	31.9	1581	1246	336	----	----	----	----	7.8	224	138	86	56.5
1982	39.8	2085	1811	274	----	----	----	----	8.9	338	236	102	40.8
1983	62.1	2613	1918	695	----	----	----	----	10.6	234	95	138	50.3
1984	69.4	2134	1292	842	----	----	----	----	11.8	352	246	106	73.9
1985	69.2	3349	2634	715	----	----	----	----	9.6	407	310	98	79.0
1986	52.6	2995	2501	495	----	----	----	----	13.1	471	337	134	82.2
1987	12.8	464	330	134	----	----	----	----	8.7	145	63	82	61.3
1988	47.7	3029	2586	443	----	----	----	----	15.8	591	429	162	28.6
1989	63.3	2933	2155	779	----	----	----	----	21.5	695	423	273	69.2
1990	55.9	2781	2218	563	----	----	----	----	15.4	634	480	154	78.7
1991	53.6	2374	1744	630	----	----	----	----	19.2	852	634	218	75.1
1992	43.2	5273	5064	208	7.2	216	146	70	10.2	403	313	91	63.8
1993	25.9	1058	718	339	14.7	510	299	211	8.1	227	131	96	51.3
1994	80.4	3342	2465	878	7.3	222	150	72	4.7	161	113	48	30.6
1995	33.1	2078	1788	290	12.5	387	225	162	8.8	321	225	96	89.2
1996	18.0	1068	890	178	8.9	267	149	117	2.6	118	92	26	35.7
1997	36.1	1919	1566	352	6.6	221	130	90	8.7	382	271	111	26.7
1998	25.0	1368	1084	284	5.9	168	84	83	5.9	286	216	70	42.0
mean	43.8	2296	1862	434	9.0	284	169	115	10.4	375	267	108	54.8

Table 7. Massachusetts spring survey indices of *Loligo pealei* abundance and biomass (strata 11-21).

year	#/tow	kg/tow
1978	11.3	1.1
1979	47.4	3.9
1980	38.0	5.0
1981	11.5	1.1
1982	15.5	1.3
1983	85.8	6.7
1984	61.9	4.3
1985	113.3	7.0
1986	48.9	6.2
1987	59.8	5.9
1988	255.5	15.9
1989	64.9	5.5
1990	136.3	8.9
1991	43.2	4.3
1992	10.8	1.2
1993	22.5	3.4
1994	17.5	1.4
1995	117.4	4.7
1996	30.8	3.1
1997	29.2	1.4
1998	46.3	0.8
average	60.4	4.4

Table 8. Estimates of seasonal age at length (from Brodziak and Macy 1996), duration of 2-mm size classes (Δt), and partial recruitment (PR) from length cohort analysis, 1987-1998.

Winter Fishery (summer hatched)

ML (cm)	Δt	predicted age (m)	geo.mean F	PR
9.5	0.49	6.2	0.11	0.05
11.5	0.41	6.7	0.32	0.15
13.5	0.35	7.1	0.64	0.31
15.5	0.31	7.5	1.01	0.48
17.5	0.28	7.8	1.39	0.66
19.5	0.25	8.1	2.11	1.00
21.5	0.23	8.3	2.17	1.00
23.5	0.21	8.5	2.01	1.00
25.5	0.19	8.7	1.85	0.88
27.5	0.18	8.9	1.09	0.52

Summer Fishery (winter hatched)

ML (cm)	Δt	predicted age (m)	geo.mean F	PR
9.5	0.37	5.8	0.11	0.11
11.5	0.35	6.2	0.31	0.32
13.5	0.33	6.6	0.50	0.52
15.5	0.32	6.9	0.59	0.62
17.5	0.31	7.2	0.74	0.78
19.5	0.30	7.5	0.93	1.00
21.5	0.30	7.8	0.95	1.00
23.5	0.30	8.1	1.00	1.00
25.5	0.31	8.4	0.81	0.85
27.5	0.31	8.7	0.58	0.60

Table 9a. Yield and spawning biomass per recruit for summer-hatched (winter fishery) *Loligo pealeii*.

```
The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
  PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
             ----------------------------------------
             Run Date:  1- 6-1999;  Time: 11:08:44.55
LOLIGO summer hatched (winter fishery) - SAW29

Proportion of F before spawning: 1.0000
Proportion of M before spawning: 1.0000
Natural Mortality is Constant at:  .300
Initial age is:  1; Last age is:  9
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> LOLIGOS.DAT
```

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	.0000	1.0000	.0000	.000	.000
2	.0000	1.0000	.0000	.001	.001
3	.0000	1.0000	.0000	.002	.002
4	.0000	1.0000	.2000	.006	.006
5	.0000	1.0000	.3000	.017	.017
6	.0500	1.0000	.7000	.056	.056
7	.3000	1.0000	1.0000	.134	.134
8	1.0000	1.0000	1.0000	.255	.255
9+	.5000	1.0000	1.0000	.409	.409

```
Summary of Yield per Recruit Analysis for:
LOLIGO summer hatched (winter fishery) - SAW29

 Slope of the Yield/Recruit Curve at F=0.00: -->        .0950
   F level at slope=1/10 of the above slope (F0.1): ----->     .609
     Yield/Recruit corresponding to F0.1: ----->        .0217
   F level to produce Maximum Yield/Recruit (Fmax): ----->   1.243
     Yield/Recruit corresponding to Fmax: ----->        .0238
   F level at 50 % of Max Spawning Potential (F50): ----->     .335
     SSB/Recruit corresponding to F50: -------->        .0768
```

Listing of Yield per Recruit Results for:
LOLIGO summer hatched (winter fishery) - SAW29

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.000	.00000	.00000	3.8583	.2185	.7154	.1535	100.00
	.100	.02623	.00773	3.7716	.1839	.6290	.1214	79.03
	.200	.04545	.01287	3.7084	.1589	.5660	.0985	64.13
	.300	.06005	.01636	3.6606	.1402	.5184	.0816	53.17
F50%	.335	.06439	.01732	3.6464	.1347	.5043	.0768	50.00
	.400	.07147	.01878	3.6234	.1258	.4814	.0690	44.91
	.500	.08061	.02047	3.5937	.1145	.4520	.0592	38.53
	.600	.08808	.02164	3.5696	.1054	.4282	.0515	33.53
F0.1	.609	.08872	.02173	3.5676	.1046	.4262	.0509	33.12
	.700	.09429	.02245	3.5498	.0980	.4085	.0454	29.56
	.800	.09953	.02300	3.5331	.0919	.3921	.0405	26.35
	.900	.10400	.02336	3.5189	.0868	.3782	.0364	23.73
	1.000	.10787	.02359	3.5068	.0826	.3662	.0331	21.57
	1.100	.11126	.02371	3.4962	.0789	.3559	.0304	19.77
	1.200	.11424	.02375	3.4869	.0758	.3469	.0280	18.26
Fmax	1.243	.11542	.02376	3.4833	.0746	.3433	.0272	17.69
	1.300	.11690	.02374	3.4787	.0731	.3389	.0261	16.98
	1.400	.11929	.02369	3.4713	.0707	.3318	.0244	15.89
	1.500	.12145	.02362	3.4647	.0686	.3254	.0230	14.95

Table 9b. Yield and spawning biomass per recruit for winter-hatched (summer fishery) *Loligo pealeii.*

```
 The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
  PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
            -------------------------------------
           Run Date:  1- 6-1999;  Time: 11:09:15.80
LOLIGO winter hatched (summer fishery) - SAW29

Proportion of F before spawning: 1.0000
Proportion of M before spawning: 1.0000
Natural Mortality is Constant at:  .300
Initial age is:  1; Last age is:  9
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> LOLIGOW.DAT
```

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	.0000	1.0000	.0000	.000	.000
2	.0000	1.0000	.0000	.001	.001
3	.0000	1.0000	.0000	.002	.002
4	.0000	1.0000	.0500	.006	.006
5	.0000	1.0000	.1000	.016	.016
6	.3000	1.0000	.2000	.036	.036
7	.7000	1.0000	.5500	.077	.077
8	1.0000	1.0000	.8500	.152	.152
9+	.6000	1.0000	.9800	.283	.283

```
Summary of Yield per Recruit Analysis for:
LOLIGO winter hatched (summer fishery) - SAW29

 Slope of the Yield/Recruit Curve at F=0.00: -->        .0772
   F level at slope=1/10 of the above slope (F0.1): ----->     .386
     Yield/Recruit corresponding to F0.1: ----->        .0118
   F level to produce Maximum Yield/Recruit (Fmax): ----->     .655
     Yield/Recruit corresponding to Fmax: ----->        .0126
   F level at 50 % of Max Spawning Potential (F50): ----->     .205
     SSB/Recruit corresponding to F50: -------->        .0452
```

Listing of Yield per Recruit Results for:
LOLIGO winter hatched (summer fishery) - SAW29

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.000	.00000	.00000	3.8583	.1477	.4690	.0905	100.00
	.100	.03660	.00582	3.7374	.1160	.3615	.0635	70.11
	.200	.06203	.00908	3.6538	.0946	.2895	.0460	50.83
F50%	.205	.06318	.00921	3.6500	.0937	.2863	.0452	49.99
	.300	.08062	.01091	3.5929	.0796	.2390	.0342	37.83
F0.1	.386	.09298	.01180	3.5526	.0700	.2068	.0270	29.86
	.400	.09474	.01190	3.5469	.0686	.2023	.0260	28.78
	.500	.10582	.01240	3.5110	.0604	.1748	.0202	22.31
	.600	.11473	.01259	3.4824	.0540	.1538	.0159	17.60
Fmax	.655	.11889	.01261	3.4690	.0512	.1444	.0141	15.57
	.700	.12205	.01260	3.4589	.0491	.1374	.0128	14.11
	.800	.12819	.01250	3.4394	.0451	.1244	.0104	11.47
	.900	.13341	.01234	3.4229	.0419	.1139	.0086	9.47
	1.000	.13792	.01214	3.4087	.0393	.1053	.0072	7.91
	1.100	.14185	.01192	3.3964	.0371	.0982	.0061	6.70
	1.200	.14533	.01170	3.3856	.0353	.0923	.0052	5.74
	1.300	.14844	.01149	3.3760	.0338	.0872	.0045	4.98
	1.400	.15123	.01128	3.3674	.0324	.0829	.0039	4.36
	1.500	.15376	.01108	3.3597	.0313	.0792	.0035	3.86

Table 10. Summary of results from alternative configurations of biomass indices for surplus production analysis of *Loligo pealeii* (MSY in thousand mt; Bratio: January 1999 biomass/B_{MSY}; Fratio: fourth quarter 1998 F/F_{MSY}; MSE: mean square error).

run	biomass indices	MSY	Bratio	Fratio	MSE	notes
5	all available indices					negative correlations
6	split CPUE index (87-93, 94-98)					negative correlations
4T	spring, fall, winter, CPUE 87-93	4.95	0.48	1.95	0.21	negative Rsquare
4S	spring, fall, winter, & Mass	3.65	0.38	3.31	0.32	negative Rsquare
3S	spring, fall & winter	4.95	0.56	1.68	0.24	negative Rsquare
3M	spring,fall & Mass	4.67	0.43	2.27	0.37	negative Rsquare
3T	CPUE 87-93, spring & fall	5.03	0.51	1.82	0.22	
2C	seasonal CPUEs, spring & fall	4.91	0.57	1.66	0.19	Appendix B
2S	spring & fall	5.13	0.69	1.36	0.25	

Table 11. Summary of results from alternative surplus production analyses of *L. pealei* with freely estimated catchability for the fall survey (qfall=2.4), and catchability set at 1.0, 0.9 and 0.8 (MSY and Bmsy in thousand mt; Bratio: January 1999 biomass/B_{MSY}; Fratio: fourth quarter 1998 F/F_{MSY}; SSE: sum of squared error).

q(fall)	**2.4**	**1.0**	**0.9**	**0.8**
MSY	5.03	6.94	8.38	14.64
Bmsy	19.12	92.82	133.90	292.70
Fmsy	0.26	0.07	0.06	0.05
q(cpue)	0.16	0.07	0.06	0.05
q(spring)	0.69	0.27	0.24	0.21
Bratio	0.51	0.23	0.17	0.09
Fratio	1.80	2.95	3.18	3.55
SSE(cpue)	5.011	5.167	5.213	5.257
SSE(spring)	2.342	2.593	2.611	2.637
SSE(fall)	2.688	2.869	2.885	2.900

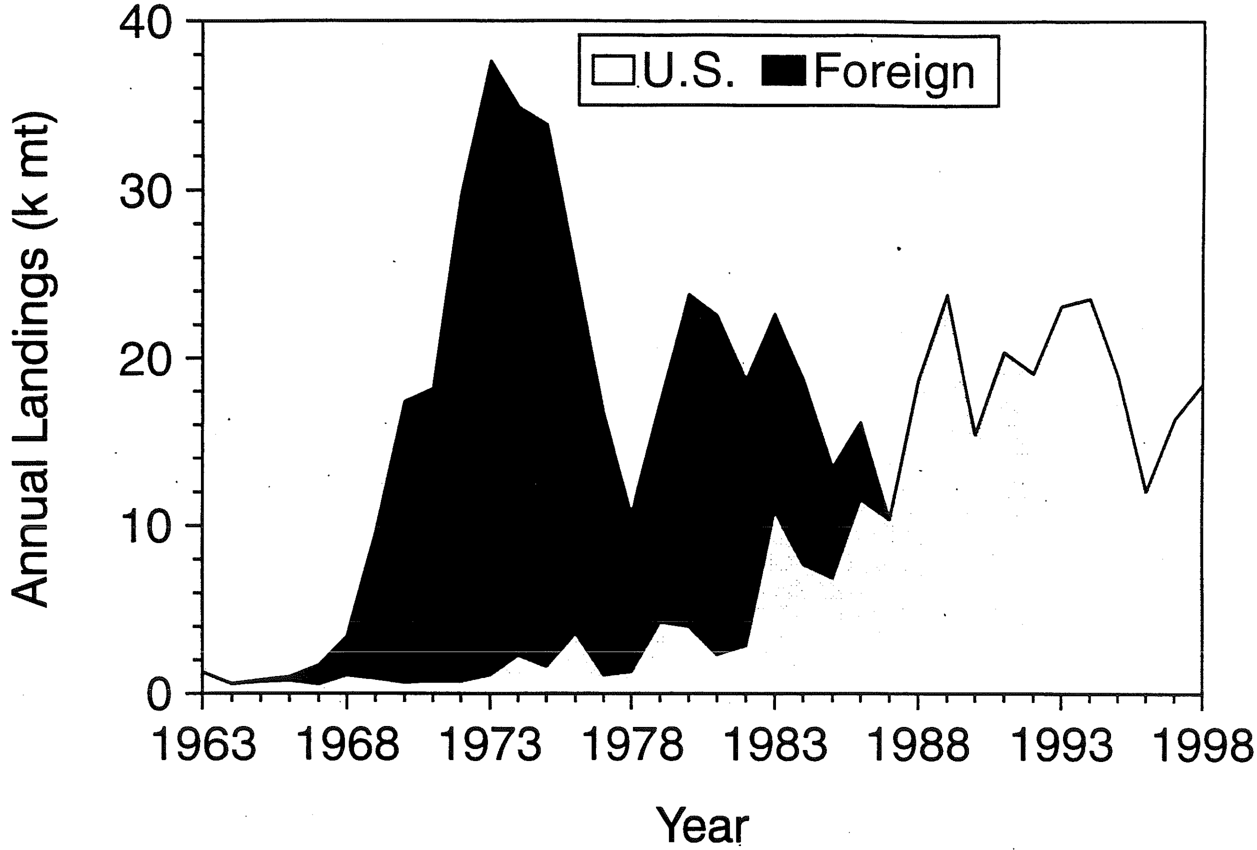


Figure 1. Annual landings of *Loligo pealeii.*

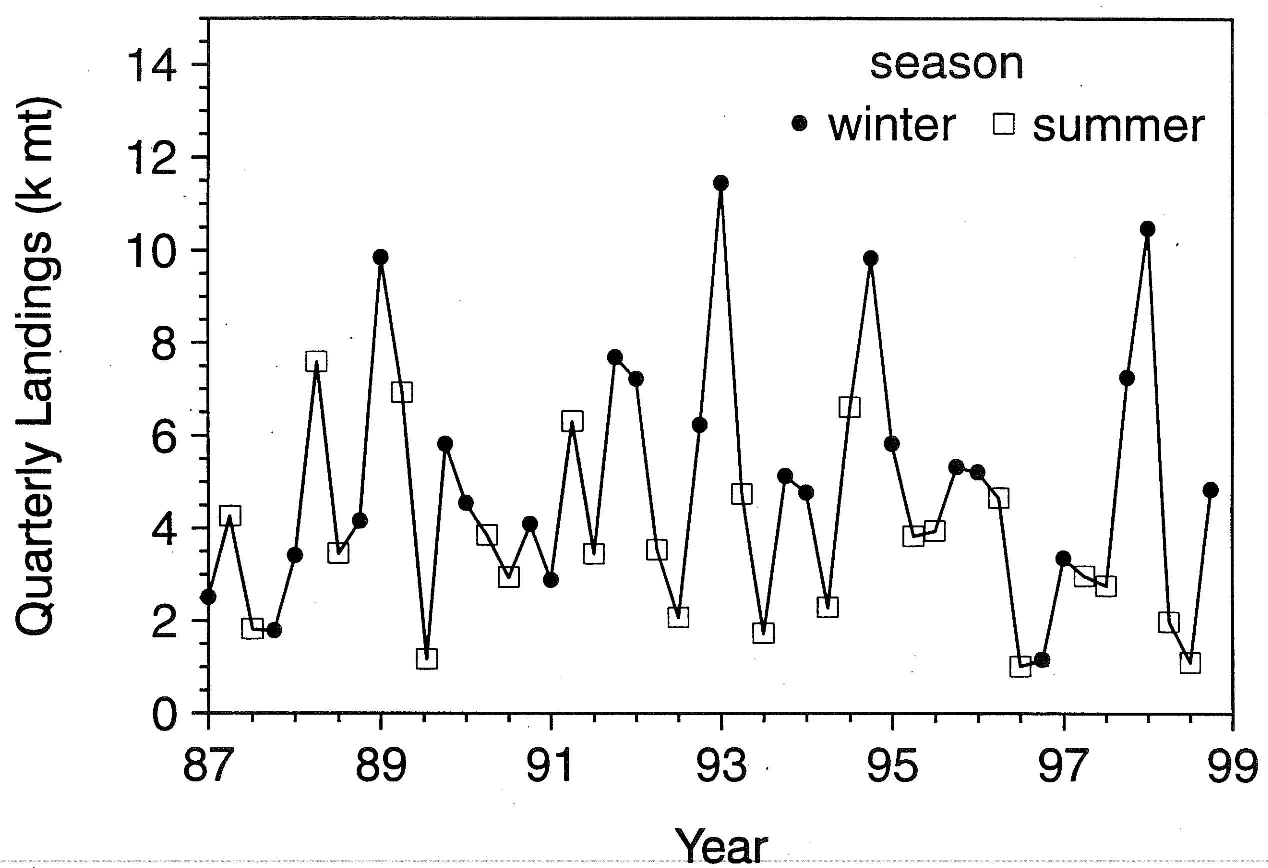


Figure 2. Quarterly landings of *Loligo pealeii.*

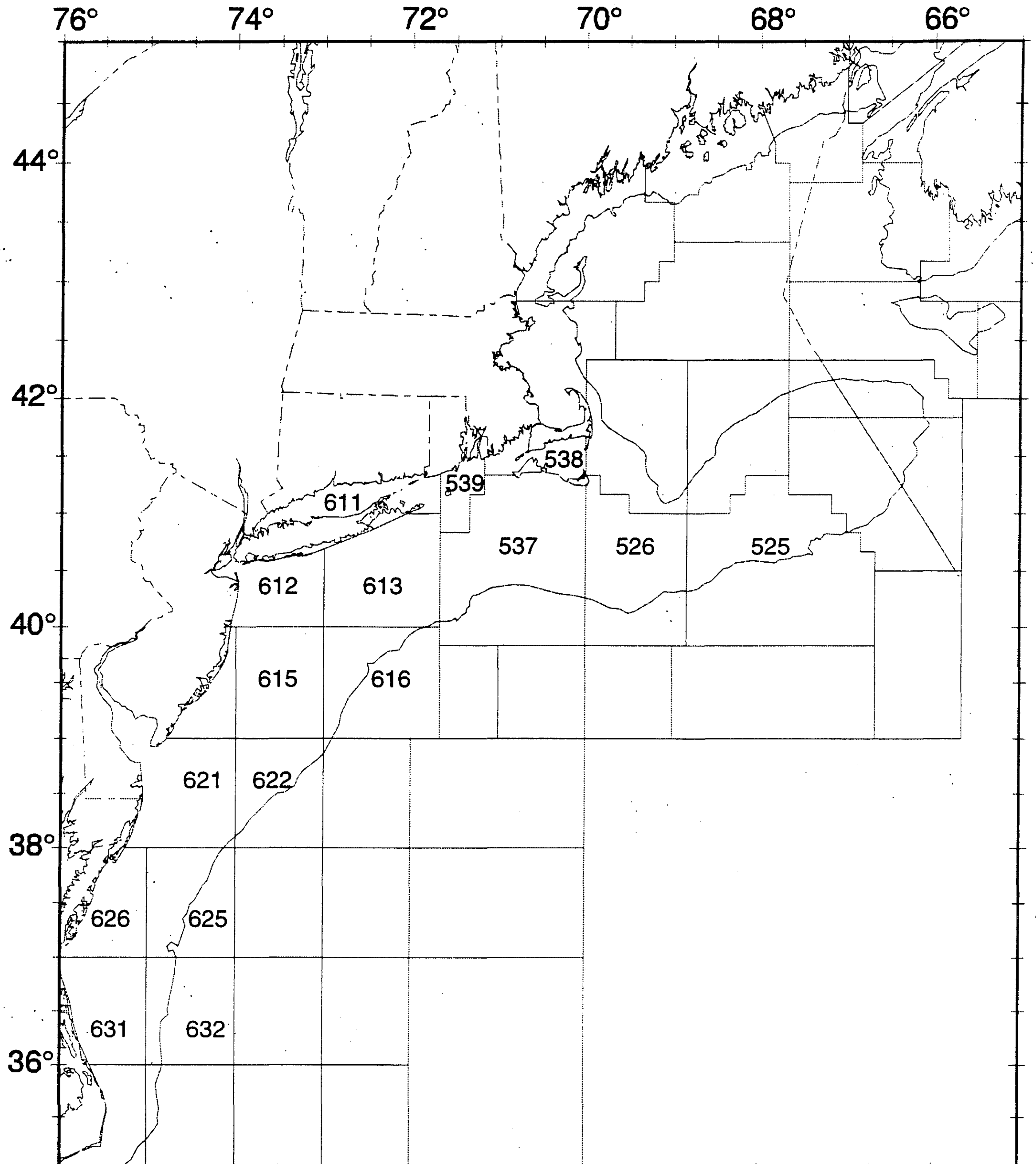


Figure 3. Principal statistical reporting areas of *Loligo pealeii* landings.

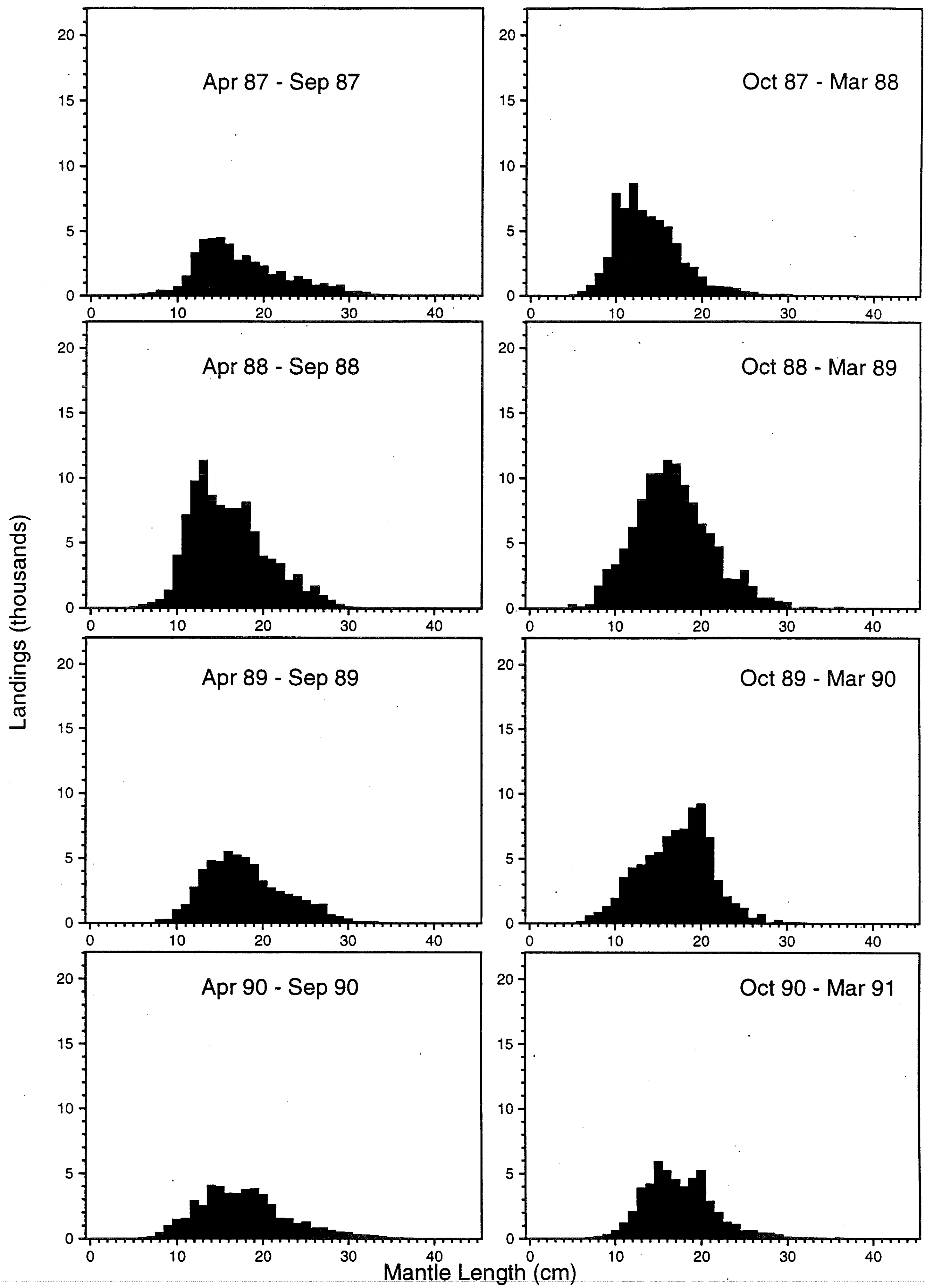


Figure 4a. Catch at length of *Loligo pealeii* landings, by season.

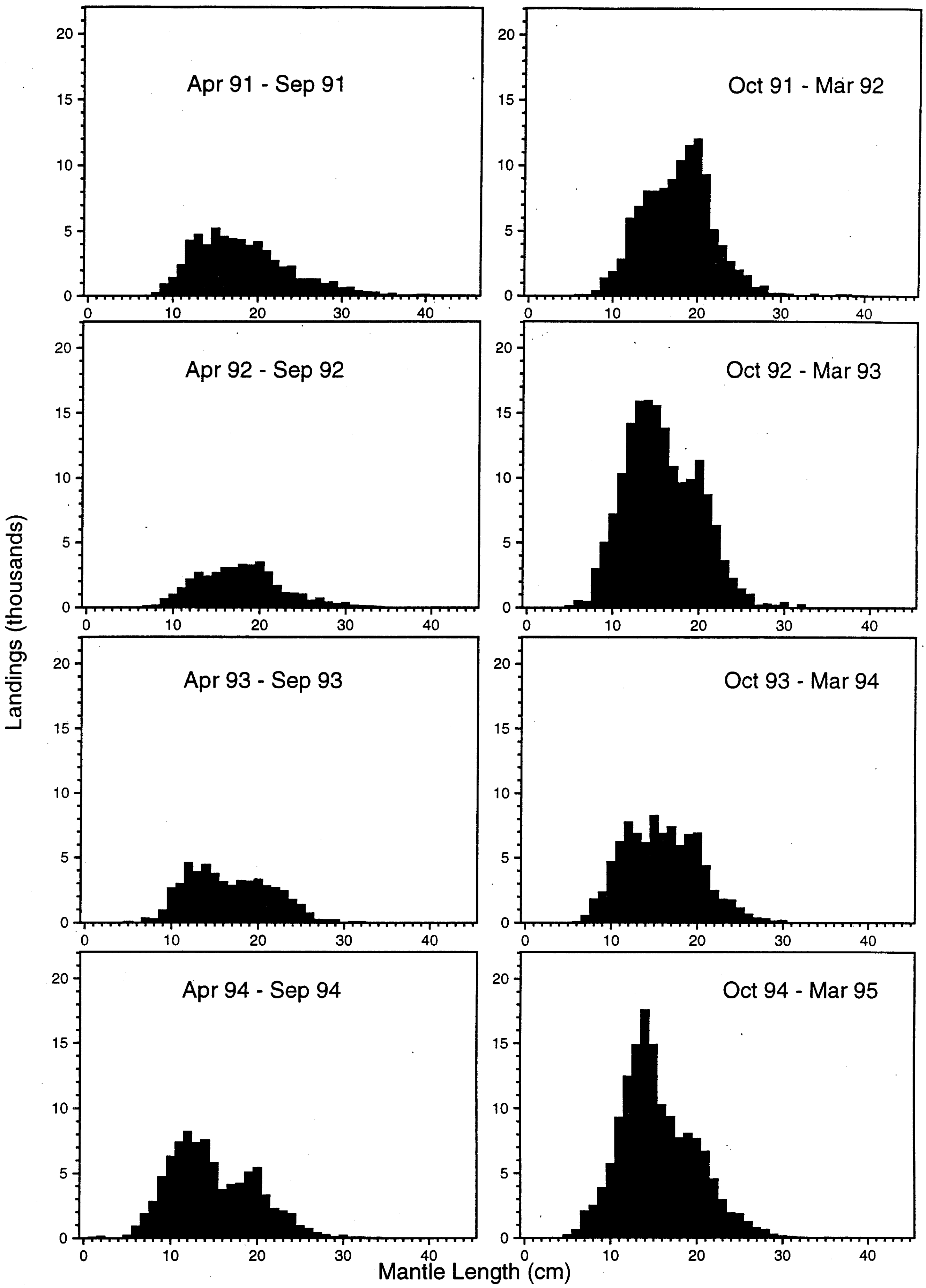


Figure 4b. Catch at length of *Loligo pealeii* landings, by season.

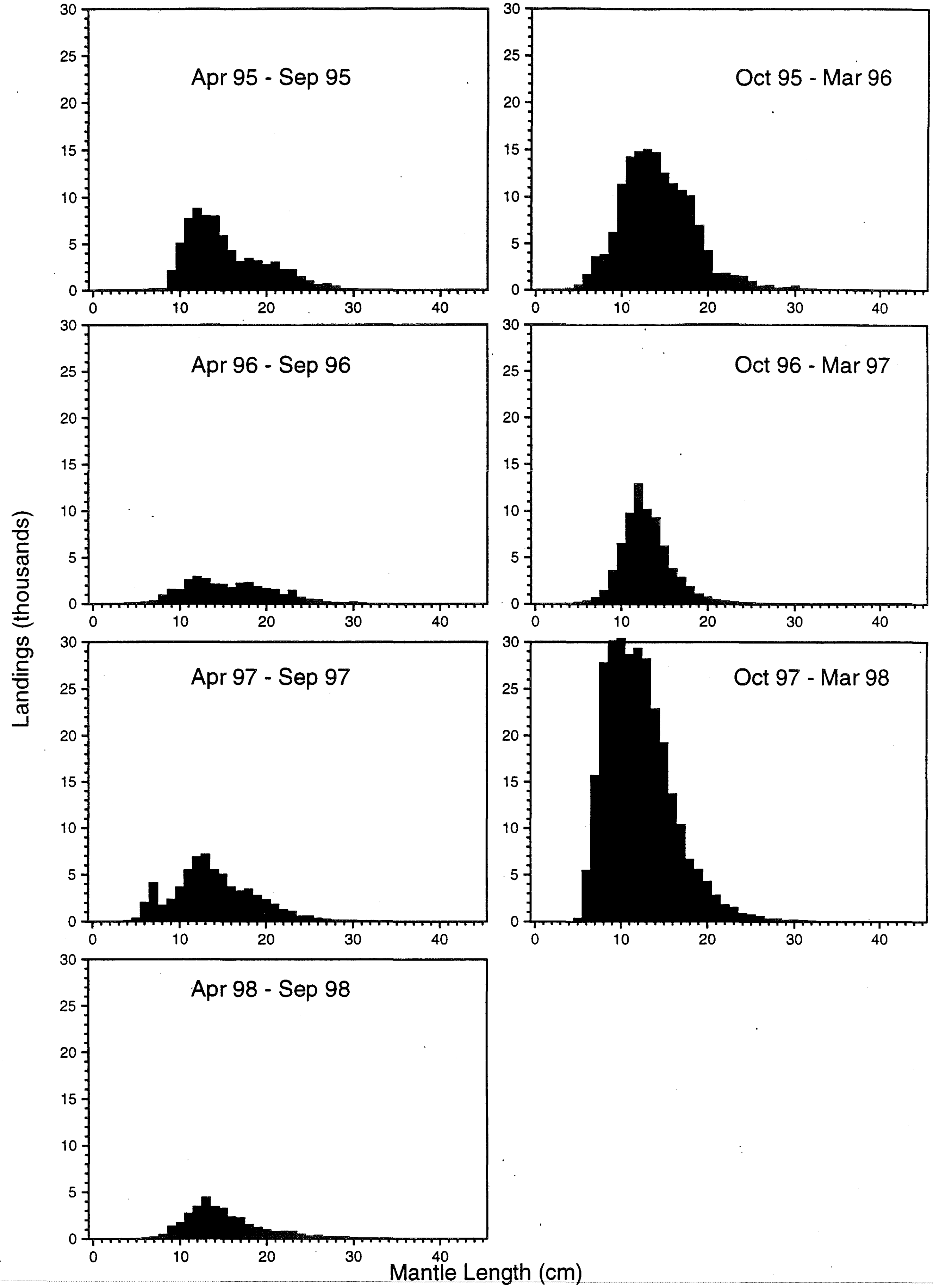


Figure 4c. Catch at length of *Loligo pealeii* landings, by season.

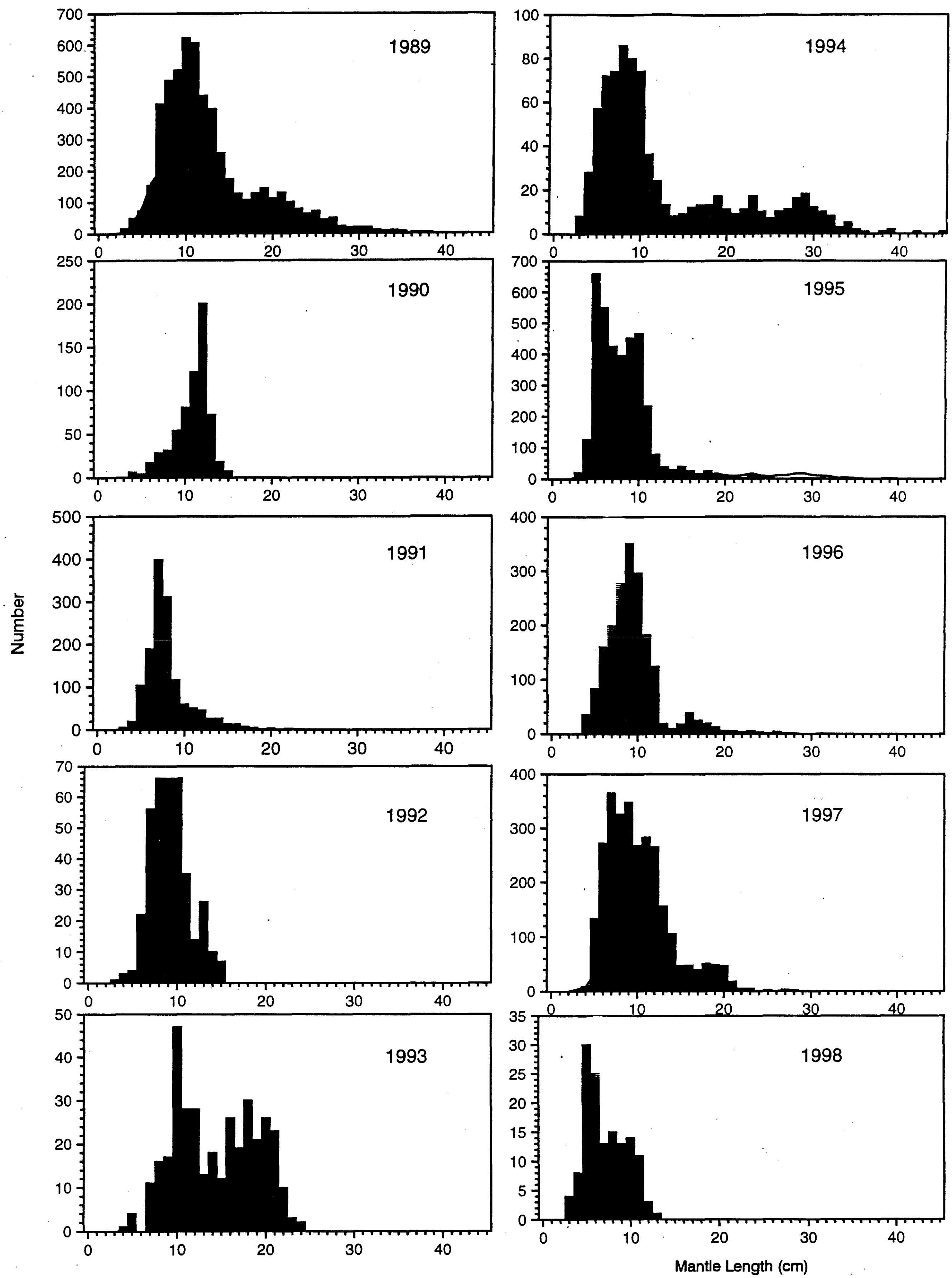


Figure 5. Size distributions of *Loligo pealeii* discards.

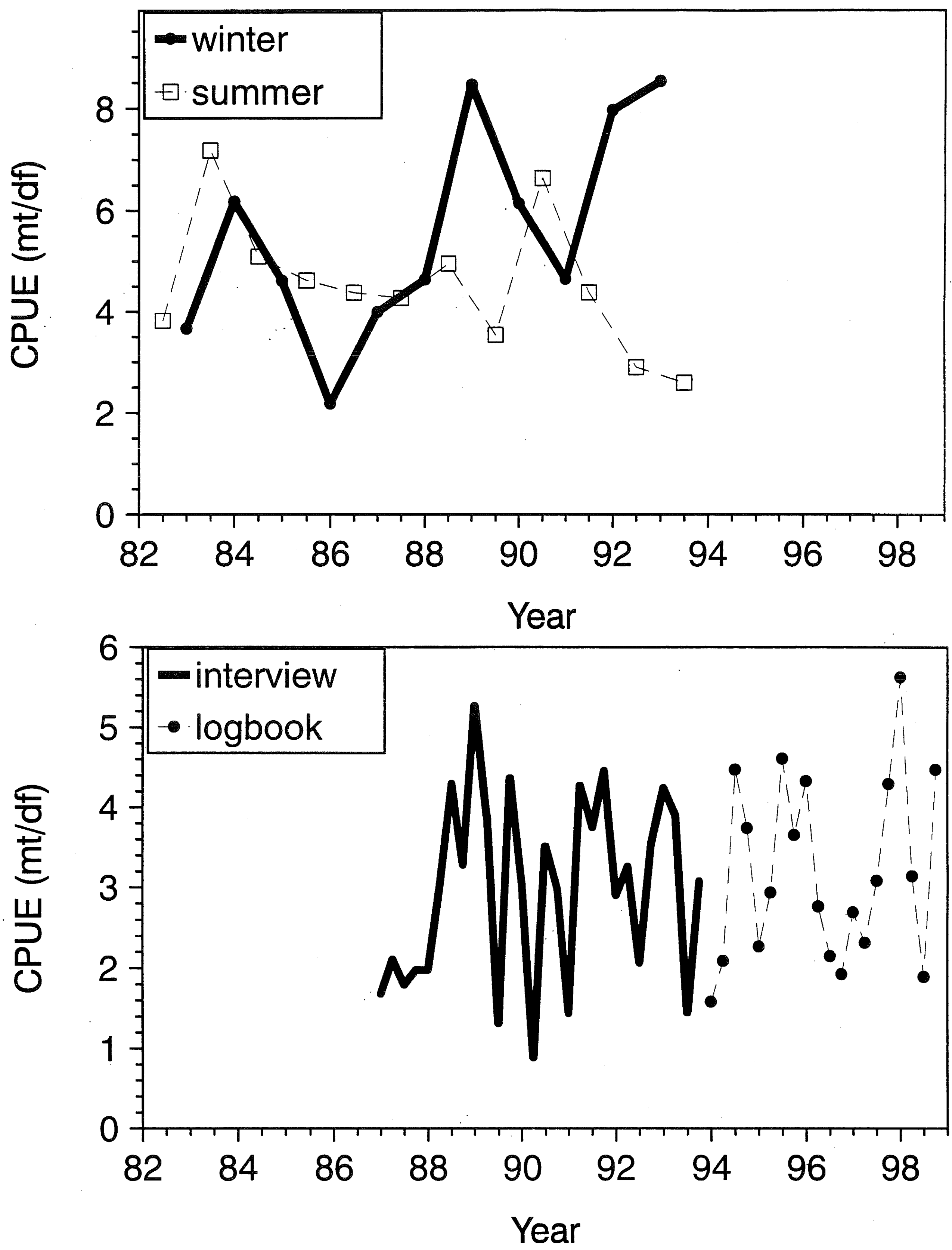


Figure 6. Standardized catch per unit effort of *Loligo pealeii.*

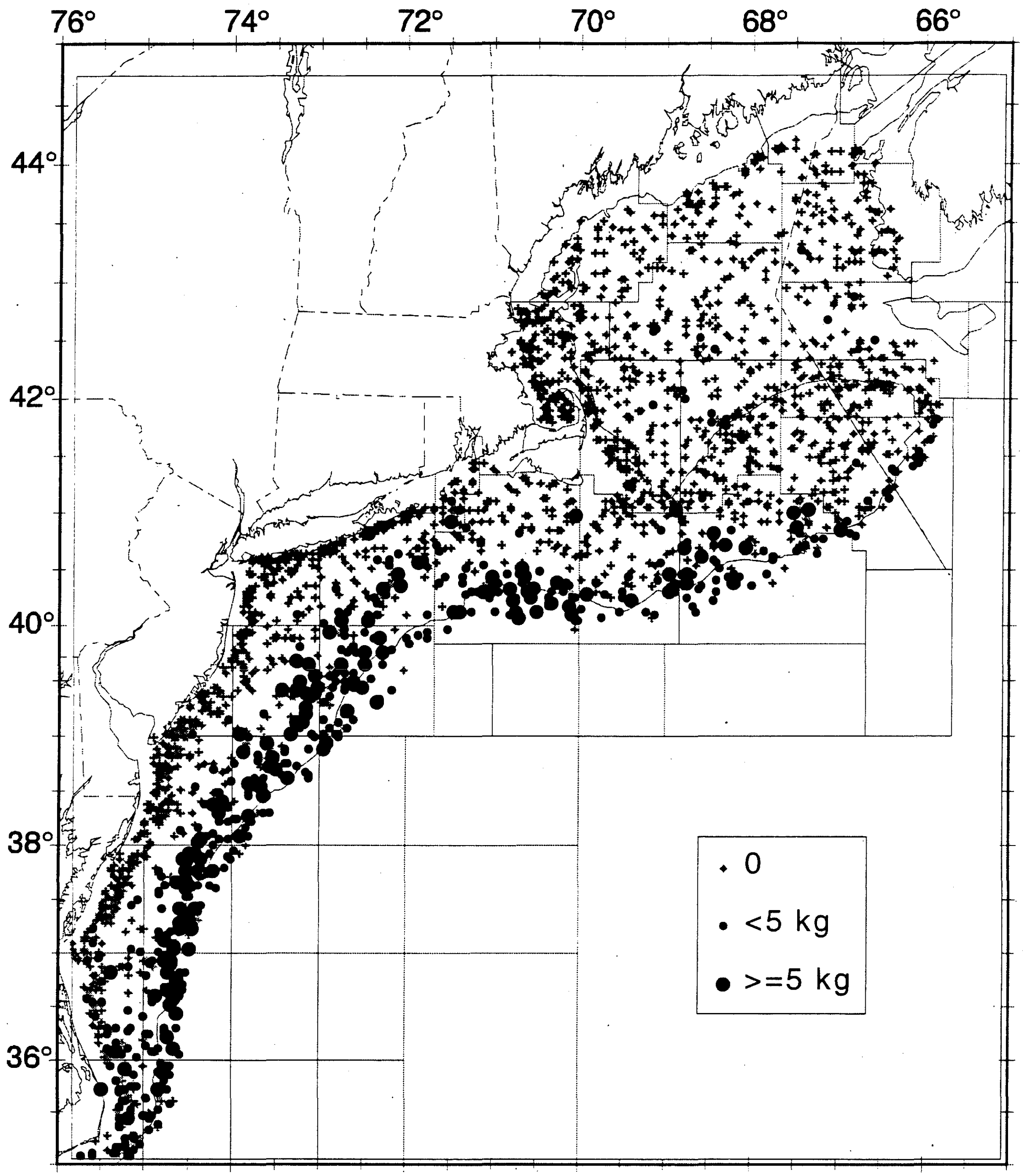


Figure 7a. Geographic distribution of *Loligo pealeii* catches from the NEFSC spring survey , 1992-1998.

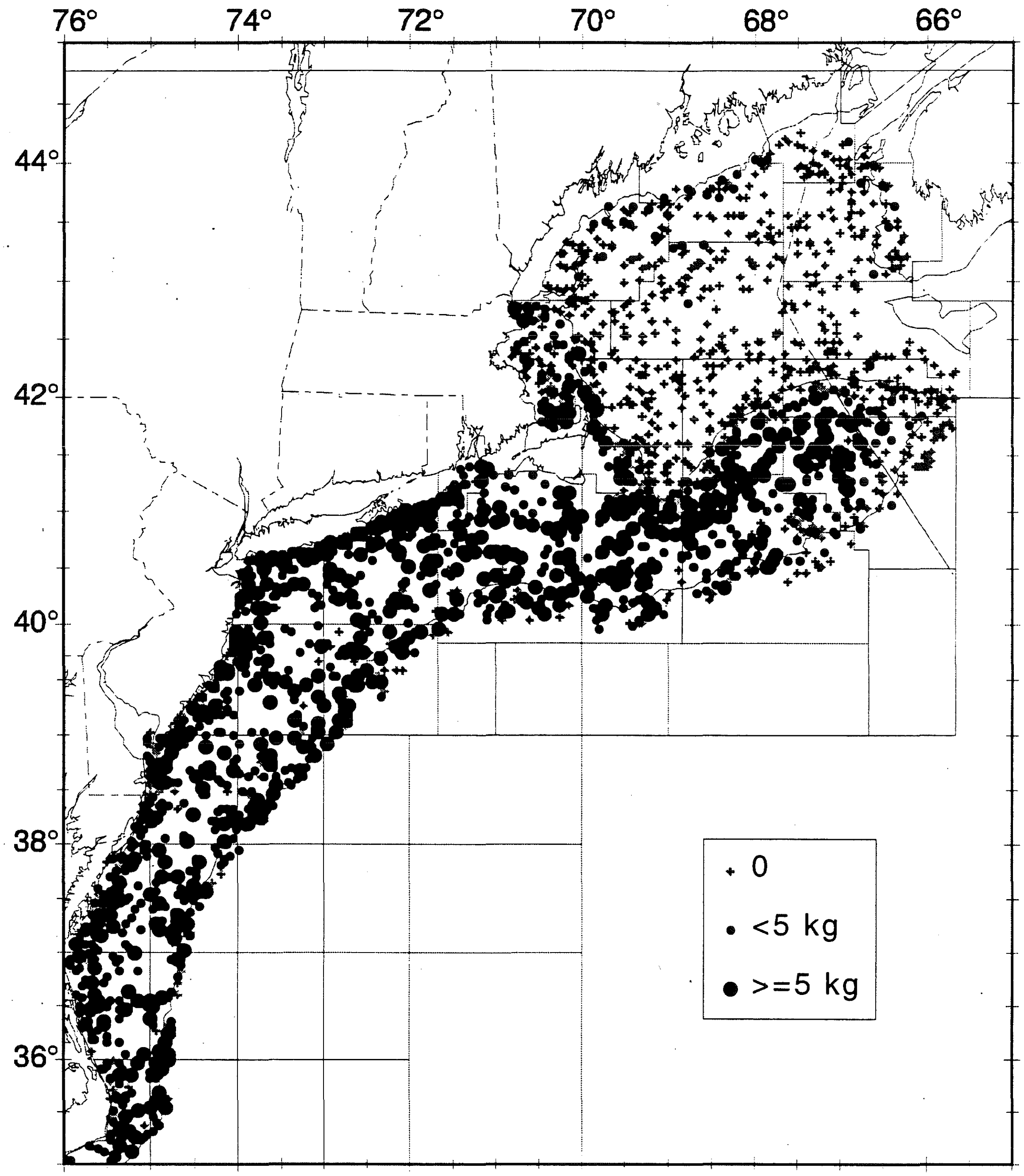


Figure 7b. Geographic distribution of *Loligo pealeii* catches from the NEFSC fall survey , 1992-1998.

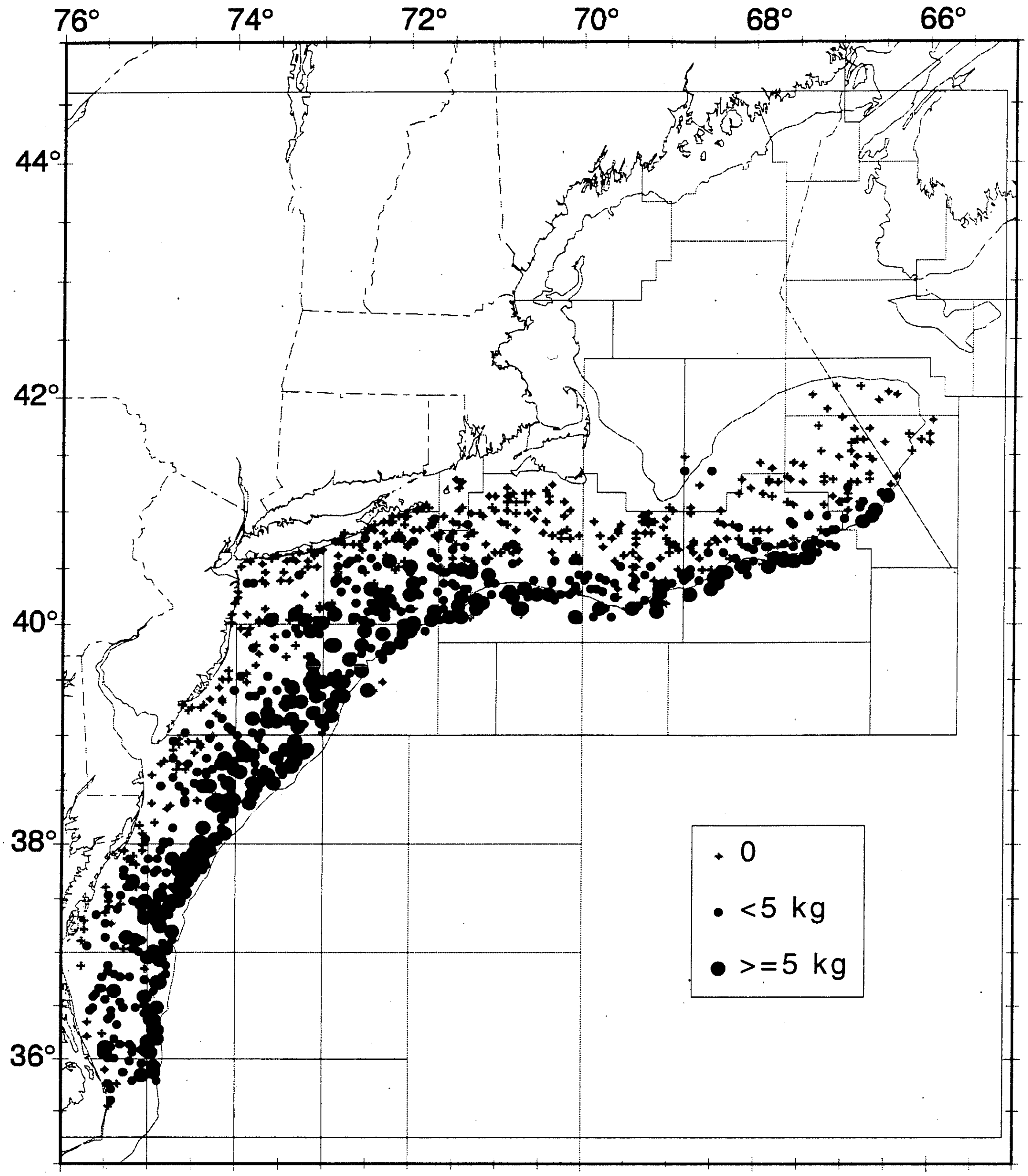
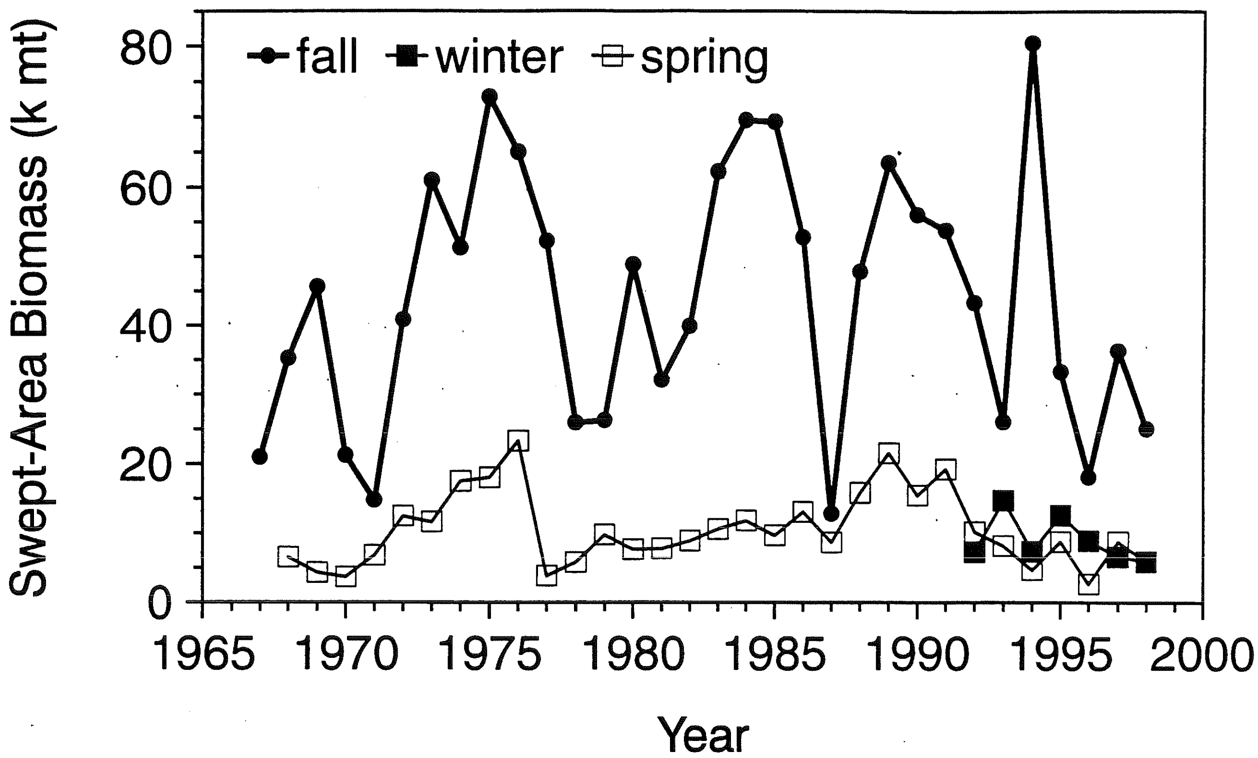


Figure 7c. Geographic distribution of *Loligo pealeii* catches from the NEFSC winter survey , 1992-1998.



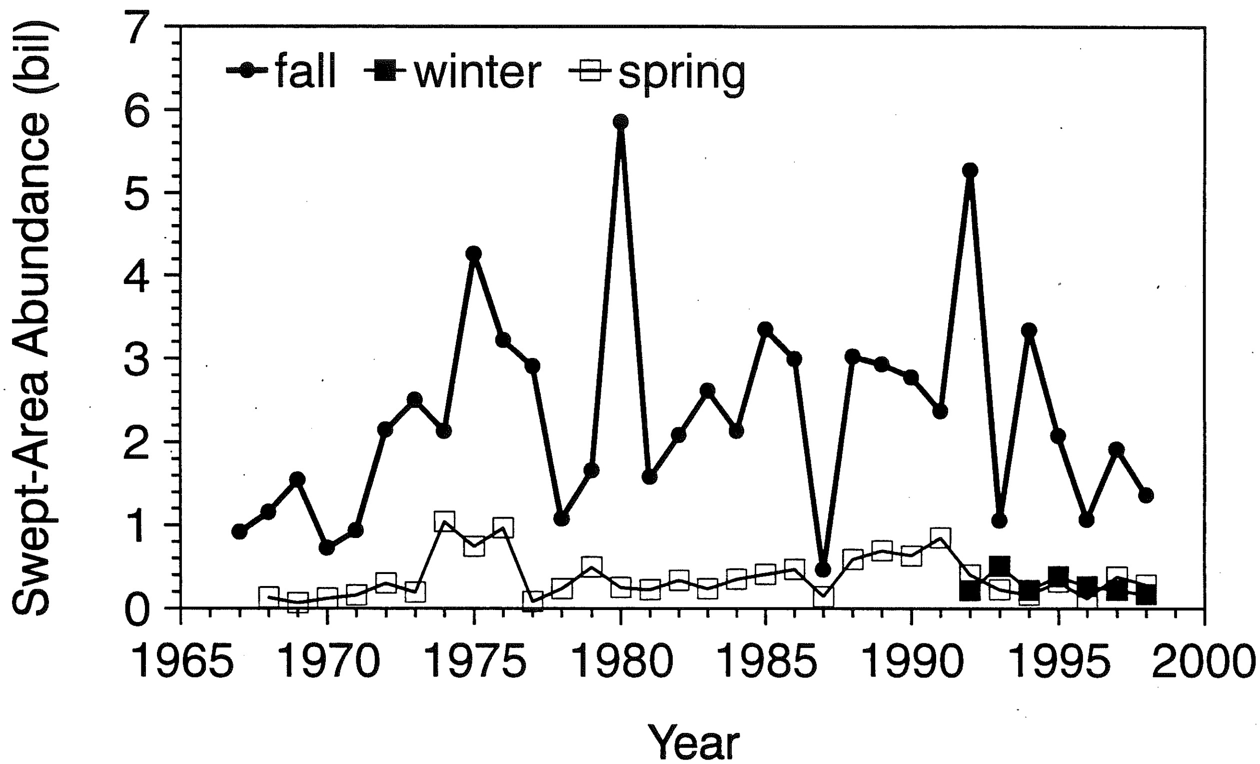


Figure 8a. Indices of *Loligo pealeii* stock biomass and abundance from NEFSC surveys.

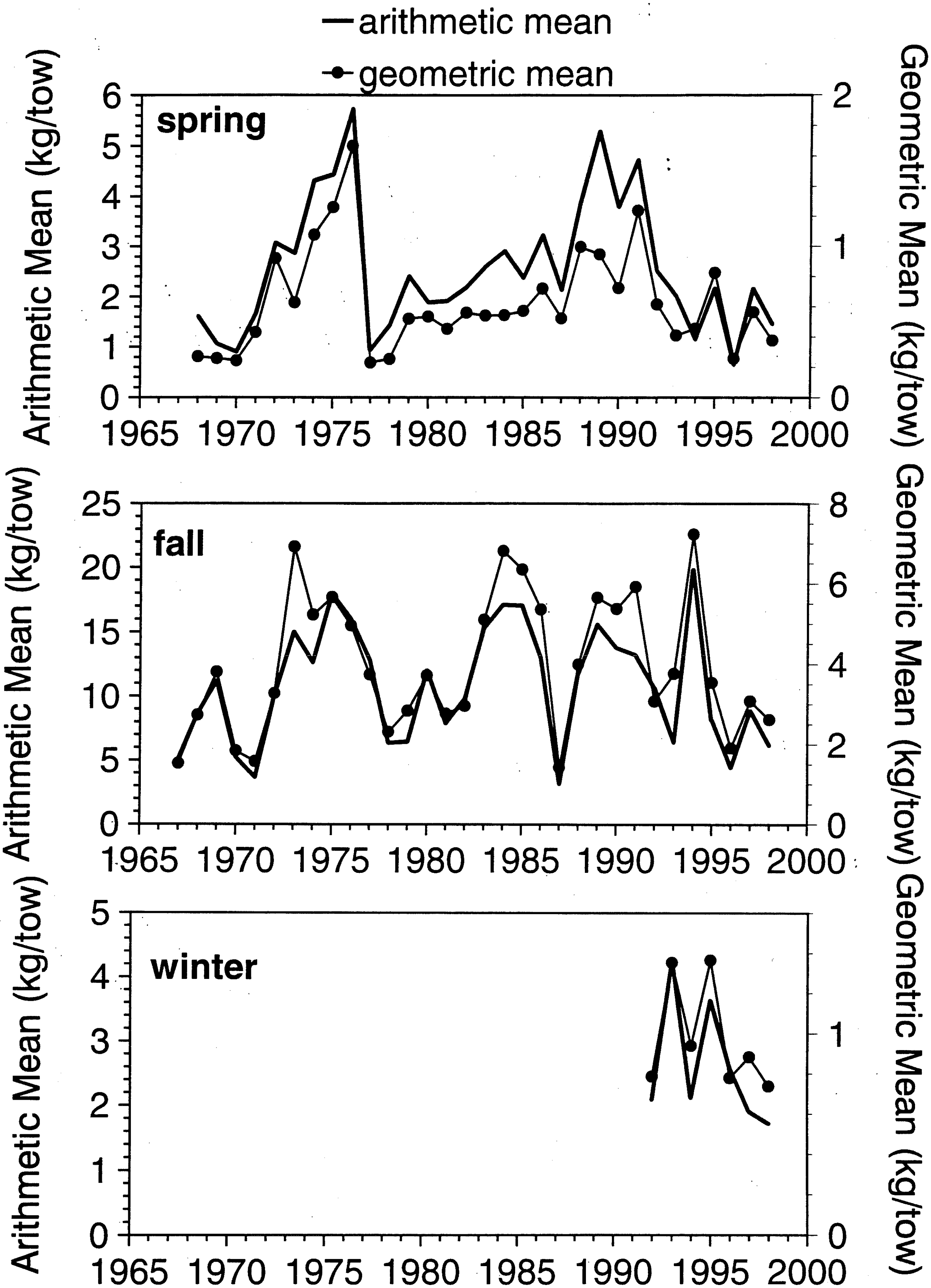


Figure 8b. Untransformed and log transformed indices of *Loligo pealeii* stock biomass from NEFSC surveys.

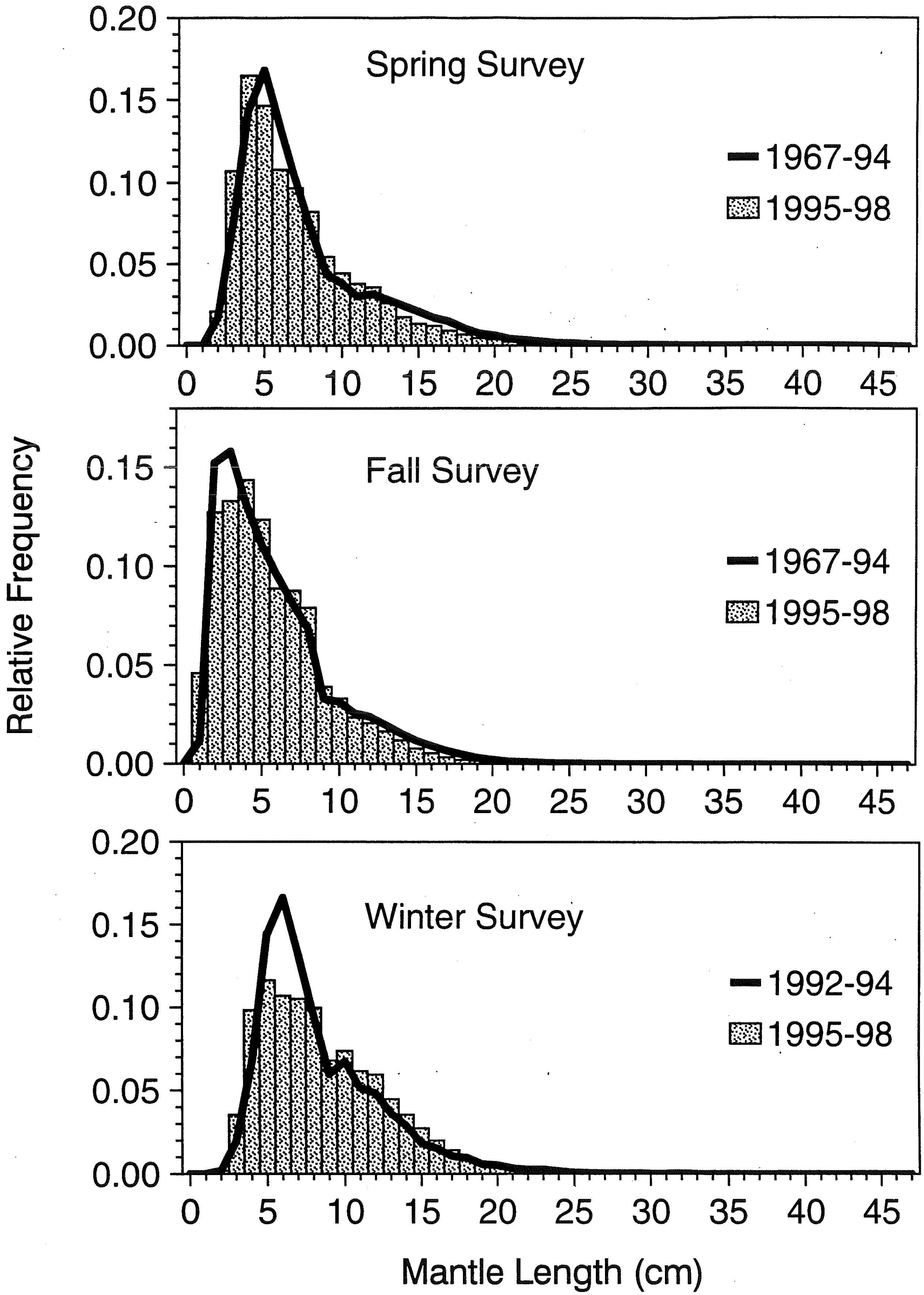


Figure 9a. Size distributions of *Loligo pealeii* from NEFSC surveys.

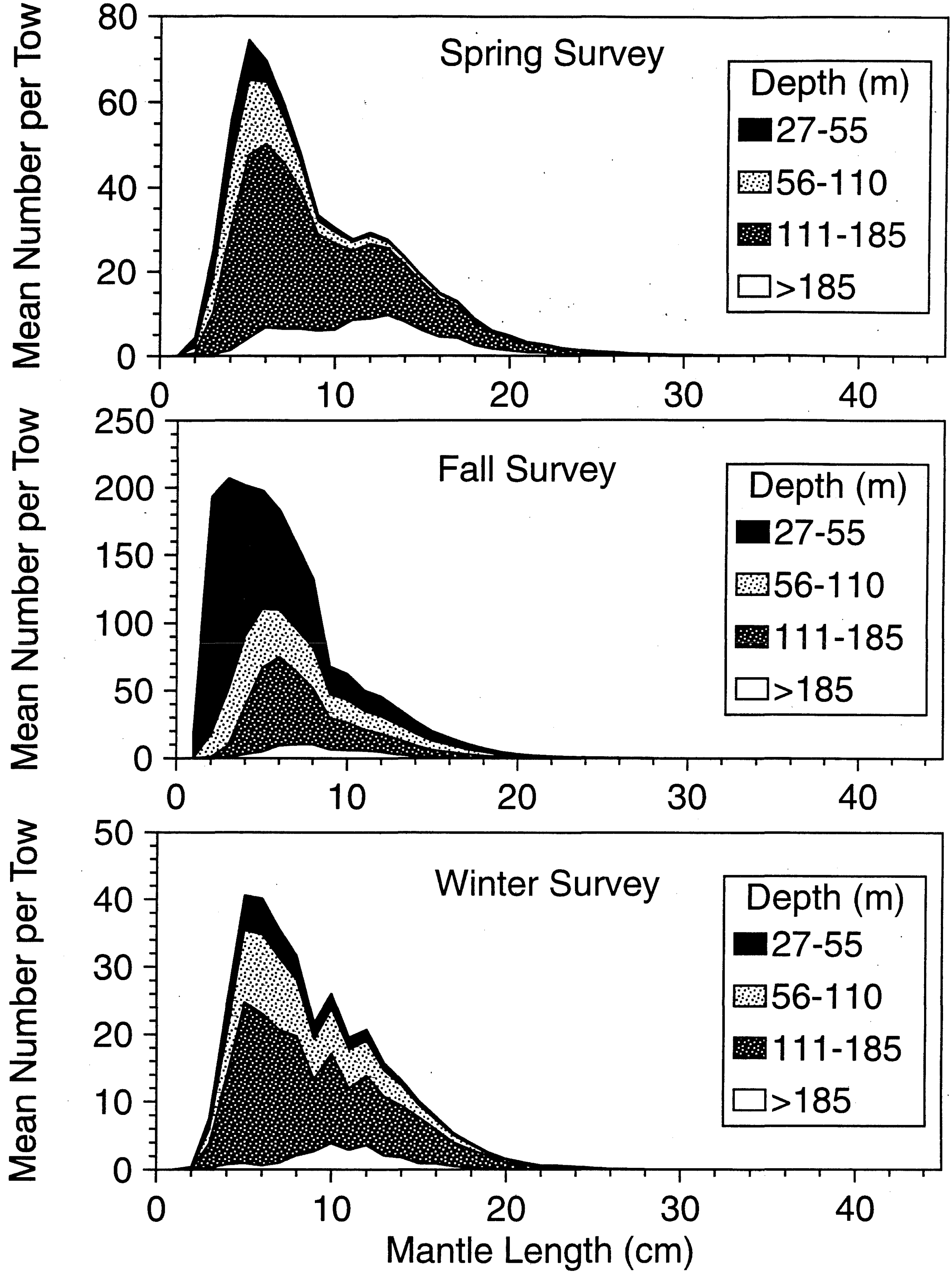


Figure 9b. Size distributions of *Loligo pealeii* from NEFSC surveys, by depth.

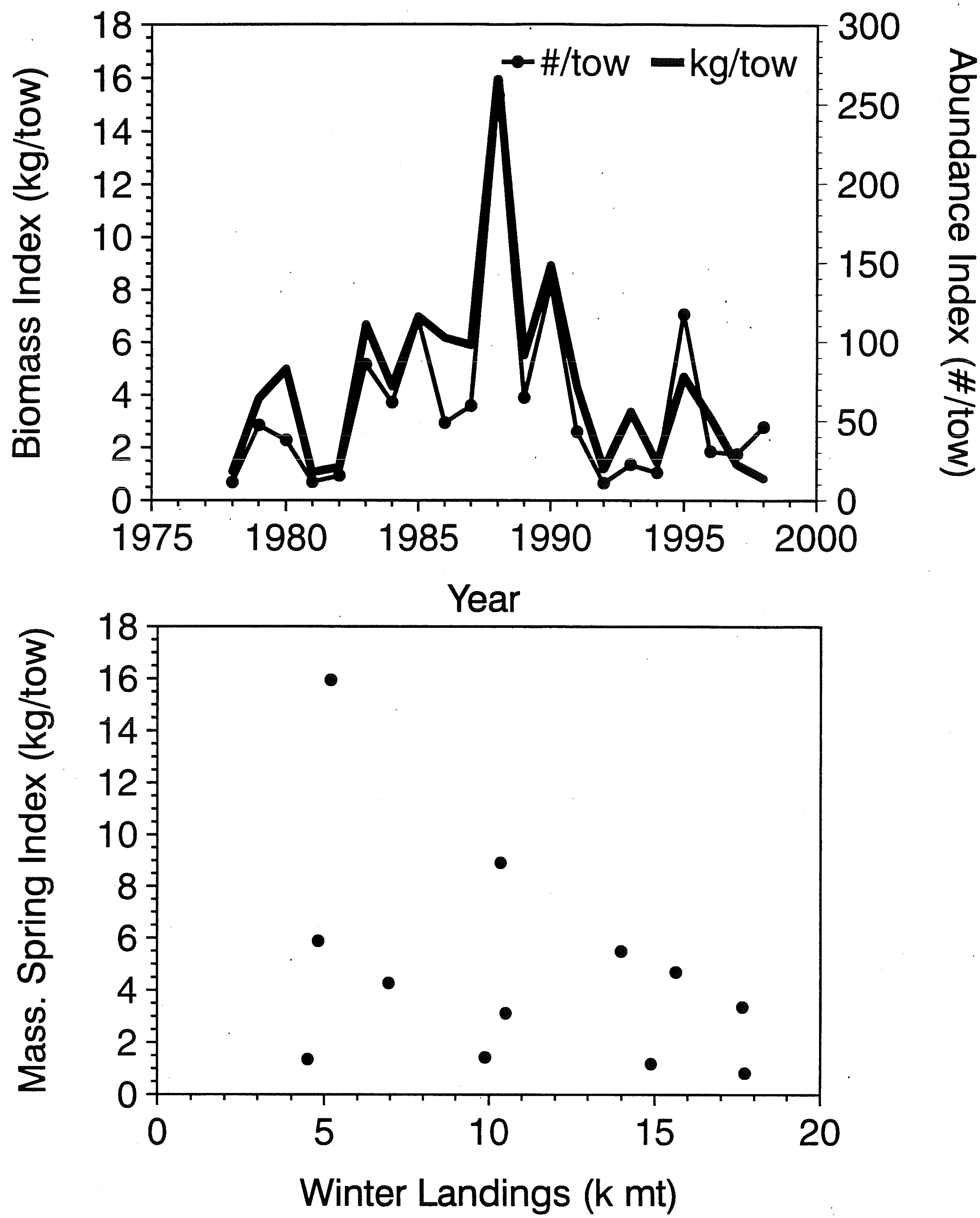


Figure 10. Indices of *Loligo pealeii* stock biomass and abundance from the Massachusets spring survey (above and relationship between winter catch (Oct.-Mar.) and subsequent inshore biomass (below).

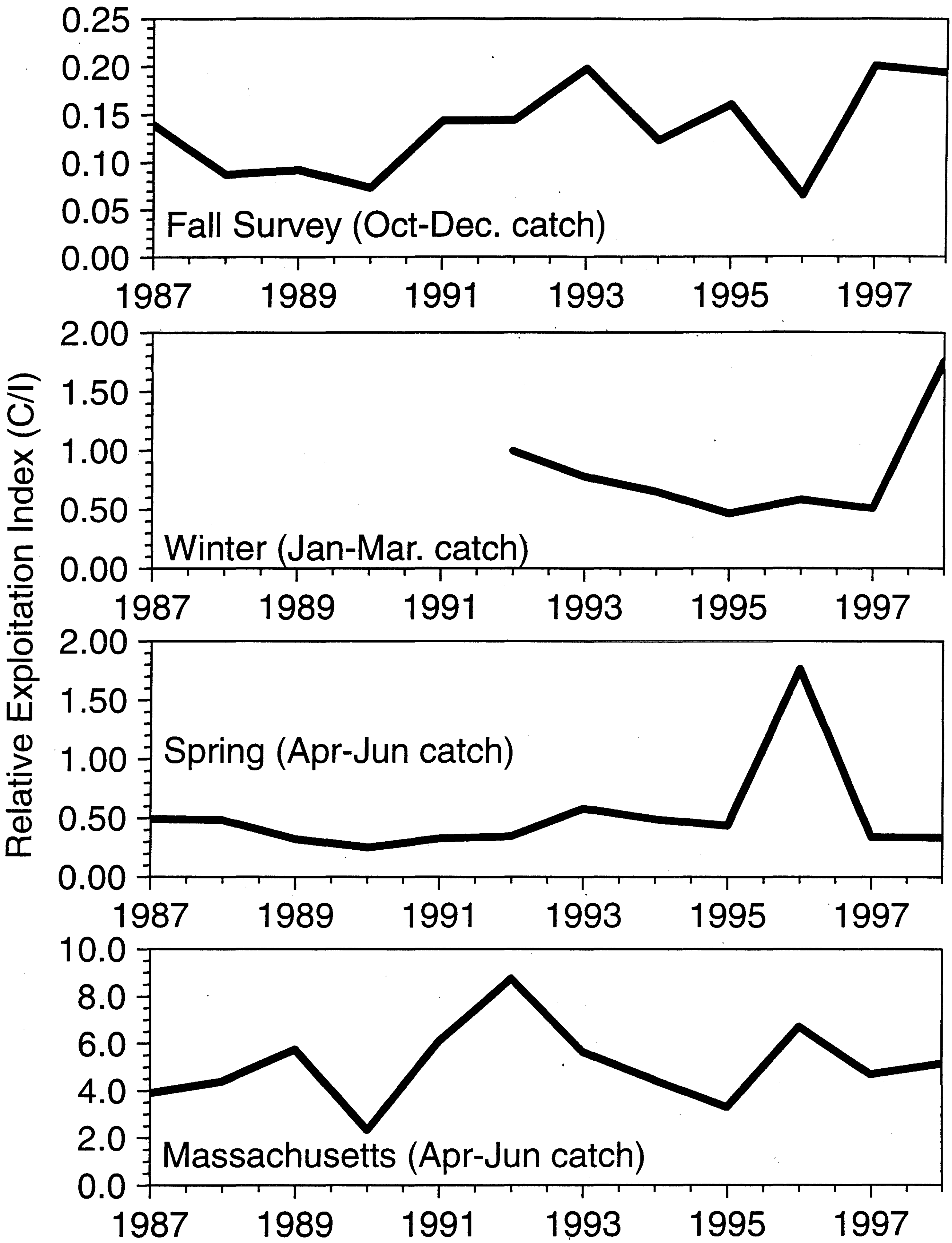


Figure 11. Survey indices of relative exploitation of *Loligo pealeii* derived as the quotient of quarterly catch and survey biomass index.

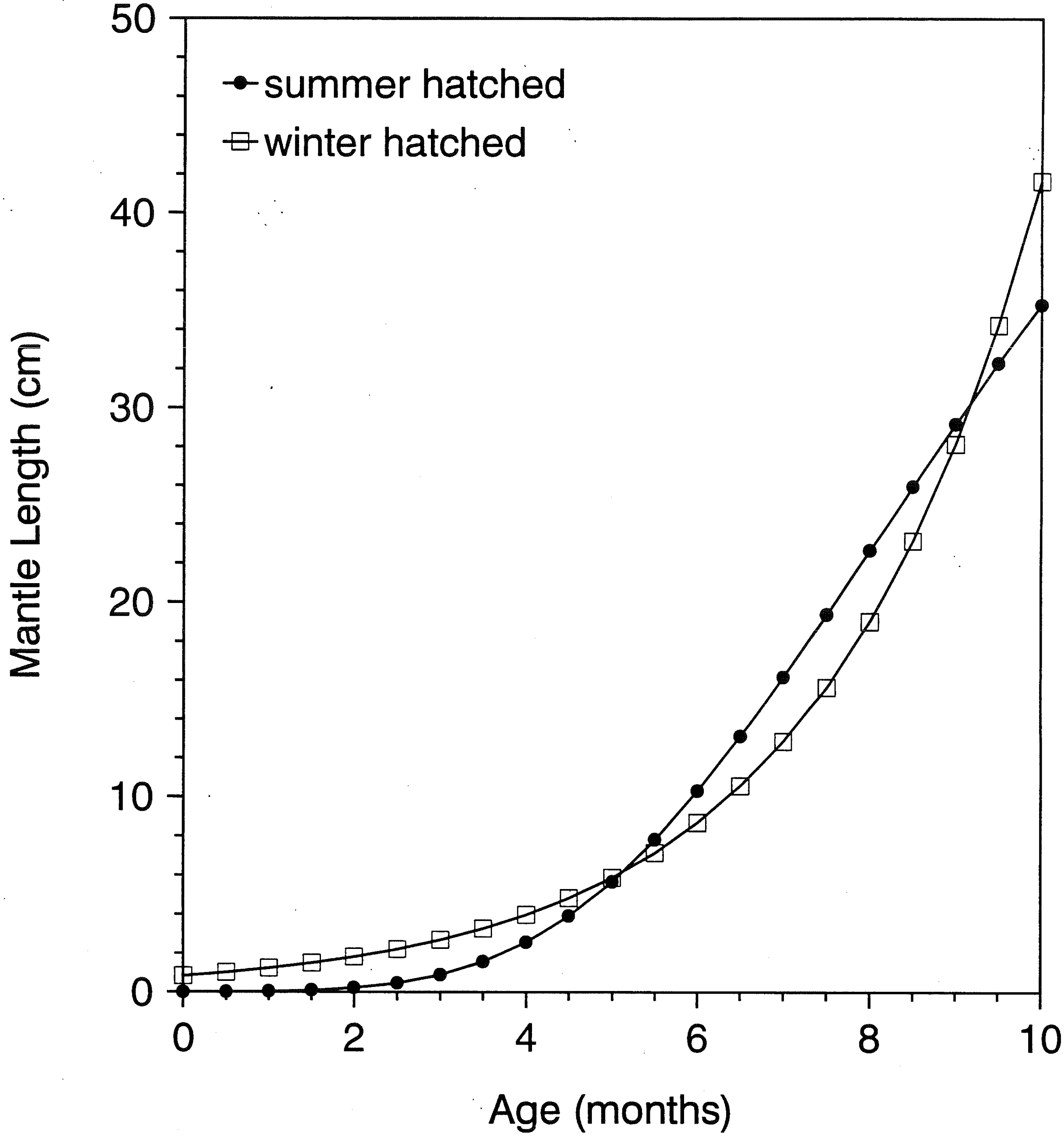


Figure 12. Estimated length at age of *Loligo pealeii* by hatch date (from Brodziak and Macy 1996).

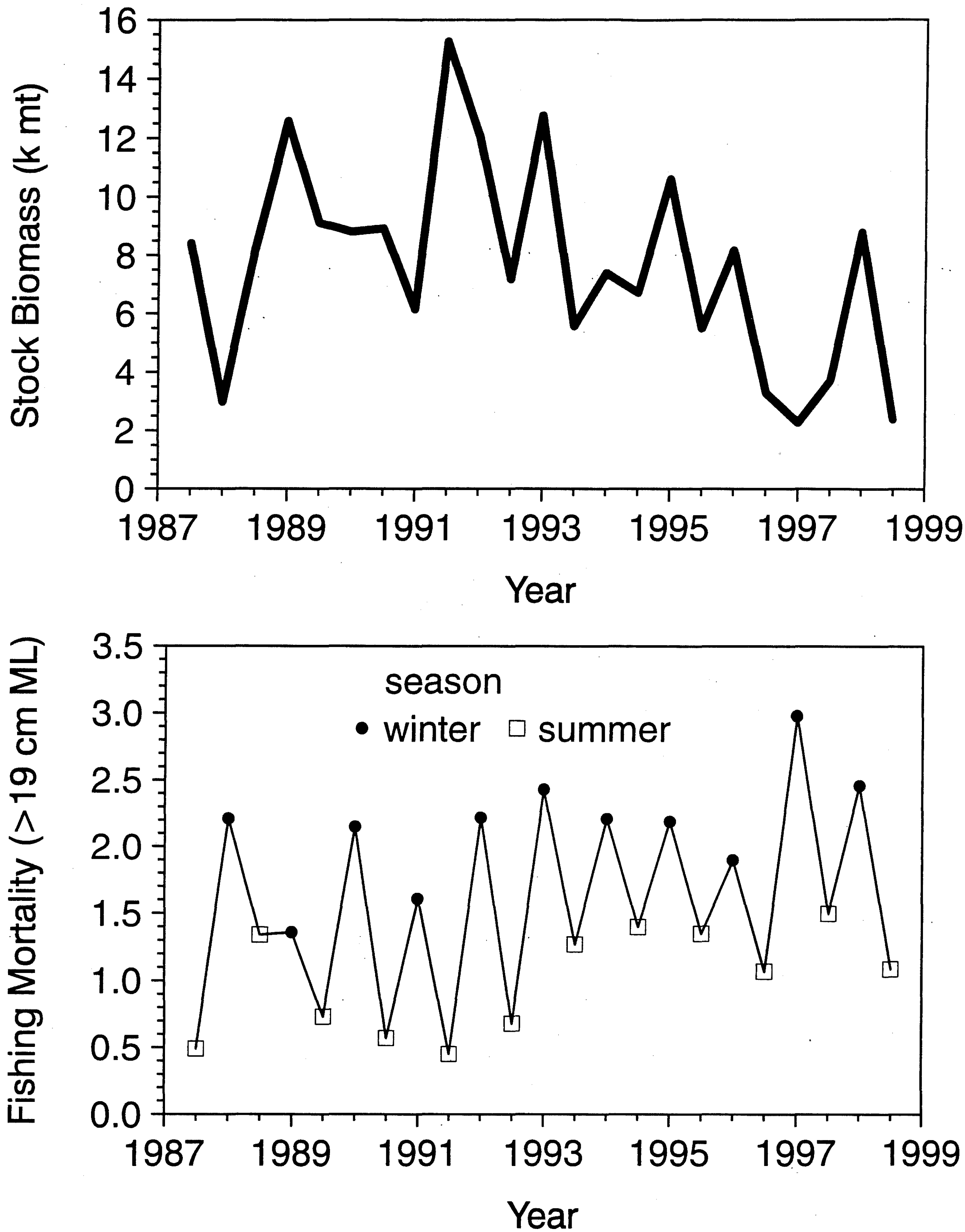


Figure 13. Stock biomass and fishing mortality of *Loligo pealeii* from LVPA.

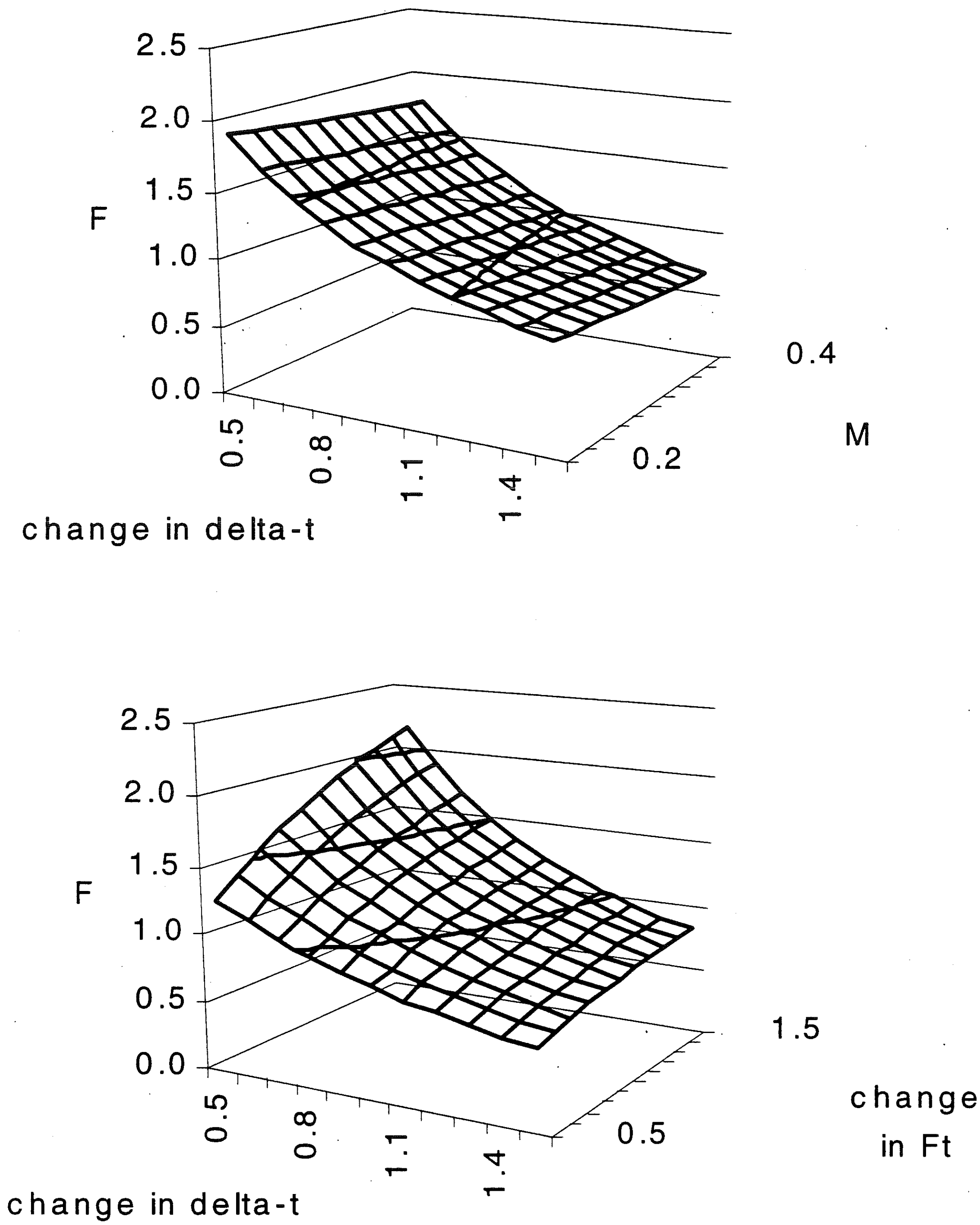
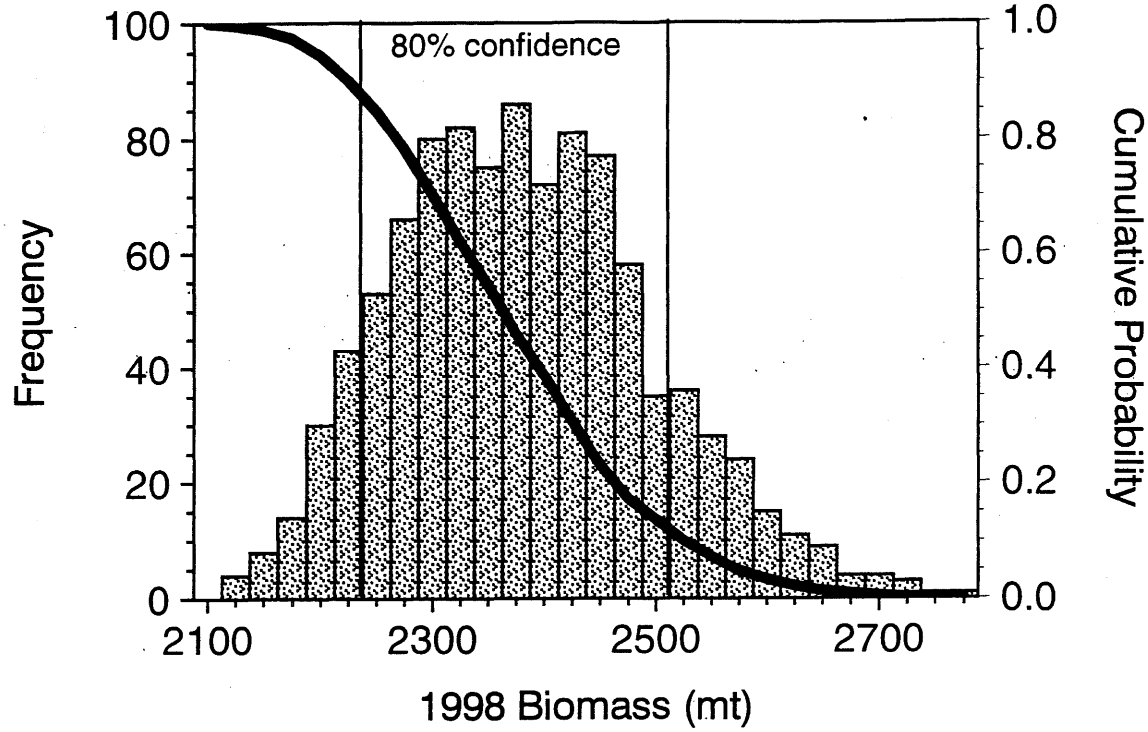


Figure 14. Sensitivity of fishing mortality estimates from LVPA of *Loligo pealeii* landings to relative change in delta-t and M (above) and relative change in delta-t and terminal F (below).



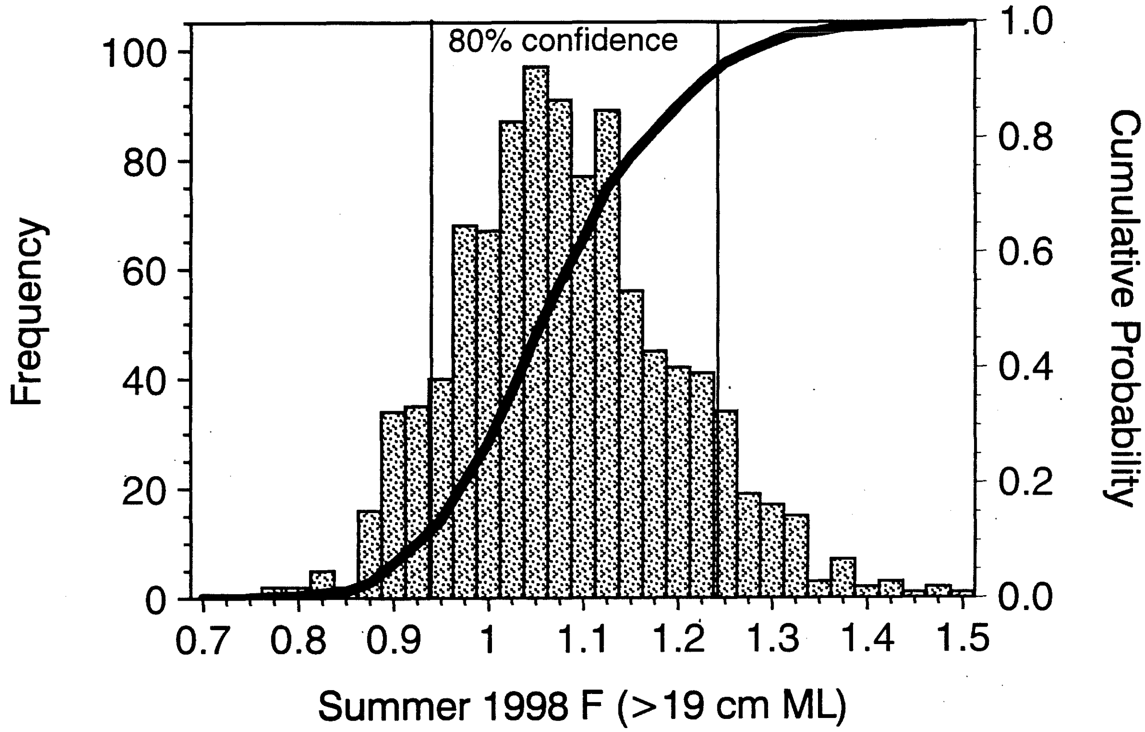


Figure 15. Monte Carlo estimates of stock biomass, and fishing mortality of *Loligo pealeii* from LVPA of 1998 summer landings with 80% confidence limits.

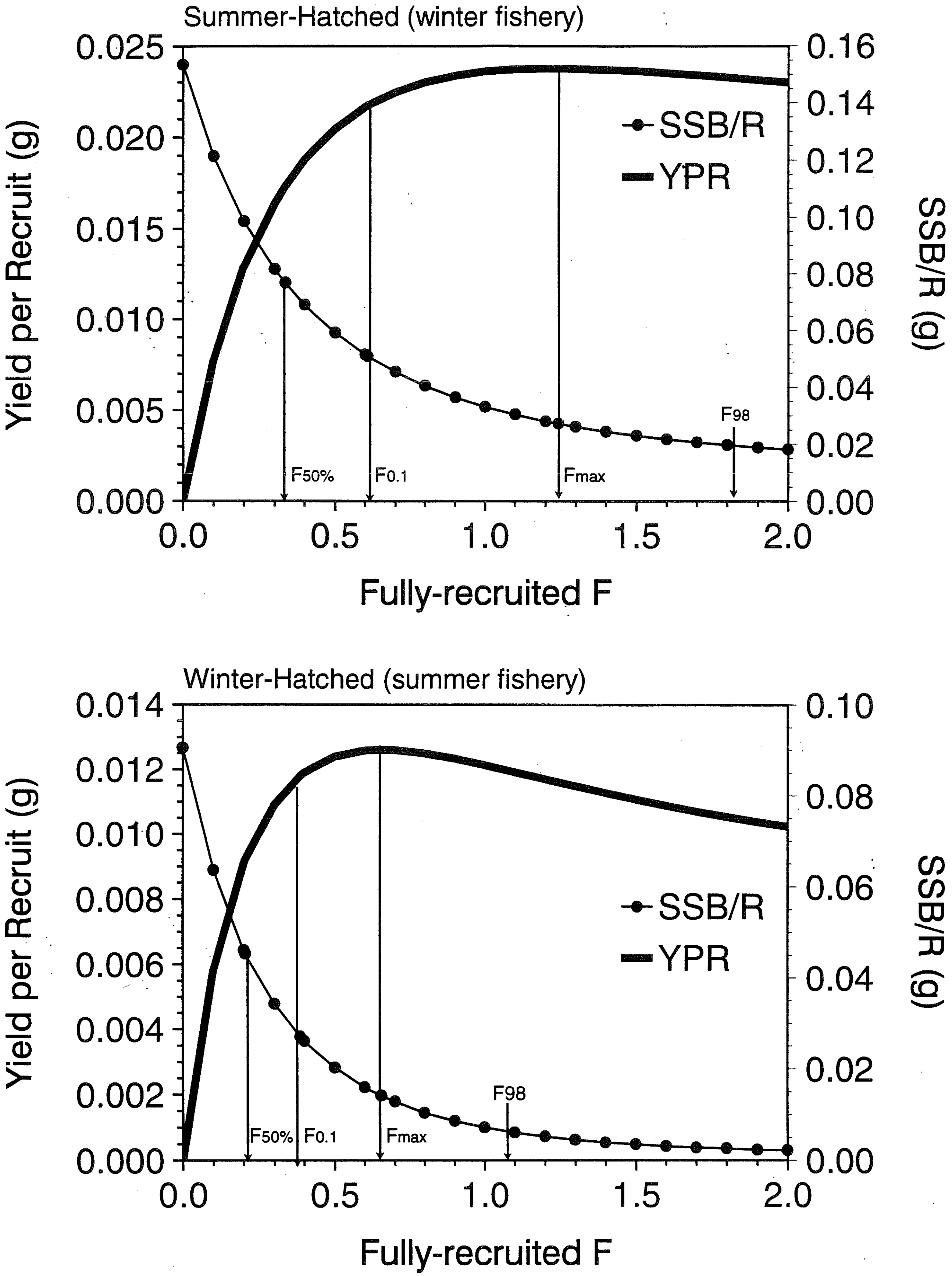


Figure 16. Yield and spawning biomass per recruit of *Loligo pealeii* by season.

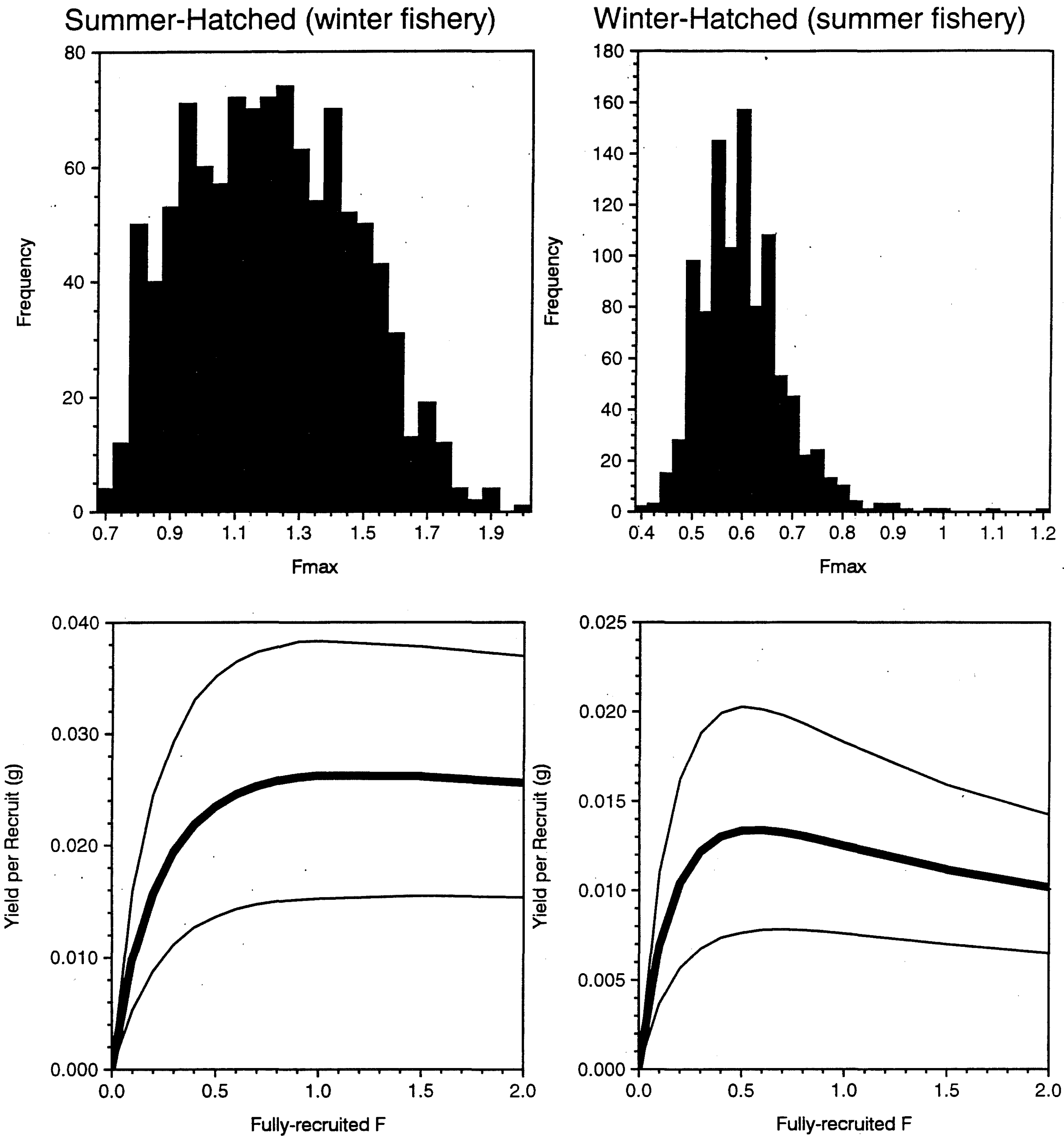


Figure 17. Monte Carlo estimates of Fmax (above) and yield per recruit (below, with 80% confidence limits) for the *Loligo pealeii* fishery, by season.

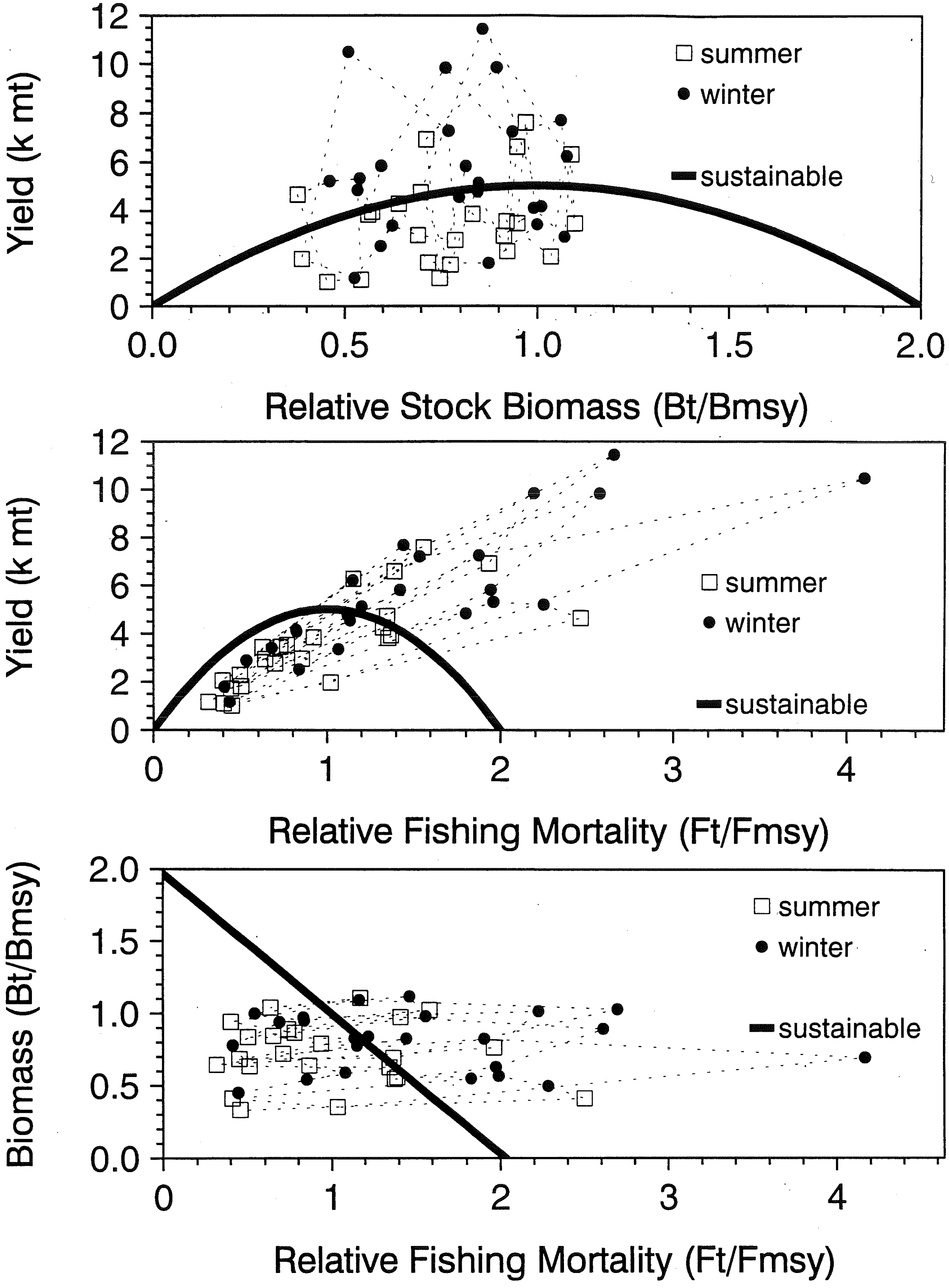


Figure 18. Biomass dynamics of *Loligo pealeii* from surplus production modeling.

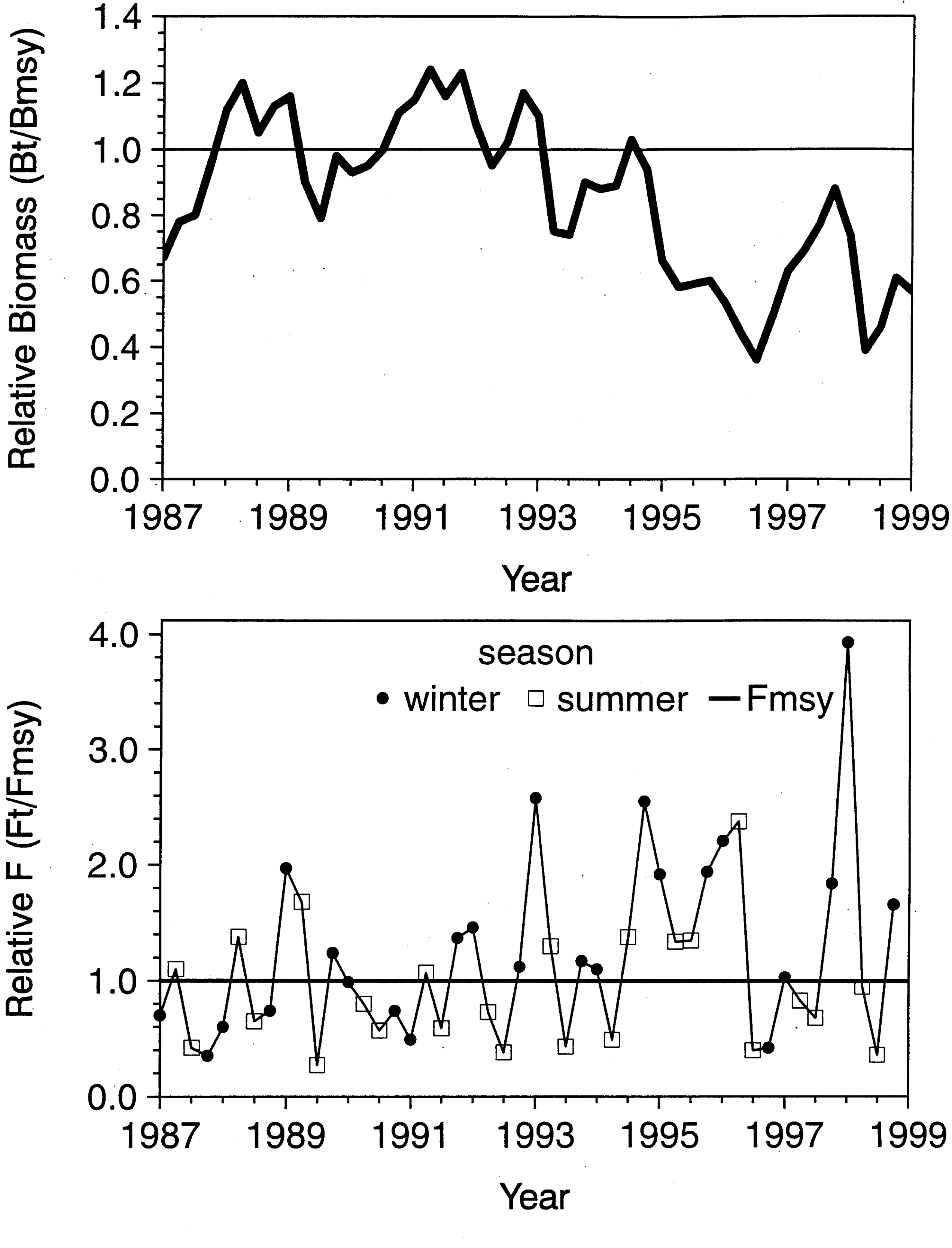


Figure 19. Stock biomass and fishing mortality of *Loligo pealeii* relative to MSY reference points from surplus production modeling.

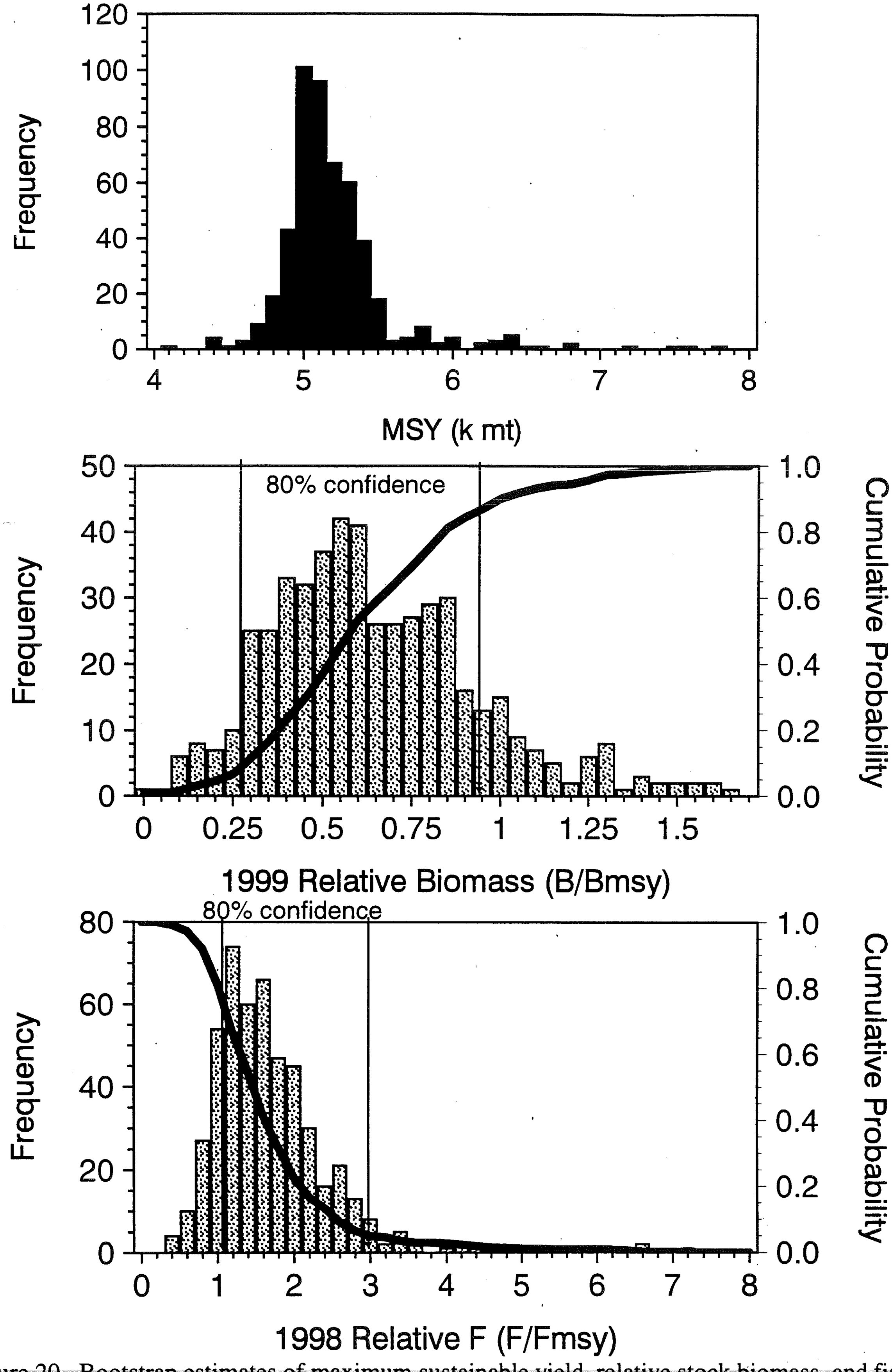


Figure 20. Bootstrap estimates of maximum sustainable yield, relative stock biomass, and fishing mortality of *Loligo pealeii* from surplus production modeling.

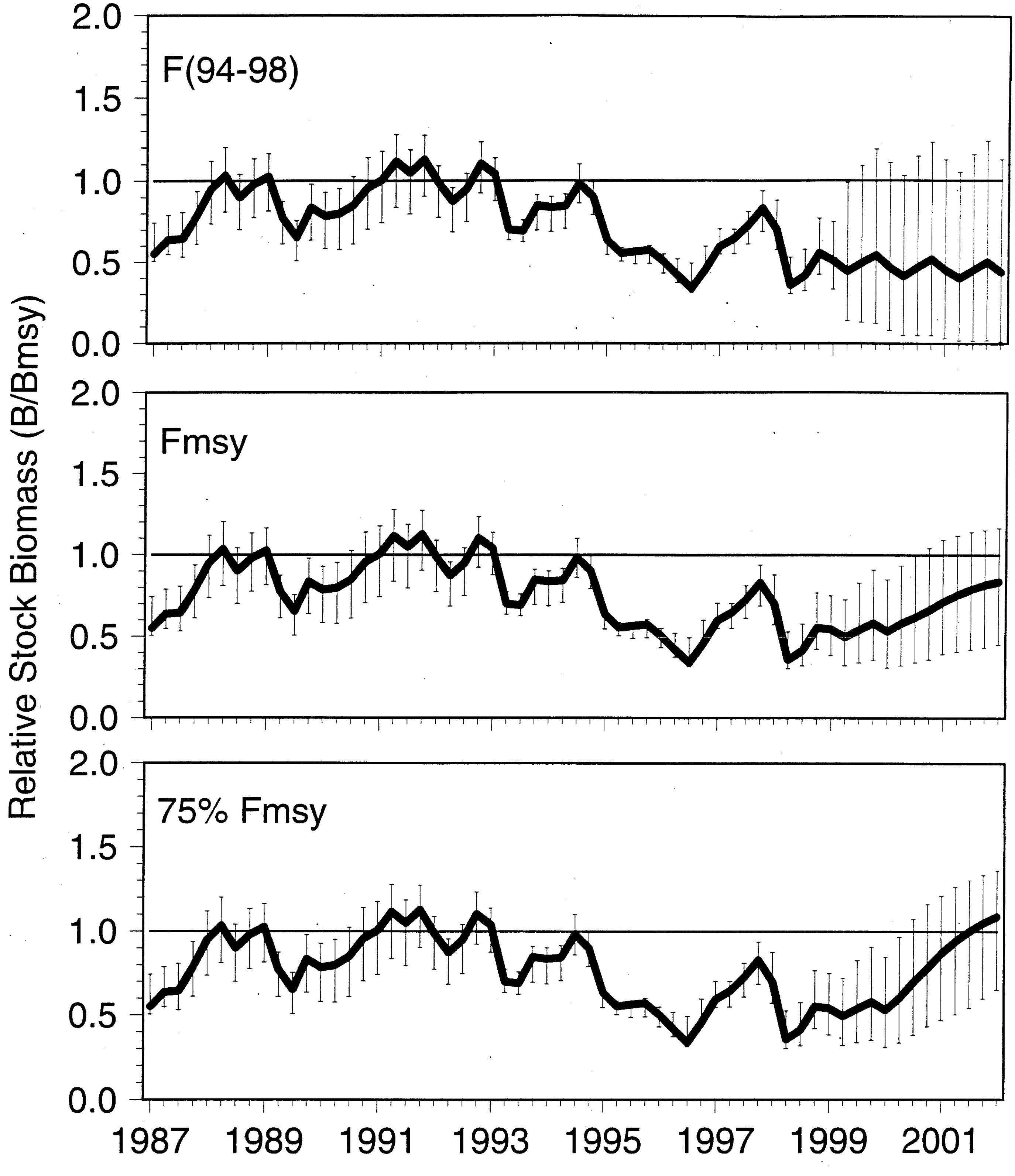


Figure 21a. Stochastic projections of relative stock biomass of *Loligo pealeii* at the overfishing definition (Fmsy) and the target F (75% Fmsy).

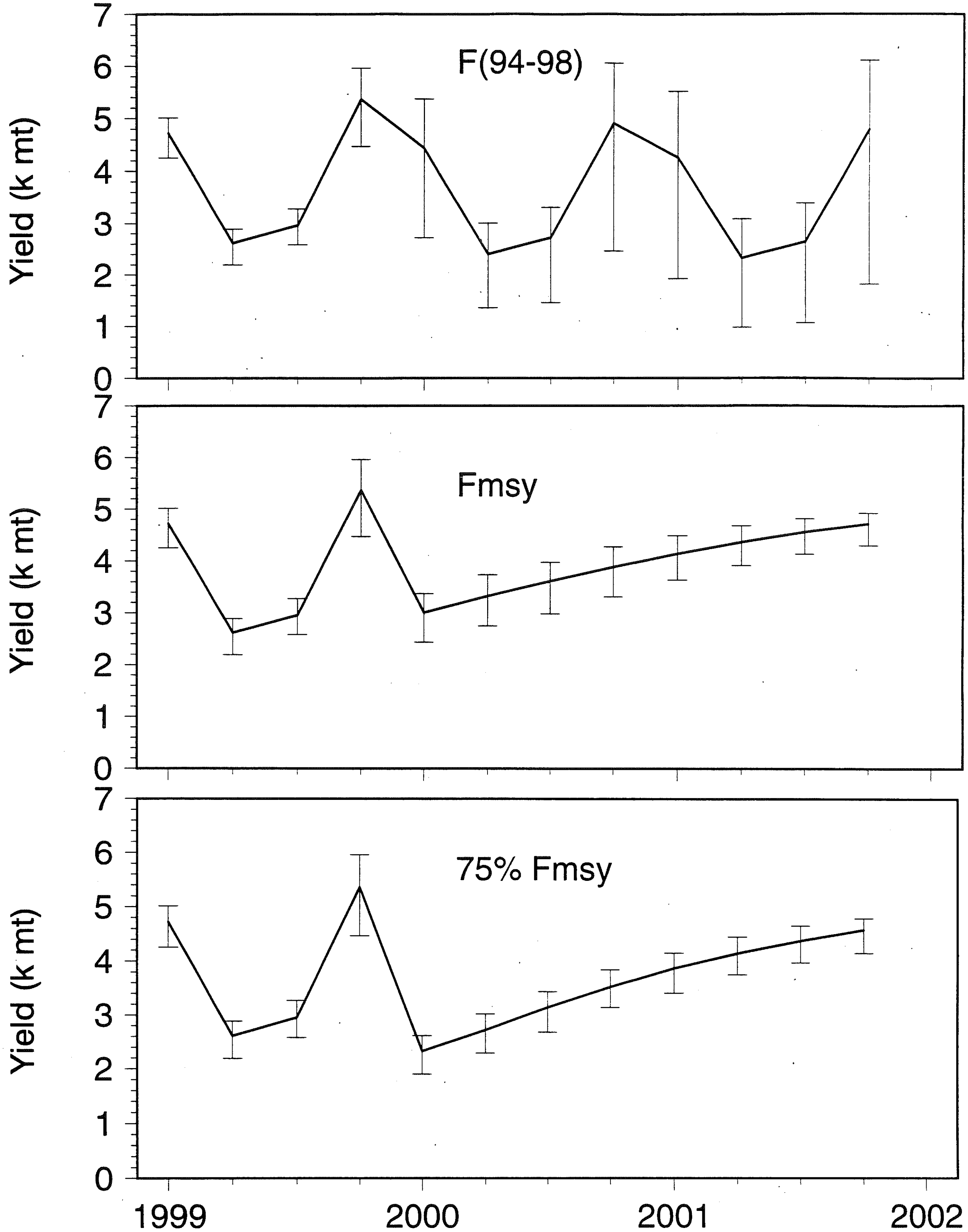


Figure 21b. Stochastic projections of *Loligo pealeii* yield at status quo F (1994-1998 seasonal averages), the overfishing definition (FMSY), and the target F (75% FMSY).

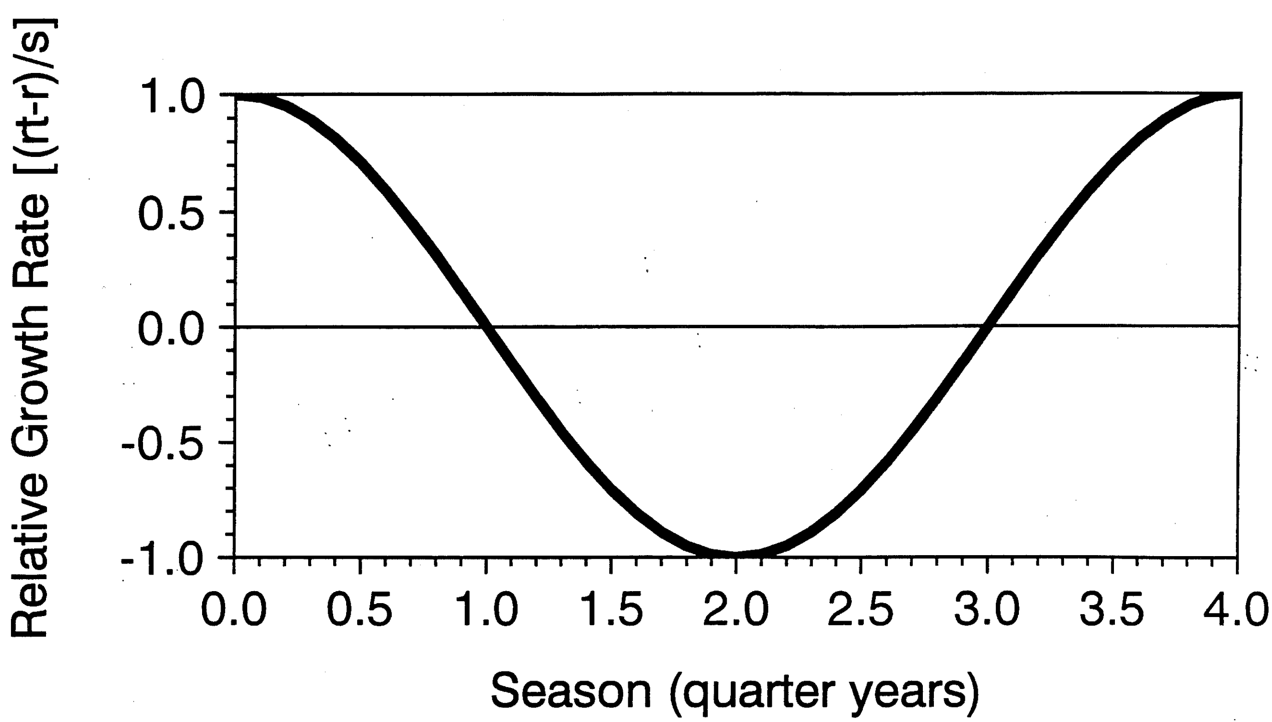


Figure 22. Hypothetic seasonal pattern of relative population growth rate [(*r*-*rt*)/**s**], where *r* is the intrinsic rate of increase, *rt* is the seasonal growth rate, and **s** is the absolute seasonal deviation.

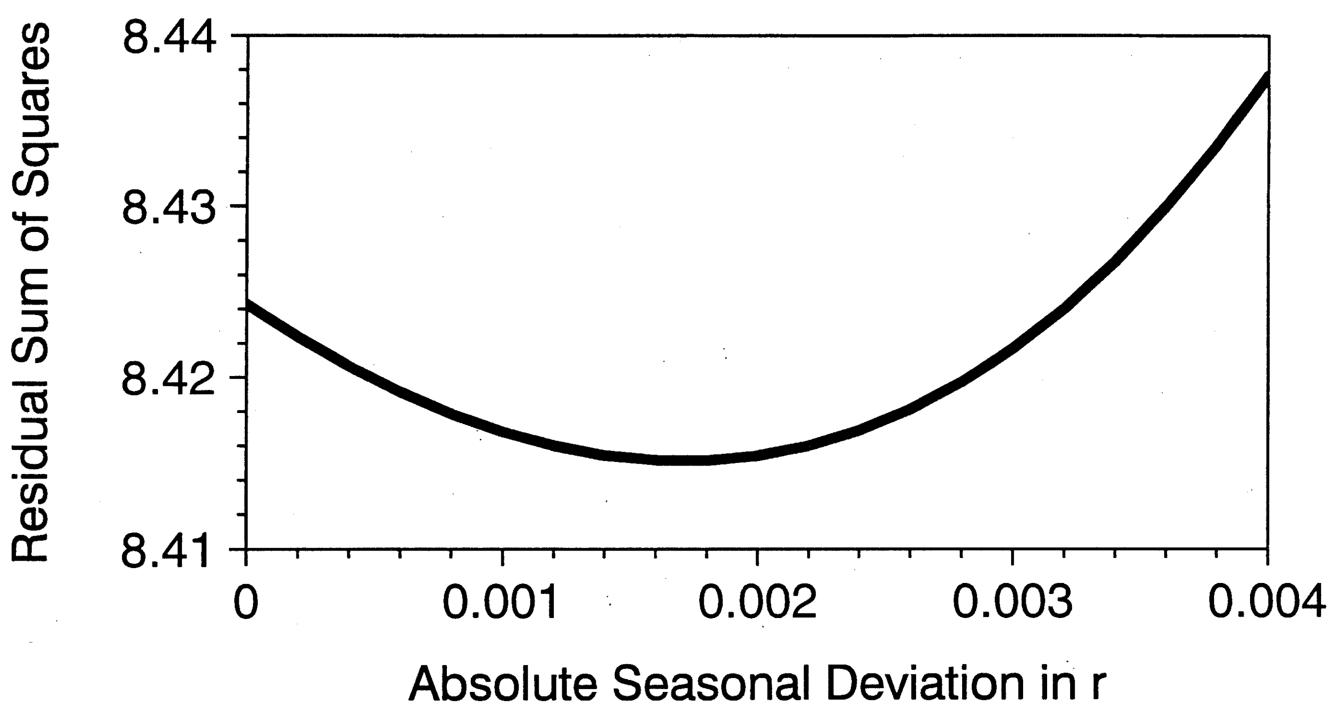


Figure 23. Response of objective function to estimates of **s**, the absolute seasonal deviation in *r*.

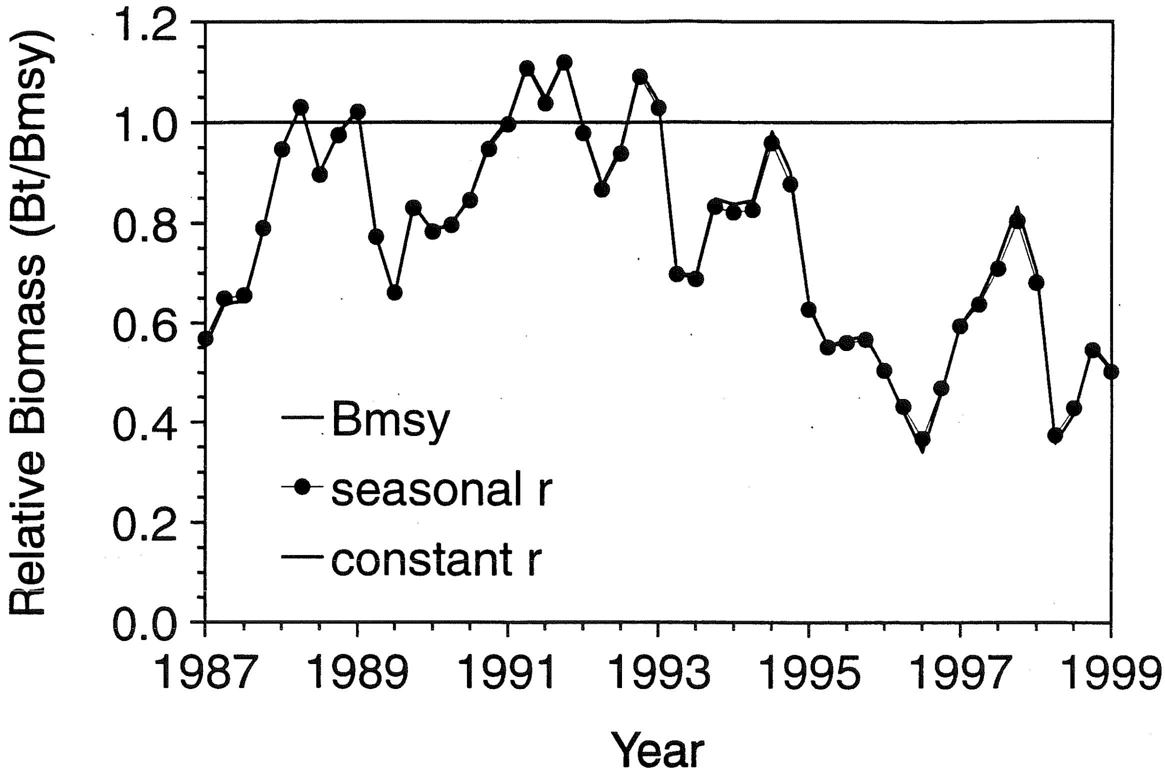


Figure 24. Comparison of relative biomass estimates from surplus production models that assume constant *r* and seasonally varying *r*.

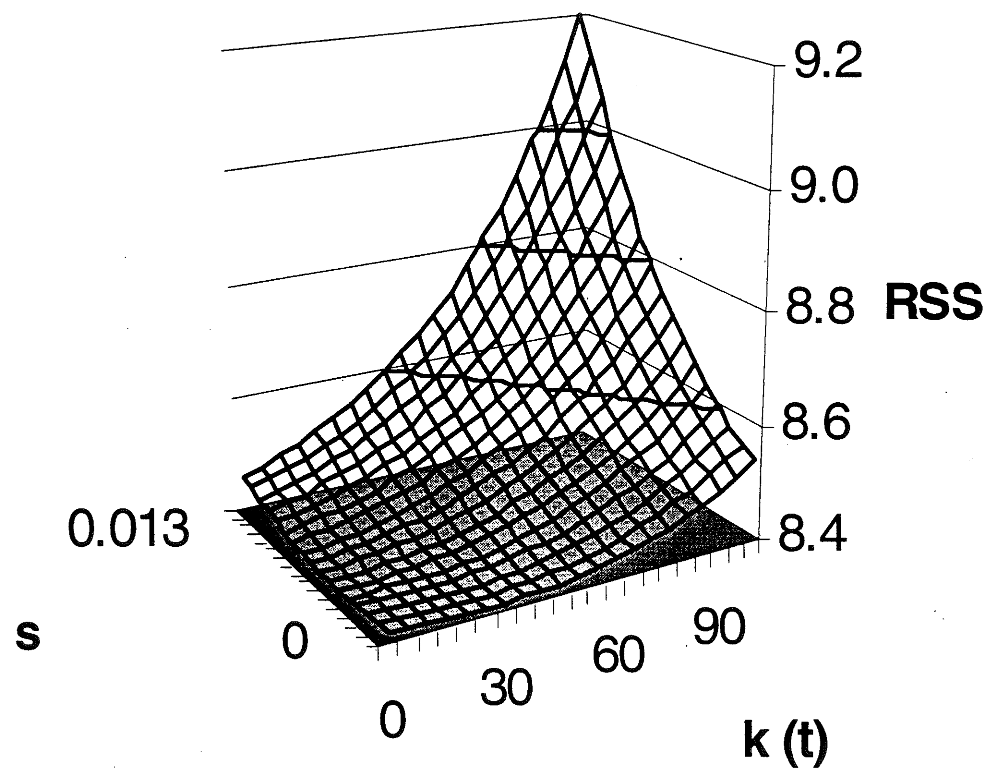


Figure 25. Response of objective function to simultaneous estimates of s (absolute seasonal deviation in *r*) and ***k*** (absolute seasonal deviation in *K*).

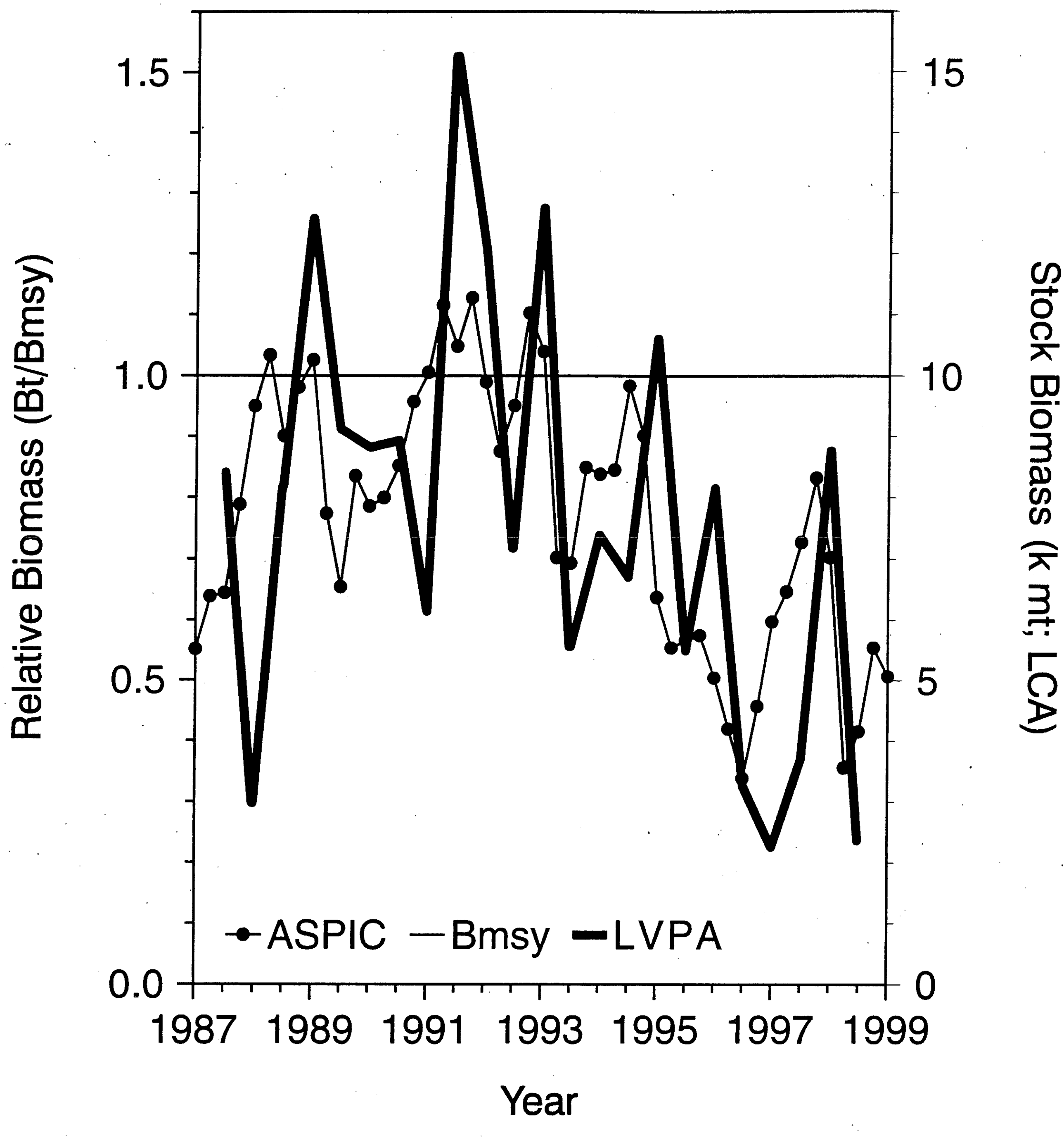


Figure 26. Comparison of relative biomass and F estimates from ASPIC with absolute biomass and F estimates from LVPA.

Length-based VPA		terminal F	0.3
Loligo		M (m)	0.3
Summer	1987 average monthly catch at size		

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	176	0.32	1760		657
27.5	266	0.31	2210	0.43	709
25.5	333	0.31	2771	0.44	756
23.5	426	0.30	3480	0.45	796
21.5	573	0.30	4409	0.48	833
19.5	800	0.30	5668	0.52	868
17.5	952	0.31	7214	0.48	876
15.5	1,396	0.32	9396	0.53	878
13.5	1,442	0.33	11883	0.41	825
11.5	788	0.35	14015	0.18	689
9.5	159	0.37	15840	0.03	516
sum	7,310		78,645		8,405
			average F	0.40	
			average F 19-24	0.49	

Length-based VPA terminal F 1.4
Loligo M (m) 0.3
Winter 1988 average monthly catch at size

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	25	0.17	126		47
27.5	21	0.18	155	0.83	50
25.5	89	0.19	255	2.30	70
23.5	190	0.21	467	2.60	107
21.5	235	0.23	742	1.74	140
19.5	593	0.25	1413	2.28	216
17.5	1,079	0.28	2655	1.98	322
15.5	1,848	0.31	4841	1.64	453
13.5	2,107	0.35	7595	0.98	527
11.5	2,560	0.41	11300	0.67	556
9.5	1,802	0.49	15015	0.28	489
sum	10,548		44,565		2,977
			average F	1.53	
			average F 19-23	2.21	

Length-based VPA terminal F 0.5
Loligo M (m) 0.3
Summer 1988 average monthly catch at size

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	56	0.32	412		154
27.5	247	0.31	711	1.45	228
25.5	477	0.31	1277	1.61	348
23.5	763	0.30	2194	1.48	502
21.5	1,173	0.30	3626	1.36	685
19.5	1,619	0.30	5663	1.16	867
17.5	2,615	0.31	8944	1.18	1,086
15.5	2,575	0.32	12531	0.76	1,171
13.5	3,323	0.33	17314	0.68	1,202
11.5	2,802	0.35	22158	0.41	1,090
9.5	881	0.37	25709	0.10	838
sum	16,532		100,539		8,172
			average F	1.02	
			average F 19-23	1.34	

Length-based VPA			terminal F		0.7
Loligo			M (m)		0.3
Winter	1989 average monthly catch at size				

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	162	0.17	1534		573
27.5	261	0.18	1886	0.85	605
25.5	757	0.19	2776	1.70	757
23.5	732	0.21	3709	1.09	849
21.5	1,724	0.23	5750	1.63	1,087
19.5	2,415	0.25	8698	1.36	1,332
17.5	3,415	0.28	13001	1.15	1,578
15.5	3,616	0.31	18047	0.76	1,687
13.5	3,102	0.35	23325	0.43	1,620
11.5	1,784	0.41	28267	0.17	1,390
9.5	1,042	0.49	33841	0.07	1,103
sum	19,008		140,834		12,581
			average F	0.92	
			average F 19-23	1.36	

Length-based VPA			terminal F		0.3
Loligo			M (m)		0.3
Summer	1989 average monthly catch at size				

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	131	0.32	1356		506
27.5	338	0.31	1842	0.69	591
25.5	516	0.31	2558	0.77	698
23.5	699	0.30	3531	0.76	808
21.5	845	0.30	4750	0.68	898
19.5	1,283	0.30	6546	0.75	1,003
17.5	1,701	0.31	8960	0.72	1,087
15.5	1,696	0.32	11629	0.52	1,087
13.5	1,480	0.33	14389	0.35	999
11.5	682	0.35	16683	0.13	820
9.5	203	0.37	18871	0.03	615
sum	9,575		91,116		9,113
			average F	0.54	
			average F 19-23	0.73	

Length-based VPA terminal F 0.4
Loligo M (m) 0.3
Winter 1990 average monthly catch at size

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	56	0.17	836		312
27.5	130	0.18	1015	0.79	326
25.5	263	0.19	1346	1.16	367
23.5	589	0.21	2040	1.69	467
21.5	1,650	0.23	3884	2.54	734
19.5	3,013	0.25	7302	2.23	1,119
17.5	2,398	0.28	10427	0.99	1,265
15.5	2,023	0.31	13559	0.55	1,267
13.5	1,621	0.35	16778	0.30	1,165
11.5	1,296	0.41	20347	0.17	1,001
9.5	526	0.49	24118	0.05	786
sum	13,564		101,652		8,809
			average F	1.05	
			average F 19-23	2.15	

Length-based VPA terminal F 0.3
Loligo M (m) 0.3
Summer 1990 average monthly catch at size

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	155	0.32	1851		691
27.5	231	0.31	2274	0.36	730
25.5	338	0.31	2845	0.43	776
23.5	430	0.30	3565	0.44	816
21.5	680	0.30	4615	0.55	872
19.5	1,187	0.30	6296	0.72	965
17.5	1,186	0.31	8149	0.53	989
15.5	1,234	0.32	10254	0.42	958
13.5	1,088	0.33	12460	0.29	865
11.5	731	0.35	14595	0.16	718
9.5	401	0.37	16744	0.07	546
sum	7,659		83,649		8,926
			average F	0.40	
			average F 19-23	0.57	

Length-based VPA			terminal F		0.6
Loligo			M (m)		0.3
Winter	1991	average monthly catch at size			

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	70	0.17	773		289
27.5	141	0.18	961	0.91	308
25.5	205	0.19	1229	0.98	335
23.5	397	0.21	1717	1.30	393
21.5	814	0.23	2678	1.66	506
19.5	1,646	0.25	4589	1.86	703
17.5	1,420	0.28	6463	0.94	784
15.5	1,860	0.31	9036	0.78	845
13.5	1,344	0.35	11460	0.37	796
11.5	538	0.41	13529	0.11	665
9.5	152	0.49	15824	0.02	516
sum	8,587		68,258		6,140
			average F	0.89	
			average F 19-23	1.61	

Length-based VPA			terminal F		0.3
Loligo			M (m)		0.3
Summer	1991	average monthly catch at size			

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	269	0.32	3688		1,377
27.5	366	0.31	4431	0.29	1,422
25.5	429	0.31	5306	0.29	1,448
23.5	746	0.30	6591	0.41	1,508
21.5	1,027	0.30	8291	0.46	1,567
19.5	1,330	0.30	10475	0.47	1,605
17.5	1,439	0.31	12999	0.40	1,578
15.5	1,616	0.32	15989	0.35	1,494
13.5	1,430	0.33	19148	0.25	1,329
11.5	1,098	0.35	22402	0.15	1,102
9.5	375	0.37	25447	0.04	829
sum	10,123		134,765		15,259
			average F	0.31	
			average F 19-23	0.45	

Length-based VPA terminal F 0.4
Loligo M (m) 0.3
Winter 1992 average monthly catch at size

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	56	0.17	885		331
27.5	224	0.18	1164	1.23	374
25.5	579	0.19	1828	2.04	499
23.5	1,073	0.21	3051	2.16	698
21.5	2,387	0.23	5727	2.47	1,082
19.5	3,928	0.25	10236	2.03	1,568
17.5	3,208	0.28	14458	0.95	1,755
15.5	2,707	0.31	18697	0.53	1,748
13.5	2,472	0.35	23387	0.33	1,624
11.5	1,455	0.41	27988	0.14	1,376
9.5	532	0.49	32970	0.04	1,075
sum	18,622		140,391		12,129
			average F	1.19	
			average F 19-23	2.22	

Length-based VPA terminal F 0.2
Loligo M (m) 0.3
Summer 1992 average monthly catch at size

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	100	0.32	1391		519
27.5	178	0.31	1713	0.37	550
25.5	256	0.31	2145	0.44	585
23.5	361	0.30	2727	0.49	624
21.5	717	0.30	3735	0.74	706
19.5	1,107	0.30	5249	0.82	804
17.5	1,043	0.31	6849	0.56	831
15.5	938	0.32	8516	0.39	796
13.5	832	0.33	10272	0.27	713
11.5	596	0.35	12024	0.15	591
9.5	263	0.37	13724	0.05	447
sum	6,390		68,345		7,168
			average F	0.43	
			average F 19-23	0.68	

Length-based VPA			terminal F	0.7
Loligo			M (m)	0.3
Winter	1993 average monthly catch at size			

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	96	0.17	856		320
27.5	76	0.18	981	0.46	315
25.5	408	0.19	1458	1.76	398
23.5	969	0.21	2550	2.38	584
21.5	2,497	0.23	5303	2.92	1,002
19.5	3,529	0.25	9367	1.98	1,435
17.5	3,409	0.28	13721	1.08	1,665
15.5	4,889	0.31	20166	0.94	1,885
13.5	5,299	0.35	27990	0.63	1,943
11.5	4,079	0.41	35977	0.31	1,769
9.5	2,033	0.49	43829	0.10	1,429
sum	27,284		162,200		12,745
			average F	1.26	
			average F 19-23	2.43	

Length-based VPA			terminal F	0.2
Loligo			M (m)	0.3
Summer	1993 average monthly catch at size			

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	33	0.32	509		190
27.5	72	0.31	634	0.40	204
25.5	348	0.31	1058	1.37	289
23.5	695	0.30	1883	1.60	431
21.5	906	0.30	3008	1.25	568
19.5	1,073	0.30	4416	0.96	676
17.5	1,003	0.31	5894	0.63	715
15.5	1,139	0.32	7675	0.53	717
13.5	1,378	0.33	9916	0.48	689
11.5	1,250	0.35	12318	0.33	606
9.5	588	0.37	14396	0.12	469
sum	8,485		61,708		5,555
			average F	0.77	
			average F 19-23	1.27	

Length-based VPA terminal F 0.6
Loligo M (m) 0.3
Winter 1994 average monthly catch at size

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	49	0.17	502		187
27.5	110	0.18	642	1.07	206
25.5	299	0.19	988	1.93	269
23.5	588	0.21	1657	2.18	379
21.5	1,139	0.23	2948	2.24	557
19.5	2,278	0.25	5533	2.23	848
17.5	2,215	0.28	8315	1.17	1,009
15.5	2,524	0.31	11763	0.82	1,099
13.5	2,172	0.35	15361	0.46	1,067
11.5	2,328	0.41	19839	0.32	976
9.5	1,166	0.49	24219	0.11	789
sum	14,869		91,767		7,387
			average F	1.25	
			average F 19-23	2.21	

Length-based VPA terminal F 0.3
Loligo M (m) 0.3
Summer 1994 average monthly catch at size

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	47	0.32	567		212
27.5	102	0.31	730	0.51	234
25.5	273	0.31	1085	1.00	296
23.5	654	0.30	1871	1.49	428
21.5	926	0.30	3014	1.27	570
19.5	1,745	0.30	5123	1.44	785
17.5	1,387	0.31	7071	0.74	858
15.5	1,591	0.32	9442	0.61	883
13.5	2,480	0.33	13022	0.68	904
11.5	2,600	0.35	17182	0.50	845
9.5	1,830	0.37	21147	0.26	689
sum	13,636		80,254		6,704
			average F	0.85	
			average F 19-23	1.40	

Length-based VPA			terminal F		0.8
Loligo			M (m)		0.3
Winter	1995 average monthly catch at size				

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	65	0.17	525		196
27.5	231	0.18	791	1.98	254
25.5	512	0.19	1363	2.53	372
23.5	808	0.21	2283	2.17	522
21.5	1,871	0.23	4373	2.56	826
19.5	2,623	0.25	7427	1.82	1,138
17.5	2,844	0.28	11026	1.13	1,338
15.5	4,191	0.31	16478	1.00	1,540
13.5	5,410	0.35	24005	0.77	1,667
11.5	3,624	0.41	30988	0.32	1,524
9.5	1,597	0.49	37586	0.10	1,225
sum	23,775		136,844		10,602
			average F	1.44	
			average F 19-23	2.19	

Length-based VPA			terminal F		0.4
Loligo			M (m)		0.3
Summer	1995 average monthly catch at size				

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	35	0.32	334		125
27.5	174	0.31	549	1.29	176
25.5	252	0.31	865	1.19	236
23.5	597	0.30	1570	1.66	359
21.5	861	0.30	2617	1.39	495
19.5	971	0.30	3881	0.99	595
17.5	1,069	0.31	5376	0.75	652
15.5	1,675	0.32	7664	0.82	716
13.5	2,650	0.33	11236	0.86	780
11.5	2,734	0.35	15341	0.60	754
9.5	1,184	0.37	18405	0.19	600
sum	12,202		67,837		5,489
			average F	0.97	
			average F 19-23	1.35	

Length-based VPA			terminal F	1.3
Loligo			M (m)	0.3
Winter	1996	average monthly catch at size		

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	102	0.17	547		204
27.5	96	0.18	675	0.88	217
25.5	209	0.19	931	1.36	254
23.5	477	0.21	1482	1.93	339
21.5	564	0.23	2169	1.38	410
19.5	1,832	0.25	4232	2.38	648
17.5	3,446	0.28	8174	2.08	992
15.5	3,978	0.31	13124	1.23	1,227
13.5	4,939	0.35	19779	0.86	1,373
11.5	4,815	0.41	27469	0.50	1,351
9.5	2,907	0.49	34919	0.19	1,138
sum	23,365		113,499		8,153
			average F	1.28	
			average F 19-23	1.90	

Length-based VPA			terminal F	0.3
Loligo			M (m)	0.3
Summer	1996	average monthly catch at size		

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	38	0.32	398		149
27.5	47	0.31	486	0.34	156
25.5	145	0.31	684	0.82	187
23.5	344	0.30	1108	1.29	254
21.5	400	0.30	1631	0.98	308
19.5	574	0.30	2386	0.95	366
17.5	738	0.31	3389	0.83	411
15.5	627	0.32	4384	0.51	410
13.5	784	0.33	5661	0.48	393
11.5	899	0.35	7226	0.40	355
9.5	491	0.37	8599	0.17	280
sum	5,086		35,950		3,268
			average F	0.68	
			average F 19-23	1.07	

Length-based VPA				terminal F	2.2
Loligo				M (m)	0.3
Winter	1997 average monthly catch at size				

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	5	0.17	18		7
27.5	11	0.18	30	2.58	10
25.5	28	0.19	60	3.33	16
23.5	54	0.21	119	3.00	27
21.5	119	0.23	250	2.97	47
19.5	286	0.25	565	2.97	87
17.5	775	0.28	1417	3.03	172
15.5	1,661	0.31	3284	2.41	307
13.5	3,229	0.35	7035	1.86	488
11.5	3,763	0.41	11936	0.99	587
9.5	1,668	0.49	15607	0.25	509
sum	11,599		40,320		2,257
			average F	2.34	
			average F 19-23	2.98	

Length-based VPA				terminal F	0.6
Loligo				M (m)	0.3
Summer	1997 average monthly catch at size				

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	33	0.32	205		77
27.5	56	0.31	284	0.75	91
25.5	145	0.31	463	1.29	126
23.5	263	0.30	781	1.43	179
21.5	504	0.30	1381	1.58	261
19.5	835	0.30	2384	1.49	365
17.5	1,103	0.31	3768	1.18	457
15.5	1,445	0.32	5655	0.98	529
13.5	2,097	0.33	8439	0.92	586
11.5	2,049	0.35	11517	0.60	566
9.5	986	0.37	13921	0.21	454
sum	9,517		48,799		3,691
			average F	1.04	
			average F 19-23	1.50	

Length-based VPA				terminal F	1.6
Loligo				M (m)	0.3
Winter	1998 average monthly catch at size				

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	49	0.17	218		81
27.5	89	0.18	321	1.86	103
25.5	205	0.19	551	2.50	150
23.5	382	0.21	980	2.46	224
21.5	755	0.23	1827	2.44	345
19.5	1,632	0.25	3657	2.48	560
17.5	2,832	0.28	6912	2.00	839
15.5	5,481	0.31	13301	1.81	1,243
13.5	8,500	0.35	23706	1.34	1,646
11.5	9,655	0.41	37031	0.79	1,821
9.5	10,066	0.49	53657	0.46	1,749
sum	39,647		142,163		8,763
			average F	1.81	
			average F 19-23	2.46	

Length-based VPA				terminal F	0.6
Loligo				M (m)	0.3
Summer	1998 average monthly catch at size				

Length (cm)	Catch (thous)	Delta-t (m)	Stock (thous)	F(m)	Biomass (mt)
29.5	34	0.32	196		73
27.5	63	0.31	281	0.86	90
25.5	92	0.31	405	0.89	110
23.5	202	0.30	654	1.28	150
21.5	243	0.30	970	1.00	183
19.5	354	0.30	1433	0.98	219
17.5	617	0.31	2216	1.11	269
15.5	926	0.32	3405	1.05	318
13.5	1,298	0.33	5118	0.94	355
11.5	1,021	0.35	6752	0.50	332
9.5	499	0.37	8078	0.18	263
sum	5,350		29,509		2,364
			average F	0.88	
			average F 19-23	1.09	

Loligo (biomass and yield in thousand mt)

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23 Jun 1999 at 13:29

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.65)

FIT Mode

Author: Michael H. Prager
National Marine Fisheries Service
Southwest Fisheries Science Center
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Tiburon, California 94920 USA

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	48	Number of bootstrap trials:	0
Number of data series:	4	Lower bound on MSY:	1.667E-01
Objective function computed:	in EFFORT	Upper bound on MSY:	2.000E+01
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	1.000E-01
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	2.000E+00
Relative conv. criterion (effort):	1.000E-04	Random number seed:	911
Maximum F allowed in fitting:	2.000	Monte Carlo search trials:	50000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	0.000E+00	1	N/A	1.000E+00	N/A	
Loss(1) Winter CPUE	7.502E-01	7	1.500E-01	1.000E+00	9.199E-01	-0.320
Loss(2) Summer CPUE	2.725E-01	7	5.450E-02	1.000E+00	2.532E+00	0.146
Loss(3) Spring Survey	2.040E+00	12	2.040E-01	1.000E+00	6.765E-01	0.389
Loss(4) Fall Survey	2.897E+00	12	2.897E-01	1.000E+00	4.764E-01	0.058
TOTAL OBJECTIVE FUNCTION:	5.96021335E+00					

Number of restarts required for convergence:	50
Est. B-ratio coverage index (0 worst, 2 best):	0.8823
Est. B-ratio nearness index (0 worst, 1 best):	1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1	6.725E-01	5.500E-01	1	1
MSY	Maximum sustainable yield	4.905E+00	5.000E+00	1	1
r	Intrinsic rate of increase	5.170E-01	5.257E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	Winter CPUE	3.255E-01	1.653E-01	1	1
q(2)	Summer CPUE	2.088E-01	1.653E-01	1	1
q(3)	Spring Survey	6.327E-01	6.936E-01	1	1
q(4)	Fall Survey	2.226E+00	1.241E+01	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	4.905E+00	Kr/4	
K	Maximum stock biomass	3.795E+01		
Bmsy	Stock biomass at MSY	1.897E+01	K/2	
Fmsy	Fishing mortality at MSY	2.585E-01	r/2	
F(0.1)	Management benchmark	2.327E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	4.856E+00	0.99*MSY	
B-ratio	Ratio of B(49) to Bmsy	5.747E-01		
F-ratio	Ratio of F(48) to Fmsy	1.660E+00		
Y-ratio	Proportion of MSY avail in 49	8.191E-01	2*Br-Br^2	Ye(49) = 4.018E+00
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	Winter CPUE	7.943E-01	r/2q(1)	f(0.1) = 7.148E-01

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1	0.182	1.276E+01	1.378E+01	2.505E+00	2.505E+00	4.533E+00	7.031E-01	6.725E-01
2	2	0.284	1.479E+01	1.501E+01	4.265E+00	4.265E+00	4.690E+00	1.099E+00	7.794E-01
3	3	0.108	1.521E+01	1.673E+01	1.815E+00	1.815E+00	4.826E+00	4.196E-01	8.019E-01
4	4	0.090	1.823E+01	1.981E+01	1.782E+00	1.782E+00	4.885E+00	3.481E-01	9.606E-01
5	5	0.154	2.133E+01	2.204E+01	3.404E+00	3.404E+00	4.775E+00	5.974E-01	1.124E+00
6	6	0.358	2.270E+01	2.122E+01	7.589E+00	7.589E+00	4.827E+00	1.383E+00	1.196E+00
7	7	0.167	1.994E+01	2.067E+01	3.451E+00	3.451E+00	4.864E+00	6.460E-01	1.051E+00
8	8	0.191	2.135E+01	2.169E+01	4.149E+00	4.149E+00	4.804E+00	7.400E-01	1.125E+00
9	9	0.509	2.200E+01	1.931E+01	9.838E+00	9.838E+00	4.876E+00	1.971E+00	1.160E+00
10	10	0.435	1.704E+01	1.591E+01	6.919E+00	6.919E+00	4.771E+00	1.683E+00	8.982E-01
11	11	0.070	1.489E+01	1.673E+01	1.164E+00	1.164E+00	4.821E+00	2.692E-01	7.850E-01
12	12	0.322	1.855E+01	1.807E+01	5.812E+00	5.812E+00	4.893E+00	1.244E+00	9.777E-01
13	13	0.255	1.763E+01	1.781E+01	4.538E+00	4.538E+00	4.886E+00	9.854E-01	9.292E-01
14	14	0.208	1.798E+01	1.852E+01	3.847E+00	3.847E+00	4.901E+00	8.034E-01	9.476E-01
15	15	0.146	1.903E+01	2.004E+01	2.933E+00	2.933E+00	4.885E+00	5.662E-01	1.003E+00
16	16	0.191	2.099E+01	2.137E+01	4.081E+00	4.081E+00	4.826E+00	7.386E-01	1.106E+00
17	17	0.127	2.173E+01	2.268E+01	2.877E+00	2.877E+00	4.714E+00	4.906E-01	1.145E+00
18	18	0.277	2.357E+01	2.272E+01	6.297E+00	6.297E+00	4.710E+00	1.072E+00	1.242E+00
19	19	0.152	2.198E+01	2.265E+01	3.443E+00	3.443E+00	4.719E+00	5.882E-01	1.158E+00
20	20	0.354	2.326E+01	2.171E+01	7.682E+00	7.682E+00	4.793E+00	1.369E+00	1.226E+00
21	21	0.377	2.037E+01	1.914E+01	7.211E+00	7.211E+00	4.899E+00	1.458E+00	1.073E+00
22	22	0.188	1.806E+01	1.876E+01	3.531E+00	3.531E+00	4.902E+00	7.280E-01	9.516E-01
23	23	0.099	1.943E+01	2.086E+01	2.061E+00	2.061E+00	4.848E+00	3.822E-01	1.024E+00
24	24	0.289	2.221E+01	2.147E+01	6.214E+00	6.214E+00	4.818E+00	1.120E+00	1.171E+00
25	25	0.666	2.082E+01	1.716E+01	1.144E+01	1.144E+01	4.811E+00	2.578E+00	1.097E+00
26	26	0.336	1.419E+01	1.411E+01	4.736E+00	4.736E+00	4.583E+00	1.298E+00	7.479E-01
27	27	0.111	1.404E+01	1.555E+01	1.725E+00	1.725E+00	4.735E+00	4.293E-01	7.398E-01
28	28	0.303	1.705E+01	1.690E+01	5.121E+00	5.121E+00	4.846E+00	1.172E+00	8.984E-01
29	29	0.283	1.677E+01	1.681E+01	4.762E+00	4.762E+00	4.841E+00	1.096E+00	8.839E-01
30	30	0.126	1.685E+01	1.818E+01	2.285E+00	2.285E+00	4.888E+00	4.863E-01	8.881E-01
31	31	0.356	1.946E+01	1.855E+01	6.603E+00	6.603E+00	4.899E+00	1.377E+00	1.025E+00
32	32	0.659	1.775E+01	1.492E+01	9.830E+00	9.830E+00	4.651E+00	2.548E+00	9.355E-01
33	33	0.496	1.257E+01	1.172E+01	5.815E+00	5.815E+00	4.184E+00	1.920E+00	6.626E-01
34	34	0.345	1.094E+01	1.106E+01	3.820E+00	3.820E+00	4.051E+00	1.336E+00	5.766E-01
35	35	0.349	1.117E+01	1.125E+01	3.933E+00	3.933E+00	4.093E+00	1.352E+00	5.888E-01
36	36	0.500	1.133E+01	1.062E+01	5.312E+00	5.312E+00	3.952E+00	1.935E+00	5.973E-01
37	37	0.570	9.973E+00	9.122E+00	5.201E+00	5.201E+00	3.579E+00	2.206E+00	5.256E-01
38	38	0.616	8.352E+00	7.551E+00	4.648E+00	4.648E+00	3.124E+00	2.382E+00	4.402E-01
39	39	0.104	6.827E+00	9.815E+00	1.019E+00	1.019E+00	3.446E+00	4.014E-01	3.598E-01
40	40	0.109	9.255E+00	1.062E+01	1.158E+00	1.158E+00	3.945E+00	4.218E-01	4.878E-01
41	41	0.267	1.204E+01	1.255E+01	3.347E+00	3.347E+00	4.341E+00	1.032E+00	6.347E-01
42	42	0.214	1.304E+01	1.384E+01	2.961E+00	2.961E+00	4.543E+00	8.278E-01	6.871E-01
43	43	0.176	1.462E+01	1.563E+01	2.753E+00	2.753E+00	4.748E+00	6.813E-01	7.704E-01
44	44	0.475	1.661E+01	1.527E+01	7.248E+00	7.248E+00	4.710E+00	1.837E+00	8.756E-01
45	45	1.015	1.408E+01	1.033E+01	1.048E+01	1.048E+01	3.837E+00	3.926E+00	7.418E-01
46	46	0.244	7.434E+00	8.083E+00	1.976E+00	1.976E+00	3.287E+00	9.458E-01	3.918E-01
47	47	0.092	8.744E+00	1.189E+01	1.099E+00	1.099E+00	3.997E+00	3.576E-01	4.608E-01
48	48	0.429	1.164E+01	1.126E+01	4.831E+00	4.831E+00	4.093E+00	1.660E+00	6.135E-01
49	49		1.090E+01						5.747E-01

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Winter CPUE

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed yield	Model yield	Resid in log effort	Resid in yield
1	1	6.278E-01	5.585E-01	0.1818	2.505E+00	2.505E+00	0.11705	0.000E+00
2	2	*	8.731E-01	0.2842	4.265E+00	4.265E+00	0.00000	0.000E+00
3	3	*	3.333E-01	0.1085	1.815E+00	1.815E+00	0.00000	0.000E+00
4	4	*	2.765E-01	0.0900	1.782E+00	1.782E+00	0.00000	0.000E+00
5	5	7.351E-01	4.745E-01	0.1544	3.404E+00	3.404E+00	0.43782	0.000E+00
6	6	*	1.099E+00	0.3576	7.589E+00	7.589E+00	0.00000	0.000E+00
7	7	*	5.131E-01	0.1670	3.451E+00	3.451E+00	0.00000	0.000E+00
8	8	*	5.877E-01	0.1913	4.149E+00	4.149E+00	0.00000	0.000E+00
9	9	1.164E+00	1.565E+00	0.5095	9.838E+00	9.838E+00	-0.29608	0.000E+00
10	10	*	1.337E+00	0.4350	6.919E+00	6.919E+00	0.00000	0.000E+00
11	11	*	2.138E-01	0.0696	1.164E+00	1.164E+00	0.00000	0.000E+00
12	12	*	9.884E-01	0.3217	5.812E+00	5.812E+00	0.00000	0.000E+00
13	13	7.402E-01	7.827E-01	0.2547	4.538E+00	4.538E+00	-0.05581	0.000E+00
14	14	*	6.381E-01	0.2077	3.847E+00	3.847E+00	0.00000	0.000E+00
15	15	*	4.497E-01	0.1464	2.933E+00	2.933E+00	0.00000	0.000E+00
16	16	*	5.867E-01	0.1909	4.081E+00	4.081E+00	0.00000	0.000E+00
17	17	6.200E-01	3.897E-01	0.1268	2.877E+00	2.877E+00	0.46444	0.000E+00
18	18	*	8.514E-01	0.2771	6.297E+00	6.297E+00	0.00000	0.000E+00
19	19	*	4.672E-01	0.1521	3.443E+00	3.443E+00	0.00000	0.000E+00
20	20	*	1.087E+00	0.3539	7.682E+00	7.682E+00	0.00000	0.000E+00
21	21	9.060E-01	1.158E+00	0.3768	7.211E+00	7.211E+00	-0.24522	0.000E+00
22	22	*	5.783E-01	0.1882	3.531E+00	3.531E+00	0.00000	0.000E+00
23	23	*	3.036E-01	0.0988	2.061E+00	2.061E+00	0.00000	0.000E+00
24	24	*	8.892E-01	0.2894	6.214E+00	6.214E+00	0.00000	0.000E+00
25	25	1.342E+00	2.048E+00	0.6664	1.144E+01	1.144E+01	-0.42210	0.000E+00
26	26	*	1.031E+00	0.3356	4.736E+00	4.736E+00	0.00000	0.000E+00
27	27	*	3.410E-01	0.1110	1.725E+00	1.725E+00	0.00000	0.000E+00
28	28	*	9.309E-01	0.3030	5.121E+00	5.121E+00	0.00000	0.000E+00
29	29	*	8.702E-01	0.2832	4.762E+00	4.762E+00	0.00000	0.000E+00
30	30	*	3.863E-01	0.1257	2.285E+00	2.285E+00	0.00000	0.000E+00
31	31	*	1.094E+00	0.3559	6.603E+00	6.603E+00	0.00000	0.000E+00
32	32	*	2.024E+00	0.6586	9.830E+00	9.830E+00	0.00000	0.000E+00
33	33	*	1.525E+00	0.4963	5.815E+00	5.815E+00	0.00000	0.000E+00
34	34	*	1.061E+00	0.3454	3.820E+00	3.820E+00	0.00000	0.000E+00
35	35	*	1.074E+00	0.3494	3.933E+00	3.933E+00	0.00000	0.000E+00
36	36	*	1.537E+00	0.5001	5.312E+00	5.312E+00	0.00000	0.000E+00
37	37	*	1.752E+00	0.5702	5.201E+00	5.201E+00	0.00000	0.000E+00
38	38	*	1.892E+00	0.6156	4.648E+00	4.648E+00	0.00000	0.000E+00
39	39	*	3.188E-01	0.1038	1.019E+00	1.019E+00	0.00000	0.000E+00
40	40	*	3.351E-01	0.1090	1.158E+00	1.158E+00	0.00000	0.000E+00
41	41	*	8.195E-01	0.2667	3.347E+00	3.347E+00	0.00000	0.000E+00
42	42	*	6.575E-01	0.2140	2.961E+00	2.961E+00	0.00000	0.000E+00
43	43	*	5.411E-01	0.1761	2.753E+00	2.753E+00	0.00000	0.000E+00
44	44	*	1.459E+00	0.4748	7.248E+00	7.248E+00	0.00000	0.000E+00
45	45	*	3.118E+00	1.0148	1.048E+01	1.048E+01	0.00000	0.000E+00
46	46	*	7.512E-01	0.2445	1.976E+00	1.976E+00	0.00000	0.000E+00
47	47	*	2.840E-01	0.0924	1.099E+00	1.099E+00	0.00000	0.000E+00
48	48	*	1.318E+00	0.4290	4.831E+00	4.831E+00	0.00000	0.000E+00

* Asterisk indicates missing value(s).

Loligo (biomass and yield in thousand mt) Page 4

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1

```
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75        1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year  Residual     ------------------------------------------------------------------------------------
   1     0.1171                                             |=====
   2     0.0000                                             |
   3     0.0000                                             |
   4     0.0000                                             |
   5     0.4378                                             |==================
   6     0.0000                                             |
   7     0.0000                                             |
   8     0.0000                                             |
   9    -0.2961                                 ============|
  10     0.0000                                             |
  11     0.0000                                             |
  12     0.0000                                             |
  13    -0.0558                                           ==|
  14     0.0000                                             |
  15     0.0000                                             |
  16     0.0000                                             |
  17     0.4644                                             |===================
  18     0.0000                                             |
  19     0.0000                                             |
  20     0.0000                                             |
  21    -0.2452                                   ==========|
  22     0.0000                                             |
  23     0.0000                                             |
  24     0.0000                                             |
  25    -0.4221                            =================|
  26     0.0000                                             |
  27     0.0000                                             |
  28     0.0000                                             |
  29     0.0000                                             |
  30     0.0000                                             |
  31     0.0000                                             |
  32     0.0000                                             |
  33     0.0000                                             |
  34     0.0000                                             |
  35     0.0000                                             |
  36     0.0000                                             |
  37     0.0000                                             |
  38     0.0000                                             |
  39     0.0000                                             |
  40     0.0000                                             |
  41     0.0000                                             |
  42     0.0000                                             |
  43     0.0000                                             |
  44     0.0000                                             |
  45     0.0000                                             |
  46     0.0000                                             |
  47     0.0000                                             |
  48     0.0000                                             |
                   ------------------------------------------------------------------------------------
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RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) Summer CPUE

Data type I0: Start-of-year biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1	0.000E+00	0.000E+00	0.0	*	2.665E+00	0.00000	0.0
2	2	0.000E+00	0.000E+00	0.0	*	3.089E+00	0.00000	0.0
3	3	1.000E+00	1.000E+00	0.0	4.270E+00	3.178E+00	0.29549	1.092E+00
4	4	0.000E+00	0.000E+00	0.0	*	3.806E+00	0.00000	0.0
5	5	0.000E+00	0.000E+00	0.0	*	4.454E+00	0.00000	0.0
6	6	0.000E+00	0.000E+00	0.0	*	4.741E+00	0.00000	0.0
7	7	1.000E+00	1.000E+00	0.0	4.950E+00	4.164E+00	0.17293	7.861E-01
8	8	0.000E+00	0.000E+00	0.0	*	4.459E+00	0.00000	0.0
9	9	0.000E+00	0.000E+00	0.0	*	4.596E+00	0.00000	0.0
10	10	0.000E+00	0.000E+00	0.0	*	3.559E+00	0.00000	0.0
11	11	1.000E+00	1.000E+00	0.0	3.540E+00	3.111E+00	0.12928	4.293E-01
12	12	0.000E+00	0.000E+00	0.0	*	3.874E+00	0.00000	0.0
13	13	0.000E+00	0.000E+00	0.0	*	3.682E+00	0.00000	0.0
14	14	0.000E+00	0.000E+00	0.0	*	3.755E+00	0.00000	0.0
15	15	1.000E+00	1.000E+00	0.0	3.630E+00	3.975E+00	-0.09086	-3.453E-01
16	16	0.000E+00	0.000E+00	0.0	*	4.383E+00	0.00000	0.0
17	17	0.000E+00	0.000E+00	0.0	*	4.538E+00	0.00000	0.0
18	18	0.000E+00	0.000E+00	0.0	*	4.922E+00	0.00000	0.0
19	19	1.000E+00	1.000E+00	0.0	4.380E+00	4.591E+00	-0.04701	-2.108E-01
20	20	0.000E+00	0.000E+00	0.0	*	4.857E+00	0.00000	0.0
21	21	0.000E+00	0.000E+00	0.0	*	4.254E+00	0.00000	0.0
22	22	0.000E+00	0.000E+00	0.0	*	3.771E+00	0.00000	0.0
23	23	1.000E+00	1.000E+00	0.0	2.900E+00	4.057E+00	-0.33580	-1.157E+00
24	24	0.000E+00	0.000E+00	0.0	*	4.639E+00	0.00000	0.0
25	25	0.000E+00	0.000E+00	0.0	*	4.348E+00	0.00000	0.0
26	26	0.000E+00	0.000E+00	0.0	*	2.964E+00	0.00000	0.0
27	27	1.000E+00	1.000E+00	0.0	2.590E+00	2.932E+00	-0.12392	-3.417E-01
28	28	0.000E+00	0.000E+00	0.0	*	3.560E+00	0.00000	0.0
29	29	0.000E+00	0.000E+00	0.0	*	3.503E+00	0.00000	0.0
30	30	0.000E+00	0.000E+00	0.0	*	3.519E+00	0.00000	0.0
31	31	0.000E+00	0.000E+00	0.0	*	4.063E+00	0.00000	0.0
32	32	0.000E+00	0.000E+00	0.0	*	3.707E+00	0.00000	0.0
33	33	0.000E+00	0.000E+00	0.0	*	2.626E+00	0.00000	0.0
34	34	0.000E+00	0.000E+00	0.0	*	2.285E+00	0.00000	0.0
35	35	0.000E+00	0.000E+00	0.0	*	2.333E+00	0.00000	0.0
36	36	0.000E+00	0.000E+00	0.0	*	2.367E+00	0.00000	0.0
37	37	0.000E+00	0.000E+00	0.0	*	2.083E+00	0.00000	0.0
38	38	0.000E+00	0.000E+00	0.0	*	1.744E+00	0.00000	0.0
39	39	0.000E+00	0.000E+00	0.0	*	1.426E+00	0.00000	0.0
40	40	0.000E+00	0.000E+00	0.0	*	1.933E+00	0.00000	0.0
41	41	0.000E+00	0.000E+00	0.0	*	2.515E+00	0.00000	0.0
42	42	0.000E+00	0.000E+00	0.0	*	2.723E+00	0.00000	0.0
43	43	0.000E+00	0.000E+00	0.0	*	3.053E+00	0.00000	0.0
44	44	0.000E+00	0.000E+00	0.0	*	3.470E+00	0.00000	0.0
45	45	0.000E+00	0.000E+00	0.0	*	2.940E+00	0.00000	0.0
46	46	0.000E+00	0.000E+00	0.0	*	1.552E+00	0.00000	0.0
47	47	0.000E+00	0.000E+00	0.0	*	1.826E+00	0.00000	0.0
48	48	0.000E+00	0.000E+00	0.0	*	2.431E+00	0.00000	0.0

* Asterisk indicates missing value(s).

Loligo (biomass and yield in thousand mt)


```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                      -1      -0.75    -0.5     -0.25      0        0.25      0.5      0.75      1
                       |   .    |   .    |   .    |   .    |   .    |   .    |   .    |   .    |
Year   Residual     ---------------------------------------------------------------------------------
  1     0.0000                                             |
  2     0.0000                                             |
  3     0.2955                                             |============
  4     0.0000                                             |
  5     0.0000                                             |
  6     0.0000                                             |
  7     0.1729                                             |=======
  8     0.0000                                             |
  9     0.0000                                             |
 10     0.0000                                             |
 11     0.1293                                             |=====
 12     0.0000                                             |
 13     0.0000                                             |
 14     0.0000                                             |
 15    -0.0909                                         ====|
 16     0.0000                                             |
 17     0.0000                                             |
 18     0.0000                                             |
 19    -0.0470                                           ==|
 20     0.0000                                             |
 21     0.0000                                             |
 22     0.0000                                             |
 23    -0.3358                                =============|
 24     0.0000                                             |
 25     0.0000                                             |
 26     0.0000                                             |
 27    -0.1239                                        =====|
 28     0.0000                                             |
 29     0.0000                                             |
 30     0.0000                                             |
 31     0.0000                                             |
 32     0.0000                                             |
 33     0.0000                                             |
 34     0.0000                                             |
 35     0.0000                                             |
 36     0.0000                                             |
 37     0.0000                                             |
 38     0.0000                                             |
 39     0.0000                                             |
 40     0.0000                                             |
 41     0.0000                                             |
 42     0.0000                                             |
 43     0.0000                                             |
 44     0.0000                                             |
 45     0.0000                                             |
 46     0.0000                                             |
 47     0.0000                                             |
 48     0.0000                                             |
                    ---------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) Spring Survey

Data type I1: Year-average biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1	0.000E+00	0.000E+00	0.0	*	8.720E+00	0.00000	0.0
2	2	1.000E+00	1.000E+00	0.0	8.652E+00	9.496E+00	-0.09307	-8.439E-01
3	3	0.000E+00	0.000E+00	0.0	*	1.059E+01	0.00000	0.0
4	4	0.000E+00	0.000E+00	0.0	*	1.253E+01	0.00000	0.0
5	5	0.000E+00	0.000E+00	0.0	*	1.395E+01	0.00000	0.0
6	6	1.000E+00	1.000E+00	0.0	1.577E+01	1.343E+01	0.16079	2.342E+00
7	7	0.000E+00	0.000E+00	0.0	*	1.308E+01	0.00000	0.0
8	8	0.000E+00	0.000E+00	0.0	*	1.372E+01	0.00000	0.0
9	9	0.000E+00	0.000E+00	0.0	*	1.222E+01	0.00000	0.0
10	10	1.000E+00	1.000E+00	0.0	2.146E+01	1.006E+01	0.75729	1.140E+01
11	11	0.000E+00	0.000E+00	0.0	*	1.058E+01	0.00000	0.0
12	12	0.000E+00	0.000E+00	0.0	*	1.143E+01	0.00000	0.0
13	13	0.000E+00	0.000E+00	0.0	*	1.127E+01	0.00000	0.0
14	14	1.000E+00	1.000E+00	0.0	1.539E+01	1.172E+01	0.27265	3.674E+00
15	15	0.000E+00	0.000E+00	0.0	*	1.268E+01	0.00000	0.0
16	16	0.000E+00	0.000E+00	0.0	*	1.352E+01	0.00000	0.0
17	17	0.000E+00	0.000E+00	0.0	*	1.435E+01	0.00000	0.0
18	18	1.000E+00	1.000E+00	0.0	1.917E+01	1.438E+01	0.28777	4.794E+00
19	19	0.000E+00	0.000E+00	0.0	*	1.433E+01	0.00000	0.0
20	20	0.000E+00	0.000E+00	0.0	*	1.374E+01	0.00000	0.0
21	21	0.000E+00	0.000E+00	0.0	*	1.211E+01	0.00000	0.0
22	22	1.000E+00	1.000E+00	0.0	1.015E+01	1.187E+01	-0.15653	-1.720E+00
23	23	0.000E+00	0.000E+00	0.0	*	1.320E+01	0.00000	0.0
24	24	0.000E+00	0.000E+00	0.0	*	1.359E+01	0.00000	0.0
25	25	0.000E+00	0.000E+00	0.0	*	1.086E+01	0.00000	0.0
26	26	1.000E+00	1.000E+00	0.0	8.140E+00	8.929E+00	-0.09251	-7.889E-01
27	27	0.000E+00	0.000E+00	0.0	*	9.837E+00	0.00000	0.0
28	28	0.000E+00	0.000E+00	0.0	*	1.070E+01	0.00000	0.0
29	29	0.000E+00	0.000E+00	0.0	*	1.064E+01	0.00000	0.0
30	30	1.000E+00	1.000E+00	0.0	4.655E+00	1.150E+01	-0.90443	-6.845E+00
31	31	0.000E+00	0.000E+00	0.0	*	1.174E+01	0.00000	0.0
32	32	0.000E+00	0.000E+00	0.0	*	9.443E+00	0.00000	0.0
33	33	0.000E+00	0.000E+00	0.0	*	7.413E+00	0.00000	0.0
34	34	1.000E+00	1.000E+00	0.0	8.762E+00	6.997E+00	0.22489	1.765E+00
35	35	0.000E+00	0.000E+00	0.0	*	7.121E+00	0.00000	0.0
36	36	0.000E+00	0.000E+00	0.0	*	6.721E+00	0.00000	0.0
37	37	0.000E+00	0.000E+00	0.0	*	5.772E+00	0.00000	0.0
38	38	1.000E+00	1.000E+00	0.0	2.635E+00	4.778E+00	-0.59489	-2.142E+00
39	39	0.000E+00	0.000E+00	0.0	*	6.211E+00	0.00000	0.0
40	40	0.000E+00	0.000E+00	0.0	*	6.720E+00	0.00000	0.0
41	41	0.000E+00	0.000E+00	0.0	*	7.939E+00	0.00000	0.0
42	42	1.000E+00	1.000E+00	0.0	8.737E+00	8.755E+00	-0.00212	-1.851E-02
43	43	0.000E+00	0.000E+00	0.0	*	9.890E+00	0.00000	0.0
44	44	0.000E+00	0.000E+00	0.0	*	9.659E+00	0.00000	0.0
45	45	0.000E+00	0.000E+00	0.0	*	6.534E+00	0.00000	0.0
46	46	1.000E+00	1.000E+00	0.0	5.883E+00	5.114E+00	0.14003	7.687E-01
47	47	0.000E+00	0.000E+00	0.0	*	7.524E+00	0.00000	0.0
48	48	0.000E+00	0.000E+00	0.0	*	7.124E+00	0.00000	0.0

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3
                   -1       -0.75     -0.5     -0.25       0        0.25      0.5      0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual   ----------------------------------------------------------------------------------
  1     0.0000                                             |
  2    -0.0931                                         ====|
  3     0.0000                                             |
  4     0.0000                                             |
  5     0.0000                                             |
  6     0.1608                                             |======
  7     0.0000                                             |
  8     0.0000                                             |
  9     0.0000                                             |
 10     0.7573                                             |==============================
 11     0.0000                                             |
 12     0.0000                                             |
 13     0.0000                                             |
 14     0.2726                                             |===========
 15     0.0000                                             |
 16     0.0000                                             |
 17     0.0000                                             |
 18     0.2878                                             |============
 19     0.0000                                             |
 20     0.0000                                             |
 21     0.0000                                             |
 22    -0.1565                                       ======|
 23     0.0000                                             |
 24     0.0000                                             |
 25     0.0000                                             |
 26    -0.0925                                         ====|
 27     0.0000                                             |
 28     0.0000                                             |
 29     0.0000                                             |
 30    -0.9044       ====================================|
 31     0.0000                                             |
 32     0.0000                                             |
 33     0.0000                                             |
 34     0.2249                                             |=========
 35     0.0000                                             |
 36     0.0000                                             |
 37     0.0000                                             |
 38    -0.5949                   ========================|
 39     0.0000                                             |
 40     0.0000                                             |
 41     0.0000                                             |
 42    -0.0021                                             |
 43     0.0000                                             |
 44     0.0000                                             |
 45     0.0000                                             |
 46     0.1400                                             |======
 47     0.0000                                             |
 48     0.0000                                             |
                  ----------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 4 (NON-BOOTSTRAPPED) Fall Survey

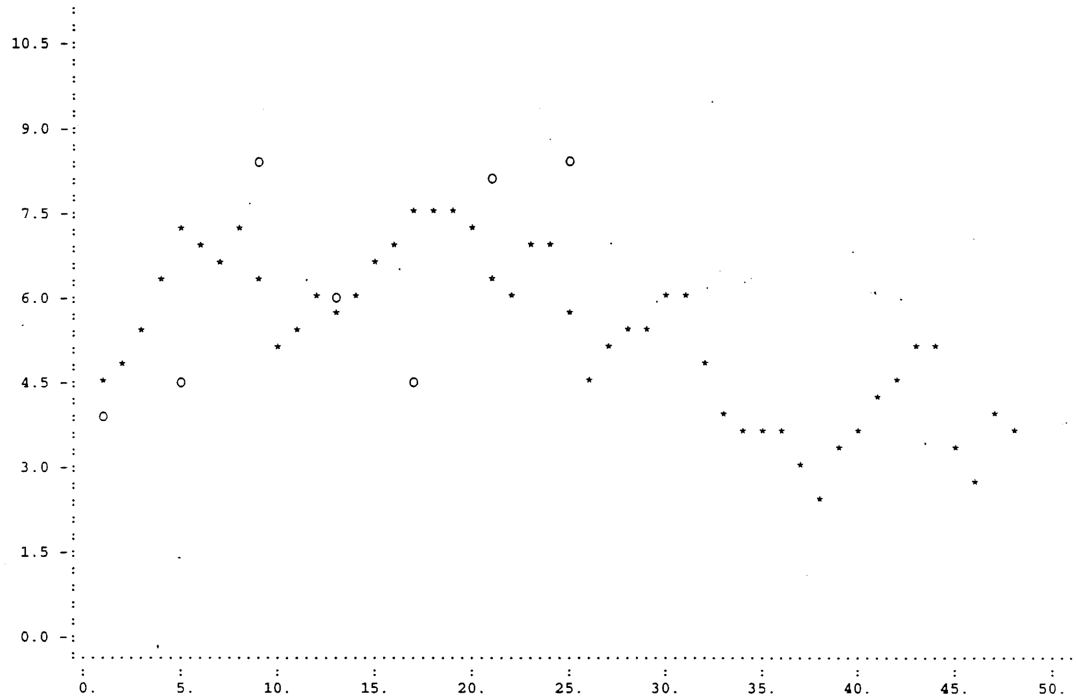
Data type I1: Year-average biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1	0.000E+00	0.000E+00	0.0	*	3.067E+01	0.00000	0.0
2	2	0.000E+00	0.000E+00	0.0	*	3.340E+01	0.00000	0.0
3	3	0.000E+00	0.000E+00	0.0	*	3.724E+01	0.00000	0.0
4	4	1.000E+00	1.000E+00	0.0	1.279E+01	4.408E+01	-1.23766	-3.130E+01
5	5	0.000E+00	0.000E+00	0.0	*	4.906E+01	0.00000	0.0
6	6	0.000E+00	0.000E+00	0.0	*	4.723E+01	0.00000	0.0
7	7	0.000E+00	0.000E+00	0.0	*	4.600E+01	0.00000	0.0
8	8	1.000E+00	1.000E+00	0.0	4.770E+01	4.828E+01	-0.01211	-5.811E-01
9	9	0.000E+00	0.000E+00	0.0	*	4.298E+01	0.00000	0.0
10	10	0.000E+00	0.000E+00	0.0	*	3.540E+01	0.00000	0.0
11	11	0.000E+00	0.000E+00	0.0	*	3.723E+01	0.00000	0.0
12	12	1.000E+00	1.000E+00	0.0	6.327E+01	4.021E+01	0.45325	2.306E+01
13	13	0.000E+00	0.000E+00	0.0	*	3.965E+01	0.00000	0.0
14	14	0.000E+00	0.000E+00	0.0	*	4.123E+01	0.00000	0.0
15	15	0.000E+00	0.000E+00	0.0	*	4.460E+01	0.00000	0.0
16	16	1.000E+00	1.000E+00	0.0	5.591E+01	4.757E+01	0.16155	8.341E+00
17	17	0.000E+00	0.000E+00	0.0	*	5.049E+01	0.00000	0.0
18	18	0.000E+00	0.000E+00	0.0	*	5.058E+01	0.00000	0.0
19	19	0.000E+00	0.000E+00	0.0	*	5.040E+01	0.00000	0.0
20	20	1.000E+00	1.000E+00	0.0	5.362E+01	4.832E+01	0.10414	5.303E+00
21	21	0.000E+00	0.000E+00	0.0	*	4.260E+01	0.00000	0.0
22	22	0.000E+00	0.000E+00	0.0	*	4.176E+01	0.00000	0.0
23	23	0.000E+00	0.000E+00	0.0	*	4.642E+01	0.00000	0.0
24	24	1.000E+00	1.000E+00	0.0	4.317E+01	4.779E+01	-0.10179	-4.626E+00
25	25	0.000E+00	0.000E+00	0.0	*	3.820E+01	0.00000	0.0
26	26	0.000E+00	0.000E+00	0.0	*	3.141E+01	0.00000	0.0
27	27	0.000E+00	0.000E+00	0.0	*	3.460E+01	0.00000	0.0
28	28	1.000E+00	1.000E+00	0.0	2.592E+01	3.762E+01	-0.37262	-1.170E+01
29	29	0.000E+00	0.000E+00	0.0	*	3.742E+01	0.00000	0.0
30	30	0.000E+00	0.000E+00	0.0	*	4.045E+01	0.00000	0.0
31	31	0.000E+00	0.000E+00	0.0	*	4.130E+01	0.00000	0.0
32	32	1.000E+00	1.000E+00	0.0	8.044E+01	3.322E+01	0.88442	4.722E+01
33	33	0.000E+00	0.000E+00	0.0	*	2.608E+01	0.00000	0.0
34	34	0.000E+00	0.000E+00	0.0	*	2.461E+01	0.00000	0.0
35	35	0.000E+00	0.000E+00	0.0	*	2.505E+01	0.00000	0.0
36	36	1.000E+00	1.000E+00	0.0	3.310E+01	2.364E+01	0.33660	9.461E+00
37	37	0.000E+00	0.000E+00	0.0	*	2.030E+01	0.00000	0.0
38	38	0.000E+00	0.000E+00	0.0	*	1.681E+01	0.00000	0.0
39	39	0.000E+00	0.000E+00	0.0	*	2.185E+01	0.00000	0.0
40	40	1.000E+00	1.000E+00	0.0	1.800E+01	2.364E+01	-0.27279	-5.644E+00
41	41	0.000E+00	0.000E+00	0.0	*	2.793E+01	0.00000	0.0
42	42	0.000E+00	0.000E+00	0.0	*	3.080E+01	0.00000	0.0
43	43	0.000E+00	0.000E+00	0.0	*	3.479E+01	0.00000	0.0
44	44	1.000E+00	1.000E+00	0.0	3.613E+01	3.398E+01	0.06136	2.150E+00
45	45	0.000E+00	0.000E+00	0.0	*	2.298E+01	0.00000	0.0
46	46	0.000E+00	0.000E+00	0.0	*	1.799E+01	0.00000	0.0
47	47	0.000E+00	0.000E+00	0.0	*	2.647E+01	0.00000	0.0
48	48	1.000E+00	1.000E+00	0.0	2.496E+01	2.506E+01	-0.00390	-9.757E-02

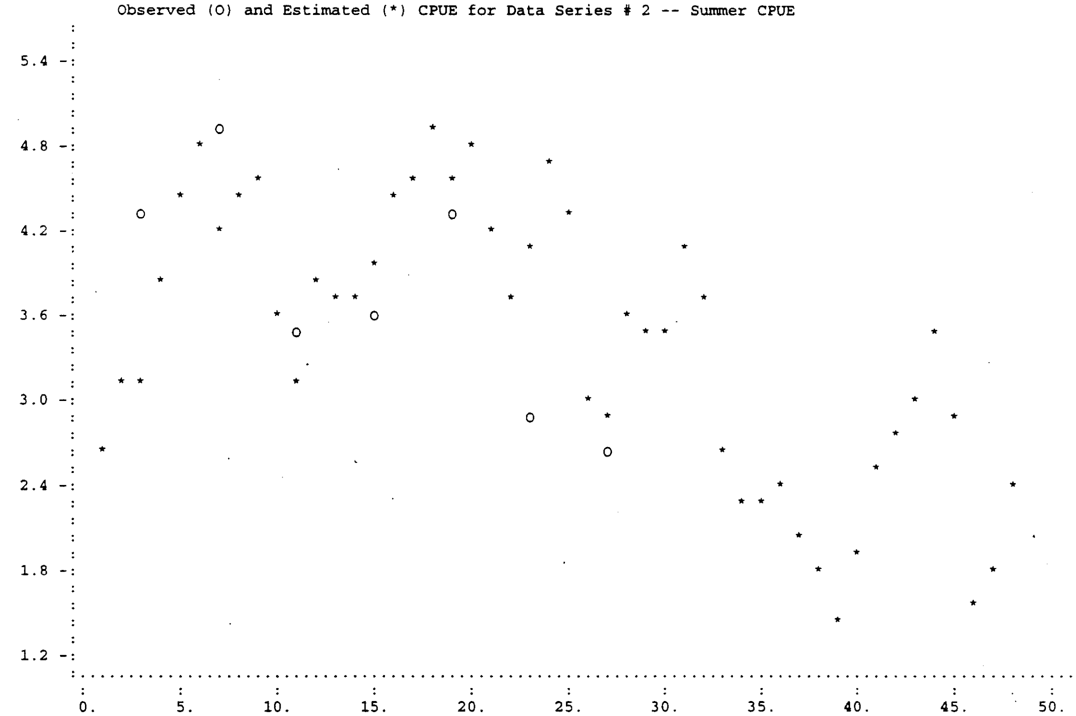
* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4
                    -2       -1.5       -1       -0.5        0        0.5        1        1.5        2
                     |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year  Residual     -------------------------------------------------------------------------------------
   1    0.0000                                              |
   2    0.0000                                              |
   3    0.0000                                              |
   4   -1.2377                     =========================|
   5    0.0000                                              |
   6    0.0000                                              |
   7    0.0000                                              |
   8   -0.0121                                              |
   9    0.0000                                              |
  10    0.0000                                              |
  11    0.0000                                              |
  12    0.4532                                              |=========
  13    0.0000                                              |
  14    0.0000                                              |
  15    0.0000                                              |
  16    0.1616                                              |===
  17    0.0000                                              |
  18    0.0000                                              |
  19    0.0000                                              |
  20    0.1041                                              |==
  21    0.0000                                              |
  22    0.0000                                              |
  23    0.0000                                              |
  24   -0.1018                                            ==|
  25    0.0000                                              |
  26    0.0000                                              |
  27    0.0000                                              |
  28   -0.3726                                       =======|
  29    0.0000                                              |
  30    0.0000                                              |
  31    0.0000                                              |
  32    0.8844                                              |==================
  33    0.0000                                              |
  34    0.0000                                              |
  35    0.0000                                              |
  36    0.3366                                              |=======
  37    0.0000                                              |
  38    0.0000                                              |
  39    0.0000                                              |
  40   -0.2728                                         =====|
  41    0.0000                                              |
  42    0.0000                                              |
  43    0.0000                                              |
  44    0.0614                                              |=
  45    0.0000                                              |
  46    0.0000                                              |
  47    0.0000                                              |
  48   -0.0039                                              |
                   -------------------------------------------------------------------------------------
```

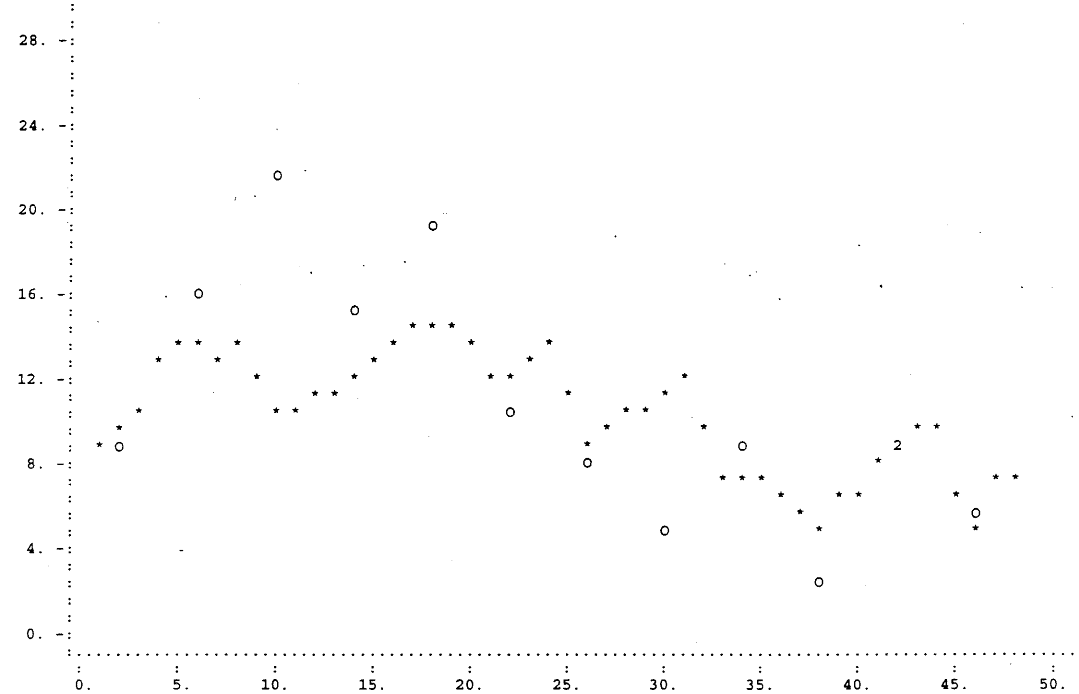
Observed (O) and Estimated (*) CPUE for Data Series # 1 -- Winter CPUE



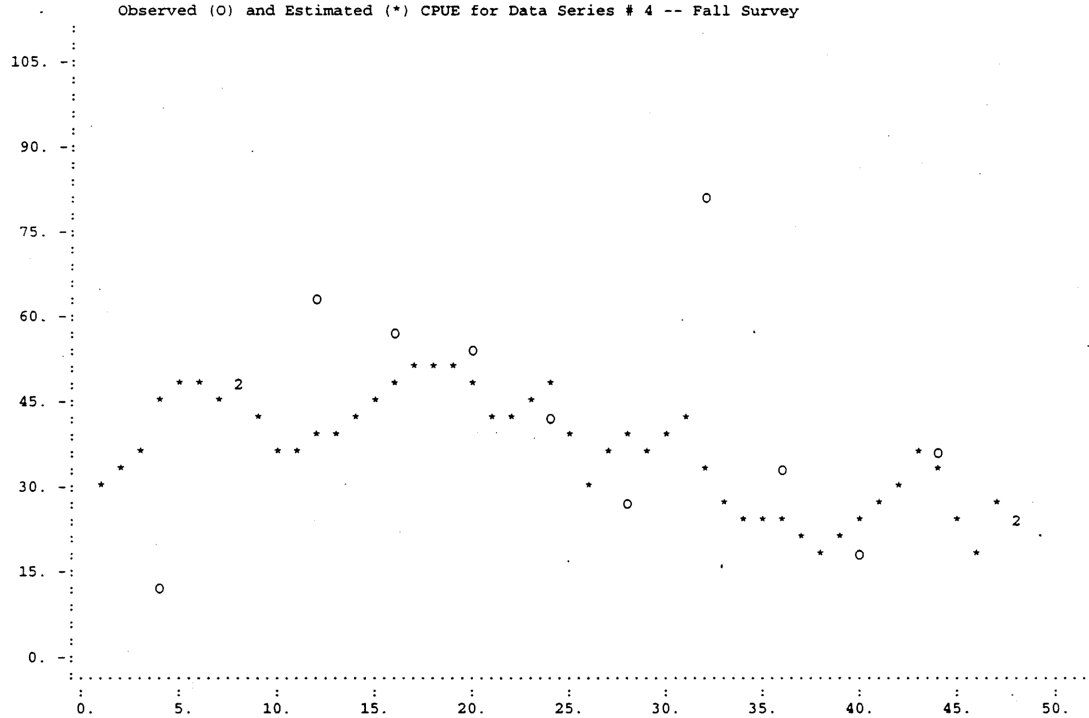
Observed (O) and Estimated (*) CPUE for Data Series # 2 -- Summer CPUE



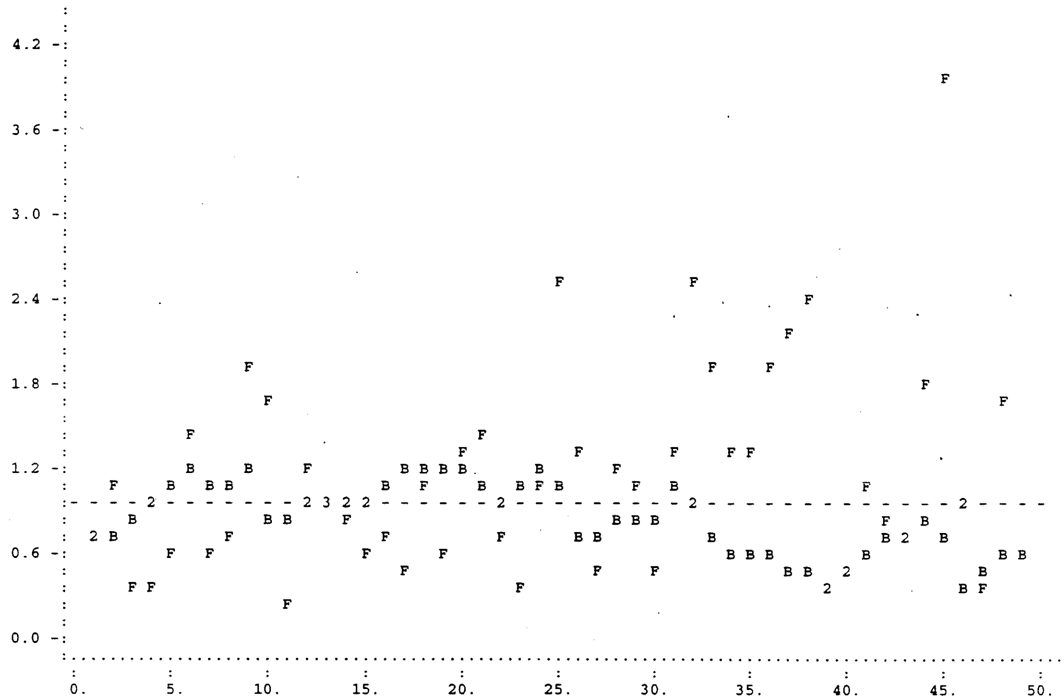
Observed (O) and Estimated (*) CPUE for Data Series # 3 -- Spring Survey



Observed (O) and Estimated (*) CPUE for Data Series # 4 -- Fall Survey



Time Plot of Estimated F-Ratio and B-Ratio



Loligo (biomass and yield in thousand mt) Page 10

RESULTS OF BOOTSTRAPPED ANALYSIS

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
B1ratio	6.930E-01	6.725E-01	-2.95%	4.494E-01	1.080E+00	5.567E-01	8.643E-01	3.075E-01	0.444
K	4.146E+01	3.795E+01	-8.46%	2.646E+01	9.573E+01	3.291E+01	5.730E+01	2.439E+01	0.588
r	4.494E-01	5.170E-01	15.04%	1.720E-01	7.165E-01	3.165E-01	5.837E-01	2.672E-01	0.595
q(1)	2.943E-01	3.255E-01	10.60%	1.618E-01	4.739E-01	2.243E-01	3.827E-01	1.584E-01	0.538
q(2)	1.856E-01	2.088E-01	12.54%	8.977E-02	3.080E-01	1.377E-01	2.399E-01	1.022E-01	0.551
q(3)	5.516E-01	6.327E-01	14.70%	2.664E-01	8.491E-01	3.982E-01	7.136E-01	3.154E-01	0.572
q(4)	2.009E+00	2.226E+00	10.78%	1.007E+00	2.970E+00	1.456E+00	2.456E+00	1.000E+00	0.498
MSY	4.794E+00	4.905E+00	2.31%	4.312E+00	5.028E+00	4.600E+00	4.917E+00	3.168E-01	0.066
Ye(49)	3.847E+00	4.018E+00	4.42%	2.348E+00	4.877E+00	3.091E+00	4.541E+00	1.450E+00	0.377
Bmsy	2.073E+01	1.897E+01	-8.46%	1.323E+01	4.786E+01	1.646E+01	2.865E+01	1.220E+01	0.588
Fmsy	2.247E-01	2.585E-01	15.04%	8.600E-02	3.583E-01	1.582E-01	2.918E-01	1.336E-01	0.595
fmsy(1)	7.579E-01	7.943E-01	4.80%	5.182E-01	9.965E-01	6.207E-01	8.821E-01	2.615E-01	0.345
fmsy(2)	1.218E+00	1.238E+00	1.59%	8.923E-01	1.652E+00	1.042E+00	1.429E+00	3.862E-01	0.317
fmsy(3)	4.021E-01	4.086E-01	1.61%	3.121E-01	5.034E-01	3.512E-01	4.489E-01	9.768E-02	0.243
fmsy(4)	1.137E-01	1.161E-01	2.13%	8.942E-02	1.500E-01	1.010E-01	1.318E-01	3.080E-02	0.271
F(0.1)	2.022E-01	2.327E-01	13.54%	7.740E-02	3.224E-01	1.424E-01	2.627E-01	1.202E-01	0.595
Y(0.1)	4.746E+00	4.856E+00	2.29%	4.269E+00	4.978E+00	4.554E+00	4.868E+00	3.137E-01	0.066
B-ratio	5.442E-01	5.747E-01	5.60%	2.726E-01	9.384E-01	3.843E-01	7.508E-01	3.665E-01	0.673
F-ratio	1.766E+00	1.660E+00	-6.03%	1.065E+00	2.961E+00	1.323E+00	2.314E+00	9.913E-01	0.561
Y-ratio	8.062E-01	8.191E-01	1.60%	5.041E-01	9.832E-01	6.511E-01	9.303E-01	2.792E-01	0.346
f0.1(1)	6.821E-01	7.148E-01	4.32%	4.664E-01	8.968E-01	5.586E-01	7.939E-01	2.353E-01	0.345
f0.1(2)	1.097E+00	1.114E+00	1.43%	8.030E-01	1.487E+00	9.382E-01	1.286E+00	3.476E-01	0.317
f0.1(3)	3.619E-01	3.677E-01	1.44%	2.809E-01	4.531E-01	3.161E-01	4.040E-01	8.792E-02	0.243
f0.1(4)	1.024E-01	1.045E-01	1.91%	8.048E-02	1.350E-01	9.092E-02	1.186E-01	2.772E-02	0.271
q2/q1	6.309E-01	6.417E-01	1.72%	4.598E-01	8.423E-01	5.386E-01	7.430E-01	2.044E-01	0.324
q3/q1	1.902E+00	1.944E+00	2.20%	1.425E+00	2.546E+00	1.604E+00	2.211E+00	6.069E-01	0.319
q4/q1	6.862E+00	6.839E+00	-0.34%	5.220E+00	9.045E+00	6.039E+00	7.879E+00	1.840E+00	0.268

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 500 trials.
- These results are conditional on the constraints placed upon MSY and r in the input file (ASPIC.INP).
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- The bias corrections used here are based on medians. This is an accepted statistical procedure, but may estimate nonzero bias for unbiased, skewed estimators.

Trials replaced for lack of convergence:	57
Trials replaced for MSY out-of-bounds:	2
Trials replaced for r out-of-bounds:	15
Residual-adjustment factor:	1.1072

Loligo (biomass and yield in thousand mt)
Status quo F (1994-1998)

Output from ASPIC-P.EXE Page 1
25 Jun 1999 at 08:03

USER CONTROL INFORMATION (FROM INPUT FILE)

Name of biomass (BIO) file	loligo2c.bio
Name of output file (this file)	loligoFs.prj
Number of years of projections	12

Year	Input data	User data type
49	1.070E+00	F:F(48)
50	5.900E-01	F:F(48)
51	5.900E-01	F:F(48)
52	1.070E+00	F:F(48)
53	1.070E+00	F:F(48)
54	5.900E-01	F:F(48)
55	5.900E-01	F:F(48)
56	1.070E+00	F:F(48)
57	1.070E+00	F:F(48)
58	5.900E-01	F:F(48)
59	5.900E-01	F:F(48)
60	1.070E+00	F:F(48)

TRAJECTORY OF RELATIVE BIOMASS (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1	6.930E-01	6.725E-01	-2.95%	4.494E-01	1.080E+00	5.567E-01	8.643E-01	3.075E-01	0.444
2	7.687E-01	7.794E-01	1.40%	5.111E-01	1.148E+00	6.269E-01	9.534E-01	3.264E-01	0.425
3	7.835E-01	8.019E-01	2.35%	4.854E-01	1.165E+00	6.175E-01	9.889E-01	3.715E-01	0.474
4	9.334E-01	9.606E-01	2.91%	6.004E-01	1.344E+00	7.597E-01	1.152E+00	3.923E-01	0.420
5	1.068E+00	1.124E+00	5.25%	6.865E-01	1.455E+00	8.791E-01	1.274E+00	3.951E-01	0.370
6	1.129E+00	1.196E+00	5.97%	7.104E-01	1.462E+00	9.005E-01	1.309E+00	4.090E-01	0.362
7	1.003E+00	1.051E+00	4.73%	6.630E-01	1.268E+00	8.420E-01	1.161E+00	3.186E-01	0.318
8	1.067E+00	1.125E+00	5.41%	6.746E-01	1.324E+00	8.527E-01	1.214E+00	3.618E-01	0.339
9	1.097E+00	1.160E+00	5.74%	6.976E-01	1.340E+00	8.808E-01	1.240E+00	3.590E-01	0.327
10	8.852E-01	8.982E-01	1.47%	6.216E-01	1.026E+00	7.663E-01	9.653E-01	1.990E-01	0.225
11	7.923E-01	7.850E-01	-0.93%	5.501E-01	9.397E-01	6.594E-01	8.754E-01	1.776E-01	0.224
12	9.306E-01	9.777E-01	5.06%	5.882E-01	1.143E+00	7.431E-01	1.068E+00	3.252E-01	0.350
13	8.832E-01	9.292E-01	5.21%	5.281E-01	1.085E+00	6.947E-01	1.015E+00	3.198E-01	0.362
14	8.955E-01	9.476E-01	5.82%	5.091E-01	1.108E+00	6.854E-01	1.031E+00	3.460E-01	0.386
15	9.445E-01	1.003E+00	6.21%	5.074E-01	1.170E+00	6.919E-01	1.085E+00	3.926E-01	0.416
16	1.038E+00	1.106E+00	6.56%	5.769E-01	1.294E+00	7.698E-01	1.194E+00	4.243E-01	0.409
17	1.078E+00	1.145E+00	6.25%	6.228E-01	1.328E+00	8.191E-01	1.233E+00	4.141E-01	0.384
18	1.171E+00	1.242E+00	6.07%	6.911E-01	1.431E+00	9.060E-01	1.326E+00	4.202E-01	0.359
19	1.104E+00	1.158E+00	4.90%	6.504E-01	1.293E+00	8.573E-01	1.225E+00	3.676E-01	0.333
20	1.170E+00	1.226E+00	4.73%	7.317E-01	1.368E+00	9.150E-01	1.290E+00	3.747E-01	0.320
21	1.036E+00	1.073E+00	3.60%	6.293E-01	1.153E+00	8.220E-01	1.115E+00	2.930E-01	0.283
22	9.346E-01	9.516E-01	1.82%	5.900E-01	1.040E+00	7.467E-01	1.004E+00	2.250E-01	0.241
23	9.893E-01	1.024E+00	3.49%	5.921E-01	1.102E+00	7.818E-01	1.060E+00	2.782E-01	0.281
24	1.128E+00	1.171E+00	3.80%	7.269E-01	1.305E+00	9.220E-01	1.227E+00	3.046E-01	0.270
25	1.060E+00	1.097E+00	3.53%	7.023E-01	1.197E+00	8.810E-01	1.141E+00	2.604E-01	0.246
26	7.762E-01	7.479E-01	-3.65%	6.091E-01	9.436E-01	6.930E-01	8.128E-01	7.089E-02	0.091
27	7.670E-01	7.398E-01	-3.55%	6.022E-01	9.379E-01	6.813E-01	8.059E-01	7.393E-02	0.096
28	8.778E-01	8.984E-01	2.35%	5.768E-01	1.016E+00	7.203E-01	9.207E-01	2.004E-01	0.228
29	8.590E-01	8.839E-01	2.90%	5.751E-01	9.389E-01	7.078E-01	9.100E-01	2.022E-01	0.235
30	8.591E-01	8.881E-01	3.38%	5.848E-01	9.608E-01	7.176E-01	9.195E-01	2.018E-01	0.235
31	9.868E-01	1.025E+00	3.90%	6.782E-01	1.171E+00	8.480E-01	1.085E+00	2.370E-01	0.240
32	9.034E-01	9.355E-01	3.55%	6.272E-01	1.048E+00	7.827E-01	9.776E-01	1.949E-01	0.216
33	6.545E-01	6.626E-01	1.24%	4.583E-01	8.629E-01	5.531E-01	7.095E-01	1.167E-01	0.178
34	5.878E-01	5.766E-01	-1.90%	4.835E-01	8.683E-01	5.373E-01	6.384E-01	6.590E-02	0.112
35	5.918E-01	5.888E-01	-0.50%	4.876E-01	7.499E-01	5.339E-01	6.267E-01	3.052E-02	0.052
36	5.860E-01	5.973E-01	1.92%	4.103E-01	6.459E-01	4.867E-01	6.047E-01	1.180E-01	0.201
37	5.253E-01	5.256E-01	0.06%	4.138E-01	8.901E-01	4.635E-01	5.964E-01	2.891E-02	0.055
38	4.616E-01	4.402E-01	-4.64%	3.638E-01	1.076E+00	4.236E-01	5.718E-01	1.406E-01	0.305
39	3.943E-01	3.598E-01	-8.73%	2.826E-01	9.193E-01	3.411E-01	5.146E-01	1.735E-01	0.440
40	5.214E-01	4.878E-01	-6.45%	4.208E-01	1.139E+00	4.668E-01	6.431E-01	1.763E-01	0.338
41	6.533E-01	6.347E-01	-2.85%	5.683E-01	1.112E+00	6.074E-01	7.567E-01	1.314E-01	0.201
42	6.875E-01	6.871E-01	-0.06%	5.297E-01	9.405E-01	6.062E-01	7.448E-01	1.017E-01	0.148
43	7.396E-01	7.704E-01	4.17%	4.961E-01	8.837E-01	6.165E-01	8.142E-01	1.977E-01	0.267
44	8.252E-01	8.756E-01	6.10%	5.279E-01	1.052E+00	6.864E-01	9.326E-01	2.462E-01	0.298
45	6.961E-01	7.418E-01	6.57%	4.539E-01	1.030E+00	5.768E-01	8.509E-01	2.191E-01	0.315
46	4.075E-01	3.918E-01	-3.86%	2.846E-01	6.863E-01	3.340E-01	5.357E-01	2.017E-01	0.495
47	4.670E-01	4.608E-01	-1.31%	3.000E-01	7.688E-01	3.649E-01	6.119E-01	2.470E-01	0.529
48	5.916E-01	6.135E-01	3.70%	3.616E-01	9.399E-01	4.694E-01	7.556E-01	2.863E-01	0.484
49	5.442E-01	5.747E-01	5.60%	2.726E-01	9.384E-01	3.843E-01	7.508E-01	3.665E-01	0.673
50	4.963E-01	5.282E-01	6.43%	2.119E-01	9.292E-01	3.215E-01	7.252E-01	4.037E-01	0.814
51	5.398E-01	5.948E-01	10.19%	1.940E-01	1.057E+00	3.388E-01	8.293E-01	4.906E-01	0.909
52	5.825E-01	6.585E-01	13.04%	1.903E-01	1.159E+00	3.537E-01	9.092E-01	5.554E-01	0.953
53	5.318E-01	5.937E-01	11.65%	1.579E-01	1.063E+00	3.091E-01	8.494E-01	5.402E-01	1.016
54	4.883E-01	5.433E-01	11.26%	1.240E-01	1.005E+00	2.679E-01	7.974E-01	5.295E-01	1.084
55	5.318E-01	6.094E-01	14.60%	1.081E-01	1.110E+00	2.684E-01	8.833E-01	6.149E-01	1.156
56	5.753E-01	6.723E-01	16.86%	1.132E-01	1.210E+00	2.989E-01	9.575E-01	6.586E-01	1.145
57	5.298E-01	6.043E-01	14.05%	9.836E-02	1.085E+00	2.619E-01	8.734E-01	6.116E-01	1.154
58	4.848E-01	5.516E-01	13.78%	7.798E-02	1.032E+00	2.375E-01	8.258E-01	5.883E-01	1.213
59	5.310E-01	6.174E-01	16.27%	6.437E-02	1.123E+00	2.307E-01	8.973E-01	6.665E-01	1.255
60	5.772E-01	6.797E-01	17.77%	5.880E-02	1.213E+00	2.444E-01	9.666E-01	7.222E-01	1.251
61	5.280E-01	6.099E-01	15.53%	6.724E-02	1.097E+00	2.353E-01	8.874E-01	6.521E-01	1.235

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

Loligo (biomass and yield in thousand mt) Output from ASPIC-P.EXE Page 2
Status quo F (1994-1998)

TRAJECTORY OF RELATIVE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1	7.305E-01	7.031E-01	-3.76%	5.113E-01	1.026E+00	6.167E-01	8.918E-01	2.751E-01	0.377
2	1.127E+00	1.099E+00	-2.45%	7.493E-01	1.595E+00	8.973E-01	1.353E+00	4.552E-01	0.404
3	4.301E-01	4.196E-01	-2.43%	2.919E-01	6.174E-01	3.495E-01	5.273E-01	1.778E-01	0.413
4	3.634E-01	3.481E-01	-4.22%	2.596E-01	5.075E-01	3.011E-01	4.363E-01	1.352E-01	0.372
5	6.326E-01	5.974E-01	-5.56%	4.755E-01	8.810E-01	5.420E-01	7.726E-01	2.305E-01	0.364
6	1.457E+00	1.383E+00	-5.03%	1.136E+00	1.994E+00	1.270E+00	1.761E+00	4.909E-01	0.337
7	6.805E-01	6.460E-01	-5.08%	5.379E-01	9.203E-01	5.948E-01	8.165E-01	2.217E-01	0.326
8	7.811E-01	7.400E-01	-5.27%	6.261E-01	1.053E+00	6.870E-01	9.369E-01	2.499E-01	0.320
9	2.053E+00	1.971E+00	-4.00%	1.707E+00	2.713E+00	1.841E+00	2.421E+00	5.806E-01	0.283
10	1.723E+00	1.683E+00	-2.31%	1.475E+00	2.379E+00	1.559E+00	2.027E+00	4.673E-01	0.271
11	2.791E-01	2.692E-01	-3.54%	2.288E-01	3.927E-01	2.454E-01	3.339E-01	8.850E-02	0.317
12	1.301E+00	1.244E+00	-4.37%	1.060E+00	1.855E+00	1.146E+00	1.609E+00	4.628E-01	0.356
13	1.034E+00	9.854E-01	-4.74%	8.366E-01	1.544E+00	9.041E-01	1.305E+00	4.008E-01	0.387
14	8.481E-01	8.034E-01	-5.28%	6.769E-01	1.287E+00	7.399E-01	1.085E+00	3.454E-01	0.407
15	5.982E-01	5.662E-01	-5.36%	4.710E-01	8.861E-01	5.189E-01	7.600E-01	2.411E-01	0.403
16	7.819E-01	7.386E-01	-5.53%	6.154E-01	1.144E+00	6.855E-01	9.806E-01	2.951E-01	0.377
17	5.172E-01	4.906E-01	-5.14%	4.099E-01	7.516E-01	4.564E-01	6.420E-01	1.855E-01	0.359
18	1.121E+00	1.072E+00	-4.40%	9.156E-01	1.587E+00	1.003E+00	1.369E+00	3.656E-01	0.326
19	6.126E-01	5.882E-01	-3.98%	5.087E-01	8.466E-01	5.529E-01	7.308E-01	1.779E-01	0.290
20	1.419E+00	1.369E+00	-3.56%	1.210E+00	1.909E+00	1.297E+00	1.663E+00	3.657E-01	0.258
21	1.503E+00	1.458E+00	-3.05%	1.336E+00	2.017E+00	1.398E+00	1.761E+00	3.639E-01	0.242
22	7.510E-01	7.280E-01	-3.05%	6.638E-01	1.004E+00	6.985E-01	8.803E-01	1.819E-01	0.242
23	3.957E-01	3.822E-01	-3.40%	3.322E-01	5.107E-01	3.581E-01	4.490E-01	9.090E-02	0.230
24	1.159E+00	1.120E+00	-3.42%	9.765E-01	1.538E+00	1.057E+00	1.322E+00	2.647E-01	0.228
25	2.636E+00	2.578E+00	-2.19%	2.255E+00	3.276E+00	2.501E+00	2.943E+00	4.308E-01	0.163
26	1.272E+00	1.298E+00	2.05%	1.106E+00	1.587E+00	1.218E+00	1.423E+00	5.949E-02	0.047
27	4.365E-01	4.293E-01	-1.65%	3.837E-01	5.467E-01	4.191E-01	4.888E-01	6.881E-02	0.158
28	1.204E+00	1.172E+00	-2.62%	1.070E+00	1.493E+00	1.124E+00	1.334E+00	2.104E-01	0.175
29	1.127E+00	1.096E+00	-2.77%	9.869E-01	1.411E+00	1.053E+00	1.262E+00	2.087E-01	0.185
30	5.031E-01	4.863E-01	-3.33%	4.196E-01	6.571E-01	4.599E-01	5.636E-01	1.036E-01	0.206
31	1.432E+00	1.377E+00	-3.85%	1.191E+00	1.921E+00	1.313E+00	1.619E+00	3.057E-01	0.214
32	2.622E+00	2.548E+00	-2.82%	2.334E+00	3.258E+00	2.481E+00	2.882E+00	4.009E-01	0.153
33	1.950E+00	1.920E+00	-1.56%	1.805E+00	2.331E+00	1.875E+00	2.088E+00	1.934E-01	0.099
34	1.353E+00	1.336E+00	-1.26%	1.275E+00	1.553E+00	1.322E+00	1.442E+00	1.204E-01	0.089
35	1.384E+00	1.352E+00	-2.33%	1.288E+00	1.614E+00	1.334E+00	1.485E+00	1.514E-01	0.109
36	1.977E+00	1.935E+00	-2.14%	1.781E+00	2.239E+00	1.906E+00	2.096E+00	1.896E-01	0.096
37	2.202E+00	2.206E+00	0.19%	1.600E+00	2.570E+00	1.970E+00	2.368E+00	1.551E-01	0.070
38	2.258E+00	2.382E+00	5.45%	1.187E+00	2.715E+00	1.864E+00	2.465E+00	6.015E-01	0.266
39	4.020E-01	4.014E-01	-0.13%	2.115E-01	4.718E-01	3.363E-01	4.364E-01	4.638E-02	0.115
40	4.052E-01	4.218E-01	4.11%	2.133E-01	4.641E-01	3.435E-01	4.375E-01	9.398E-02	0.232
41	1.036E+00	1.032E+00	-0.41%	7.092E-01	1.262E+00	9.136E-01	1.121E+00	1.508E-01	0.146
42	8.623E-01	8.278E-01	-4.00%	7.266E-01	1.112E+00	7.898E-01	9.802E-01	1.904E-01	0.221
43	7.212E-01	6.813E-01	-5.54%	5.700E-01	9.896E-01	6.422E-01	8.332E-01	1.909E-01	0.265
44	1.963E+00	1.837E+00	-6.41%	1.524E+00	2.789E+00	1.726E+00	2.302E+00	5.764E-01	0.294
45	3.998E+00	3.926E+00	-1.82%	3.016E+00	5.128E+00	3.313E+00	4.538E+00	1.071E+00	0.268
46	9.410E-01	9.458E-01	0.51%	5.906E-01	1.325E+00	7.319E-01	1.145E+00	4.130E-01	0.439
47	3.802E-01	3.576E-01	-5.95%	2.533E-01	5.565E-01	3.055E-01	4.704E-01	1.649E-01	0.434
48	1.766E+00	1.660E+00	-6.03%	1.065E+00	2.961E+00	1.323E+00	2.314E+00	9.913E-01	0.561
49	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561
50	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
51	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
52	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561
53	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561
54	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
55	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
56	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561
57	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561
58	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
59	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
60	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561

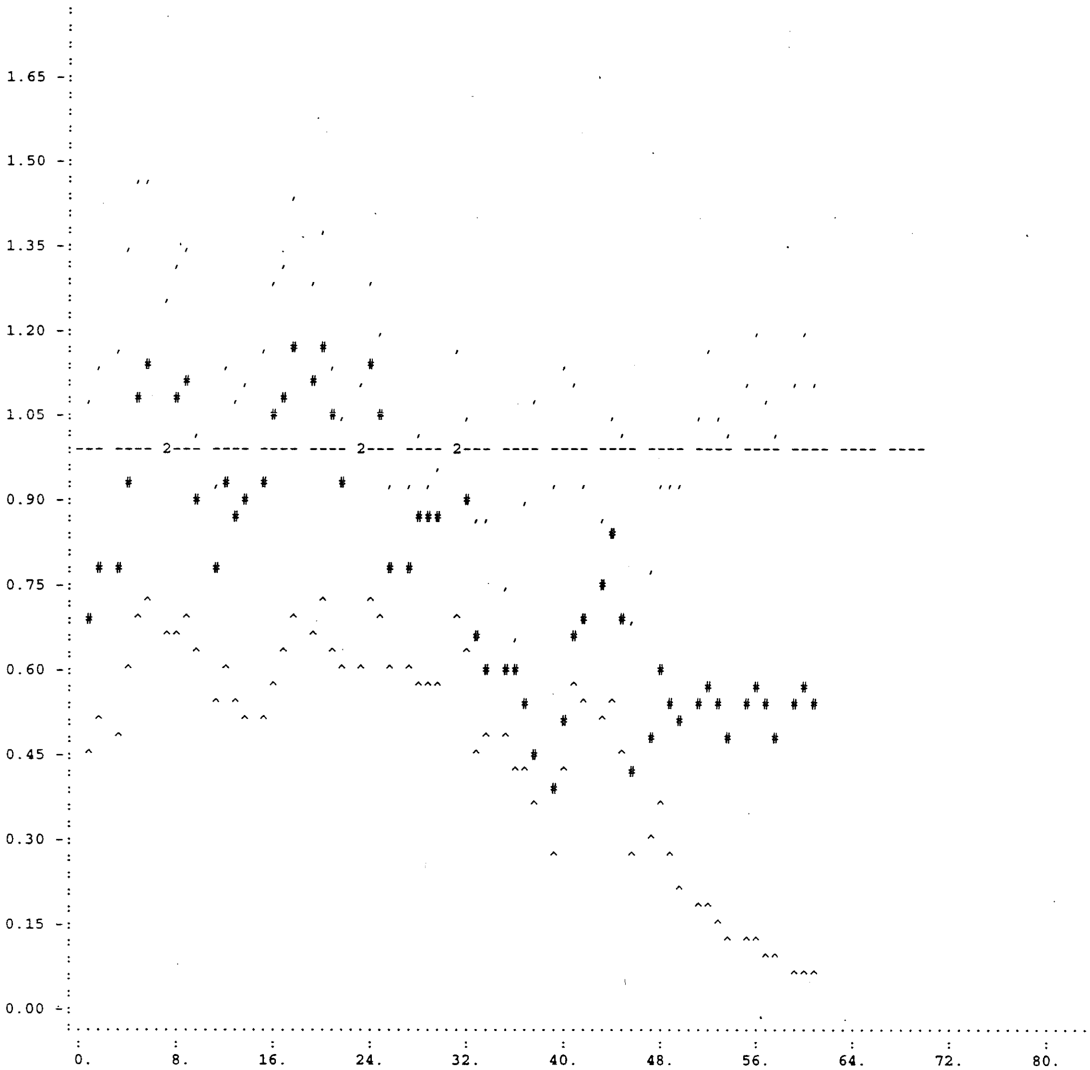
TABLE OF PROJECTED YIELDS

49	4.722E+00	4.796E+00	1.56%	3.714E+00	5.125E+00	4.252E+00	5.013E+00	7.617E-01	0.161
50	2.614E+00	2.697E+00	3.19%	1.647E+00	3.015E+00	2.192E+00	2.884E+00	6.921E-01	0.265
51	2.955E+00	3.011E+00	1.90%	2.002E+00	3.498E+00	2.581E+00	3.273E+00	6.925E-01	0.234
52	5.365E+00	5.441E+00	1.42%	3.232E+00	6.339E+00	4.468E+00	5.959E+00	1.491E+00	0.278
53	4.759E+00	4.943E+00	3.87%	2.227E+00	5.799E+00	3.610E+00	5.523E+00	1.913E+00	0.402
54	2.641E+00	2.769E+00	4.84%	9.554E-01	3.299E+00	1.798E+00	3.095E+00	1.296E+00	0.491
55	3.014E+00	3.080E+00	2.18%	1.299E+00	3.693E+00	2.253E+00	3.460E+00	1.207E+00	0.400
56	5.456E+00	5.546E+00	1.65%	2.222E+00	6.661E+00	4.051E+00	6.250E+00	2.198E+00	0.403
57	4.800E+00	5.025E+00	4.69%	1.528E+00	5.976E+00	3.230E+00	5.716E+00	2.486E+00	0.518
58	2.673E+00	2.808E+00	5.05%	6.278E-01	3.382E+00	1.655E+00	3.203E+00	1.548E+00	0.579
59	3.058E+00	3.117E+00	1.91%	9.519E-01	3.788E+00	2.088E+00	3.553E+00	1.465E+00	0.479
60	5.518E+00	5.603E+00	1.54%	1.608E+00	6.735E+00	3.719E+00	6.348E+00	2.629E+00	0.476

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

Loligo (biomass and yield in thousand mt) Output from ASPIC-P.EXE Page 5
Status quo F (1994-1998)

Bias-Corrected Time Plot of B-Ratio (#) with Approximate 80% Confidence Interval (^,)
(Dashed reference line is 1.0)



NOTE: Estimates beginning in 50 depend on the user projection data listed on page 1.

Loligo (biomass and yield in thousand mt)
F99=F94-98 F00-01=Fmsy

Output from ASPIC-P.EXE Page 1
25 Jun 1999 at 08:18

USER CONTROL INFORMATION (FROM INPUT FILE)

Name of biomass (BIO) file	loligo2c.bio
Name of output file (this file)	loligoFo.prj
Number of years of projections	12

Year	Input data	User data type
49	1.070E+00	F:F(48)
50	5.900E-01	F:F(48)
51	5.900E-01	F:F(48)
52	1.070E+00	F:F(48)
53	6.000E-01	F:F(48)
54	6.000E-01	F:F(48)
55	6.000E-01	F:F(48)
56	6.000E-01	F:F(48)
57	6.000E-01	F:F(48)
58	6.000E-01	F:F(48)
59	6.000E-01	F:F(48)
60	6.000E-01	F:F(48)

TRAJECTORY OF RELATIVE BIOMASS (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1	6.930E-01	6.725E-01	-2.95%	4.494E-01	1.080E+00	5.567E-01	8.643E-01	3.075E-01	0.444
2	7.687E-01	7.794E-01	1.40%	5.111E-01	1.148E+00	6.269E-01	9.534E-01	3.264E-01	0.425
3	7.835E-01	8.019E-01	2.35%	4.854E-01	1.165E+00	6.175E-01	9.889E-01	3.715E-01	0.474
4	9.334E-01	9.606E-01	2.91%	6.004E-01	1.344E+00	7.597E-01	1.152E+00	3.923E-01	0.420
5	1.068E+00	1.124E+00	5.25%	6.865E-01	1.455E+00	8.791E-01	1.274E+00	3.951E-01	0.370
6	1.129E+00	1.196E+00	5.97%	7.104E-01	1.462E+00	9.005E-01	1.309E+00	4.090E-01	0.362
7	1.003E+00	1.051E+00	4.73%	6.630E-01	1.268E+00	8.420E-01	1.161E+00	3.186E-01	0.318
8	1.067E+00	1.125E+00	5.41%	6.746E-01	1.324E+00	8.527E-01	1.214E+00	3.618E-01	0.339
9	1.097E+00	1.160E+00	5.74%	6.976E-01	1.340E+00	8.808E-01	1.240E+00	3.590E-01	0.327
10	8.852E-01	8.982E-01	1.47%	6.216E-01	1.026E+00	7.663E-01	9.653E-01	1.990E-01	0.225
11	7.923E-01	7.850E-01	-0.93%	5.501E-01	9.397E-01	6.594E-01	8.754E-01	1.776E-01	0.224
12	9.306E-01	9.777E-01	5.06%	5.882E-01	1.143E+00	7.431E-01	1.068E+00	3.252E-01	0.350
13	8.832E-01	9.292E-01	5.21%	5.281E-01	1.085E+00	6.947E-01	1.015E+00	3.198E-01	0.362
14	8.955E-01	9.476E-01	5.82%	5.091E-01	1.108E+00	6.854E-01	1.031E+00	3.460E-01	0.386
15	9.445E-01	1.003E+00	6.21%	5.074E-01	1.170E+00	6.919E-01	1.085E+00	3.926E-01	0.416
16	1.038E+00	1.106E+00	6.56%	5.769E-01	1.294E+00	7.698E-01	1.194E+00	4.243E-01	0.409
17	1.078E+00	1.145E+00	6.25%	6.228E-01	1.328E+00	8.191E-01	1.233E+00	4.141E-01	0.384
18	1.171E+00	1.242E+00	6.07%	6.911E-01	1.431E+00	9.060E-01	1.326E+00	4.202E-01	0.359
19	1.104E+00	1.158E+00	4.90%	6.504E-01	1.293E+00	8.573E-01	1.225E+00	3.676E-01	0.333
20	1.170E+00	1.226E+00	4.73%	7.317E-01	1.368E+00	9.150E-01	1.290E+00	3.747E-01	0.320
21	1.036E+00	1.073E+00	3.60%	6.293E-01	1.153E+00	8.220E-01	1.115E+00	2.930E-01	0.283
22	9.346E-01	9.516E-01	1.82%	5.900E-01	1.040E+00	7.467E-01	1.004E+00	2.250E-01	0.241
23	9.893E-01	1.024E+00	3.49%	5.921E-01	1.102E+00	7.818E-01	1.060E+00	2.782E-01	0.281
24	1.128E+00	1.171E+00	3.80%	7.269E-01	1.305E+00	9.220E-01	1.227E+00	3.046E-01	0.270
25	1.060E+00	1.097E+00	3.53%	7.023E-01	1.197E+00	8.810E-01	1.141E+00	2.604E-01	0.246
26	7.762E-01	7.479E-01	-3.65%	6.091E-01	9.436E-01	6.930E-01	8.128E-01	7.089E-02	0.091
27	7.670E-01	7.398E-01	-3.55%	6.022E-01	9.379E-01	6.813E-01	8.059E-01	7.393E-02	0.096
28	8.778E-01	8.984E-01	2.35%	5.768E-01	1.016E+00	7.203E-01	9.207E-01	2.004E-01	0.228
29	8.590E-01	8.839E-01	2.90%	5.751E-01	9.389E-01	7.078E-01	9.100E-01	2.022E-01	0.235
30	8.591E-01	8.881E-01	3.38%	5.848E-01	9.608E-01	7.176E-01	9.195E-01	2.018E-01	0.235
31	9.868E-01	1.025E+00	3.90%	6.782E-01	1.171E+00	8.480E-01	1.085E+00	2.370E-01	0.240
32	9.034E-01	9.355E-01	3.55%	6.272E-01	1.048E+00	7.827E-01	9.776E-01	1.949E-01	0.216
33	6.545E-01	6.626E-01	1.24%	4.583E-01	8.629E-01	5.531E-01	7.095E-01	1.167E-01	0.178
34	5.878E-01	5.766E-01	-1.90%	4.835E-01	8.683E-01	5.373E-01	6.384E-01	6.590E-02	0.112
35	5.918E-01	5.888E-01	-0.50%	4.876E-01	7.499E-01	5.339E-01	6.267E-01	3.052E-02	0.052
36	5.860E-01	5.973E-01	1.92%	4.103E-01	6.459E-01	4.867E-01	6.047E-01	1.180E-01	0.201
37	5.253E-01	5.256E-01	0.06%	4.138E-01	8.901E-01	4.635E-01	5.964E-01	2.891E-02	0.055
38	4.616E-01	4.402E-01	-4.64%	3.638E-01	1.076E+00	4.236E-01	5.718E-01	1.406E-01	0.305
39	3.943E-01	3.598E-01	-8.73%	2.826E-01	9.193E-01	3.411E-01	5.146E-01	1.735E-01	0.440
40	5.214E-01	4.878E-01	-6.45%	4.208E-01	1.139E+00	4.668E-01	6.431E-01	1.763E-01	0.338
41	6.533E-01	6.347E-01	-2.85%	5.683E-01	1.112E+00	6.074E-01	7.567E-01	1.314E-01	0.201
42	6.875E-01	6.871E-01	-0.06%	5.297E-01	9.405E-01	6.062E-01	7.448E-01	1.017E-01	0.148
43	7.396E-01	7.704E-01	4.17%	4.961E-01	8.837E-01	6.165E-01	8.142E-01	1.977E-01	0.267
44	8.252E-01	8.756E-01	6.10%	5.279E-01	1.052E+00	6.864E-01	9.326E-01	2.462E-01	0.298
45	6.961E-01	7.418E-01	6.57%	4.539E-01	1.030E+00	5.768E-01	8.509E-01	2.191E-01	0.315
46	4.075E-01	3.918E-01	-3.86%	2.846E-01	6.863E-01	3.340E-01	5.357E-01	2.017E-01	0.495
47	4.670E-01	4.608E-01	-1.31%	3.000E-01	7.688E-01	3.649E-01	6.119E-01	2.470E-01	0.529
48	5.916E-01	6.135E-01	3.70%	3.616E-01	9.399E-01	4.694E-01	7.556E-01	2.863E-01	0.484
49	5.442E-01	5.747E-01	5.60%	2.726E-01	9.384E-01	3.843E-01	7.508E-01	3.665E-01	0.673
50	4.963E-01	5.282E-01	6.43%	2.119E-01	9.292E-01	3.215E-01	7.252E-01	4.037E-01	0.814
51	5.398E-01	5.948E-01	10.19%	1.940E-01	1.057E+00	3.388E-01	8.293E-01	4.906E-01	0.909
52	5.825E-01	6.585E-01	13.04%	1.903E-01	1.159E+00	3.537E-01	9.092E-01	5.554E-01	0.953
53	5.318E-01	5.937E-01	11.65%	1.579E-01	1.063E+00	3.091E-01	8.494E-01	5.402E-01	1.016
54	5.792E-01	6.549E-01	13.07%	1.552E-01	1.156E+00	3.222E-01	9.341E-01	6.119E-01	1.056
55	6.171E-01	7.115E-01	15.31%	1.507E-01	1.232E+00	3.408E-01	9.927E-01	6.519E-01	1.057
56	6.622E-01	7.623E-01	15.12%	1.353E-01	1.279E+00	3.575E-01	1.040E+00	6.823E-01	1.030
57	7.115E-01	8.068E-01	13.39%	1.590E-01	1.310E+00	3.922E-01	1.091E+00	6.992E-01	0.983
58	7.530E-01	8.447E-01	12.18%	1.621E-01	1.327E+00	4.068E-01	1.116E+00	7.092E-01	0.942
59	7.890E-01	8.766E-01	11.10%	1.629E-01	1.337E+00	4.190E-01	1.140E+00	7.211E-01	0.914
60	8.155E-01	9.028E-01	10.71%	1.505E-01	1.341E+00	4.307E-01	1.152E+00	7.214E-01	0.885
61	8.363E-01	9.241E-01	10.51%	1.644E-01	1.345E+00	4.520E-01	1.165E+00	7.128E-01	0.852

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

Loligo (biomass and yield in thousand mt) Output from ASPIC-P.EXE Page 2
F99=F94-98 F00-01=Fmsy

TRAJECTORY OF RELATIVE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1	7.305E-01	7.031E-01	-3.76%	5.113E-01	1.026E+00	6.167E-01	8.918E-01	2.751E-01	0.377
2	1.127E+00	1.099E+00	-2.45%	7.493E-01	1.595E+00	8.973E-01	1.353E+00	4.552E-01	0.404
3	4.301E-01	4.196E-01	-2.43%	2.919E-01	6.174E-01	3.495E-01	5.273E-01	1.778E-01	0.413
4	3.634E-01	3.481E-01	-4.22%	2.596E-01	5.075E-01	3.011E-01	4.363E-01	1.352E-01	0.372
5	6.326E-01	5.974E-01	-5.56%	4.755E-01	8.810E-01	5.420E-01	7.726E-01	2.305E-01	0.364
6	1.457E+00	1.383E+00	-5.03%	1.136E+00	1.994E+00	1.270E+00	1.761E+00	4.909E-01	0.337
7	6.805E-01	6.460E-01	-5.08%	5.379E-01	9.203E-01	5.948E-01	8.165E-01	2.217E-01	0.326
8	7.811E-01	7.400E-01	-5.27%	6.261E-01	1.053E+00	6.870E-01	9.369E-01	2.499E-01	0.320
9	2.053E+00	1.971E+00	-4.00%	1.707E+00	2.713E+00	1.841E+00	2.421E+00	5.806E-01	0.283
10	1.723E+00	1.683E+00	-2.31%	1.475E+00	2.379E+00	1.559E+00	2.027E+00	4.673E-01	0.271
11	2.791E-01	2.692E-01	-3.54%	2.288E-01	3.927E-01	2.454E-01	3.339E-01	8.850E-02	0.317
12	1.301E+00	1.244E+00	-4.37%	1.060E+00	1.855E+00	1.146E+00	1.609E+00	4.628E-01	0.356
13	1.034E+00	9.854E-01	-4.74%	8.366E-01	1.544E+00	9.041E-01	1.305E+00	4.008E-01	0.387
14	8.481E-01	8.034E-01	-5.28%	6.769E-01	1.287E+00	7.399E-01	1.085E+00	3.454E-01	0.407
15	5.982E-01	5.662E-01	-5.36%	4.710E-01	8.861E-01	5.189E-01	7.600E-01	2.411E-01	0.403
16	7.819E-01	7.386E-01	-5.53%	6.154E-01	1.144E+00	6.855E-01	9.806E-01	2.951E-01	0.377
17	5.172E-01	4.906E-01	-5.14%	4.099E-01	7.516E-01	4.564E-01	6.420E-01	1.855E-01	0.359
18	1.121E+00	1.072E+00	-4.40%	9.156E-01	1.587E+00	1.003E+00	1.369E+00	3.656E-01	0.326
19	6.126E-01	5.882E-01	-3.98%	5.087E-01	8.466E-01	5.529E-01	7.308E-01	1.779E-01	0.290
20	1.419E+00	1.369E+00	-3.56%	1.210E+00	1.909E+00	1.297E+00	1.663E+00	3.657E-01	0.258
21	1.503E+00	1.458E+00	-3.05%	1.336E+00	2.017E+00	1.398E+00	1.761E+00	3.639E-01	0.242
22	7.510E-01	7.280E-01	-3.05%	6.638E-01	1.004E+00	6.985E-01	8.803E-01	1.819E-01	0.242
23	3.957E-01	3.822E-01	-3.40%	3.322E-01	5.107E-01	3.581E-01	4.490E-01	9.090E-02	0.230
24	1.159E+00	1.120E+00	-3.42%	9.765E-01	1.538E+00	1.057E+00	1.322E+00	2.647E-01	0.228
25	2.636E+00	2.578E+00	-2.19%	2.255E+00	3.276E+00	2.501E+00	2.943E+00	4.308E-01	0.163
26	1.272E+00	1.298E+00	2.05%	1.106E+00	1.587E+00	1.218E+00	1.423E+00	5.949E-02	0.047
27	4.365E-01	4.293E-01	-1.65%	3.837E-01	5.467E-01	4.191E-01	4.888E-01	6.881E-02	0.158
28	1.204E+00	1.172E+00	-2.62%	1.070E+00	1.493E+00	1.124E+00	1.334E+00	2.104E-01	0.175
29	1.127E+00	1.096E+00	-2.77%	9.869E-01	1.411E+00	1.053E+00	1.262E+00	2.087E-01	0.185
30	5.031E-01	4.863E-01	-3.33%	4.196E-01	6.571E-01	4.599E-01	5.636E-01	1.036E-01	0.206
31	1.432E+00	1.377E+00	-3.85%	1.191E+00	1.921E+00	1.313E+00	1.619E+00	3.057E-01	0.214
32	2.622E+00	2.548E+00	-2.82%	2.334E+00	3.258E+00	2.481E+00	2.882E+00	4.009E-01	0.153
33	1.950E+00	1.920E+00	-1.56%	1.805E+00	2.331E+00	1.875E+00	2.088E+00	1.934E-01	0.099
34	1.353E+00	1.336E+00	-1.26%	1.275E+00	1.553E+00	1.322E+00	1.442E+00	1.204E-01	0.089
35	1.384E+00	1.352E+00	-2.33%	1.288E+00	1.614E+00	1.334E+00	1.485E+00	1.514E-01	0.109
36	1.977E+00	1.935E+00	-2.14%	1.781E+00	2.239E+00	1.906E+00	2.096E+00	1.896E-01	0.096
37	2.202E+00	2.206E+00	0.19%	1.600E+00	2.570E+00	1.970E+00	2.368E+00	1.551E-01	0.070
38	2.258E+00	2.382E+00	5.45%	1.187E+00	2.715E+00	1.864E+00	2.465E+00	6.015E-01	0.266
39	4.020E-01	4.014E-01	-0.13%	2.115E-01	4.718E-01	3.363E-01	4.364E-01	4.638E-02	0.115
40	4.052E-01	4.218E-01	4.11%	2.133E-01	4.641E-01	3.435E-01	4.375E-01	9.398E-02	0.232
41	1.036E+00	1.032E+00	-0.41%	7.092E-01	1.262E+00	9.136E-01	1.121E+00	1.508E-01	0.146
42	8.623E-01	8.278E-01	-4.00%	7.266E-01	1.112E+00	7.898E-01	9.802E-01	1.904E-01	0.221
43	7.212E-01	6.813E-01	-5.54%	5.700E-01	9.896E-01	6.422E-01	8.332E-01	1.909E-01	0.265
44	1.963E+00	1.837E+00	-6.41%	1.524E+00	2.789E+00	1.726E+00	2.302E+00	5.764E-01	0.294
45	3.998E+00	3.926E+00	-1.82%	3.016E+00	5.128E+00	3.313E+00	4.538E+00	1.071E+00	0.268
46	9.410E-01	9.458E-01	0.51%	5.906E-01	1.325E+00	7.319E-01	1.145E+00	4.130E-01	0.439
47	3.802E-01	3.576E-01	-5.95%	2.533E-01	5.565E-01	3.055E-01	4.704E-01	1.649E-01	0.434
48	1.766E+00	1.660E+00	-6.03%	1.065E+00	2.961E+00	1.323E+00	2.314E+00	9.913E-01	0.561
49	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561
50	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
51	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
52	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561
53	1.060E+00	9.958E-01	-6.03%	6.391E-01	1.776E+00	7.939E-01	1.389E+00	5.948E-01	0.561
54	1.060E+00	9.958E-01	-6.03%	6.391E-01	1.776E+00	7.939E-01	1.389E+00	5.948E-01	0.561
55	1.060E+00	9.958E-01	-6.03%	6.391E-01	1.776E+00	7.939E-01	1.389E+00	5.948E-01	0.561
56	1.060E+00	9.958E-01	-6.03%	6.391E-01	1.776E+00	7.939E-01	1.389E+00	5.948E-01	0.561
57	1.060E+00	9.958E-01	-6.03%	6.391E-01	1.776E+00	7.939E-01	1.389E+00	5.948E-01	0.561
58	1.060E+00	9.958E-01	-6.03%	6.391E-01	1.776E+00	7.939E-01	1.389E+00	5.948E-01	0.561
59	1.060E+00	9.958E-01	-6.03%	6.391E-01	1.776E+00	7.939E-01	1.389E+00	5.948E-01	0.561
60	1.060E+00	9.958E-01	-6.03%	6.391E-01	1.776E+00	7.939E-01	1.389E+00	5.948E-01	0.561

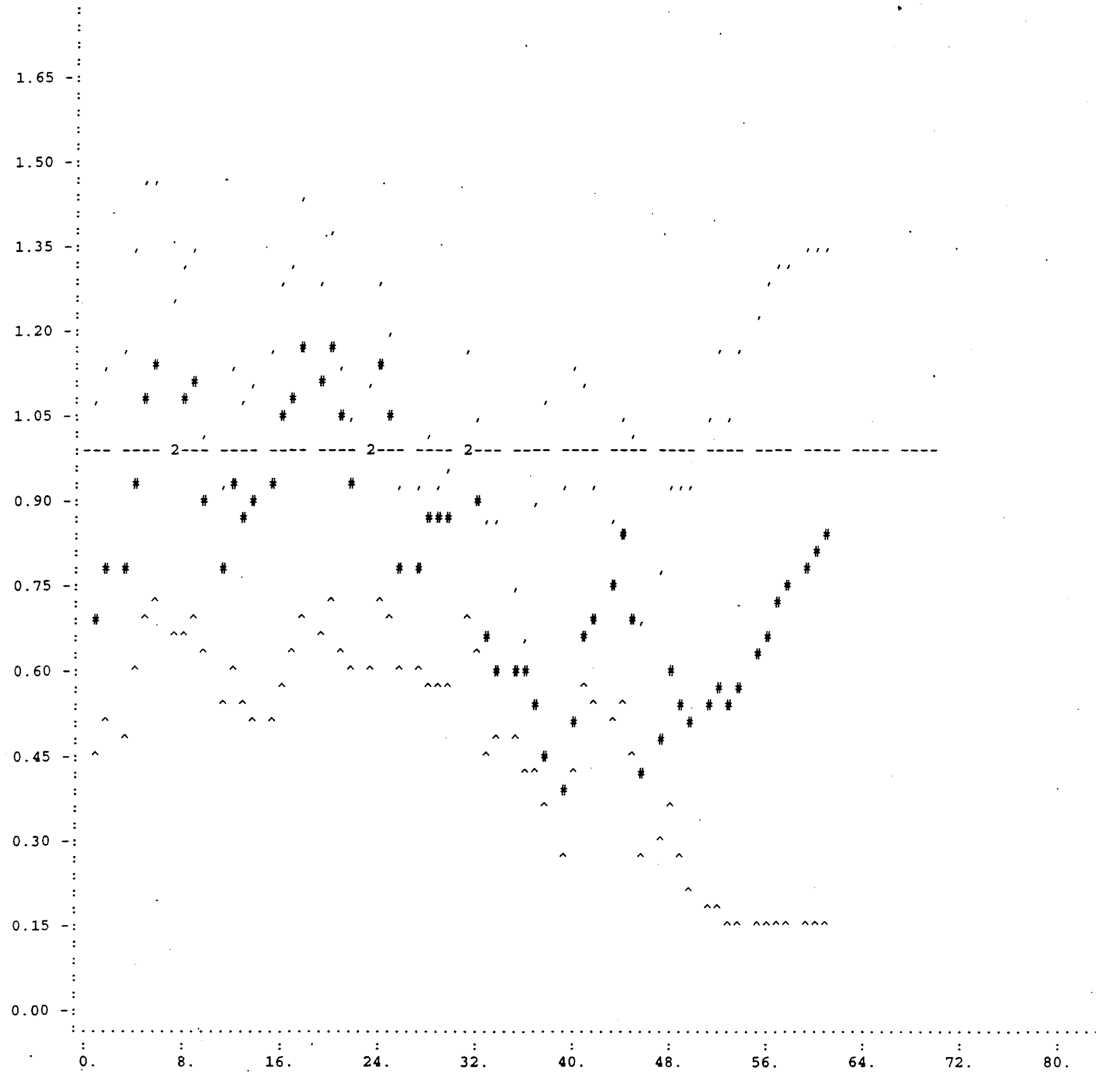
TABLE OF PROJECTED YIELDS

49	4.722E+00	4.796E+00	1.56%	3.714E+00	5.125E+00	4.252E+00	5.013E+00	7.617E-01	0.161
50	2.614E+00	2.697E+00	3.19%	1.647E+00	3.015E+00	2.192E+00	2.884E+00	6.921E-01	0.265
51	2.955E+00	3.011E+00	1.90%	2.002E+00	3.498E+00	2.581E+00	3.273E+00	6.925E-01	0.234
52	5.365E+00	5.441E+00	1.42%	3.232E+00	6.339E+00	4.468E+00	5.959E+00	1.491E+00	0.278
53	3.004E+00	3.051E+00	1.56%	1.612E+00	3.588E+00	2.435E+00	3.373E+00	9.373E-01	0.312
54	3.323E+00	3.339E+00	0.48%	1.815E+00	3.984E+00	2.750E+00	3.735E+00	9.852E-01	0.296
55	3.613E+00	3.602E+00	-0.30%	2.017E+00	4.270E+00	2.982E+00	3.972E+00	9.901E-01	0.274
56	3.888E+00	3.835E+00	-1.37%	2.428E+00	4.551E+00	3.310E+00	4.275E+00	9.657E-01	0.248
57	4.143E+00	4.036E+00	-2.58%	2.928E+00	4.790E+00	3.637E+00	4.493E+00	8.568E-01	0.207
58	4.367E+00	4.206E+00	-3.69%	3.269E+00	4.988E+00	3.914E+00	4.685E+00	7.711E-01	0.177
59	4.563E+00	4.348E+00	-4.73%	3.519E+00	5.081E+00	4.137E+00	4.819E+00	6.828E-01	0.150
60	4.724E+00	4.463E+00	-5.52%	3.809E+00	5.165E+00	4.304E+00	4.928E+00	6.240E-01	0.132

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

Loligo (biomass and yield in thousand mt) Output from ASPIC-P.EXE Page 5
F99=F94-98 F00-01=Fmsy

Bias-Corrected Time Plot of B-Ratio (#) with Approximate 80% Confidence Interval (^,)
(Dashed reference line is 1.0)



NOTE: Estimates beginning in 50 depend on the user projection data listed on page 1.

Loligo (biomass and yield in thousand mt) Output from ASPIC-P.EXE Page 1
F99=F94-98 F00-01=75%Fmsy 25 Jun 1999 at 08:18

USER CONTROL INFORMATION (FROM INPUT FILE)

Name of biomass (BIO) file	loligo2c.bio
Name of output file (this file)	loligoFt.prj
Number of years of projections	12

Year	Input data	User data type
49	1.070E+00	F:F(48)
50	5.900E-01	F:F(48)
51	5.900E-01	F:F(48)
52	1.070E+00	F:F(48)
53	4.500E-01	F:F(48)
54	4.500E-01	F:F(48)
55	4.500E-01	F:F(48)
56	4.500E-01	F:F(48)
57	4.500E-01	F:F(48)
58	4.500E-01	F:F(48)
59	4.500E-01	F:F(48)
60	4.500E-01	F:F(48)

TRAJECTORY OF RELATIVE BIOMASS (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1	6.930E-01	6.725E-01	-2.95%	4.494E-01	1.080E+00	5.567E-01	8.643E-01	3.075E-01	0.444
2	7.687E-01	7.794E-01	1.40%	5.111E-01	1.148E+00	6.269E-01	9.534E-01	3.264E-01	0.425
3	7.835E-01	8.019E-01	2.35%	4.854E-01	1.165E+00	6.175E-01	9.889E-01	3.715E-01	0.474
4	9.334E-01	9.606E-01	2.91%	6.004E-01	1.344E+00	7.597E-01	1.152E+00	3.923E-01	0.420
5	1.068E+00	1.124E+00	5.25%	6.865E-01	1.455E+00	8.791E-01	1.274E+00	3.951E-01	0.370
6	1.129E+00	1.196E+00	5.97%	7.104E-01	1.462E+00	9.005E-01	1.309E+00	4.090E-01	0.362
7	1.003E+00	1.051E+00	4.73%	6.630E-01	1.268E+00	8.420E-01	1.161E+00	3.186E-01	0.318
8	1.067E+00	1.125E+00	5.41%	6.746E-01	1.324E+00	8.527E-01	1.214E+00	3.618E-01	0.339
9	1.097E+00	1.160E+00	5.74%	6.976E-01	1.340E+00	8.808E-01	1.240E+00	3.590E-01	0.327
10	8.852E-01	8.982E-01	1.47%	6.216E-01	1.026E+00	7.663E-01	9.653E-01	1.990E-01	0.225
11	7.923E-01	7.850E-01	-0.93%	5.501E-01	9.397E-01	6.594E-01	8.754E-01	1.776E-01	0.224
12	9.306E-01	9.777E-01	5.06%	5.882E-01	1.143E+00	7.431E-01	1.068E+00	3.252E-01	0.350
13	8.832E-01	9.292E-01	5.21%	5.281E-01	1.085E+00	6.947E-01	1.015E+00	3.198E-01	0.362
14	8.955E-01	9.476E-01	5.82%	5.091E-01	1.108E+00	6.854E-01	1.031E+00	3.460E-01	0.386
15	9.445E-01	1.003E+00	6.21%	5.074E-01	1.170E+00	6.919E-01	1.085E+00	3.926E-01	0.416
16	1.038E+00	1.106E+00	6.56%	5.769E-01	1.294E+00	7.698E-01	1.194E+00	4.243E-01	0.409
17	1.078E+00	1.145E+00	6.25%	6.228E-01	1.328E+00	8.191E-01	1.233E+00	4.141E-01	0.384
18	1.171E+00	1.242E+00	6.07%	6.911E-01	1.431E+00	9.060E-01	1.326E+00	4.202E-01	0.359
19	1.104E+00	1.158E+00	4.90%	6.504E-01	1.293E+00	8.573E-01	1.225E+00	3.676E-01	0.333
20	1.170E+00	1.226E+00	4.73%	7.317E-01	1.368E+00	9.150E-01	1.290E+00	3.747E-01	0.320
21	1.036E+00	1.073E+00	3.60%	6.293E-01	1.153E+00	8.220E-01	1.115E+00	2.930E-01	0.283
22	9.346E-01	9.516E-01	1.82%	5.900E-01	1.040E+00	7.467E-01	1.004E+00	2.250E-01	0.241
23	9.893E-01	1.024E+00	3.49%	5.921E-01	1.102E+00	7.818E-01	1.060E+00	2.782E-01	0.281
24	1.128E+00	1.171E+00	3.80%	7.269E-01	1.305E+00	9.220E-01	1.227E+00	3.046E-01	0.270
25	1.060E+00	1.097E+00	3.53%	7.023E-01	1.197E+00	8.810E-01	1.141E+00	2.604E-01	0.246
26	7.762E-01	7.479E-01	-3.65%	6.091E-01	9.436E-01	6.930E-01	8.128E-01	7.089E-02	0.091
27	7.670E-01	7.398E-01	-3.55%	6.022E-01	9.379E-01	6.813E-01	8.059E-01	7.393E-02	0.096
28	8.778E-01	8.984E-01	2.35%	5.768E-01	1.016E+00	7.203E-01	9.207E-01	2.004E-01	0.228
29	8.590E-01	8.839E-01	2.90%	5.751E-01	9.389E-01	7.078E-01	9.100E-01	2.022E-01	0.235
30	8.591E-01	8.881E-01	3.38%	5.848E-01	9.608E-01	7.176E-01	9.195E-01	2.018E-01	0.235
31	9.868E-01	1.025E+00	3.90%	6.782E-01	1.171E+00	8.480E-01	1.085E+00	2.370E-01	0.240
32	9.034E-01	9.355E-01	3.55%	6.272E-01	1.048E+00	7.827E-01	9.776E-01	1.949E-01	0.216
33	6.545E-01	6.626E-01	1.24%	4.583E-01	8.629E-01	5.531E-01	7.095E-01	1.167E-01	0.178
34	5.878E-01	5.766E-01	-1.90%	4.835E-01	8.683E-01	5.373E-01	6.384E-01	6.590E-02	0.112
35	5.918E-01	5.888E-01	-0.50%	4.876E-01	7.499E-01	5.339E-01	6.267E-01	3.052E-02	0.052
36	5.860E-01	5.973E-01	1.92%	4.103E-01	6.459E-01	4.867E-01	6.047E-01	1.180E-01	0.201
37	5.253E-01	5.256E-01	0.06%	4.138E-01	8.901E-01	4.635E-01	5.964E-01	2.891E-02	0.055
38	4.616E-01	4.402E-01	-4.64%	3.638E-01	1.076E+00	4.236E-01	5.718E-01	1.406E-01	0.305
39	3.943E-01	3.598E-01	-8.73%	2.826E-01	9.193E-01	3.411E-01	5.146E-01	1.735E-01	0.440
40	5.214E-01	4.878E-01	-6.45%	4.208E-01	1.139E+00	4.668E-01	6.431E-01	1.763E-01	0.338
41	6.533E-01	6.347E-01	-2.85%	5.683E-01	1.112E+00	6.074E-01	7.567E-01	1.314E-01	0.201
42	6.875E-01	6.871E-01	-0.06%	5.297E-01	9.405E-01	6.062E-01	7.448E-01	1.017E-01	0.148
43	7.396E-01	7.704E-01	4.17%	4.961E-01	8.837E-01	6.165E-01	8.142E-01	1.977E-01	0.267
44	8.252E-01	8.756E-01	6.10%	5.279E-01	1.052E+00	6.864E-01	9.326E-01	2.462E-01	0.298
45	6.961E-01	7.418E-01	6.57%	4.539E-01	1.030E+00	5.768E-01	8.509E-01	2.191E-01	0.315
46	4.075E-01	3.918E-01	-3.86%	2.846E-01	6.863E-01	3.340E-01	5.357E-01	2.017E-01	0.495
47	4.670E-01	4.608E-01	-1.31%	3.000E-01	7.688E-01	3.649E-01	6.119E-01	2.470E-01	0.529
48	5.916E-01	6.135E-01	3.70%	3.616E-01	9.399E-01	4.694E-01	7.556E-01	2.863E-01	0.484
49	5.442E-01	5.747E-01	5.60%	2.726E-01	9.384E-01	3.843E-01	7.508E-01	3.665E-01	0.673
50	4.963E-01	5.282E-01	6.43%	2.119E-01	9.292E-01	3.215E-01	7.252E-01	4.037E-01	0.814
51	5.398E-01	5.948E-01	10.19%	1.940E-01	1.057E+00	3.388E-01	8.293E-01	4.906E-01	0.909
52	5.825E-01	6.585E-01	13.04%	1.903E-01	1.159E+00	3.537E-01	9.092E-01	5.554E-01	0.953
53	5.318E-01	5.937E-01	11.65%	1.579E-01	1.063E+00	3.091E-01	8.494E-01	5.402E-01	1.016
54	6.031E-01	6.949E-01	15.22%	1.456E-01	1.217E+00	3.370E-01	9.674E-01	6.304E-01	1.045
55	6.990E-01	7.926E-01	13.40%	1.708E-01	1.326E+00	3.823E-01	1.074E+00	6.920E-01	0.990
56	7.808E-01	8.824E-01	13.00%	1.913E-01	1.399E+00	4.324E-01	1.161E+00	7.290E-01	0.934
57	8.686E-01	9.610E-01	10.64%	1.931E-01	1.438E+00	4.707E-01	1.210E+00	7.396E-01	0.851
58	9.413E-01	1.027E+00	9.14%	2.157E-01	1.464E+00	5.054E-01	1.263E+00	7.581E-01	0.805
59	1.000E+00	1.081E+00	8.12%	2.263E-01	1.485E+00	5.437E-01	1.303E+00	7.588E-01	0.759
60	1.048E+00	1.124E+00	7.22%	2.415E-01	1.499E+00	6.007E-01	1.335E+00	7.346E-01	0.701
61	1.088E+00	1.157E+00	6.33%	2.819E-01	1.508E+00	6.524E-01	1.361E+00	7.082E-01	0.651

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

Loligo (biomass and yield in thousand mt) Output from ASPIC-P.EXE Page 2
F99=F94-98 F00-01=75%Fmsy

TRAJECTORY OF RELATIVE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1	7.305E-01	7.031E-01	-3.76%	5.113E-01	1.026E+00	6.167E-01	8.918E-01	2.751E-01	0.377
2	1.127E+00	1.099E+00	-2.45%	7.493E-01	1.595E+00	8.973E-01	1.353E+00	4.552E-01	0.404
3	4.301E-01	4.196E-01	-2.43%	2.919E-01	6.174E-01	3.495E-01	5.273E-01	1.778E-01	0.413
4	3.634E-01	3.481E-01	-4.22%	2.596E-01	5.075E-01	3.011E-01	4.363E-01	1.352E-01	0.372
5	6.326E-01	5.974E-01	-5.56%	4.755E-01	8.810E-01	5.420E-01	7.726E-01	2.305E-01	0.364
6	1.457E+00	1.383E+00	-5.03%	1.136E+00	1.994E+00	1.270E+00	1.761E+00	4.909E-01	0.337
7	6.805E-01	6.460E-01	-5.08%	5.379E-01	9.203E-01	5.948E-01	8.165E-01	2.217E-01	0.326
8	7.811E-01	7.400E-01	-5.27%	6.261E-01	1.053E+00	6.870E-01	9.369E-01	2.499E-01	0.320
9	2.053E+00	1.971E+00	-4.00%	1.707E+00	2.713E+00	1.841E+00	2.421E+00	5.806E-01	0.283
10	1.723E+00	1.683E+00	-2.31%	1.475E+00	2.379E+00	1.559E+00	2.027E+00	4.673E-01	0.271
11	2.791E-01	2.692E-01	-3.54%	2.288E-01	3.927E-01	2.454E-01	3.339E-01	8.850E-02	0.317
12	1.301E+00	1.244E+00	-4.37%	1.060E+00	1.855E+00	1.146E+00	1.609E+00	4.628E-01	0.356
13	1.034E+00	9.854E-01	-4.74%	8.366E-01	1.544E+00	9.041E-01	1.305E+00	4.008E-01	0.387
14	8.481E-01	8.034E-01	-5.28%	6.769E-01	1.287E+00	7.399E-01	1.085E+00	3.454E-01	0.407
15	5.982E-01	5.662E-01	-5.36%	4.710E-01	8.861E-01	5.189E-01	7.600E-01	2.411E-01	0.403
16	7.819E-01	7.386E-01	-5.53%	6.154E-01	1.144E+00	6.855E-01	9.806E-01	2.951E-01	0.377
17	5.172E-01	4.906E-01	-5.14%	4.099E-01	7.516E-01	4.564E-01	6.420E-01	1.855E-01	0.359
18	1.121E+00	1.072E+00	-4.40%	9.156E-01	1.587E+00	1.003E+00	1.369E+00	3.656E-01	0.326
19	6.126E-01	5.882E-01	-3.98%	5.087E-01	8.466E-01	5.529E-01	7.308E-01	1.779E-01	0.290
20	1.419E+00	1.369E+00	-3.56%	1.210E+00	1.909E+00	1.297E+00	1.663E+00	3.657E-01	0.258
21	1.503E+00	1.458E+00	-3.05%	1.336E+00	2.017E+00	1.398E+00	1.761E+00	3.639E-01	0.242
22	7.510E-01	7.280E-01	-3.05%	6.638E-01	1.004E+00	6.985E-01	8.803E-01	1.819E-01	0.242
23	3.957E-01	3.822E-01	-3.40%	3.322E-01	5.107E-01	3.581E-01	4.490E-01	9.090E-02	0.230
24	1.159E+00	1.120E+00	-3.42%	9.765E-01	1.538E+00	1.057E+00	1.322E+00	2.647E-01	0.228
25	2.636E+00	2.578E+00	-2.19%	2.255E+00	3.276E+00	2.501E+00	2.943E+00	4.308E-01	0.163
26	1.272E+00	1.298E+00	2.05%	1.106E+00	1.587E+00	1.218E+00	1.423E+00	5.949E-02	0.047
27	4.365E-01	4.293E-01	-1.65%	3.837E-01	5.467E-01	4.191E-01	4.888E-01	6.881E-02	0.158
28	1.204E+00	1.172E+00	-2.62%	1.070E+00	1.493E+00	1.124E+00	1.334E+00	2.104E-01	0.175
29	1.127E+00	1.096E+00	-2.77%	9.869E-01	1.411E+00	1.053E+00	1.262E+00	2.087E-01	0.185
30	5.031E-01	4.863E-01	-3.33%	4.196E-01	6.571E-01	4.599E-01	5.636E-01	1.036E-01	0.206
31	1.432E+00	1.377E+00	-3.85%	1.191E+00	1.921E+00	1.313E+00	1.619E+00	3.057E-01	0.214
32	2.622E+00	2.548E+00	-2.82%	2.334E+00	3.258E+00	2.481E+00	2.882E+00	4.009E-01	0.153
33	1.950E+00	1.920E+00	-1.56%	1.805E+00	2.331E+00	1.875E+00	2.088E+00	1.934E-01	0.099
34	1.353E+00	1.336E+00	-1.26%	1.275E+00	1.553E+00	1.322E+00	1.442E+00	1.204E-01	0.089
35	1.384E+00	1.352E+00	-2.33%	1.288E+00	1.614E+00	1.334E+00	1.485E+00	1.514E-01	0.109
36	1.977E+00	1.935E+00	-2.14%	1.781E+00	2.239E+00	1.906E+00	2.096E+00	1.896E-01	0.096
37	2.202E+00	2.206E+00	0.19%	1.600E+00	2.570E+00	1.970E+00	2.368E+00	1.551E-01	0.070
38	2.258E+00	2.382E+00	5.45%	1.187E+00	2.715E+00	1.864E+00	2.465E+00	6.015E-01	0.266
39	4.020E-01	4.014E-01	-0.13%	2.115E-01	4.718E-01	3.363E-01	4.364E-01	4.638E-02	0.115
40	4.052E-01	4.218E-01	4.11%	2.133E-01	4.641E-01	3.435E-01	4.375E-01	9.398E-02	0.232
41	1.036E+00	1.032E+00	-0.41%	7.092E-01	1.262E+00	9.136E-01	1.121E+00	1.508E-01	0.146
42	8.623E-01	8.278E-01	-4.00%	7.266E-01	1.112E+00	7.898E-01	9.802E-01	1.904E-01	0.221
43	7.212E-01	6.813E-01	-5.54%	5.700E-01	9.896E-01	6.422E-01	8.332E-01	1.909E-01	0.265
44	1.963E+00	1.837E+00	-6.41%	1.524E+00	2.789E+00	1.726E+00	2.302E+00	5.764E-01	0.294
45	3.998E+00	3.926E+00	-1.82%	3.016E+00	5.128E+00	3.313E+00	4.538E+00	1.071E+00	0.268
46	9.410E-01	9.458E-01	0.51%	5.906E-01	1.325E+00	7.319E-01	1.145E+00	4.130E-01	0.439
47	3.802E-01	3.576E-01	-5.95%	2.533E-01	5.565E-01	3.055E-01	4.704E-01	1.649E-01	0.434
48	1.766E+00	1.660E+00	-6.03%	1.065E+00	2.961E+00	1.323E+00	2.314E+00	9.913E-01	0.561
49	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561
50	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
51	1.042E+00	9.792E-01	-6.03%	6.285E-01	1.747E+00	7.806E-01	1.366E+00	5.849E-01	0.561
52	1.890E+00	1.776E+00	-6.03%	1.140E+00	3.168E+00	1.416E+00	2.476E+00	1.061E+00	0.561
53	7.947E-01	7.468E-01	-6.03%	4.794E-01	1.332E+00	5.954E-01	1.041E+00	4.461E-01	0.561
54	7.947E-01	7.468E-01	-6.03%	4.794E-01	1.332E+00	5.954E-01	1.041E+00	4.461E-01	0.561
55	7.947E-01	7.468E-01	-6.03%	4.794E-01	1.332E+00	5.954E-01	1.041E+00	4.461E-01	0.561
56	7.947E-01	7.468E-01	-6.03%	4.794E-01	1.332E+00	5.954E-01	1.041E+00	4.461E-01	0.561
57	7.947E-01	7.468E-01	-6.03%	4.794E-01	1.332E+00	5.954E-01	1.041E+00	4.461E-01	0.561
58	7.947E-01	7.468E-01	-6.03%	4.794E-01	1.332E+00	5.954E-01	1.041E+00	4.461E-01	0.561
59	7.947E-01	7.468E-01	-6.03%	4.794E-01	1.332E+00	5.954E-01	1.041E+00	4.461E-01	0.561
60	7.947E-01	7.468E-01	-6.03%	4.794E-01	1.332E+00	5.954E-01	1.041E+00	4.461E-01	0.561

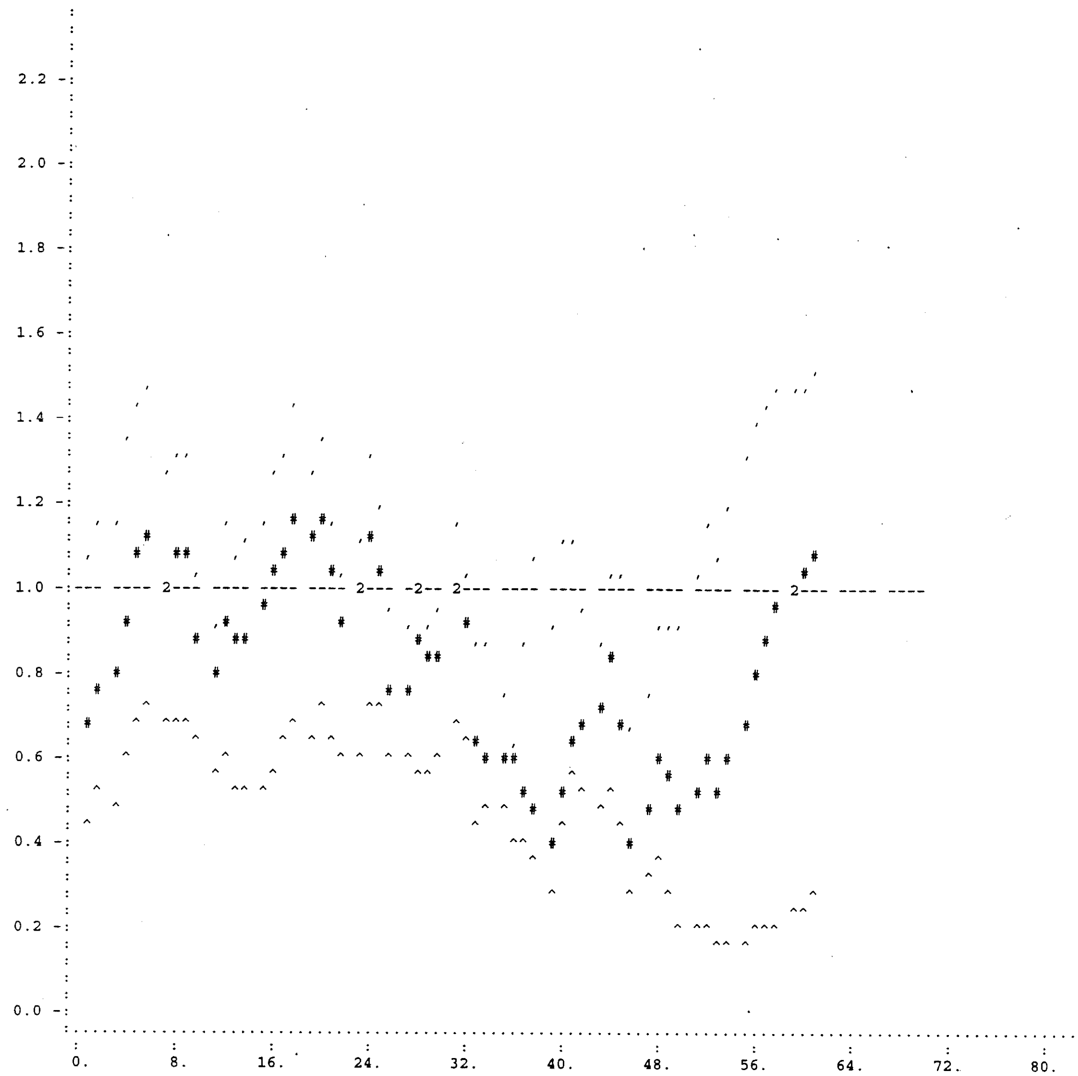
TABLE OF PROJECTED YIELDS

49	4.722E+00	4.796E+00	1.56%	3.714E+00	5.125E+00	4.252E+00	5.013E+00	7.617E-01	0.161
50	2.614E+00	2.697E+00	3.19%	1.647E+00	3.015E+00	2.192E+00	2.884E+00	6.921E-01	0.265
51	2.955E+00	3.011E+00	1.90%	2.002E+00	3.498E+00	2.581E+00	3.273E+00	6.925E-01	0.234
52	5.365E+00	5.441E+00	1.42%	3.232E+00	6.339E+00	4.468E+00	5.959E+00	1.491E+00	0.278
53	2.333E+00	2.361E+00	1.16%	1.327E+00	2.791E+00	1.909E+00	2.620E+00	7.112E-01	0.305
54	2.728E+00	2.726E+00	-0.04%	1.652E+00	3.263E+00	2.297E+00	3.024E+00	7.273E-01	0.267
55	3.145E+00	3.071E+00	-2.37%	2.108E+00	3.709E+00	2.689E+00	3.441E+00	7.517E-01	0.239
56	3.526E+00	3.380E+00	-4.14%	2.642E+00	4.112E+00	3.149E+00	3.849E+00	6.998E-01	0.198
57	3.873E+00	3.646E+00	-5.86%	2.928E+00	4.384E+00	3.414E+00	4.153E+00	7.390E-01	0.191
58	4.151E+00	3.866E+00	-6.87%	3.320E+00	4.624E+00	3.757E+00	4.452E+00	6.951E-01	0.167
59	4.379E+00	4.042E+00	-7.69%	3.552E+00	4.786E+00	3.977E+00	4.657E+00	6.804E-01	0.155
60	4.584E+00	4.180E+00	-8.81%	3.722E+00	4.937E+00	4.153E+00	4.793E+00	6.402E-01	0.140

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

Loligo (biomass and yield in thousand mt) Output from ASPIC-P.EXE Page 5
F99=F94-98 F00-01=75%Fmsy

Bias-Corrected Time Plot of B-Ratio (#) with Approximate 80% Confidence Interval (^,)
(Dashed reference line is 1.0)



NOTE: Estimates beginning in 50 depend on the user projection data listed on page 1.