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An Assessment of Newfoundland and Labrador Snow Crab in 2004

Évaluation du stock de crabe des neiges de Terre-Neuve et du Labrador pour l'année 2004

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ABSTRACT

Resource status was evaluated, by NAFO Division, based on trends in biomass, recruitment prospects and mortality. Data were derived from the fall Div. 2J3KLNO multi-species bottom trawl survey, inshore Div. 3KL trap surveys, and fishery data from logbooks as well as observer data. The fall multispecies survey is conducted near the end of the fishing season and so is considered to provide an index of the exploitable biomass that will be available to the fishery in the following year. Trends in biomass within Div. 2J3KLNO were inferred based on comparison of trends in the fall survey exploitable biomass indices with offshore fishery catch per unit effort (CPUE) trends. Short-term recruitment prospects were inferred from comparison of fall survey pre-recruit indices with an observer-based index of crabs discarded in the fishery. Long-term recruitment trends were based on annual progression of male size groups through fall survey size frequency distributions. Mortality was inferred from exploitation rate indices, observer based indices of handling mortality and prevalence of Bitter Crab Disease (BCD). No fishery-independent data were available for Subdiv. 3Ps or Div. 4R. In Div. 2J the exploitable biomass remains low but recruitment appears promising in the short term. The exploitation rate as well as pre-recruit handling mortality remained relatively high in 2004. Continued exploitation, in the short term, would likely impose a very high mortality on immediate pre-recruits that would seriously impair recovery of the exploitable biomass. In Div. 3K, the exploitable biomass remains low and offshore recruitment is expected to remain unchanged in the short term. The exploitation rate as well as pre-recruit handling mortality remained relatively high in 2004. Fishery-induced mortality is expected to remain high in 2005 if the recent catch level is maintained and current fishing practices persist. In Div. 3L the fall survey biomass index and the commercial CPUE do not agree. The survey data suggest a decrease since 1996, while the fishery continues to perform at a high level. Recruitment is expected to remain relatively low in the short term, while the exploitation rate index remains relatively high. The percent discarded in the fishery has declined since 1998, suggesting reduced handling mortality on pre-recruits. The effect on exploitation rate of maintaining the current catch level is unknown, because trends in the biomass indices do not agree. In Div. 3NO trends in the fall survey exploitable biomass index and pre-recruit index cannot be interpreted because of wide margins of error. However, the fishery continues to perform at a high level but observer data suggest that recruitment will remain relatively low in the short term. The effects of maintaining the current catch level on the exploitation rate are unknown but handling mortality on pre-recruits remains relatively low. In SubDiv. 3Ps both inshore and offshore CPUE have declined substantially in recent years and recruitment is expected to change little in the short term. Assuming that CPUE reflects the exploitable biomass, and the declining trend continues, exploitation rate and pre-recruit mortality will likely remain high if the current catch level is maintained. In Div. 4R, it is not possible to infer trends in exploitable biomass from commercial CPUE data because of recent changes in the spatial distribution of fishing effort. The observer data for this area are insufficient to estimate a reliable pre-recruit index or infer levels of handling

mortality. The effects of maintaining the current catch level on the exploitation rate are unknown. The percentage of mature females bearing full clutches of viable eggs has remained high with no clear trend throughout Div. 2J3KLNO since 1995. Spatial and temporal trends in the prevalence of BCD are unclear and implications for mortality are unknown.

RÉSUMÉ

Nous évaluons l'état des ressources de crabe des neiges dans chacune des divisions de l'OPANO en nous fondant sur les tendances relatives à la biomasse, aux perspectives de recrutement et aux taux de mortalité. Les données utilisées proviennent du relevé plurispécifique au chalut de fond effectué en automne dans les divisions 2J3KLNO, de relevés au casier effectués dans les eaux côtières de la division 3KL, des journaux de bord des pêcheurs et des données des observateurs. Comme le relevé plurispécifique d'automne est effectué vers la fin de la saison de pêche, nous considérons qu'il donne un indice de la biomasse exploitable qui sera disponible l'année suivante. Nous avons déduit les tendances relatives à la biomasse dans les divisions 2J3KLNO en comparant les tendances relatives aux indices de la biomasse exploitable dérivés des relevés d'automne aux tendances relatives aux prises par unité d'effort (PUE) de la pêche hauturière. Quant aux perspectives de recrutement à court terme, nous les avons déduites en comparant les indices d'abondance des prérecrues dérivés des relevés d'automne à un indice du nombre de crabes rejetés établi par les observateurs. Les tendances à long terme relatives au recrutement reposent sur l'entrée annuelle des groupes de taille des mâles dans les répartitions des fréquences de tailles provenant des relevés d'automne. Nous avons déduit le taux de mortalité à partir des indices du taux d'exploitation, d'un indice du taux de mortalité due à la manipulation établi par des observateurs et de la prévalence de la maladie du crabe amer. Aucune donnée indépendante de la pêche n'était disponible pour la sous-division 3Ps ou la division 4R. Dans la division 2J, la biomasse exploitable demeure à un faible niveau, mais le recrutement semble prometteur à court terme. Le taux d'exploitation ainsi que le taux de mortalité des prérecrues due à la manipulation sont demeurés relativement élevés en 2004. L'exploitation continue, à court terme, résultera probablement en une mortalité très élevée chez les prérecrues immédiates, ce qui nuira sérieusement au rétablissement de la biomasse exploitable. Dans la division 3K, la biomasse exploitable demeure à un faible niveau, et nous nous attendons à ce que le recrutement extracôtier ne change pas à court terme. Le taux d'exploitation ainsi que le taux de mortalité des prérecrues due à la manipulation sont demeurés relativement élevés en 2004. On s'attend à ce que le taux de mortalité due à la pêche demeure élevé en 2005 si le taux de prises récent est maintenu et si les pratiques de pêche actuelles persistent. Dans la division 3L, l'indice de la biomasse dérivé du relevé d'automne et les PUE de la pêche commerciale ne concordent pas. Les données du relevé semblent indiquer un déclin depuis 1996, mais l'activité de pêche demeure élevée. Nous nous attendons à ce que le recrutement demeure relativement faible à court terme, tandis que l'indice du taux d'exploitation demeure relativement élevé. Le pourcentage d'individus rejetés a diminué depuis 1998, ce qui laisse supposer que la mortalité des prérecrues due à la manipulation a aussi diminué. L'effet qu'aura le maintien des taux de prises actuels sur le taux d'exploitation est inconnu parce que les tendances relatives aux indices de la biomasse ne concordent pas. Dans les divisions 3NO, nous ne pouvons pas interpréter les tendances relatives aux indices de la biomasse exploitable et des prérecrues dérivés du relevé d'automne

en raison des grandes marges d’erreur. Cependant, la pêche continue d’enregistrer de fortes prises, mais les données des observateurs laissent entendre que le recrutement demeurera relativement faible à court terme. L’effet qu’aura le maintien des taux de prises actuels sur le taux d’exploitation est inconnu, mais le taux de mortalité due à la manipulation chez les prérecrues demeure relativement faible. Dans la sous-division 3Ps, les PUE en eaux côtières et extracôtières ont diminué fortement ces dernières années, et nous nous attendons à ce que le recrutement varie peu à court terme. Dans l’hypothèse où les PUE reflètent la biomasse exploitable et où la tendance à la baisse se poursuive, le taux d’exploitation et le taux de mortalité des prérecrues demeureront probablement élevés si le taux de prises actuel ne change pas. Dans la division 4R, il est impossible d’établir des tendances relatives à la biomasse exploitable d’après les données sur les PUE de la pêche commerciale en raison des changements récents dans la répartition spatiale de l’effort de pêche. Nous ne disposons pas de suffisamment de données des observateurs pour estimer un indice des prérecrues fiable ou pour déduire des taux de mortalité due à la manipulation. L’effet qu’a le maintien des taux de prises actuels sur le taux d’exploitation est inconnu. Le pourcentage de femelles adultes portant de grosses grappes d’œufs viables est demeuré élevé, mais aucune tendance claire n’a été dégagée dans les divisions 2J3KLNO depuis 1995. Les tendances spatiales et temporelles relatives à la prévalence de la maladie du crabe amer ne sont pas claires, et les répercussions sur la mortalité sont inconnues.

INTRODUCTION

The Newfoundland and Labrador snow crab (*Chionoecetes opilio*) fishery began in 1968 and was largely limited to NAFO Div. 3KL until the mid 1980's. It has since expanded throughout Div. 2J3KLNOP4R and is prosecuted by several fleet sectors. The resource declined during the early 1980's but then recovered and remained very large throughout the 1990's. Resource declines have become evident in some areas in recent years (Dawe et al. 2004). Management of the increasingly diverse fishery led to the development of 41 quota-controlled areas with over 3500 licence/permit holders under enterprise allocation by 1999. Management areas (Fig. 1) hold no relationship with biological units.

The fishery is prosecuted using conical baited traps set in longlines. The minimum legal size is 95 mm carapace width (CW). This regulation excludes females from the fishery while ensuring that a portion of the adult males in the population remain available for reproduction. The minimum legal mesh size of traps is 135 mm, to allow small crabs to escape. Under-sized and soft-shelled males that are retained in the traps are returned to the sea and an unknown proportion of these discards die.

This document presents research survey data and fishery data used in evaluating the status of the Newfoundland and Labrador snow crab resource throughout NAFO Div. 2J3KLNOP4R in 2004. Data from the fall Div. 2J3KLNO 1995-2004 multispecies bottom trawl surveys are presented to provide information on trends in biomass, recruitment, and mortality over the time series. These survey data have been used in annual snow crab assessments since 1997 (Dawe et al. 2004). Multispecies survey indices are compared with other relevant indices derived from fisher logbook data, observer data, and inshore Div. 3KL trap survey data, toward inferring changes in resource status for 2005 and beyond.

METHODOLOGY

FALL MULTISPECIES SURVEY DATA

Data on total catch numbers and weight were acquired from the 1995 to 2004 fall stratified random bottom trawl surveys, which extended throughout NAFO Div. 2J3KLNO. The 1996-98 surveys also extended to NAFO Div. 2GH and to inshore strata, not included in the 1995 and 1999 surveys. Inshore strata were also surveyed during 2000-04. The 2004 Div. 3L offshore survey was not fully completed and a sub-set of data has been used for analyses. These surveys utilized the Campelen 1800 survey trawl lined with a 9.5 mm liner in standard tows of 15 min duration.

Snow crab catches from each set were sorted, weighed and counted by sex. Catches were sampled in their entirety or sub-sampled by sex. The carapace width (CW, mm) of individuals of both sexes was measured and shell condition was assigned one of three categories: (1) new-shelled - these crab had molted in spring of the current year, have a low meat yield throughout most of the fishing season, and are generally not retained in the current fishery until fall; (2) intermediate-shelled – these crab last molted in the previous year and are fully recruited to the fishery throughout the current fishing season; (3) old-shelled – these crab have been available to the fishery for at least 2 years. Males that undergo their terminal molt in the spring will remain new-shelled throughout the fishery season of that year and will not be fully hardened until the following year. Therefore new-shelled legal-sized crabs are not considered to be part of the exploitable biomass, although it is recognized that some of these males are retained by the fishery late in the season. It is assumed that all males with small chelae molt each spring and so remain new-shelled between molts. In reality, however, an annually variable proportion of small-clawed males will not molt in any given year ('skip molters') and so will develop 'older shells' between molts. For each year that a crab skips a molt, its eventual recruitment is delayed by a year.

Males were also sampled for chela height (CH, 0.1 mm). Males develop enlarged chelae when they undergo a final molt, which may occur at any size larger than about 40 mm CW. Therefore only males with small chelae will continue to molt and subsequently recruit to the fishery. A model which separates two 'clouds' of chela height on carapace width data ($CW = 0.0806CH^{1.1999}$) was applied to classify each individual as either adult (large-clawed), versus or adolescent or juvenile (small-clawed).

Maturity status was determined for females and relative fullness and stage of development of egg clutches were assessed. Occurrence of advanced stages of BCD was noted in both sexes based on macroscopic examination. In cases of unclear external characteristics, crabs were dissected and classified based on observation of the hemolymph. Observation of cloudy or milky hemolymph was taken as support for classification of such specimens as infected.

Annual changes in abundance indices of legal-sized males were examined, by shell condition toward evaluating the internal consistency of the data series. Males enter the legal-size group as new-shelled crabs, after the spring molt, and begin to contribute to the legal old-shelled group in the following year. Hence we would expect annual changes in abundance to be first seen in new-shelled legal-sized males and to be followed by similar trends in old-shelled males.

Indices were calculated from post-season fall surveys, using STRAP (Smith and Somerton 1981), to represent the exploitable biomass and pre-recruit biomass in the following year. The exploitable biomass index was calculated as the fall survey biomass index of adult (large-clawed) legal-sized (>95 mm CW) males, regardless of shell condition. Adult males are terminally molted, so that no members of this category would molt in spring and all adults in the fall survey (including new-shelled adults) would be fully recruited to the fishery in the following year. The pre-recruit index was calculated by applying a 19 mm CW growth increment (Hoenig et al. 1994) to all adolescent (small-clawed) males larger than 75 mm CW caught in the fall survey, before applying STRAP. The resultant pre-recruit index represented a component of legal-sized (>95 mm CW) males that would be recently-molted, new-shelled and not recruited to the fishery of the next year, but would begin to recruit (as older-shelled males) in the following year. However, some of these recently-molted males would have remained adolescent, and so would molt one more time before achieving adulthood and subsequently recruiting to the fishery, as older-shelled males, one additional year later (i.e. 3 years after the survey year).

These exploitable and pre-recruit biomass indices were calculated using the raw survey data. It is known that catchability of crabs by the survey trawl (i.e. trawl efficiency) is lower than 1 and varies with substrate type and crab size (Dawe et al. 2002a). However, trends in raw ('unstandardized') indices are comparable to those in 'standardized' indices (Dawe et al. 2003), that partially account for effects of substrate type and crab size.

Projection of biomass indices from the survey year does not account for annual variability in natural mortality or in the proportion of adolescent males that do not molt in the following spring (skip-molters). Biomass indices are comparable among years because only those survey strata common among all years were included in the analysis. Inshore survey strata were not included in calculating biomass indices because they were not surveyed in some years.

Spatial distribution was compared among years for Div. 2J3KLNO using the fall survey abundance index data. ACON (G. Black, pers. com.) was used to describe the distribution of exploitable (>94 mm CW adults) and pre-recruit (>75 mm CW adolescents) males as described above.

The ratio of the annual catch to the exploitable biomass index (projected from the survey of the previous year) was calculated by NAFO Div. to provide an index of exploitation rate. This does not estimate absolute exploitation rate, because the exploitable biomass index underestimates absolute biomass and, consequently exploitation rate is overestimated by these ratios. However long-term changes in these ratios may be interpreted as reflecting trends in exploitation rate within each division. It is recognized that annual changes in these ratios may be due to changes in catchability (i.e. trawl efficiency) rather than exploitation rate. However we feel that long-term trends (since 1996) provide a useful indication of trends in exploitation rates. Inshore commercial catches and data from inshore survey strata were not included in calculating the ratios because inshore survey strata were not surveyed in all years.

To examine size composition of males, survey catches by carapace width were grouped into 3 mm CW intervals and adjusted up to total population abundance indices. Each size interval was partitioned, based on chela allometry, between juveniles and adolescents (small-clawed) versus adults (large-clawed).

FISHERY LOGBOOK DATA

Data on commercial catch (kg) and fishing effort (number of trap hauls) were obtained from vessel logbooks. These data were compiled by the Statistics Divison, Policy and Economics Branch, Newfoundland and Labrador Region of the Department of Fisheries and Oceans. Catch per unit of effort (CPUE, kg/trap haul) was calculated by year and NAFO Division. CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in catch or effort levels, seasonality of fishing, or other fishing practices (e.g. soak time and mesh size). Long-term trends in logbook CPUE are presented here as a fishery-based index of trends in biomass, separately for inshore and offshore areas. Annual offshore values for recent years are also used here for comparison with the offshore exploitable biomass indices from fall multispecies surveys. Trends in inshore CPUE are compared with trends in inshore research trap survey catch rate indices.

OBSERVER CATCH-EFFORT DATA

Data were available from the Observer Program for the same time series as those from the fall multispecies surveys (1995-2004). These observer set and catch data included details for each set observed, number of traps hauled, landed catch (kg) and discarded catch (kg). An observer-based CPUE index (kg landed/trap haul), was calculated for comparison with offshore logbook CPUE.

A discard index (kg discarded/trap haul) was calculated for comparison with the pre-recruit index from fall multispecies surveys. Although the discard index and the survey pre-recruit biomass index are defined differently, they both include contributions by sub-legal-sized crabs (undersized males versus >75 mm CW adolescents respectively) as well as by recently-molted males (‘soft’-shelled males >94 mm CW versus adolescents >75 mm CW). While the catch rate (kg/trap haul) of discarded crabs is viewed as a potentially useful index of recruitment, the percent discarded (by weight) is viewed as a potentially useful index of indirect fishing mortality associated with handling and releasing pre-recruits.

Data were also available from at-sea biological sampling of trap catches by observers. Entire trap catches of males were sampled for carapace width (mm) and shell condition. Shell condition categories differed slightly from those described above for fall surveys, in that new-shelled males (recently-molted) were partitioned between soft-shelled (chela easily shattered) and new hard-shelled (chela not easily shattered). Also categories of crabs not recently molted (intermediate-shelled and old-shelled in fall surveys) were pooled into a single category. These biological sampling data were used to identify specific categories of discards (i.e. ‘undersized’ and ‘soft’ legal-sized) for comparison with total discards from observer set and catch data. Also, seasonal trends in the percentage of soft-shelled crabs were described. Discarding is believed to impose a high mortality on recently-molted (especially ‘soft’) immediate pre-recruits. A soft-shell protocol was imposed in some areas in 2004, to close specific small fishing areas when the percentage of soft-shell crab reached 20%.

INSHORE TRAP SURVEYS

Data were available from an inshore Div. 3K trapping survey that has been carried out in White and Notre Dame bays annually from 1994 to 2004, with the exception of 2001. The survey has consistently been conducted in September and occupies 5 of the inshore fall multispecies survey strata (Fig. 38) with a target of 8 sets per stratum. Each set includes 6 traps, with crabs sampled from two large-meshed (commercial, 135 mm) traps and two small-meshed (27 mm) traps. Catch rate indices (kg/trap haul) were calculated, for legal sized males, by shell category (new-shelled recently-molted versus older-shelled), as well as by claw type (small clawed juveniles plus adolescents versus large-clawed adults).

Data were also available from three inshore trap surveys (1979-2004) within Div. 3L. These surveys were conducted in different seasons; spring (Northeast Avalon), summer (Bonavista Bay), and fall (Conception Bay) and concentrated on sampling the commercial fishing strata. For each seasonal survey series catch rate indices (kg/trap haul) were calculated, for legal-sized males (excluding new-shelled males) and compared with fishery logbook CPUE trends for the relevant local crab management area.

RESULTS AND DISCUSSION

DIVISION 2J3KLNO

The fishery

The fishery began in Trinity Bay (Management area 6A, Fig. 1) in 1968. Initially, crabs were taken as gillnet by-catch but within several years there was a directed trap fishery in inshore areas along the northeast coast of Div. 3KL during spring through fall.

Until the early 1980's, the fishery was prosecuted by approximately 50 vessels limited to 800 traps each. In 1981 fishing was restricted to the NAFO division where the licence holder resided. During 1982-87 there were major declines in the resource in traditional areas in Div. 3K and 3L while new fisheries started in Div. 2J, SubDiv. 3Ps and offshore Div. 3K. Since the late 1980's the resource has increased in these areas. A snow crab fishery began in Div. 4R in 1993.

Licences supplemental to groundfishing were issued in Div. 3K and SubDiv. 3Ps in 1985, in Div. 3L in 1987, and in Div. 2J in the early 1990's. Since 1989 there has been a further expansion in the offshore. Temporary permits for inshore vessels <35 ft, introduced in 1995, were converted to licences in 2003. There are now several fleet sectors and about 3350 licence holders.

In the late 1980's quota control was initiated in all management areas (Fig. 1) of each division. All fleets have designated trap limits, quotas, trip limits, fishing areas within divisions, and differing seasons.

Landings for Div. 2J3KLNOP4R (Table 1, Fig. 2) increased steadily from about 10,000 t annually during the late 1980's to 69,000 t in 1999 largely due to expansion of the fishery to offshore areas. They decreased by 20% to 55,400 t in 2000, in association with a 17% reduction in TAC, before increasing slightly to 59,400 t in 2002. Landings have declined since 2002 to 55,650 t in 2004 in association with reduced annual TACs.

Effort, as indicated by estimated trap hauls, has approximately tripled throughout the 1990's. It declined in 2000 and increased slightly thereafter. Increasing effort in the 1990's was primarily due to the increased number of vessels <35 ft with temporary seasonal permits. Effort has been broadly distributed in recent years (Fig. 3).

Spatial distribution from fall multispecies surveys

The fall distribution of exploitable males (legal-sized adults, Fig. 4 and 5) as well as immediate pre-recruits (>75 mm adolescents, Fig. 6 and 7) throughout NAFO Div. 2J3KLNO in 2004 was generally similar to the distribution pattern observed throughout 1997-2003, as previously described (Dawe et al. 2004, Dawe and Colbourne 2002). Large males were virtually absent from the deepest sets (>500 m) along the Div. 3K slope, but they extended to greater depths along the more northern Div. 2J slope and along the more southern Div. 3LN slope. They were virtually absent over a broad area of the shallow (<100 m) southern Grand Bank. Survey catches of exploitable males in 2004 (Fig. 4 and 5) were more variable in offshore Div. 2J3K than they were in 2003 and appeared to be reduced in Div. 3L, especially inshore, in survey catches of pre-recruit males in 2004 were also reduced from 2003, especially inshore (Fig. 6 and Fig. 7). Any change in distribution in offshore Div. 3L in 2004 is unclear due to incomplete survey coverage in that year (Fig. 5 and 7).

Trends in distribution over the 1995-2000 period were reviewed by Dawe et al. (2003) and Dawe and Colbourne (2002). These trends included gradual spatial shifts in highest densities of most size groups, but also sharp annual and area-specific changes in survey catch rates. Such sharp area-specific annual changes in density that occur across both sexes and the entire broad male size range imply spatial and annual variability in catchability by the survey trawl (Dawe and Colbourne 2002).

Biomass and abundance

The fall multi-species survey is considered to represent a post-fishery survey, although a small proportion of the annual catch was taken during the September-December survey period in some years. Therefore the biomass index from any survey year is considered to represent an index of the exploitable biomass available to the fishery of the following year.

The exploitable biomass index and associated abundance index (Fig. 8) have both declined since 1998, by more than a factor of 3, to their lowest levels in 2004.

Recruitment

The fall survey pre-recruit biomass index (Fig. 9) declined by 73% from 1996 to 2002 and has since remained at a low level. The pre-recruit abundance index similarly declined from 1996 to 2002 and has since remained at a low level.

There is higher uncertainty associated with the pre-recruit index than with the exploitable biomass index. This difference in uncertainty is not due to differences in precision of estimates but is primarily related to differences in molt status between the two groups. The exploitable biomass index is comprised exclusively of males that were terminally-molted adults in the fall survey, whereas the pre-recruit index includes a large component of males that were adolescents as small as 76 mm CW during the survey. The projection of the pre-recruit index assumes that all those adolescents will molt, survive, grow by 19 mm CW and subsequently recruit (over the following two years, involving yet an additional molt for those that remained legal-sized adolescents), as older-shelled males. In reality, the biomass of new-shelled pre-recruit crabs is greatly affected by annual variability in natural mortality, growth increment and proportions that fail to molt. These variables currently cannot be predicted and so are not accounted for.

Negative relationships between bottom temperature and snow crab CPUE have been demonstrated at lags of 6-10 years (Fig. 10) suggesting that cold conditions early in the life history are associated with the production of strong year classes. Therefore the recent warm oceanographic regime (Colbourne et al. 2005) may have resulted in impaired snow crab productivity.

Temperatures on the Newfoundland Shelf were below normal in most years from the mid-1980's to about 1995. These were years of high crab productivity that led to high commercial catch rates during the 1990's. Warmer conditions since 1996 might have led to reduced productivity during this more recent period and could negatively impact future recruitment and commercial catch rates.

Productivity of crab during early life history has also been linked to the winter and spring sea ice cover on the Newfoundland Shelf (Dawe et al. 2004). The formation and melting of sea ice greatly influences the layering of the water column and, hence, the maintenance of primary and secondary production during spring within the near-surface layer (<50 m). It has been hypothesized that an important mechanism determining snow crab larval survival is a combination of nutrient supply, production of zooplankton, and physical oceanographic processes.

Correlation between the commercial CPUE in Div. 3L and ice cover at a time lag (10 years) approximating the mean age of crabs in the fishery provides a forecast of future fishery performance (Dawe et al. 2004). The model (Fig. 11) predicts a decline in CPUE up to 2006 and gradual recovery thereafter. However uncertainty in the forecast, illustrated in the 95% confidence intervals (C.I.), increases with time.

Mortality

Natural mortality; bitter crab disease (BCD): BCD has been observed in snow crab, based on macroscopic observations, at low levels throughout 1996-2004. The prevalence and distribution of this parasitic disease throughout the Newfoundland-southern Labrador Continental Shelf (Div. 2J3KLNO) has been described in detail by Dawe (2002).

BCD appears to have extended southward during 1999-2004 (Fig. 12 and 13) with highest prevalence having moved from Div. 2J in 1999, to Div. 3K in 2000, and having much of its distribution shifted from Div. 3K into Div. 3L during 2001-04. This shift into Div. 3L, beginning in 2001 was coincident with a great increase in survey catch rates of smallest males in Div. 3L in 2001 (Dawe et al. 2002). Annual changes in prevalence of BCD are presented later, on a divisional basis.

BCD occurs in both sexes and all sizes of snow crab. Its prevalence in mature females is comparable to that in males of similar size (Dawe 2002). It is unknown how well disease prevalence in trawl-caught samples, especially based on recognition of external characteristics in chronic cases, represents true prevalence in the population, but it seems likely that our observations underestimate true prevalence. Relationships of prevalence with density are unclear (Dawe 2002) and implications for mortality are unknown.

DIVISION 2J

The fishery

Landings increased slightly from 330 t in 1985 to 600 t in 1990, before increasing to about 3200 t during 1995-97 (Table 2, Fig. 14). They peaked in 1999 at 5400 t but have since declined to 1900 t in 2004, due to reductions in TAC, while effort increased by 42%.

Biomass

Commercial catch rates (CPUE) have oscillated over the time series (Table 2, Fig. 15). They initially decreased during 1985-1987, increased to a peak in 1991, decreased again to 1995, and increased to the most recent peak in 1998. CPUE has since declined steadily by 77% since 1998 to a record low level in 2004. This decline was evident throughout Div. 2J, with no substantial changes in the spatial distribution of fishing effort in recent years (Fig. 16).

The logbook CPUE and observed CPUE agreed fairly well (Fig. 17). Trends in CPUE throughout the season (Fig. 18 and Fig. 19) indicated that initial CPUE decreased during 2001-04 and that CPUE was lowest in 2004 throughout most of the fishing season.

The fall multispecies survey exploitable biomass index (Table 3, Fig. 20) increased steadily during 1995-98, decreased by 94% from 1998 to 2002, and has remained low during 2002-04. Trends in both the fall survey index and fishery CPUE indicate that the biomass has declined since 1998.

Production

Recruitment: We examined annual changes in abundance indices of legal-sized males from fall multispecies surveys, by shell condition, toward evaluating the internal consistency of the data series (Fig. 21). Males enter the legal-size group as new-shelled crabs, after the spring molt, and begin to contribute to the legal old-shelled group in the following year. Trends in the abundance index by shell condition reflect this process, in that the abundance index of new-shelled males peaked in 1998 whereas that of old-shelled males peaked one year later, in 1999. The abundance index of new-shelled males dropped sharply (by 72%) in 1999, whereas abundance of old-shelled crabs steadily declined, by 84%, during 1999-2002. The abundance of new-shelled crabs has increased since 2002 back to 1999-2001 levels while the abundance of old-shelled crabs has remained at about 2002 levels**.** This suggests that the resource has become increasingly dependent upon relatively weak annual recruitment.

The fall survey pre-recruit index and observer discard pre-recruit index (Table 4, Fig. 22) increased steadily from 1995 to 1998. They both decreased from 1998 to a lower level during 1999-2001. The survey index decreased in 2002, remained low in 2003, and increased sharply in 2004. The observer index increased in 2002, was unchanged in 2003, and increased slightly in 2004.

The fall survey and observer pre-recruit indices agree that recruitment appears promising in the short term. The survey data indicate an increase in abundance of sub-legal sized males that will begin to achieve legal size in 2005, as new-shelled immediate pre-recruits, and will recruit to the fishery as older-shelled crabs predominately in 2006-07.

The size compositions from fall multispecies surveys were examined initially with the abundance index (ordinate) truncated for smallest males (<50 mm CW), in order to focus on trends in abundance for larger males (Fig. 23). The decline in commercial-sized males since 1998, as well as in pre-recruits from 1998 to 2003 is well-reflected in these size frequencies. The increase in the pre-recruit index in 2004 is well-reflected by a prominent modal group of adolescents at about 75-92 mm CW.

The non-truncated size distributions (Fig. 24) suggest that indices of smallest males (<50 mm CW) increased during 1999-2001 and then decreased. While the modal group of 75-92 mm CW pre-recruits in 2004 may have been derived from the large modal group of <50 mm CW males in 2001, there has been no clear evidence of modal progression over the time series. Therefore long-term recruitment prospects are unknown.

Size distributions from at-sea sampling by observers (Fig. 25) indicate that modal CW decreased from about 110-113 mm in 2002 to 92 mm in 2004, due to a decrease in catch rate of largest males and an increase in catch rates of smallest males. Although these observations suggest some increase in recruitment, there is high uncertainty associated with low observer coverage; particularly in 2003 (unpublished data). Observer biological sampling shows increasing catch rates of undersized males in the fishery since 2002 while catch rates of legal-sized males have continued to decline (Fig. 26). These observer indices agree with the fall survey that recruitment appears promising in the short term.

Reproduction: The percentage of mature females carrying full clutches of viable eggs (Fig. 27) remained above 90% until 2000 (excepting the anomalous 1999 value), but declined from 94% in 2000 to 74-78% in 2001-03 before increasing back to 94% in 2004. It is uncertain whether this apparent decline in mating success from 2001 to 2003 is due to the decline in availability of legal-sized males. Also, it is unknown whether declines in fecundity of this apparent level would affect subsequent abundance of settling megalopae.

Mortality

Exploitation: The exploitation rate index decreased from 1996 to 1998 (Fig. 28), was unchanged in 1999, then increased from 1999 to 2001. It changed little in 2002 but increased sharply in 2003, despite a decrease in landings. It decreased in 2004 to its second highest level in the time series.

Indirect fishing mortality: The percentage of the total catch discarded, by weight, in the fishery (Fig. 28) decreased from 16-18% during 1995-98 to 11-12% during 1999-2001. It increased sharply in 2002, was unchanged in 2003 and further increased to a record high level of 72% in 2004, implying increased handling mortality on under-sized and soft-shelled pre-recruits in the 2004 fishery. The percent discarded by weight underestimates numbers discarded and associated implied mortality. Deaths in numbers would be much greater than suggested by percentage discarded by weight because new-shelled crabs are generally smaller than older-shelled (recruited) crabs, and undersized crabs are smaller.

Snow crabs that are caught and released as undersized and/or soft-shelled in the fishery are subject to multiple stresses and have unknown survival rates. Time out of water, air temperature, water temperature and shell hardness all influence the mortality level on discarded snow crab (Miller 1977). Other environmental factors such as wind speed, sunlight and size of the crab may also influence survivability (Dufour et al. 1997). Poor handling practices such as prolonged exposure on deck, dropping or throwing crab as well as inducing limb loss increases mortality levels associated with catching and discarding crabs. Recently-molted (soft-shelled) snow crab are more subject to damage and mortality than hard-shelled crab (Dufour et al. 1997; Miller 1977).

The percentage of soft shelled crab present in the catch per week has been much higher during 2002-2004 than in 2001 (Fig. 29). Peaks in percentage of soft-shell have been occurring progressively earlier each year. Peak soft-shell prevalence occurred in week 17 in 2002, week 13 in 2003 and week 10 in 2004. These trends may be due to depletion of recruited (older-shelled) crabs, earlier molting, or increased catchability of soft-shelled immediate pre-recruits in recent years. Regardless of the cause, this implies an increase in mortality on new-shelled crab in the fishery in recent years.

In the short term, handling mortality in the fishery is expected to increase. Continued exploitation, in the short term, would likely impose a very high mortality on immediate pre-recruits that would seriously impair recovery of the exploitable biomass.

Natural mortality; bitter crab disease (BCD): BCD has been most prevalent in small crabs of 40-59 mm CW in Div. 2J (Fig. 30). Prevalence, in new-shelled males, has generally been low in this area, usually about 2-3% occurrence for that size range, excepting 1999, when 18.2% of new-shelled males in that size group were visibly infected. No crabs of that size range were visibly infected in 2004. BCD prevalence increased in 2002, particularly in smallest males of <40 mm CW (from 0.2 to 3.6%) and in intermediate-sized males of 60-75 mm CW (from 0 to 2.6%). Overall prevalence has declined since 2002. BCD prevalence was at a low level in 2004 relative to other years and was confined to the extreme size groups.

DIVISION 3K

The fishery

Landings averaged about 3300 t during 1985-1990 then increased to about 21,400 t in 1999. Landings declined by 29% to 15,300 t in 2000 and 2001 (Table 5, Fig. 31), due to a reduction in TAC imposed in those years. They increased to 16,500 t in 2002-2004 due to an increase in TAC. Effort decreased during 1999-2001, then increased by 17% to 2003, and further increased by 37% in 2004. The percentage of the total landings derived from inshore increased from 8 to 23% over the past four years.

Biomass

Commercial catch rates have oscillated over the time series (Table 5, Fig. 32). The offshore commercial CPUE decreased 32% from 1998 to 2001, remained at this relatively low level until 2003, and decreased sharply in 2004. Inshore commercial CPUE has been consistently lower than offshore CPUE. Inshore CPUE declined during 1993-2000, increased sharply in 2001, and has since declined to about the long-term average. The spatial distribution of CPUE was similar to that of 2003 (Fig. 33). Areas fished changed little from 1999 to 2003 (Dawe et al. 2004), with the exception of the virtual disappearance, since 1999, of the fishery east of 51W along the slope and southeast of the Funk Island Bank.

The offshore logbook CPUE and observed CPUE agreed well in 2004, for the first time, with observed CPUE being lower than logbook CPUE from 1998 to 2003 (Fig. 34). However they agreed that offshore CPUE declined during 1998-2001 and changed little until 2003. The reduction in logbook CPUE was very sharp in 2004 while the observer CPUE remained unchanged from 2003. There were clear annual differences in CPUE trends throughout the season (Fig. 35 and 36). CPUEs were lower throughout the season in 2004 than in the previous three years (Fig. 36). A late-season increase in weekly CPUE in 2004 was due to an increase in the proportion of new-shelled crab being caught and retained after the fishery re-opened in the fall, having been closed in summer due to a high incidence of soft-shelled crab in the catch.

The fall multispecies survey exploitable biomass index increased sharply in 1996 (Table 6, Fig. 37) and remained at a high level during 1996-98. It dropped by more than half in 1999 and increased slightly during 2000 and 2001. It declined by 68% from 2001 to 2003 and remained low in 2004.

Catch rates from the inshore Div 3K trapping survey (Fig. 38) show that in all 5 strata there was a sharp decrease in catch rates of new-shelled pre-recruits in 2004. In recent years catch rates of new-shelled pre-recruits have been much higher than those of older-shelled recruited crabs in the three deepest strata that are commercially fished (610, 613 and 614, Fig. 38), indicating depletion of the exploitable biomass and increased dependence on recruitment. Catch rates (of both shell categories) in 2004 remained higher in White Bay than in Notre Dame Bay (Fig. 38). Catch rates of older-shelled crabs increased in commercially-fished strata of White Bay in 2004 following a peak in the pre-recruit catch rate the previous year (Fig. 38). Meanwhile, the catch rate of older-shelled crabs in commercially-fished stratum 610 of Notre Dame Bay decreased to a record low level in 2004.

Production

Recruitment: Annual changes in the abundance index by shell condition do not show a consistent trend of peaks in new-shelled abundance preceding peaks in old-shelled abundance (Fig. 40), as was evident in Div. 2J. This may be due to annual differences in catchability of crabs by the survey trawl. Such changes in catchability or trawl efficiency may be related to changes in trawl configuration or changes in distribution of crabs with respect to depth and substrate type (Dawe et al. 2002).

Both the fall survey pre-recruit index (Table 7) and the observer discard pre-recruit index increased between 1995 and 1997 (Fig. 41), and declined to 1999. The observer index has since varied at a relatively low level. The survey index declined during 2000-03 before increasing in 2004 to about the 10-year average. Offshore recruitment is expected to remain unchanged in the short term.

The truncated size compositions from fall multispecies surveys (Fig. 42) show a decline in commercial-sized males since 1996 and of adolescent pre-recruits since 1997. There is no clear indication of any increase in recruitment in the short term, based on males larger than about 50 mm CW.

The non-truncated size distributions (Fig. 43) suggest that indices of smallest males (<50 mm CW) were relatively high during 2000-01 and decreased thereafter. However this is unreliable as an indication of long-term recruitment because there has been no evidence of modal groups progressing through the size range over the time series. Therefore, long-term recruitment prospects are unknown.

Size distributions from at-sea sampling by observers (Fig. 44) indicate that modal CW decreased from about 110 mm in 1999 to about 101 mm in 2000 as catch rates of small males increased, suggesting some increase in recruitment in 2000. There was little change in 2001, but modal CW increased to 110 mm CW in 2002 and was unchanged in 2003 and 2004.

Data from at-sea sampling by observers since 1999 show that the catch rate of undersized crab peaked in 2000, declined sharply to 2002 and has since varied at a relatively low level (Fig. 45). Observer CPUE of legal-sized crabs peaked in 2002 two years later than did undersized crabs, and declined sharply to 2004. This supports our conclusion that offshore recruitment is expected to remain unchanged in the short term.

Size composition by stratum of all males from the September (post-season) inshore trap survey (Fig. 46-50) shows a prominent group of sublegal-sized crabs in 1998, in most strata, that recruited until 2003. This trend is clearest in the White Bay strata (Fig. 46-48), resulting in peak catch rates of new-shelled immediate pre-recruits in 2003 in all three strata (Fig. 39). Size distributions from all five inshore strata consistently showed a pronounced decrease in catch rate across the full size range, strongly suggesting reduced catchability in the 2004 survey. This is reflected in the sharp decrease in the catch rate of new-shelled immediate pre-recruits in 2004 in all five strata. Therefore, inshore recruitment prospects are unknown.

Reproduction: The percentage of mature females carrying full clutches of viable eggs (Fig. 51) has varied at a high level, exceeding 80% in all years but 1996.

Mortality

Exploitation: The exploitation rate index decreased from 1996 to 1997 (Fig. 52) and increased steadily from 1997 to 2000. It changed little to 2003, before increasing sharply in 2004.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 52) increased from 1999 to 2001 and remained relatively high, at about 30%, during 2001-03. It then increased to about 40%, implying relatively high handling mortality on small and new-shelled pre-recruits during the fishery in 2004.

The percentage of soft-shelled crab in the catch by week has increased and occurred progressively earlier in the season in 2003 and 2004 than in the previous two years (Fig 53). This implies an increased catchability, and subsequent mortality, of new-shelled immediate pre-recruits in the fishery in recent years. Handling and fishery-induced mortality is expected to remain high in 2005 if the recent catch level is maintained and current fishing practices persist.

Natural mortality; bitter crab disease (BCD): Prevalence of BCD, from multispecies survey samples, has been higher in this area than in any other division, with maximum levels during 1996-98 in the order of 8% in 40-59 mm CW males (Fig. 54). Prevalence had decreased in 2003 but increased in 2004 among new-shelled males of all size groups back to about the average for the 2000’s. Implications for mortality are unknown. Prevalence in legal-sized new-shelled males was the highest in the time series in 2004, at about 2%.

BCD has consistently been more prevalent in the inshore Div. 3K trap survey samples (Fig. 55-56) than in the predominately offshore Campelen trawl samples. This may reflect confounding effects of spatial differences in surveys and gear selectivity of diseased crabs. We believe that BCD was not prominent in inshore Div. 3K in the early 1990's because we detected no BCD in 1994, the first year of our survey. Furthermore, in White Bay (Fig. 55), it was detected only in the shallowest stratum in 1995, especially in smallest males, despite our sampling in both deeper strata that year. Between 1995 and 1999 there was a clear progression of BCD to successively larger crabs and successively greater depths, such that about 12% of legal-sized new-shelled crabs in the deepest stratum were infected in 1999. Prevalence is higher in adolescents than in adults, and prevalence in new-shelled adolescents increased with size in all strata except deep Notre Dame Bay stratum 610 (Fig 57 and 58). Prevalence in new-shelled adolescents was at very low levels in 2002 and 2003 in all strata except stratum 610. It increased sharply in shallow White Bay stratum 615 in 2004 (Fig. 57), especially in the two largest size groups which were fully infected, while remaining virtually absent in the shallower White Bay strata. It also increased in 2004 in both Notre Dame Bay strata (Fig. 58).

DIVISION 3L

The fishery

Landings increased from about 1300 t in 1975 to 13,000 t in 1981, before decreasing to 2600 t in 1985 (Table 8, Fig. 59). They increased steadily to peak at 26,200 t in 1999, before declining to 22,600 t in 2000. They increased by 15% to 26,000 t in 2003, and 25,800 t in 2004 due to changes in TAC. Meanwhile, effort has increased by nearly 75% since 2000. Inshore landings have represented 25% of the total in the past three years.

Biomass

Commercial catch rates (Table 8, Fig. 60) in the offshore increased sharply from 1991-1992 and have since remained high but declined by 22% between 2002 and 2004. Inshore CPUE decreased by 21% in 2003 and remained unchanged in 2004. Inshore CPUE has been consistently lower than offshore CPUE.

The spatial distribution of CPUE became less aggregated after 2001 (Fig. 61), as CPUE declined slightly. Only the aggregations furthest offshore have changed little over time. The spatial distribution of CPUE changed very little from 2003 to 2004.

The trends in logbook CPUE have agreed well with observed CPUE since 1998 (Fig. 62). There were notable annual differences in initial offshore CPUE and trends throughout the season (Fig. 63 and 64). Offshore CPUE was lower in 2004 than in the three previous years.

The fall survey exploitable biomass index (Table 9, Fig. 65) declined from 1996 to 2000 and remained relatively low until it further decreased in 2004. Disagreement between the exploitable biomass index and CPUE throughout most of the time series introduces uncertainty regarding trends in biomass, but both indices decreased in the past two years. Additional uncertainty is associated with the incomplete survey conducted in Div. 3L in 2004. Fishery CPUE data and catch rates from a post-season trap survey (Fig. 66) indicate that two of these missed strata were important for snow crab.

Catch rates from trap surveys in 3 localized inshore areas have declined since the 1990's (Fig. 67-72).

Production

Recruitment: Annual changes in the multi-species survey abundance by shell condition (Fig. 73) reflected greater internal consistency than was evident in Div. 3K. Abundance of new-shelled legal-sized males declined from a peak in 1995, whereas old-shelled legal-sized males peaked at least two years later, in 1997. Abundance of new-shelled males continued to decline to 1999 before stabilizing, whereas the decline in old-shelled males extended one year later, to 2000, before stabilizing. These consistent trends show no clear evidence of strong changes in catchability or 'year effects', as were suggested in Div. 3K. In 2004, the proportion of old-shelled crabs fell below that of new-shelled crabs for the first time since their peaks in the late 1990's.

The fall survey pre-recruit biomass index (Table 10, Fig. 74) has been low since 1997 while the observer discard pre-recruit index has declined since 1997 (Fig. 75). Recruitment is expected to remain relatively low in the short term.

The truncated size compositions from fall multispecies surveys (Fig. 75) show a decline in commercial-sized males, as well as of adolescent pre-recruits since 1996. There is no clear indication of any increase in recruitment in the short term, based on males larger than about 50 mm CW.

The non-truncated size distributions (Fig. 76) suggest that indices of smallest males (<50 mm CW) were high during 2001-02, but this group of crabs has since declined. This is unreliable as an indication of long-term recruitment because there has been no evidence of modal groups progressing through the size range over the time series. Therefore, long-term recruitment prospects are unknown.

Size distributions from at-sea sampling by observers (Fig. 77) became increasingly platykurtic over the past six years. Modal CW increased from 98 mm in 1999 to about 98-110 mm in 2004 as catch rates of small males decreased, suggesting declining recruitment. Observer catch rates of under-sized males have declined steadily since 2000 (Fig. 78).

Reproduction: The percentage of mature females carrying full clutches of viable eggs declined overall throughout the time series to 50% in 2001, increased to about 90% in 2002-03 and declined to 81% in 2004 (Fig. 79).

Mortality

Exploitation: The exploitation rate index increased from 1996-2000 and remained high thereafter (Fig 80). The effect on exploitation rate of maintaining the current catch level remains unclear because trends in the exploitable biomass index and CPUE do not agree.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 80) increased from 1995 to 1997, decreased sharply in 1998, then declined gradually until 2004, implying decreased handling mortality on pre-recruits.

The percentage of soft-shelled crab in the catch throughout the season (Fig. 81) was lower than in 2J or 3K. Percent soft-shelled was slightly higher in 2004 than in the previous years but exceeded 20% of the catch only in one week.

Natural mortality; bitter crab disease (BCD): BCD has generally occurred at lower levels in Div. 3L than in Div. 3K. Prevalence in Div. 3L, from fall multi-species surveys (Fig. 82) has increased since 2002 to highest levels in the time series. The 2004 levels approached 8% in new-shelled males of some size groups, as was seen in Div. 3K during earlier years. This appears to reflect a shift of maximum prevalence from Div. 3K south to Div. 3L in recent years.

DIVISION 3NO

The fishery

The fishery began in the mid-1980’s in Div. 3O and expanded along the shelf edge in 1999. Landings increased sharply in 1999 and averaged 5200 t over the past six years (Table 11, Fig. 83). Effort has increased greatly since the start of the fishery and is currently at its highest level.

Biomass

CPUE has remained high in recent years relative to other areas (Fig. 84) but decreased by 26% between 2002 and 2004. The fishery has been concentrated along the shelf edge (Fig. 85) with no substantial change in areas fished during 2000-04.

Observed CPUE was consistently lower than logbook CPUE, but showed a similar trend (Fig. 86) with both indices agreeing well in 2004. CPUE in 2004 was lower throughout the season in 3N, and for most weeks in 3O, than in the three previous years (Fig. 87-90).

Because estimates of the exploitable biomass indices (Table 12, Fig 91-93), as determined from fall multi-species surveys, have wide margins of error and show no clear trend, no inferences about biomass can be made from these data.

Production

Recruitment: Annual changes in the multispecies survey abundance index by shell condition (Fig. 94 and 95) reflected greater internal consistency in Div. 3N than Div. 3O. In Div. 3N, abundance of new-shelled legal-sized males increased from 1995 to a peak in 1998, whereas old-shelled legal-sized males peaked three years later in 2001. Abundance of new-shelled males declined from 1998 to 2001 whereas the abundance of old-shell crab declined later, from 2001 to 2003. New-shell crab catch rate increased from 2001 to 2003 and remained unchanged in 2004 and old-shelled crab catch rate increased from 2003 to 2004. In Div. 3O the trends are not as consistent, with abundance of new-shelled and old-shelled males declining since 2001 and 1998 respectively.

Wide margins of error introduce uncertainty in interpreting the fall multi-species survey pre-recruit index (Table 13, Fig. 96). However, biological data from the survey index (Fig. 97 and 98) as well as data from at-sea observers (Fig. 99 and 100) indicate that recruitment is expected to remain relatively low in the short term. This agrees with the observer discard pre-recruit index (Fig. 96), which has declined since 1999. Longer-term recruitment prospects are unknown. The long-term recruitment indices are especially unreliable for Div. 3NO because of broader confidence intervals about the mean estimates for any size group than in the more northern divisions. Low and variable precision of mean estimates is reflected in the abundance-at-CW data (Dawe et al. 2002b) and preclude inferences about long-term recruitment.

Size distributions from at-sea sampling by observers in Div. 3N (Fig. 99) showed a gradual increase in modal CW over the past 6 years. Modal CW increased from 101 mm in 1999 to 113 mm in 2000 and 119 mm in 2003-04, as catch rates of small males steadily declined, suggesting declining recruitment. The trend was not as consistent in Div. 3O in that there appeared to be some increase in recruitment during 2000-02, based on decreasing modal CW and increasing catch rate of sub-legal sized males. However recruitment apparently decreased in 2003 and was at a low level in 2004, based on a decrease in catch rate of small males. Observer sampling indicates the catch rate of undersized crab has declined from 1999 to 2004 in Div. 3NO (Fig. 101).

Reproduction: There was no clear trend in the percentage of females carrying full clutches of viable eggs in Div 3N or Div. 3O (Fig. 102). Percent full clutches exceeded 95% in most years. Division 3N has had 100% of females carrying full clutches in 2003 and 2004 while in Div. 3O only about 80% of clutches were full in the past two years, perhaps due to low sample sizes.

Mortality

Exploitation: Trends in exploitation rate are unclear because of uncertainties associated with the exploitable biomass index but the fishery continues to perform at a high level. The effects of maintaining the current catch level on the exploitation rate are unknown.

Indirect fishing mortality: Prevalence of soft-shelled crab in Div 3NO catches (Fig. 103).remained low relative to all other areas throughout the past four years. The percentage of the total catch discarded in the fishery declined by more than half from 1999 to 2002 and has remained steady during the last 3 years at a low level, implying low handling mortality on pre-recruits (Fig. 104).

Natural mortality; bitter crab disease (BCD): BCD has been virtually absent from Div. 3NO, based on fall multi-species survey trawl samples.

SUBDIVISON 3PS

The fishery

The fishery began in 1985 with landings not exceeding 1000 t until 1994 when the offshore fishery began (Table 14, Fig. 105). Landings rose steadily until 1999 due to increased TACs and averaged 7800 t during 1999-2002. They decreased by 38% from 7600 t in 2002 to 4700 t in 2004, due to reductions in TAC. Effort increased by 59% from 2001 to 2003 before decreasing by 10% in 2004.

The percentage of the total catch taken inshore declined from 39% to 27% over the past three years.

Biomass

Inshore CPUE declined from 2001 to 2004 by 67% whereas offshore CPUE declined by 67% from 1999 to 2003 and remained unchanged in 2004 (Fig. 106).

The spatial distribution of offshore commercial fishing effort expanded steadily during 1992-99 while the catch increased (Dawe et al. 2004). Expansion continued until 2002, as the catch remained high and CPUE declined steadily. The distribution of fishing effort has contracted since 2002 (Fig. 107) while total effort has remained high.

The logbook CPUE and observed CPUE agreed in 2004 (Fig 108), but observed CPUE was generally lower than logbook CPUE throughout the time series. Both indices show that CPUE declined from 1999-2003 with the logbook CPUE remaining unchanged and the observed CPUE increasing slightly in 2004.

Trends in CPUE throughout the season (Fig. 109 and 110) indicated that initial and weekly CPUE decreased during 2001-04 and that CPUE was lowest in 2004 throughout the fishing season.

No estimates of the exploitable biomass index are available as there are no reliable research survey data from this area.

Production

Immediate Recruitment: Size distributions from at-sea sampling by observers (Fig. 111) showed a decrease in catch rate of legal-sized males as well as smaller males in recent years. Sub-legal (undersized) males declined steadily during 2001-03 (Fig. 112) whereas the decline in legal-sized males began a year later (2002-03). Observer catch rates for both groups increased slightly in 2004.

The observer discard pre-recruit index (Fig. 113) has changed little over the past six years (1999-2004). Recruitment is expected to change little in the short term.

Long-term Recruitment: No data.

Mortality

Exploitation: Assuming that recent CPUE reflects low exploitable biomass, exploitation rate and pre-recruit mortality will likely remain high if the current catch level is maintained.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 113) decreased from 46% in 2003 to 34% in 2004, implying reduced handling mortality on pre-recruits during the 2004 fishery.

The occurrence of soft shell crab in the weekly catch has been variable, but remained at low levels relative Div 2J3K during the past four years (Fig 114). Percentage soft-shelled crab was especially low throughout 2004.

Natural mortality; bitter crab disease (BCD): There are no data on BCD from this area.

DIVISION 4R AND SUBDIVISION 3PN

The fishery

The fishery began in the early 1990's with landings not exceeding 1000 t until 1998 (Table 15, Fig. 115). Landings increased by 88% from 930 t in 1997 to 1750 t in 2002, due to increases in TAC, and then dropped by 17% to 1450 t in 2004. The TAC was not fully taken in the past two years. Effort increased steadily until 2001, decreased in 2002 and increased in 2003-2004. CPUE is consistently low relative to other divisions (Fig. 116).

Biomass

It is not possible to infer trends in exploitable biomass from commercial CPUE data because of recent changes in the spatial distribution of fishing effort (Fig. 117 and 118). Furthermore, there are insufficient fishery independent data from this area.

Observed CPUE and logbook CPUE differed greatly showing no common trend (Fig. 119), due to inadequate observer coverage.

Trends in CPUE throughout the season during the past four years (Fig. 120 and 121) indicated that initial CPUE was lowest in 2004 and 2004 CPUE remained lowest throughout the fishing season.

Production

Immediate Recruitment: The observer data for this area are insufficient to estimate a reliable pre-recruit index. Similarly, annual size distributions show no trend due to insufficient at-sea sampling (Fig. 122). Therefore, short-term recruitment prospects are unknown.

Long-term Recruitment: No data are available.

Mortality

The observer data are insufficient to infer levels of handling mortality on pre-recruits.

The effects of maintaining the current catch level on the exploitation rate and pre-recruit mortality are unknown.

Natural mortality; bitter crab disease (BCD): There are no data on BCD from this area.

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Table 1. TAC (t) and landings (t) by year for Division 2J3KLNOP4R.

Year	TAC	Landings
1981		14,196
1982		13,498
1983		11,113
1984		9,555
1985		7,974
1986	8,825	8,968
1987	8,325	6,680
1988	8,526	9,588
1989	9,970	8,326
1990	12,800	11,026
1991	15,670	16,162
1992	14,470	16,437
1993	18,550	22,922
1994	23,650	27,917
1995	27,875	32,334
1996	34,864	37,967
1997	42,015	45,726
1998	46,525	52,640
1999	61,761	69,042
2000	51,169	55,350
2001	52,252	56,714
2002	56,981	59,397
2003	56,330	58,347
2004	53,590	55,653

Table 2. TAC (t), landings (t), effort (trap hauls), and CPUE (kg/haul) by year for Division 2J.

Year	TAC	Landings	Effort	CPUE
1985		332	24,776	13.4
1986	925	468	38,361	12.2
1987	925	232	25,778	9
1988	926	456	50,667	9
1989	920	483	39,917	12.1
1990	920	602	47031	12.8
1991	1,420	1,003	68231	14.7
1992	1,420	1,494	121463	12.3
1993	2,300	2,267	190504	11.9
1994	2,900	2,971	330111	9
1995	3,050	3,189	393704	8.1
1996	2,800	3,102	326526	9.5
1997	2,800	3,183	286757	11.1
1998	3,500	4,098	276892	14.8
1999	4,655	5,428	402074	13.5
2000	3,411	3,673	303554	12.1
2001	3,340	3,738	424773	8.8
2002	3,381	3,521	577213	6.1
2003	2,265	2,532	575455	4.4
2004	1,780	1,925	534722	3.6

Table 3. Fall multi-species survey exploitable biomass index by year for Division 2J.

Year	Biomass (T)	Confidence Intervals (+/-)		Mean Kg/Set
		Upper	Lower	
1995	3,367	4,742	1,991	1.13
1996	5,546	7,655	3,437	1.87
1997	10,196	16,238	4,155	3.44
1998	12,376	18,154	6,598	4.17
1999	6,117	8,159	4,075	2.06
2000	3,505	4,437	2,574	1.18
2001	3,161	3,775	2,346	1.06
2002	798	1,283	314	0.27
2003	945	1,600	291	0.32
2004	1,389	2,070	709	0.47

Table 4. Fall multi-species survey pre-recruit index by year for Division 2J.

Year	Biomass (t)	Confidence Intervals (+/-)		Mean kg/set
		Upper	Lower	
1995	1,937	2,832	1,042	0.65
1996	2,339	3,467	1,211	0.79
1997	2,783	4,182	1,384	0.94
1998	3,384	4,523	2,244	1.14
1999	1,082	1,999	165	0.36
2000	1,211	1,759	663	0.41
2001	1,254	3,095	-587	0.42
2002	547	2,992	-1,897	0.18
2003	835	1,224	426	0.28
2004	4,716	34,239	-24,806	1.59

Table 5. TAC (t), landings (t), effort (trap hauls), and CPUE (kg/haul) by year for Division 3K.

Year	AC	Landings	Effort	CPUE Offshore	CPUE Inshore
1981		1,303	110,424		
1982		2,443	294,337		
1983		4,898	612,250		
1984		5,031	606,145		
1985		4,001	689,828		
1986	4,000	4,277	1,069,250		
1987	4,000	2,678	723,784		
1988	2,550	2,681	570,426		
1989	2,350	2,346	418,929		
1990	4,380	4,309	398,981	14.7	6.7
1991	7,650	8,353	673,629	14.9	9.3
1992	6,650	7,543	633,866	13.3	9.5
1993	8,575	10,463	721,586	16.2	10.5
1994	9,800	10,724	794,370	15.3	9.1
1995	11,450	12,326	1,018,678	13.7	8.3
1996	12,950	14,210	1,280,180	13	6.4
1997	14,300	14,796	1,395,849	13.4	5.8
1998	15,740	16,839	1,357,984	14.9	5.7
1999	18,192	21,386	2,138,600	13.3	4
2000	13,493	15,390	1,710,000	11	4.4
2001	13,693	15,288	1,544,242	10	8.9
2002	15,378	16,352	1,619,010	10.6	8.3
2003	15,608	16,502	1,737,053	10.3	7.3
2004	15,593	16,460	2,318,310	7.6	5.8

Table 6. Fall multi-species survey exploitable biomass index by year for Division 3K.

Year	Biomass (t)	Confidence Intervals (+/-)		Mean kg/set
		Upper	Lower	
1995	10,073	12,679	7,467	2.06
1996	19,373	23,470	15,276	3.97
1997	18,486	22,667	14,306	3.79
1998	18,457	22,938	13,976	3.78
1999	8,408	10,919	5,898	1.72
2000	9,791	12,192	7,390	2.01
2001	11,143	15,688	6,599	2.28
2002	8,615	11,232	5,998	1.76
2003	3,567	4,555	2,579	0.73
2004	5,479	6,938	4,020	1.12

Table 7. Fall multi-species survey pre-recruit index by year for Division 3K.

Year	Biomass (t)	Confidence Intervals (+/-)		Mean kg/set
		Upper	Lower	
1995	6,412	8,932	3,893	1.31
1996	10,010	13,648	6,371	2.05
1997	12,880	17,255	8,505	2.64
1998	9,790	13,861	5,720	2.01
1999	3,400	4,811	1,990	0.7
2000	8,925	12,365	5,485	1.83
2001	6,287	8,517	4,058	1.29
2002	4,796	6,852	2,740	0.98
2003	2,340	4,193	488	0.48
2004	5,415	9,200	1,631	1.11

Table 8. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/haul) by year for Division 3L.

Year	TAC	Landings	Effort	CPUE Offshore	CPUE Inshore
1981		12,855	851,325		
1982		11,041	716,948		
1983		6,211	627,374		
1984		4,524	706,875		
1985		2,638	507,308		
1986	3,300	3,506	480,274		
1987	2,800	3,133	352,022		
1988	4,450	5,319	625,765		
1989	6,000	4,423	614,306		
1990	6,800	5,394	719,200	8.1	7.4
1991	5,900	6,430	803,750	9.7	7.7
1992	5,900	6,992	568,455	18.1	11.4
1993	7,175	9,074	677,164	16.7	12.9
1994	10,100	11,944	785,789	16.9	15.2
1995	11,650	14,007	828,817	18.9	15.6
1996	14,775	16,416	1,124,384	16.4	13.1
1997	18,925	20,691	1,477,929	17.3	11.6
1998	19,975	23,289	1,464,717	17.6	11.4
1999	26,375	26,220	1,628,571	17.6	11.4
2000	22,710	22,600	1,221,622	19.2	11.7
2001	23,655	23,469	1,356,590	18.7	10.7
2002	26,448	25,013	1,583,101	18.3	11.2
2003	27,807	26,046	1,915,147	16.6	8.8
2004	27,288	25,746	2,110,328	14.2	8.4

Table 9. Fall multi-species survey exploitable biomass index by year for Division 3L.

Year	Biomass (t)	Confidence Intervals (+/-)		Mean kg/set
		Upper	Lower	
1995	19,527	25,572	13,482	3.39
1996	31,093	38,009	24,176	5.36
1997	18,577	24,107	13,046	3.2
1998	22,054	28,023	16,085	3.8
1999	12,197	15,515	8,879	2.1
2000	9,101	13,256	4,947	1.57
2001	11,577	15,429	7,725	1.99
2002	11,044	16,243	5,845	1.9
2003	9,455	13,202	5,709	1.63
2004	3,965			

Table 10. Fall multi-species survey pre-recruit index by year for Division 3L.

Year	Biomass (t)	Confidence Intervals (+/-)		Mean kg/set
		Upper	Lower	
1995	9,061	12,743	5,379	1.57
1996	25,342	33,387	17,298	4.37
1997	8,011	10,736	5,286	1.38
1998	8,507	11,163	5,851	1.47
1999	4,454	6,708	2,200	0.77
2000	4,623	7,222	2,024	0.8
2001	2,915	4,587	1,244	0.5
2002	2,205	3,004	1,407	0.38
2003	4,277	6,842	1,713	0.74
2004	1,364			

Table 11. TAC (t), landings (t), effort (trap hauls) and CPUE (kg/haul) by year for Division 3NO.

Year	TAC	Landings	Effort	CPUE
1985		7		
1986				
1987				
1988		327		
1989		531		
1990		78		
1991		19		
1992				
1993		148		
1994		106		
1995		14	615	22.76
1996		427	33,126	12.89
1997		1,454	99,453	14.62
1998		730	40,176	18.17
1999	3,250	6,506	337,623	19.27
2000	2,425	4,173	216,330	19.29
2001	2,425	4,697	240,010	19.57
2002	2,425	5,023	245,864	20.43
2003	2,670	5,592	293,543	19.05
2004	2,670	5,283	343,722	15.37

Table 12. Fall multi-species survey exploitable biomass index by year for Division 3NO.

Year	3N Biomass (t)	3N Confidence Intervals (+/-)		3O Biomass (t)	3O Confidence Intervals (+/-)		3N Mean kg/set	3O Mean kg/set
		Upper	Lower		Upper	Lower		
1995	1,952	3,265	639	1,056	2,953	-841	0.76	0.6
1996	6,404	10,934	1,875	1,371	7,963	-5,222	2.5	0.78
1997	4,292	8,204	381	1,683	2,933	431	1.68	0.96
1998	9,364	20,309	-1,580	3,234	6,051	416	3.66	1.85
1999	6,681	9,686	3,676	1,223	7,807	-5,362	2.61	0.67
2000	4,456	9,001	-89	1,105	1,575	633	1.74	0.63
2001	8,850	15,656	2,045	1,341	2,646	36	3.46	0.77
2002	4,021	5,718	2,324	959	9,017	-7,099	1.57	0.55
2003	4,226	6,874	1,579	383	734	31	1.65	0.22
2004	4,667	12,056	-2,722	234	507	-39	1.83	0.13

Table 13. Fall multi-species survey pre-recruit index by year for Division 3NO.

Year	3N Biomass (t)	3N Confidence Intervals (+/-)		3O Biomass (t)	3O Confidence Intervals (+/-)		3N Mean kg/set	3O Mean kg/set
		Upper	Lower		Upper	Lower		
1995	2,224	17,216	-12,767	678	4,940	-3,584	0.87	0.39
1996	7,515	21,733	-6,703	831	1,602	59	2.93	0.48
1997	5,798	46,530	34,933	1,269	3,200	-663	2.26	0.76
1998	9,838	66,516	-46,840	1,668	4,600	-1,263	3.84	0.96
1999	2,917	4,734	1,101	1,544	6,103	-3,016	1.14	0.84
2000	3,962	7,606	317	226	1,112	-661	1.55	0.13
2001	4,674	7,401	1,947	392	1,017	-233	1.82	0.22
2002	2,029	4,813	-755	81	827	-656	0.79	0.05
2003	1,894	3,687	101	241	633	-154	0.74	0.14
2004	1,279	12,071	-9,514	86	294	-124	0.5	0.05

Table 14. TAC (t), landings (t), effort (trap hauls) and CPUE (kg/haul) by year for Subdivision 3Ps.

Year	TAC	Landings	Effort	CPUE Offshore	CPUE Inshore
1981		38	2,533		
1982		14	9,333		
1983		4	263		
1984					
1985		705	110,156		
1986	600	584	166,857		
1987	600	587	195,667		
1988	600	723	133,889		
1989	700	528	96,000		
1990	700	597	124,375		4.8
1991	700	309	67,174		4.7
1992	500	170	16,832		11.8
1993	500	829	74,685		11.2
1994	850	1,538	103,919	19.5	15.5
1995	1,725	1,929	158,115	15.5	9.6
1996	3,050	2,974	177,024	16.3	18.8
1997	4,600	4,675	286,810	19.1	12.5
1998	6,000	6,624	399,036	24.1	11.2
1999	7,959	7,905	510,000	24.5	10.4
2000	7,700	7,887	559,362	20.7	9.9
2001	7,600	7,839	519,139	16.2	12.2
2002	7,600	7,637	763,700	12.1	7.9
2003	6,085	6,113	826,081	8.3	6.1
2004	4,395	4,720	737,500	8.2	4

Table 15. TAC (t), landings (t), effort (trap hauls) and CPUE (kg/haul) by year for Division 4R3Pn.

Year	TAC	Landings	Effort	CPUE Offshore	CPUE Inshore
1985		291			
1986		133			
1987		50			
1988		82			
1989		15			
1990		46			
1991		48			
1992		238			
1993		141	28,776		4.9
1994		634	112,411		5.6
1995		869	145,805	5.3	7.4
1996	1,289	838	180,603	3.9	5.3
1997	1,390	927	149,516	5.8	6.2
1998	1,310	1,060	252,381	3.6	5.5
1999	1,330	1,597	325,918	4.4	6.2
2000	1,430	1,627	332,041	5	4.8
2001	1,539	1,683	374,000	4.4	5.1
2002	1,749	1,851	293,810	5.1	8.8
2003	1,895	1,562	284,000	3.7	9.4
2004	1,864	1,462	332,273	3.2	7.6

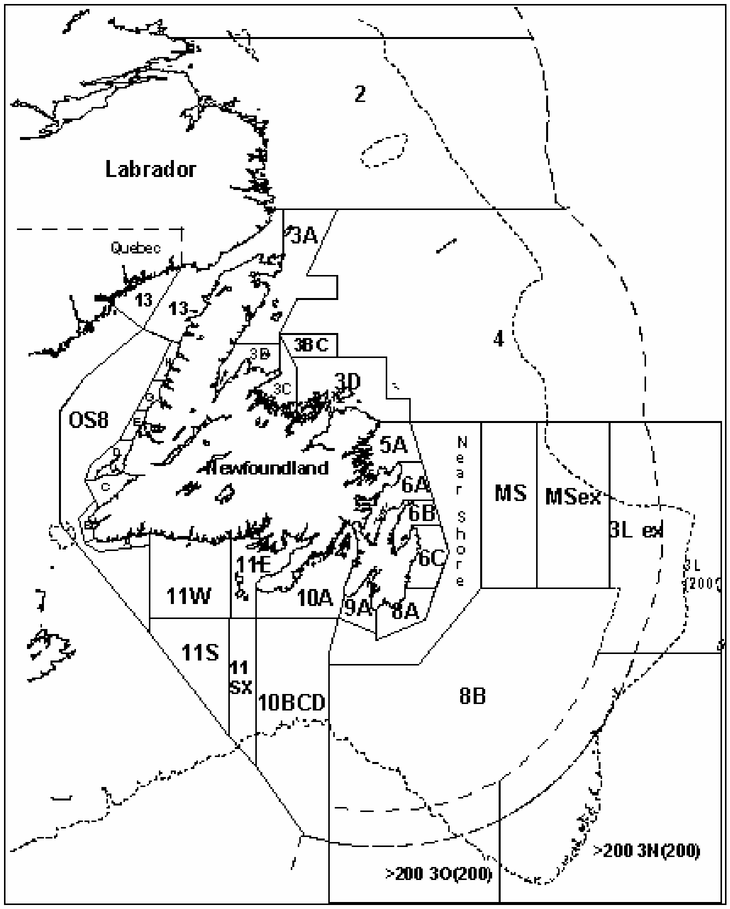

Figure 1. Newfoundland and Labrador snow crab management areas.

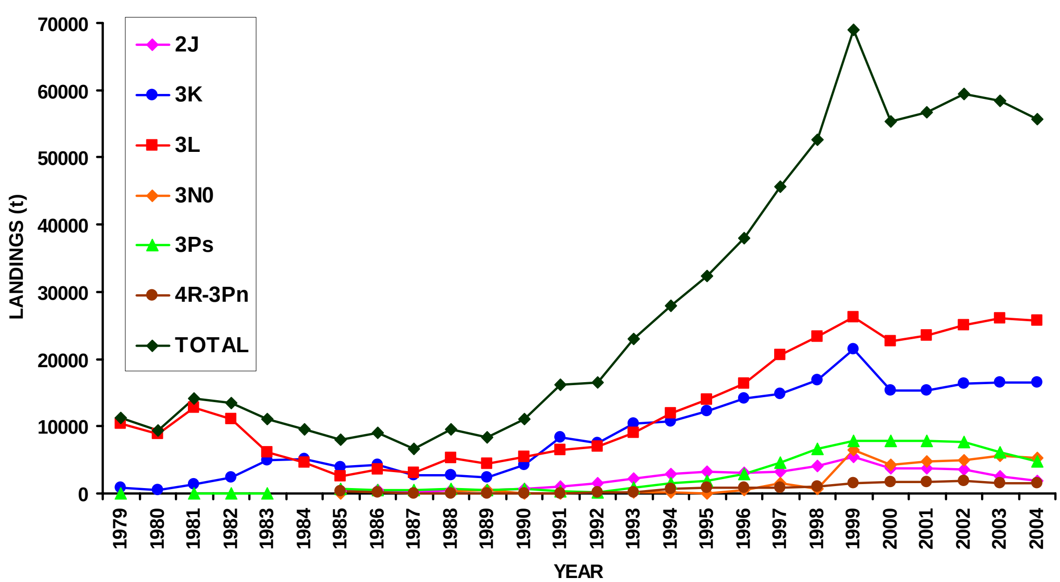

Figure 2. Trends in annual landings by NAFO Division.

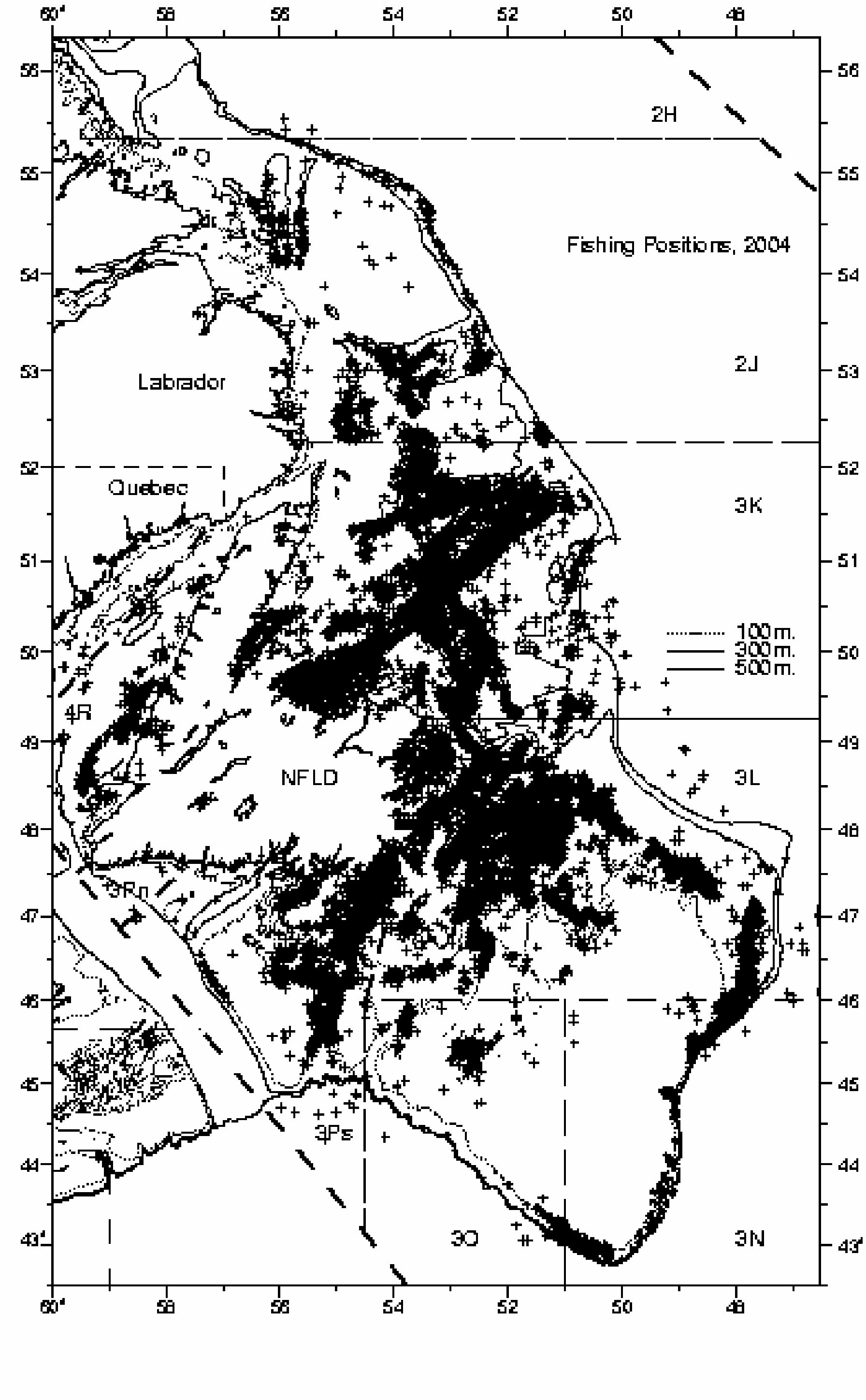

Figure 3. Spatial distribution of commercial fishing effort during 2004.

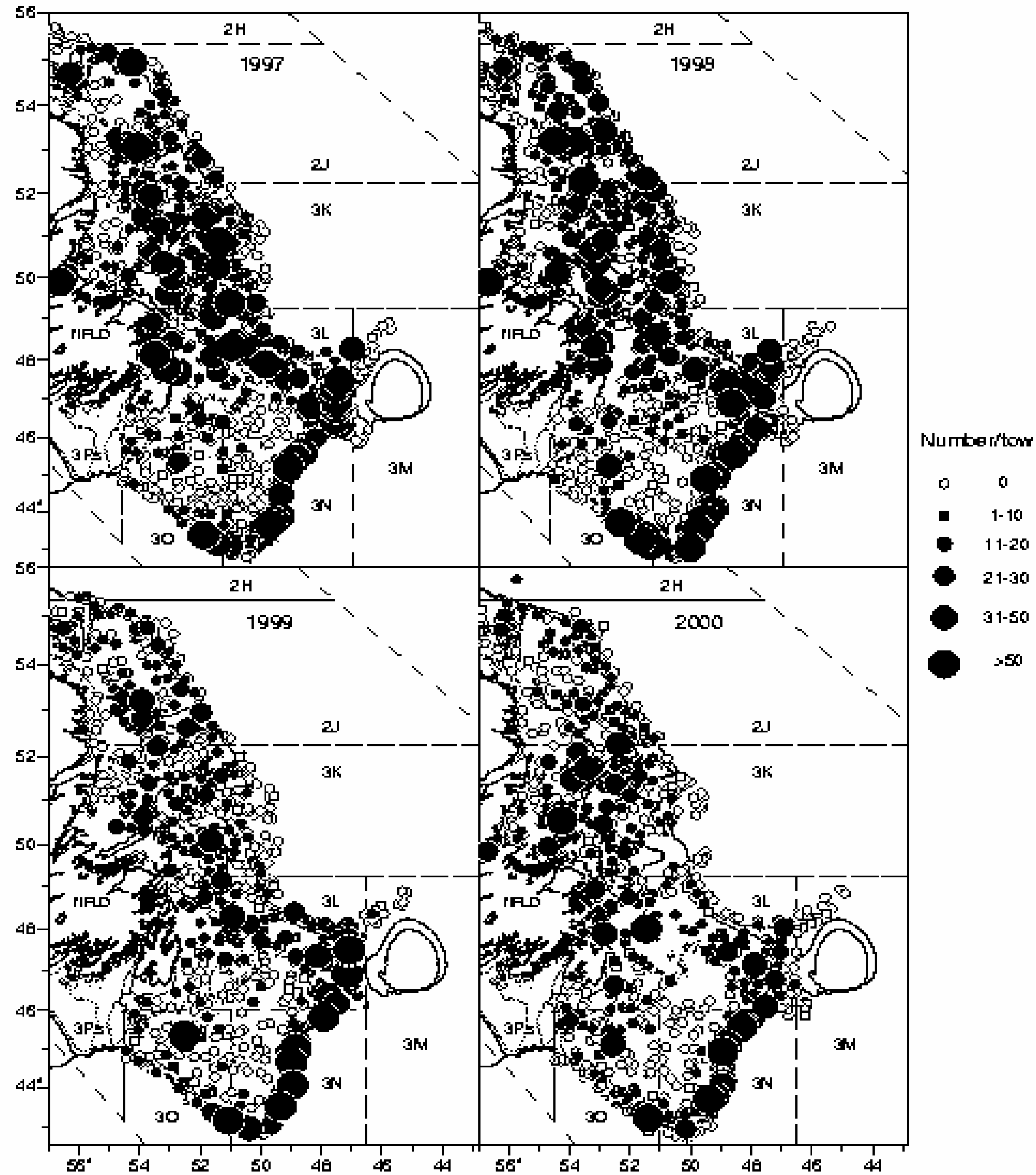

Figure 4. Distribution of exploitable males (>94mm CW adults) from fall Division 2J3KLNO multi-species surveys from 1997 to 2000.

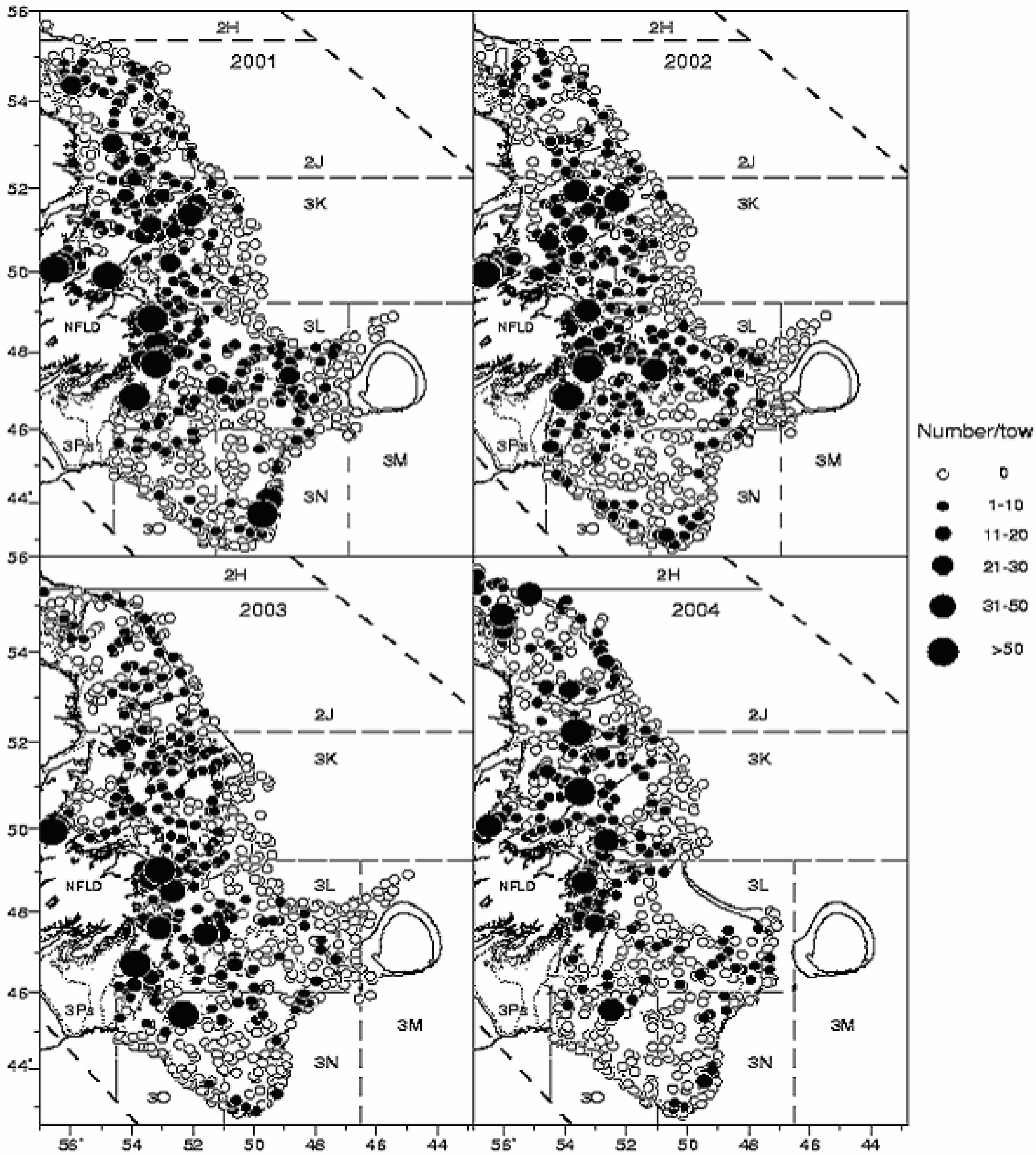

Figure 5. Distribution of exploitable males (>94mm CW adults) from fall Division 2J3KLNO multi-species surveys from 2001 to 2004.

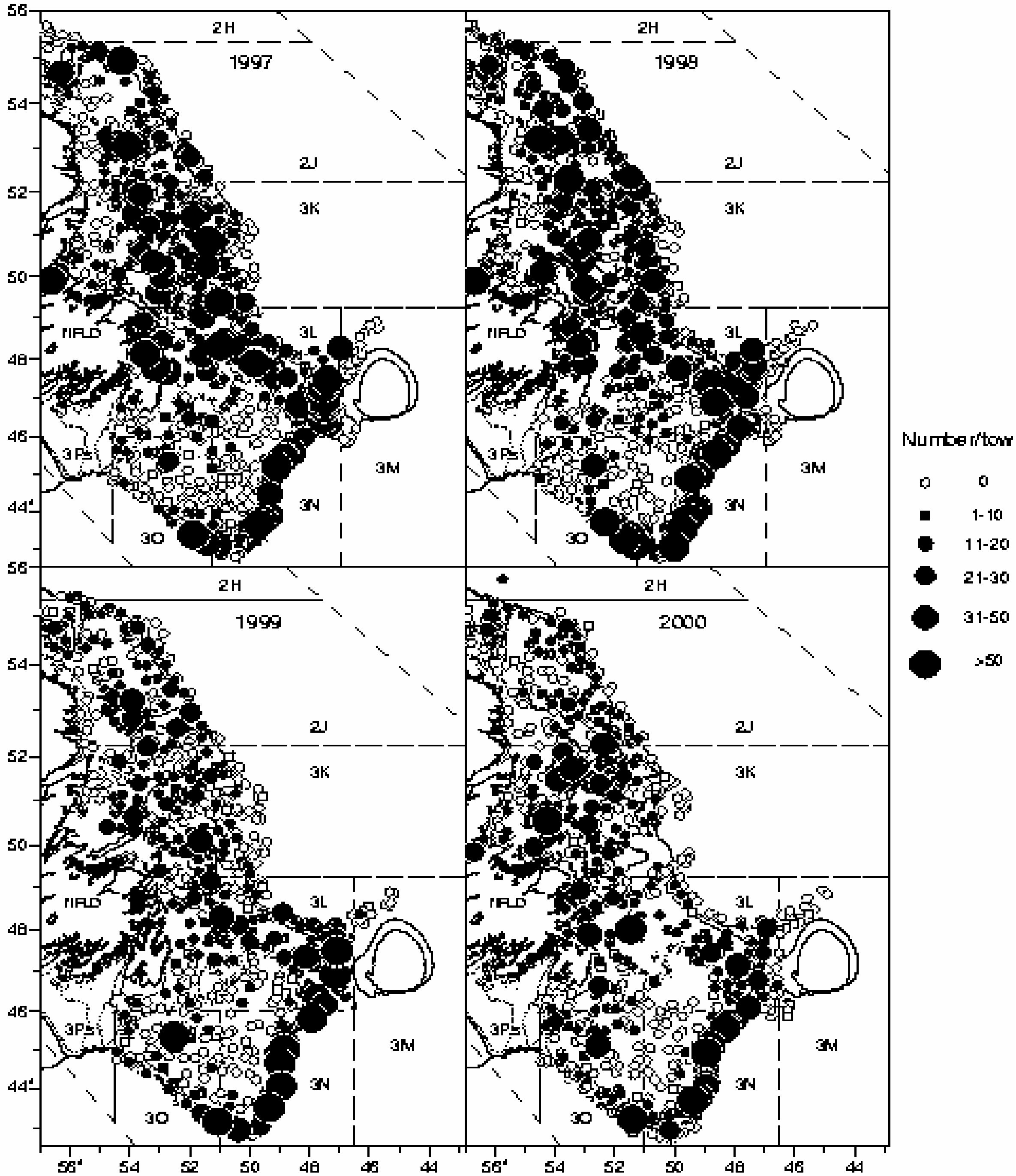

Figure 6. Distribution of pre-recruit males (>75 mm CW adolescents) from fall Division 2J3KLNO multi-species bottom trawl surveys from 1997 to 2000.

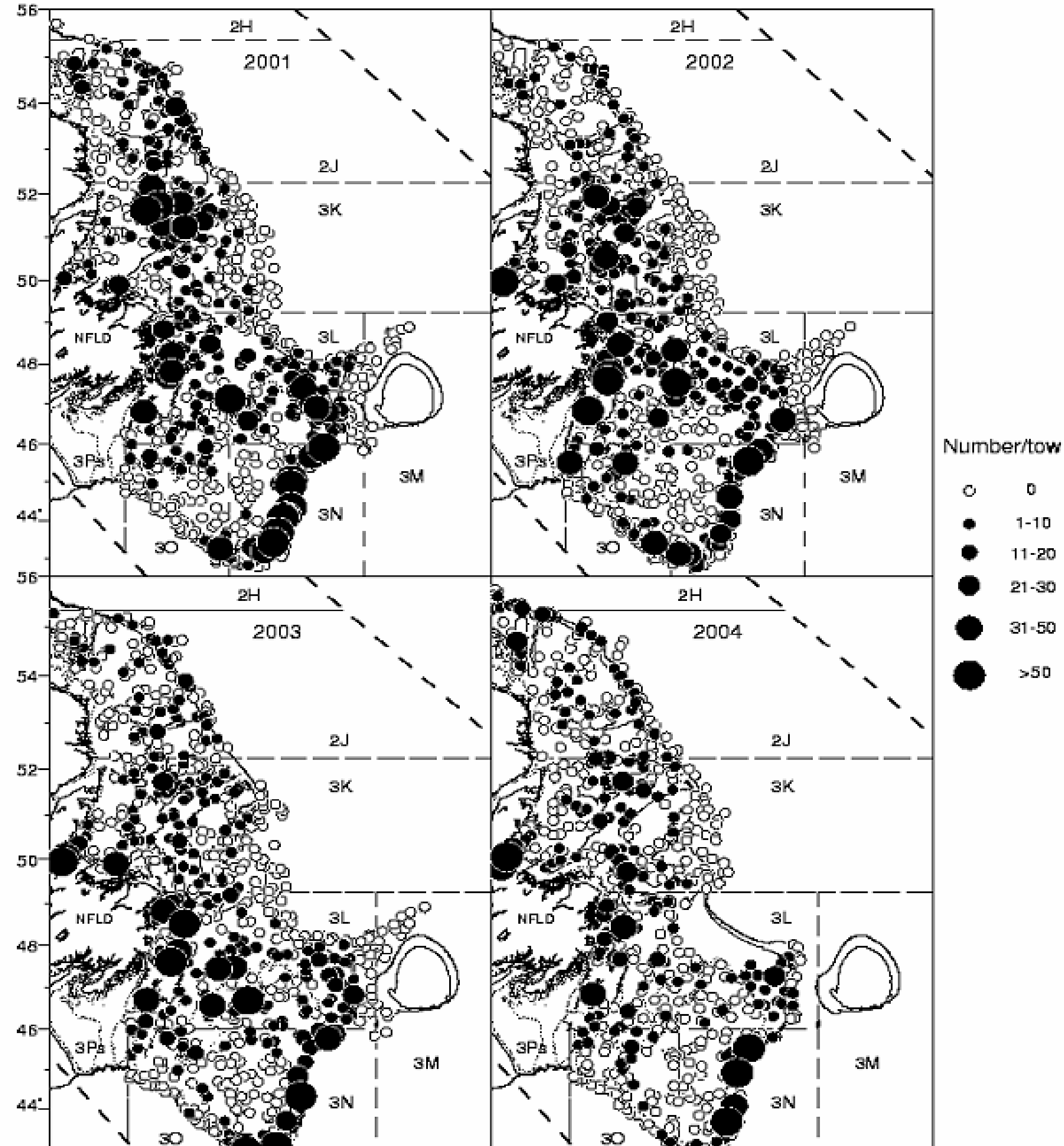

Figure 7. Distribution of pre-recruit males (>75 mm CW adolescents) from fall Division 2J3KLNO multi-species bottom trawl surveys from 2001 to 2004.

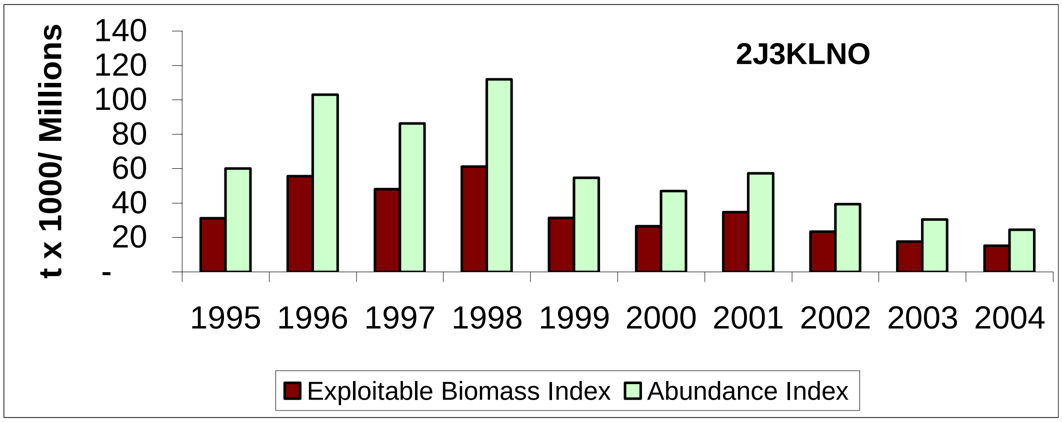

Figure 8. Annual trends in the fall multi-species survey exploitable biomass and abundance indices, for Division 2J3KLNO.

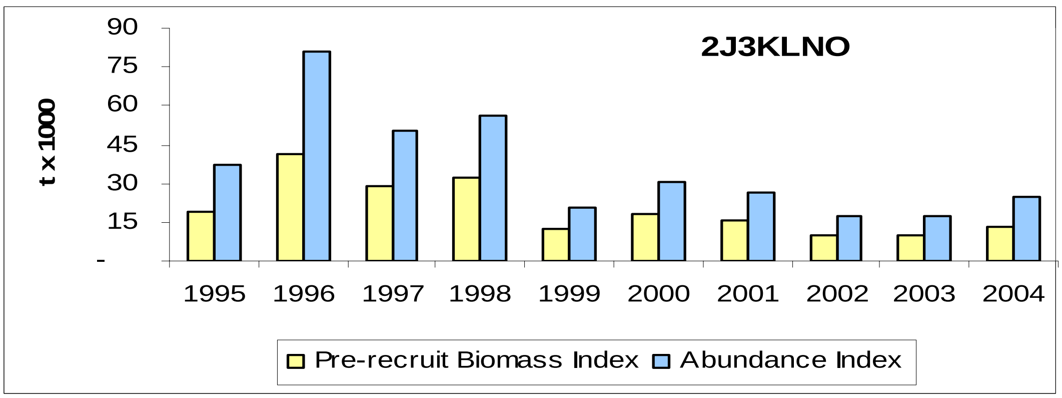

Figure 9. Annual trends in the fall multi-species survey pre-recruit biomass and abundance indices, for Division 2J3KLNO.

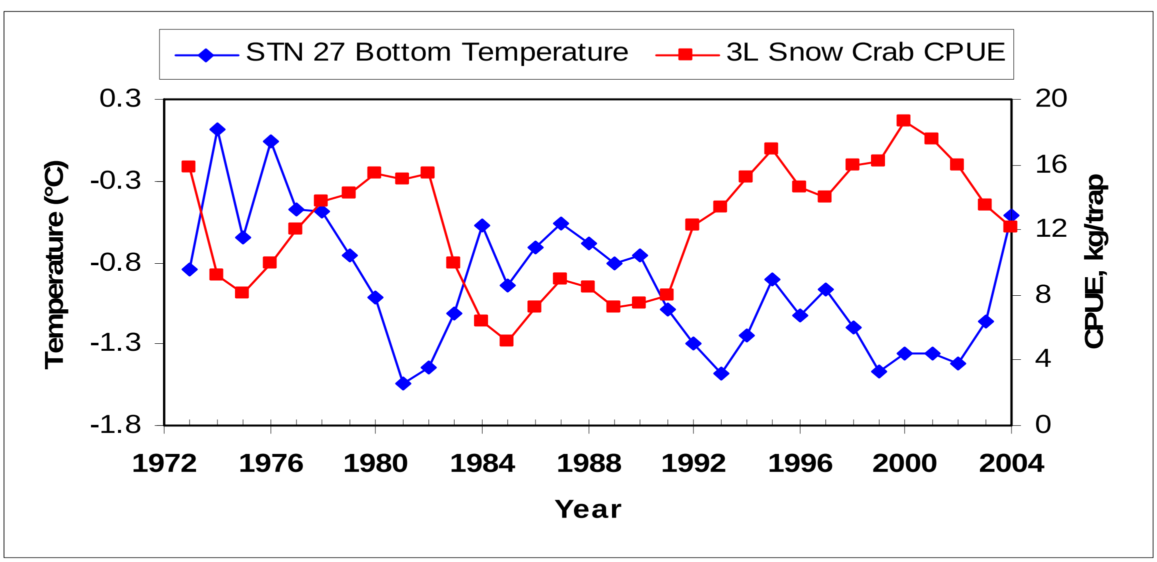

Figure 10. Trends in Division 3L CPUE and lagged (8 years) Station 27 bottom temperature.

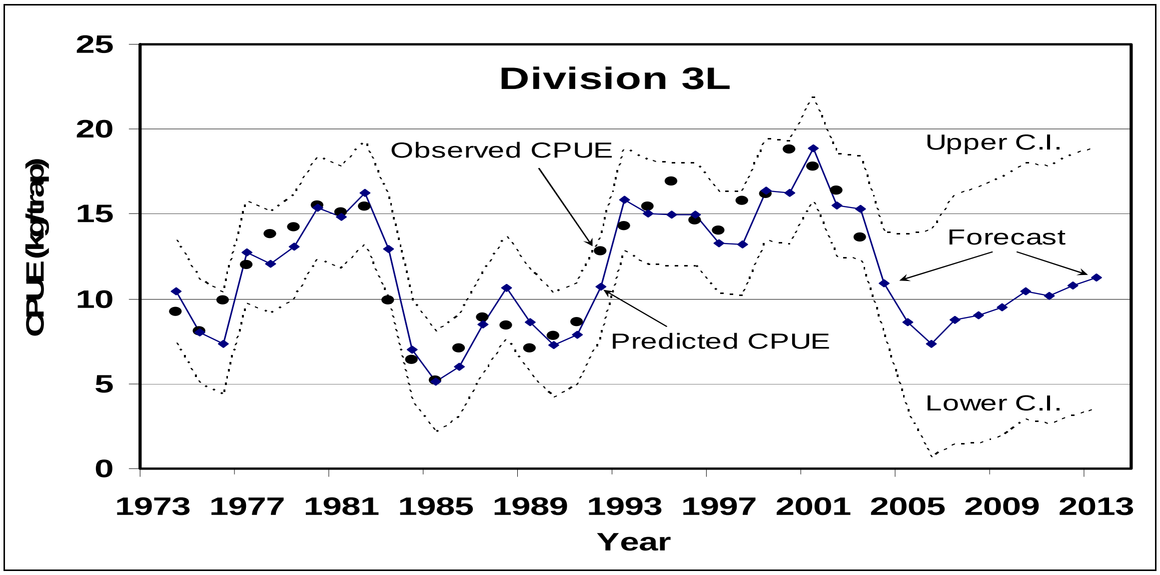

Figure 11. Comparison of observed Division 3L CPUE values with those predicted by a model that includes ice cover 10 years earlier as an explanatory variable.

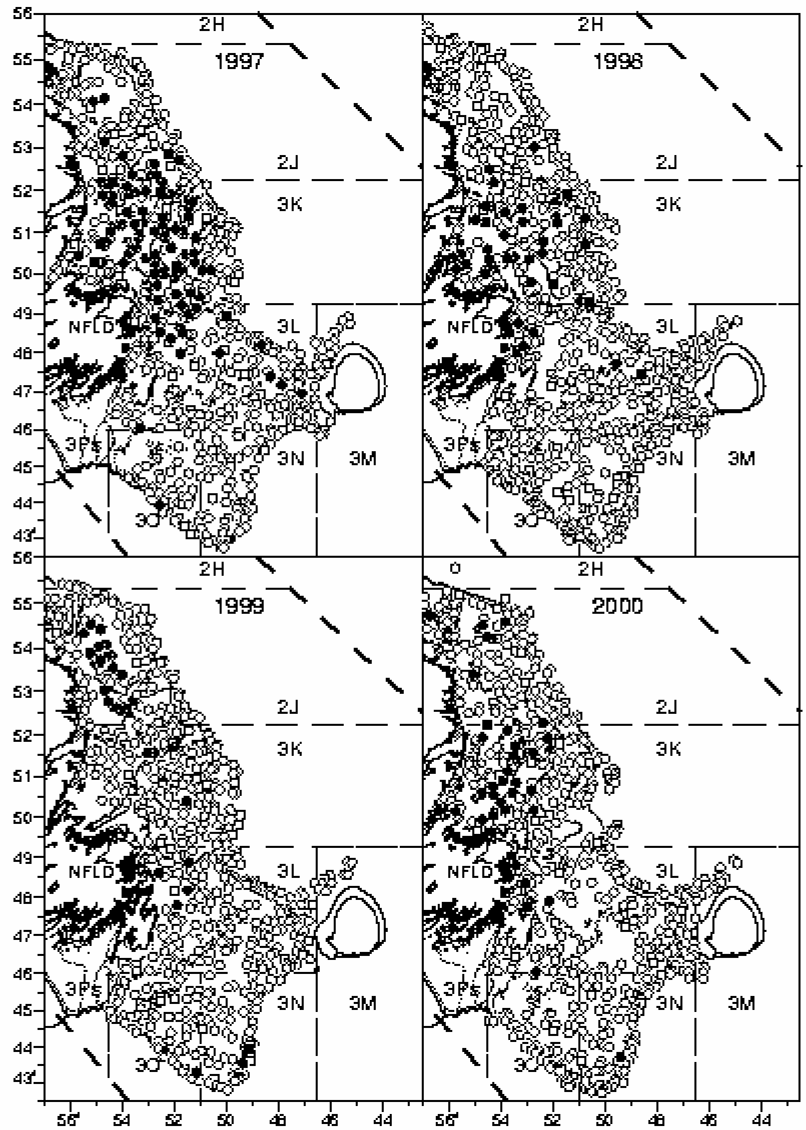

Figure 12. Distribution by year of survey sets where BCD was encountered (closed circles) versus all other sets (open circles) from 1997 to 2000.

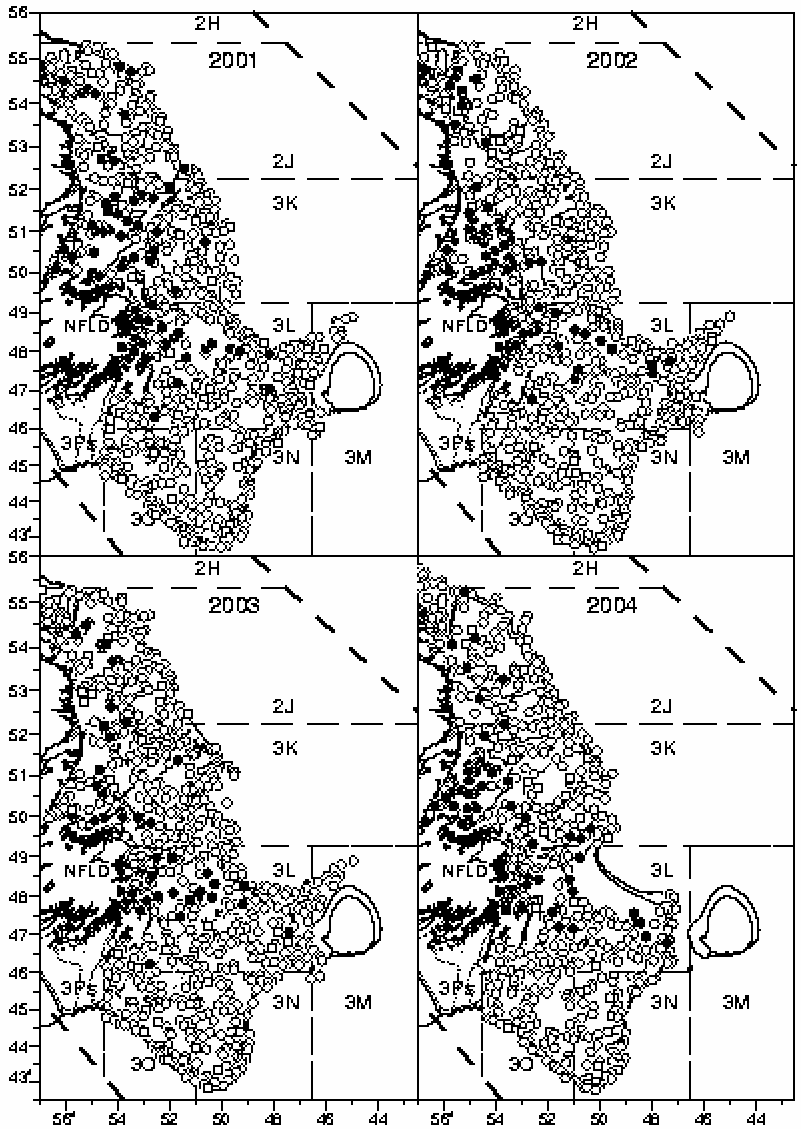

Figure 13. Distribution by year of survey sets where BCD was encountered (closed circles) versus all other sets (open circles) from 2001 to 2004.

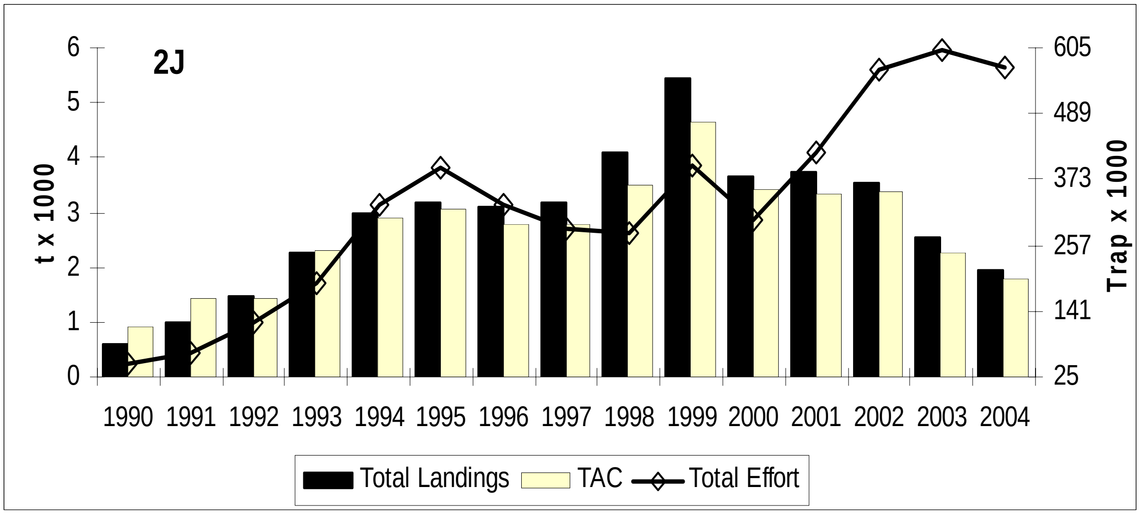

Figure 14. Annual trends in Division 2J landings, TAC, and fishing effort.

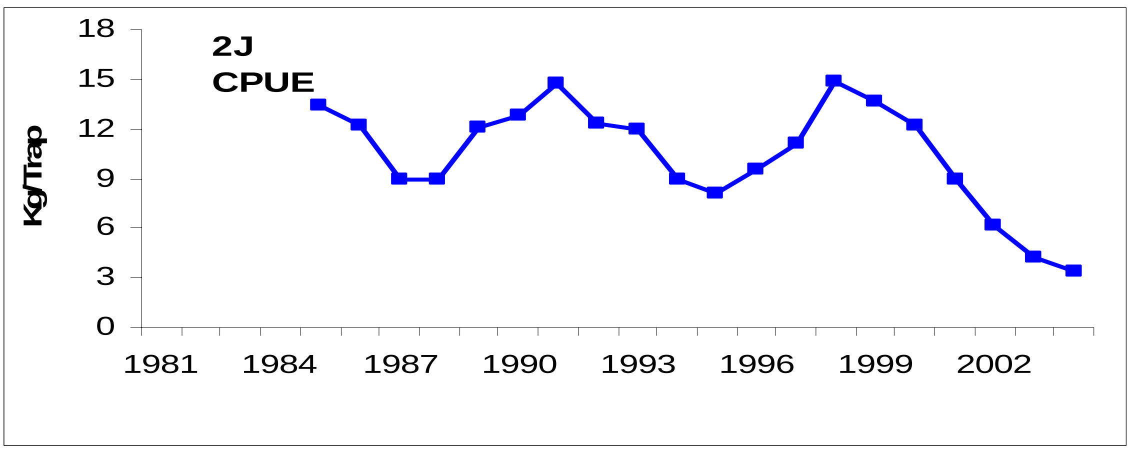

Figure 15. Annual trend in Division 2J commercial CPUE.

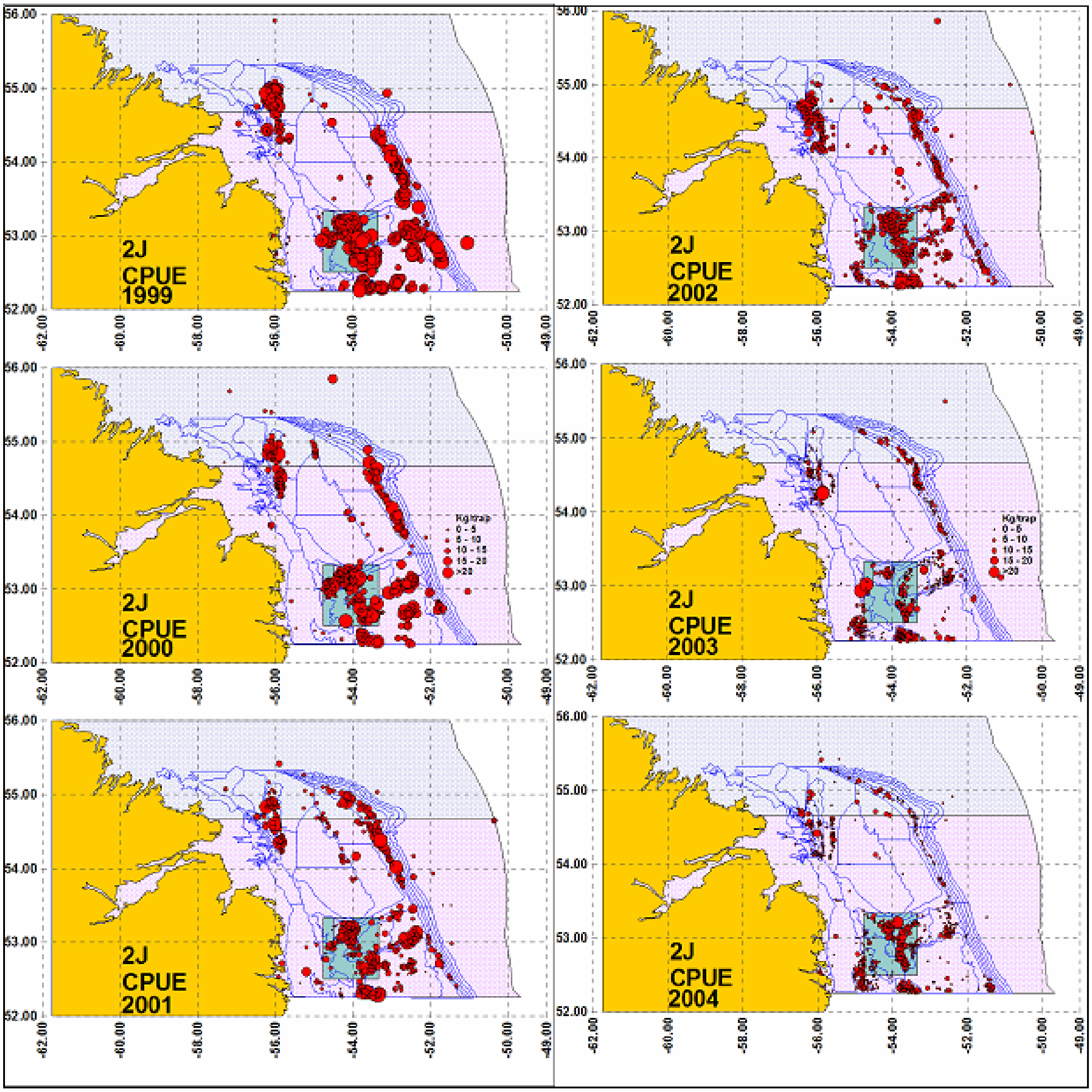

Figure 16. Spatial distribution of Division 2J commercial CPUE by year showing the Hawke channel closed area.

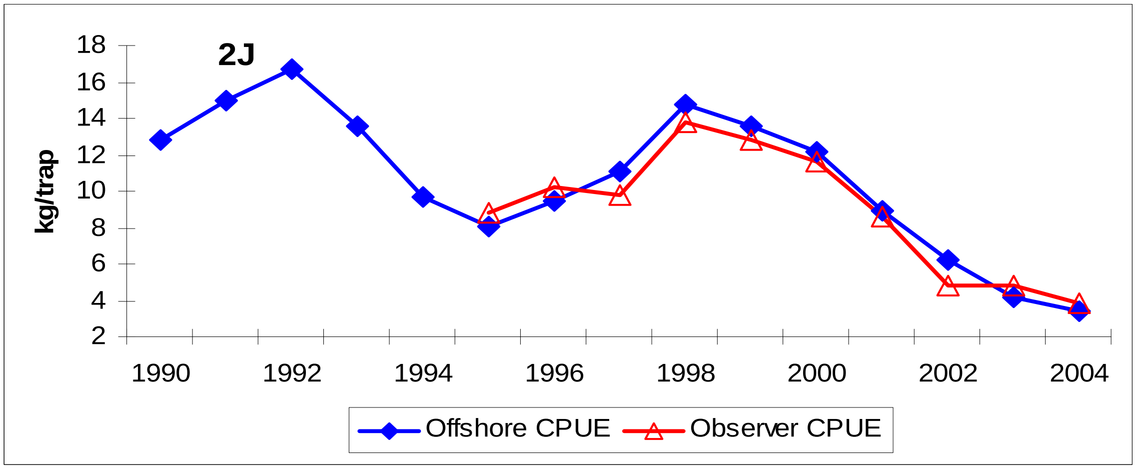

Figure 17. Annual trends in logbook-based CPUE vs. observer-based CPUE in the Division 2J fishery.

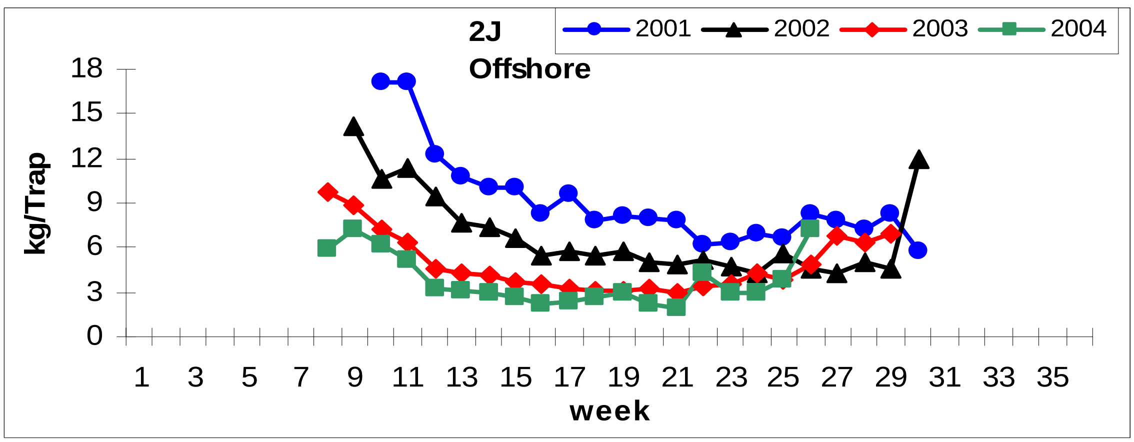

Figure 18. Seasonal trend in CPUE, by week, for Division 2J during 2001-04.

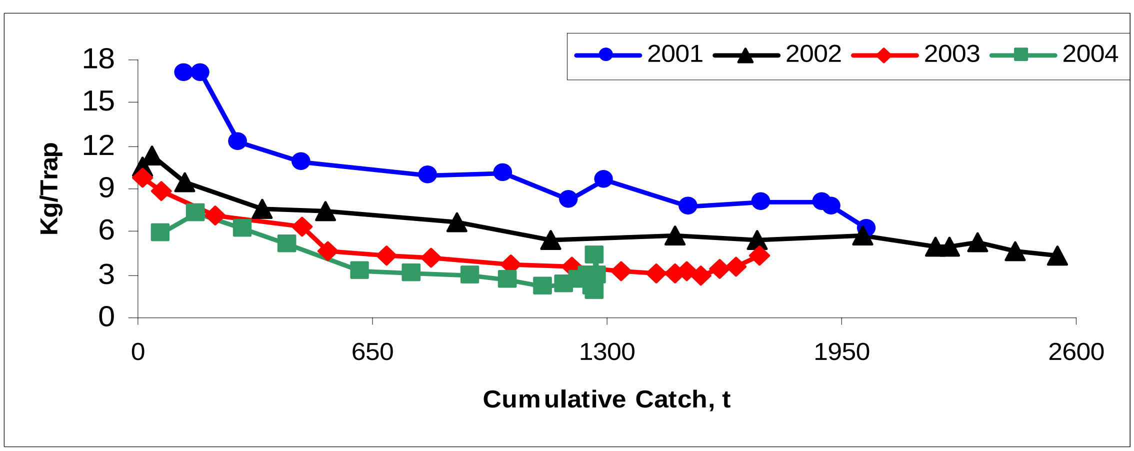

Figure 19. Seasonal trend in CPUE, in relation to cumulative catch, for Division 2J during 2001-04.

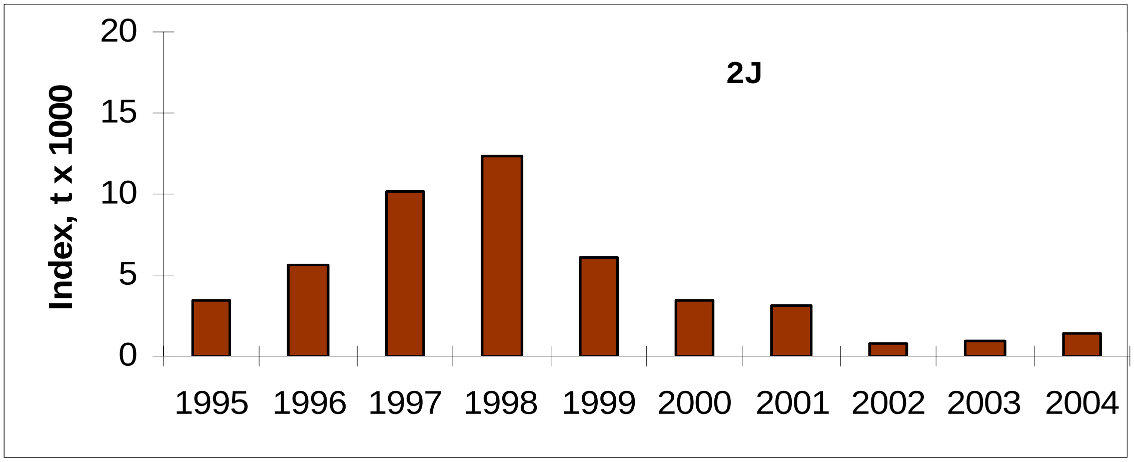

Figure 20. Annual trend in the Division 2J fall multi-species survey exploitable biomass index.

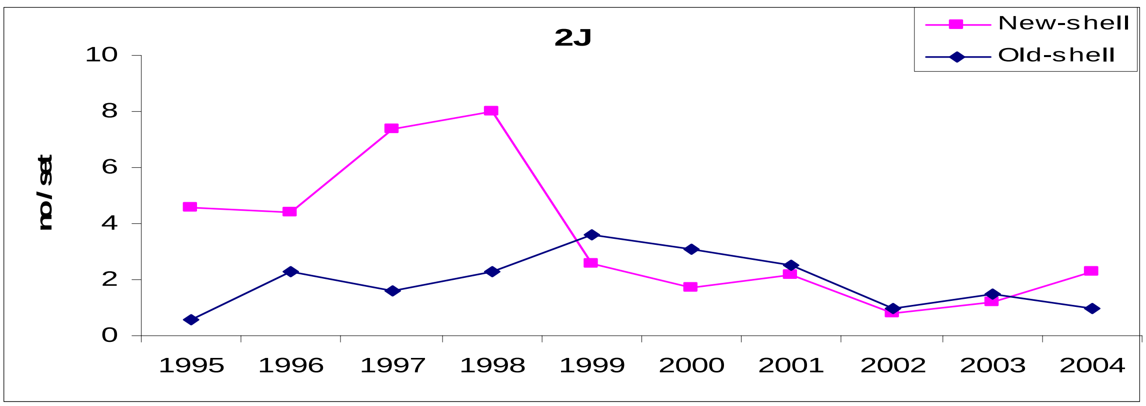

Figure 21. Annual trend, by shell condition, in abundance indices of legal-sized males for Division 2J from fall multi-species surveys.

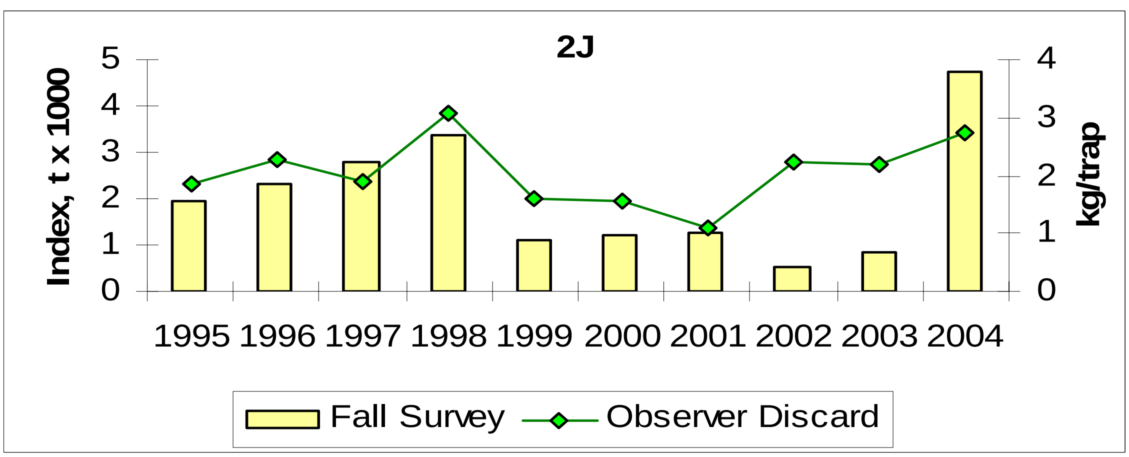

Figure 22. Annual trends in the Division 2J fall multi-species survey pre-recruit biomass index and the observer discard pre-recruit index.

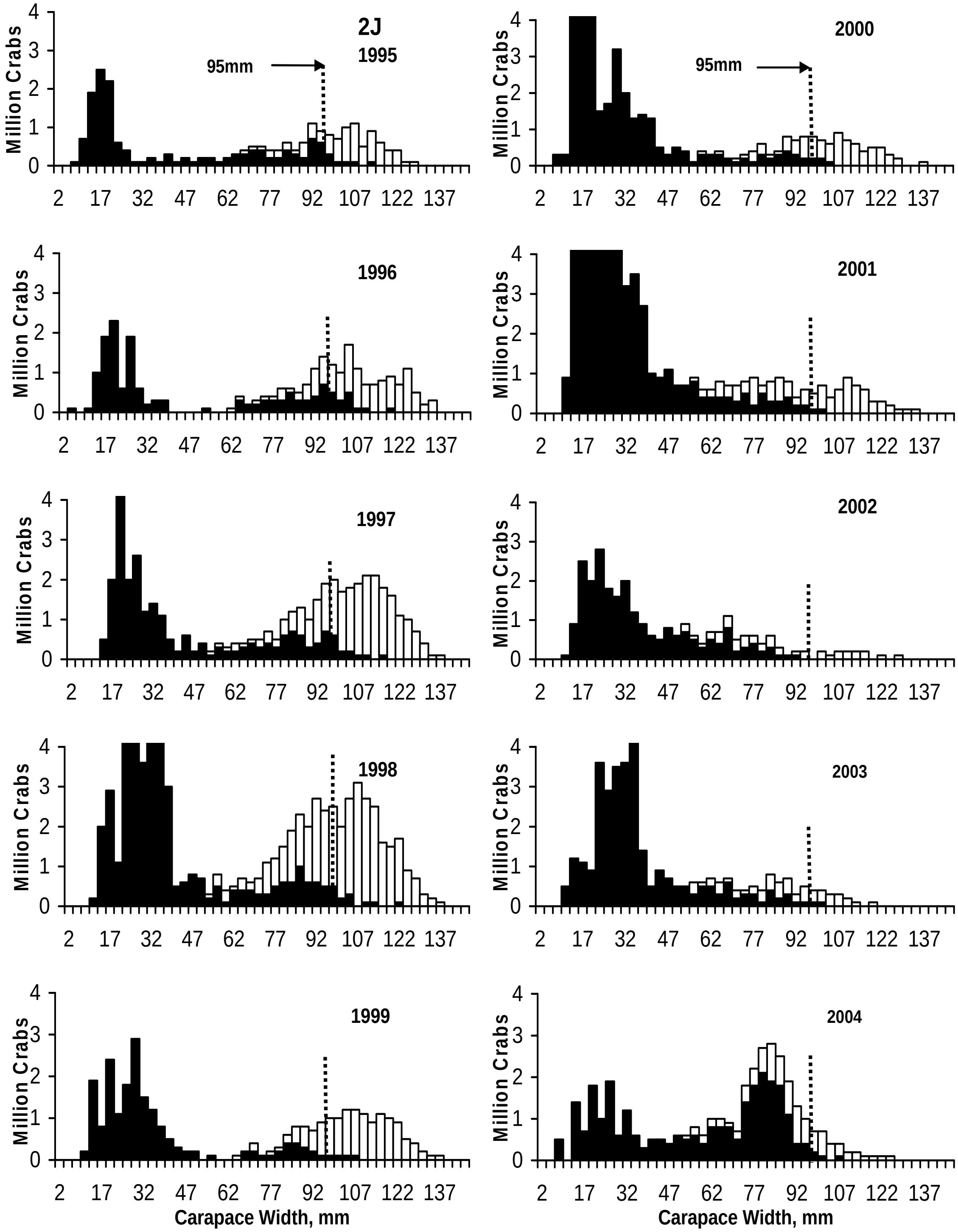

Figure 23. Truncated distribution of abundance (index) by carapace width for Division 2J juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

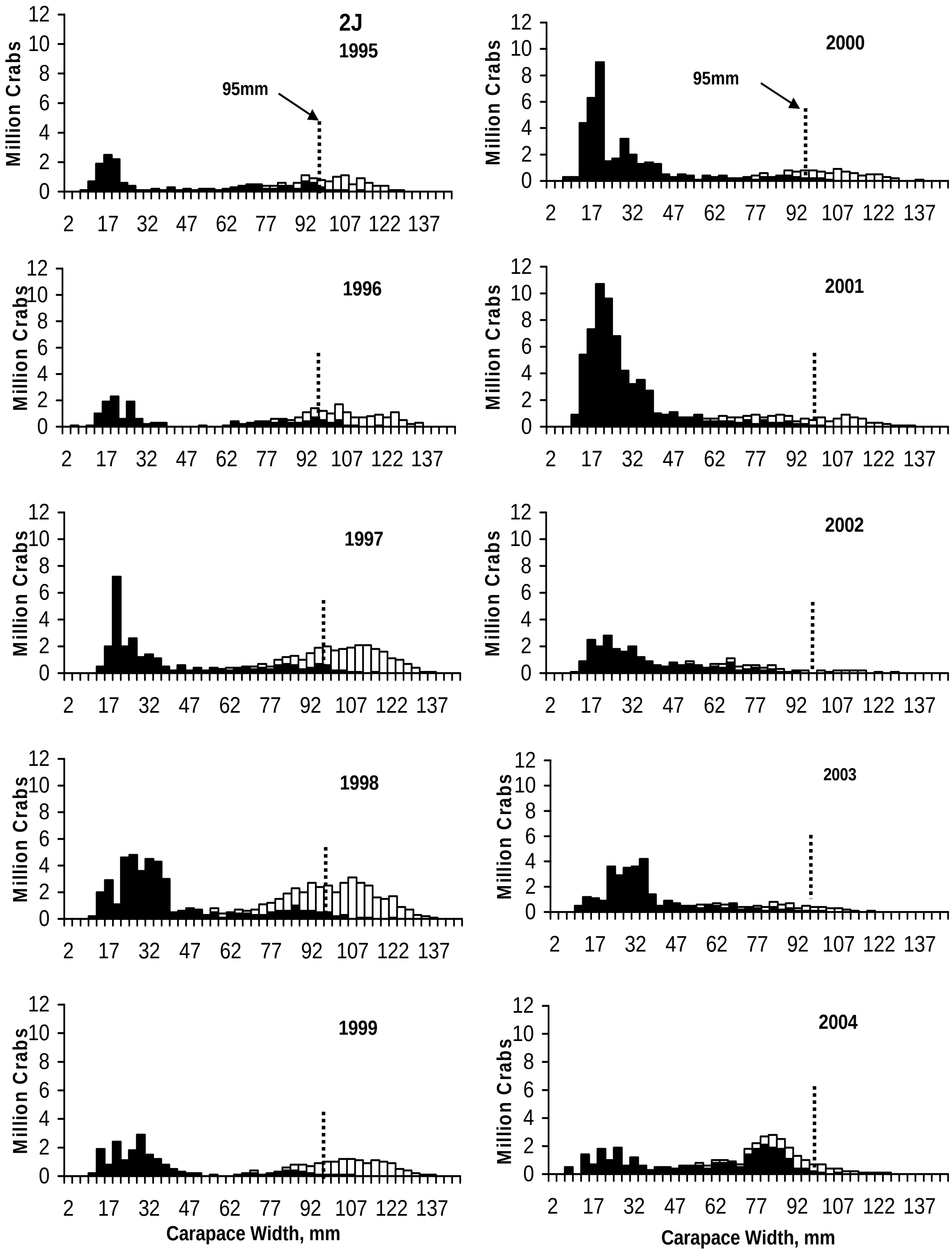

Figure 24. Distribution of abundance (index) by carapace width for Division 2J juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

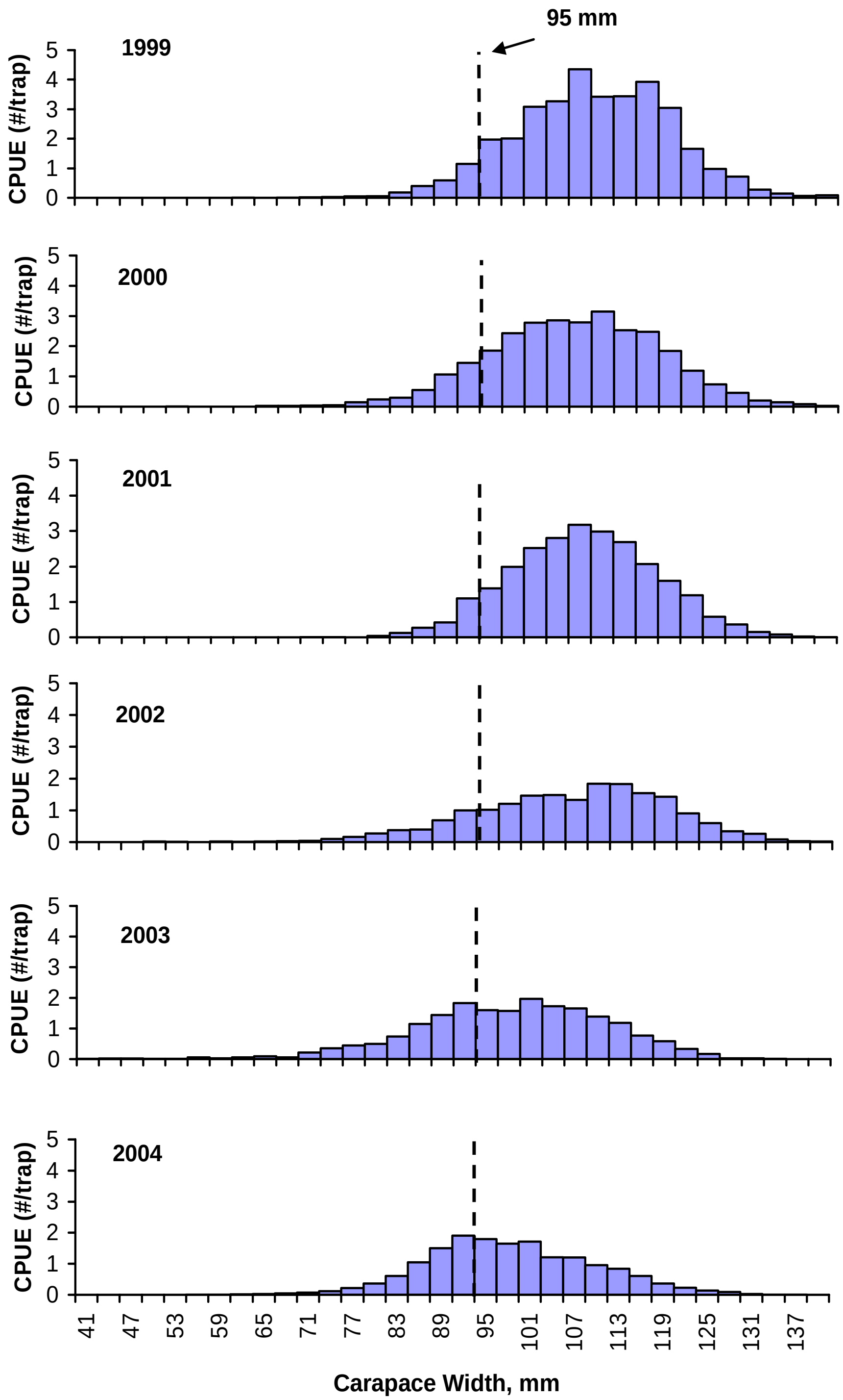

Figure 25. Annual trend in male carapace width distributions from observer at-sea sampling for Division 2J.

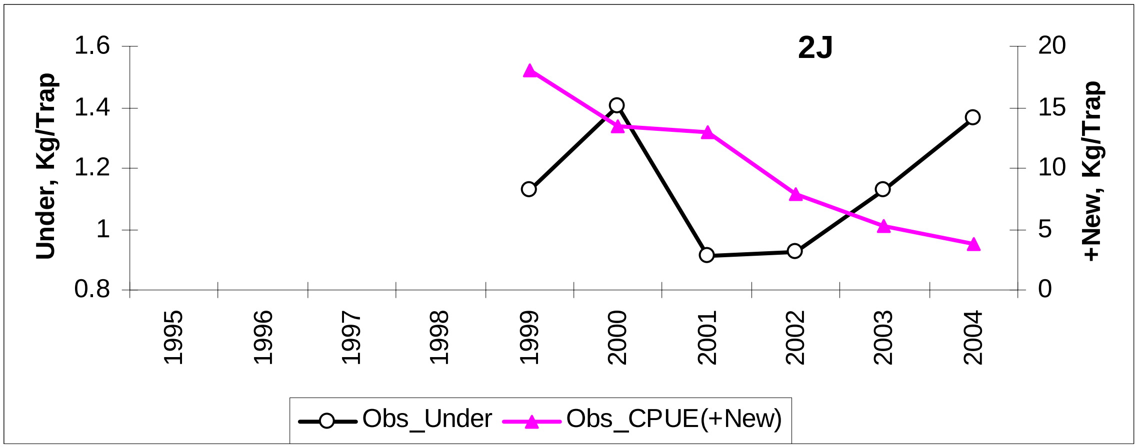

Figure 26. Annual trends in observer-based CPUE of all legal-sized males, including new-shelled, from biological sampling, versus catch rates of sub-legal (under-sized) crabs for Division 2J.

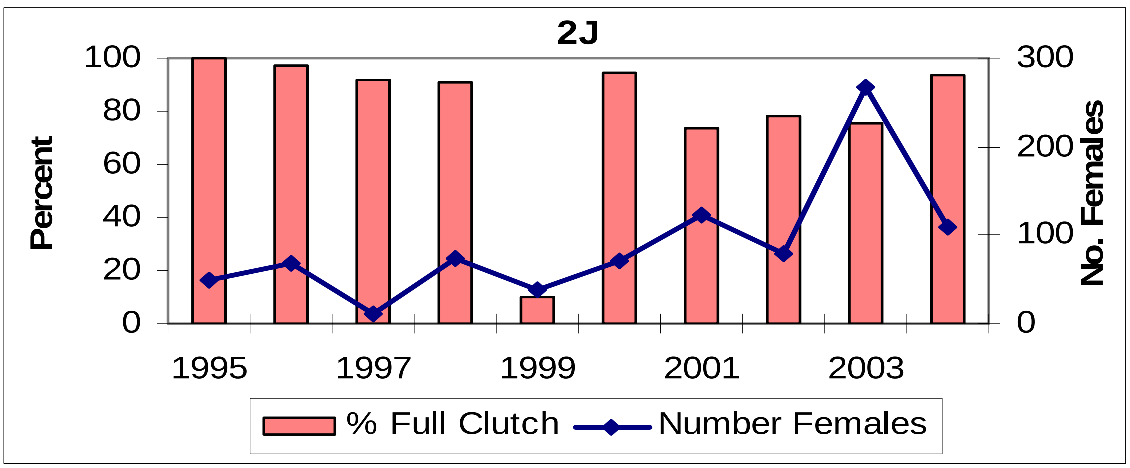

Figure 27. Annual trend in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 2J from fall multi-species surveys.

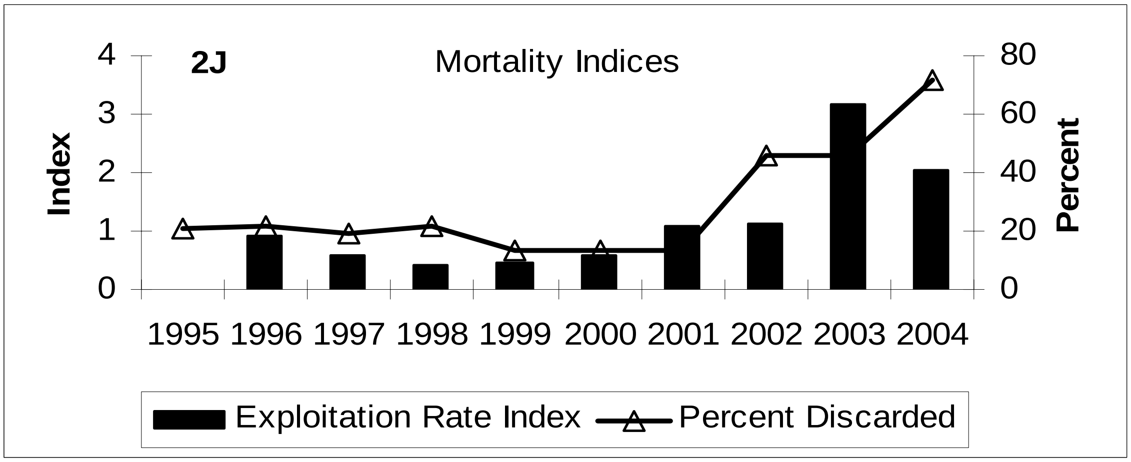

Figure 28. Annual trends in two Division 2J mortality indices.

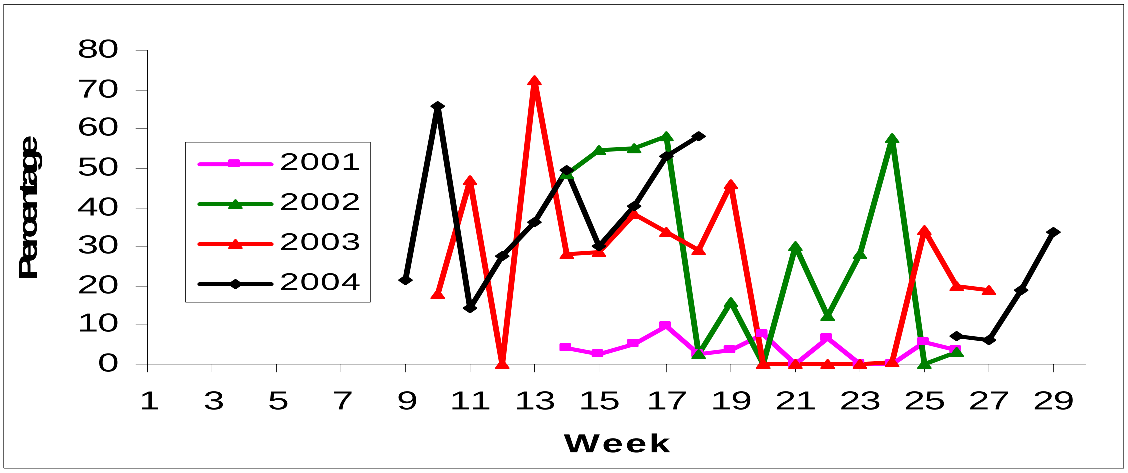

Figure 29. Seasonal trend (from April 01) in the percentage of legal-sized crabs that are soft-shelled by year (2001-04), from at-sea sampling by observers in Division 2J.

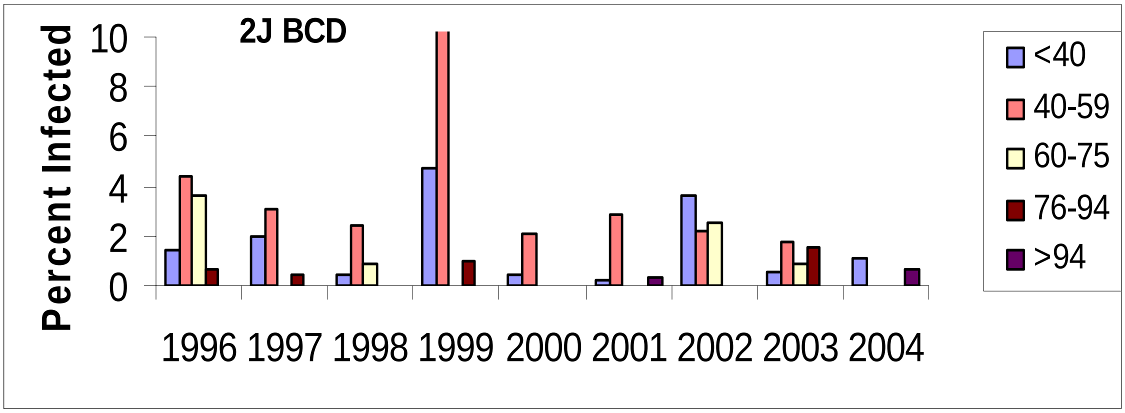

Figure 30. Annual trends in prevalence of BCD in Division 2J by male size group from fall multi-species surveys.

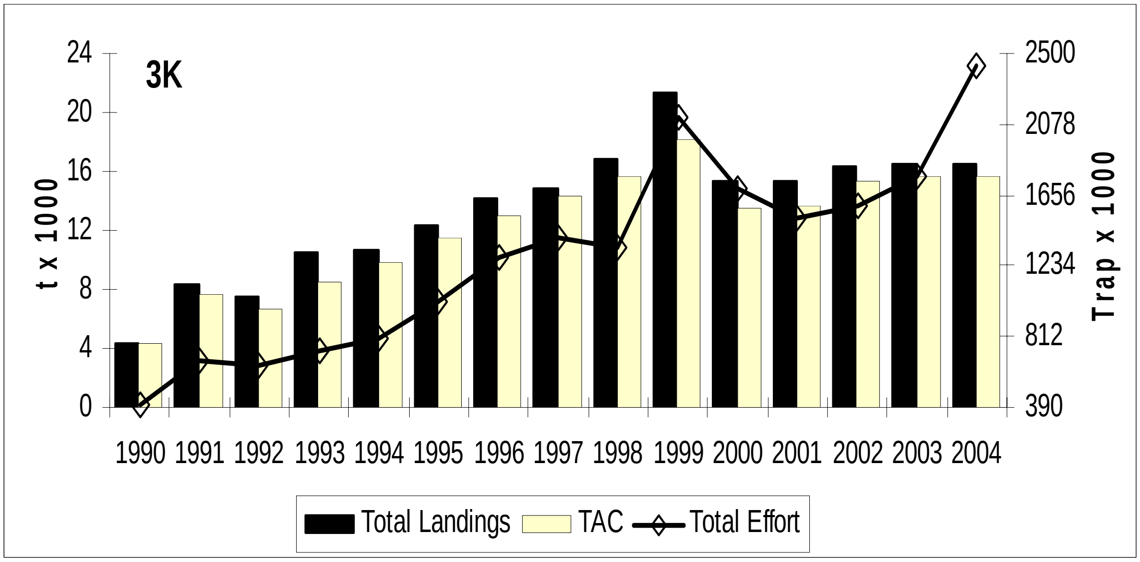

Figure 31. Annual trends in Division 3K Landings, TAC and fishing effort.

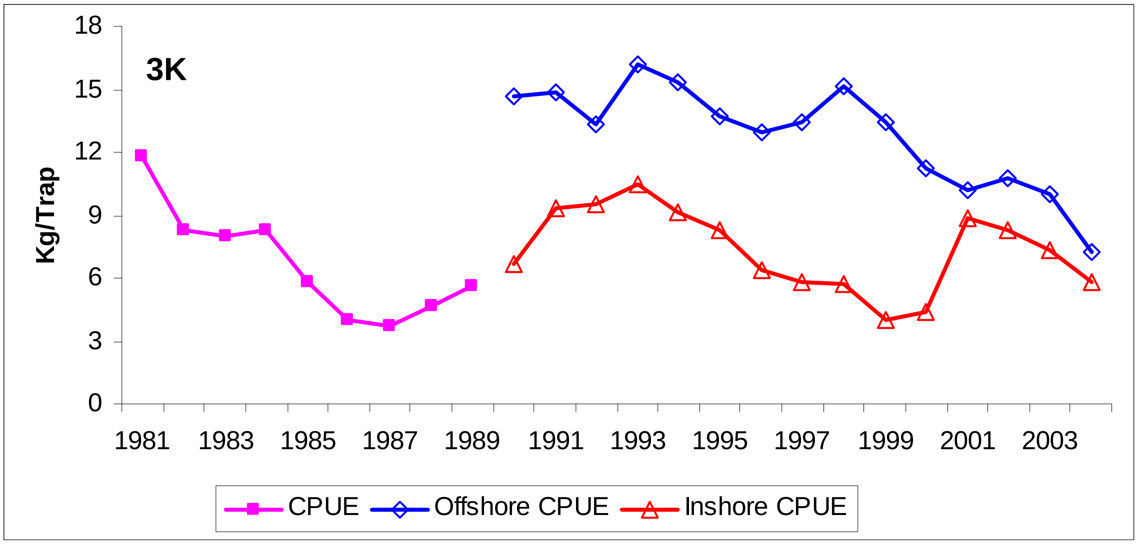

Figure 32. Annual trends in Division 3K commercial CPUE.

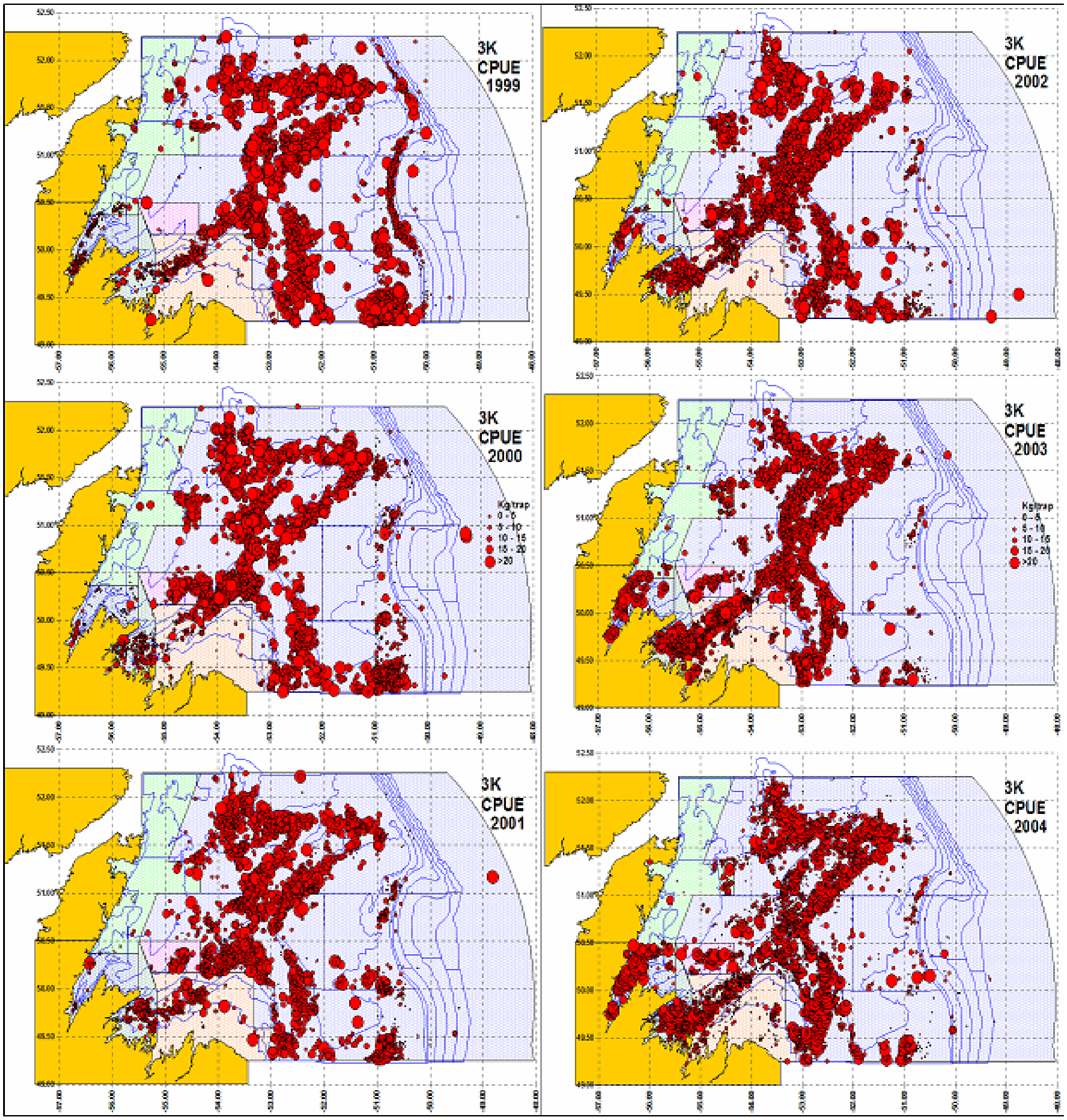

Figure 33. Spatial distribution of Division 3K commercial CPUE by year.

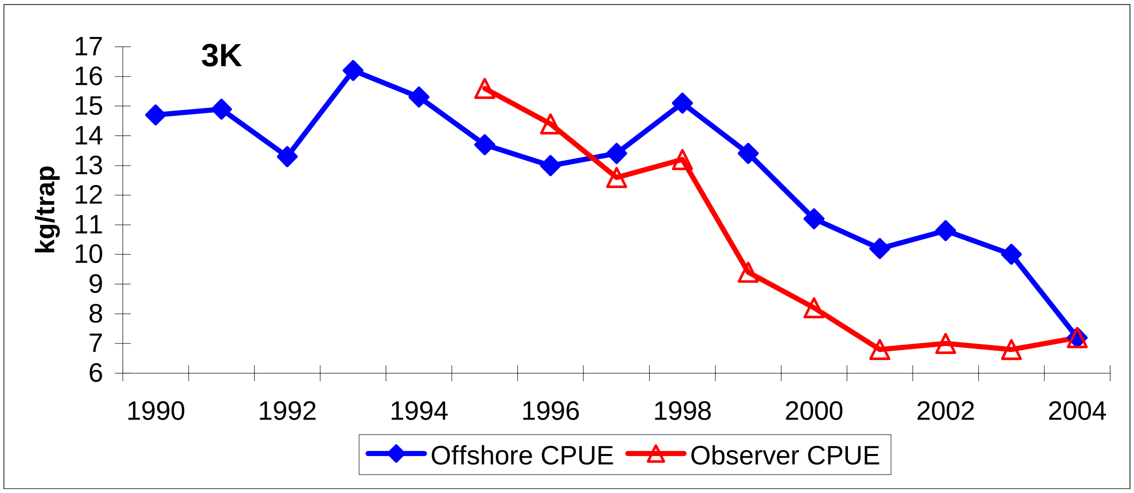

Figure 34. Annual trends in logbook- based offshore CPUE vs. observer - based CPUE in the Division 3K fishery.

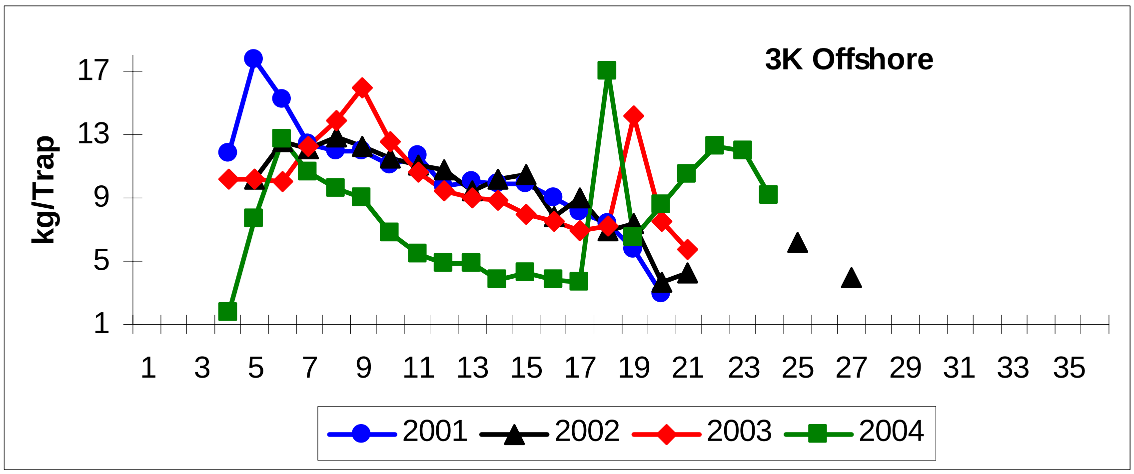

Figure 35. Seasonal trends in CPUE by week, for recent years for offshore Division 3K.

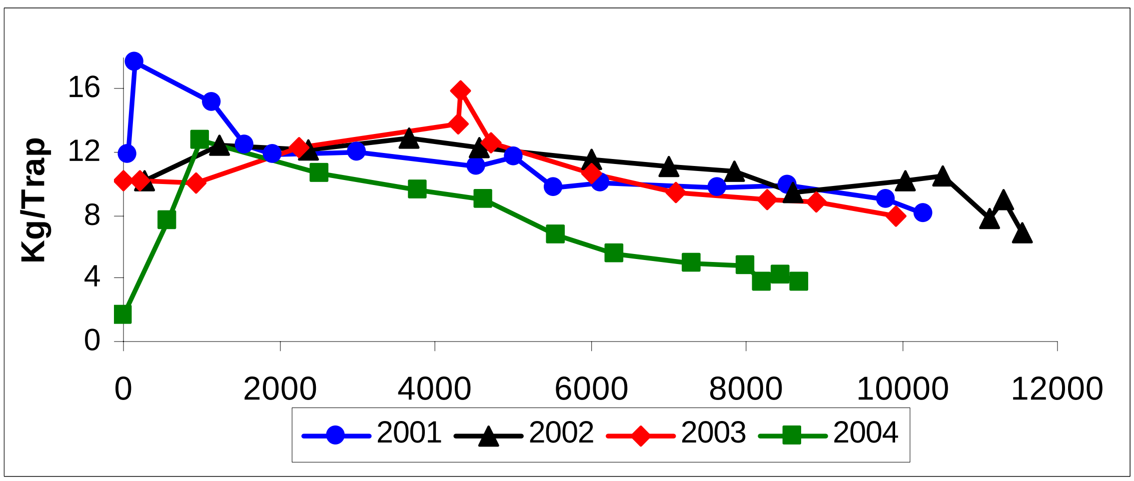

Figure 36. Seasonal trends in CPUE by cumulative catch for offshore Division 3K.

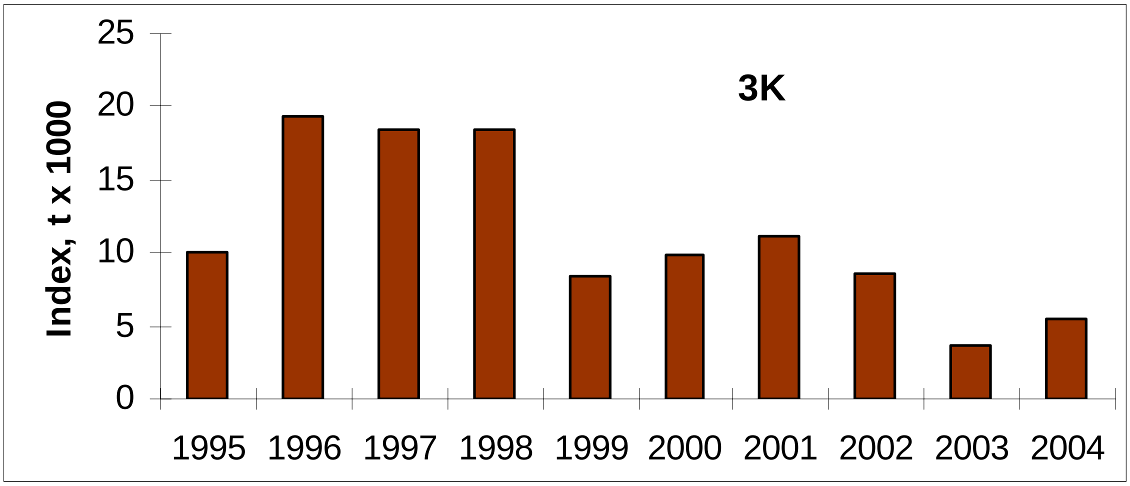

Figure 37. Annual trend in the Division 3K fall multi-species survey exploitable biomass index.

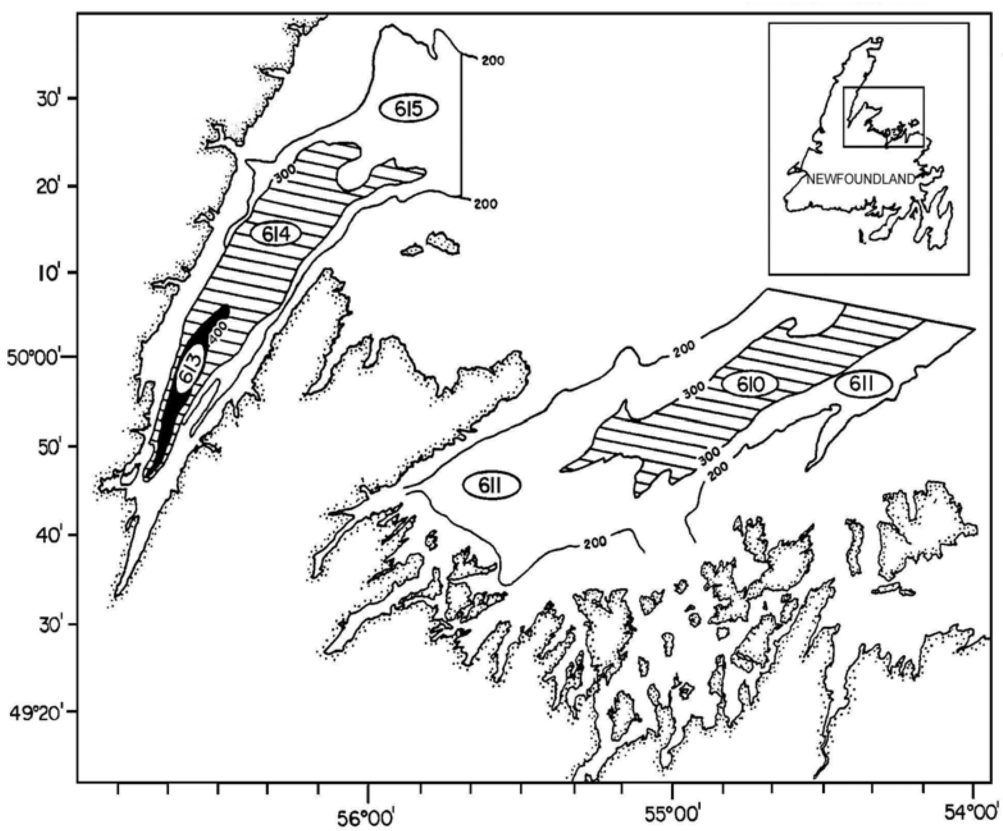

Figure 38. Location map showing inshore Division 3K strata sampled during White Bay/Notre Dame Bay September trapping surveys.

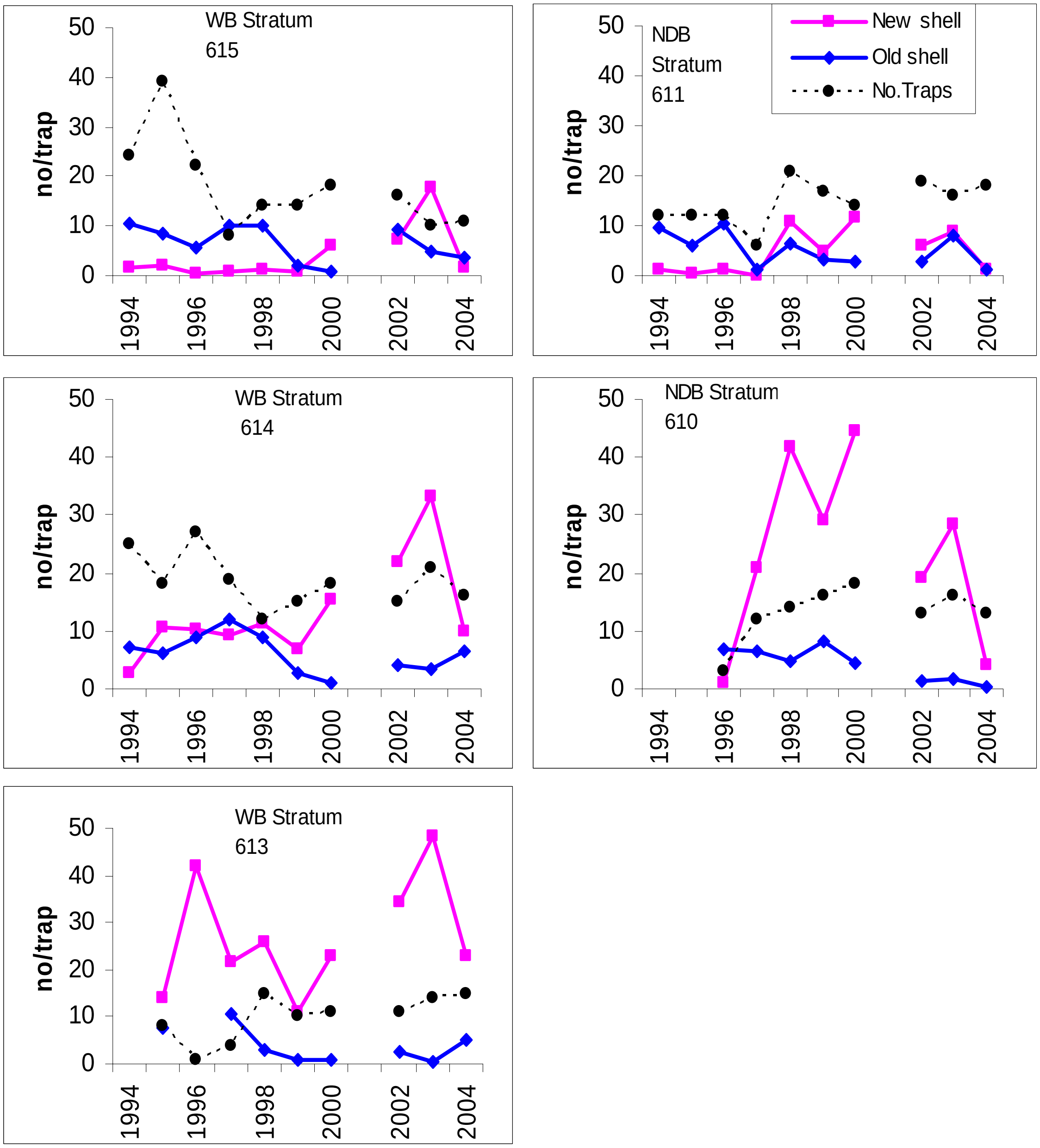

Figure 39. Annual trends in catch rates of legal sized crabs by shell category and stratum from inshore Division 3K trap surveys in White Bay and Notre Dame Bay, 1994-2004; no survey was conducted in 2001.

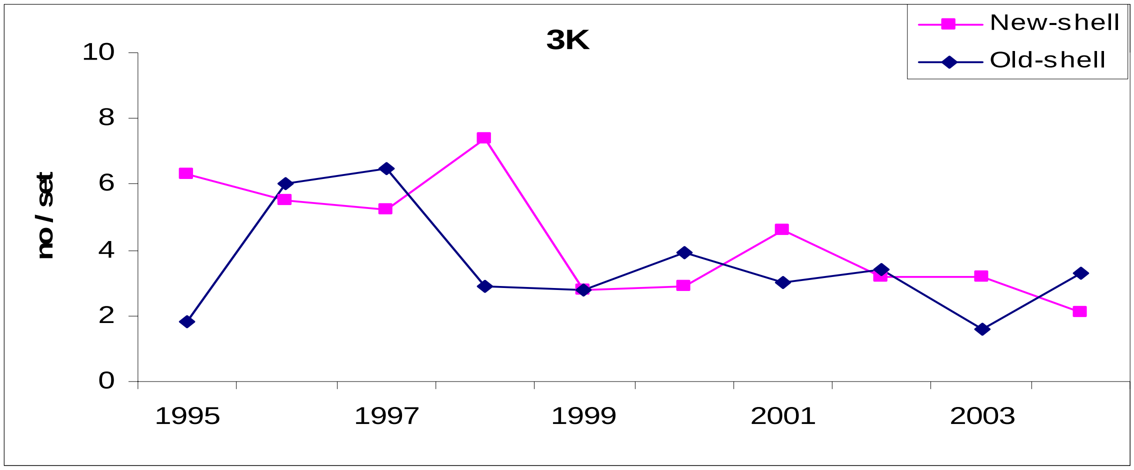

Figure 40. Annual trends, by shell condition, in abundance indices of legal-sized males for Division 3K from fall multi-species surveys.

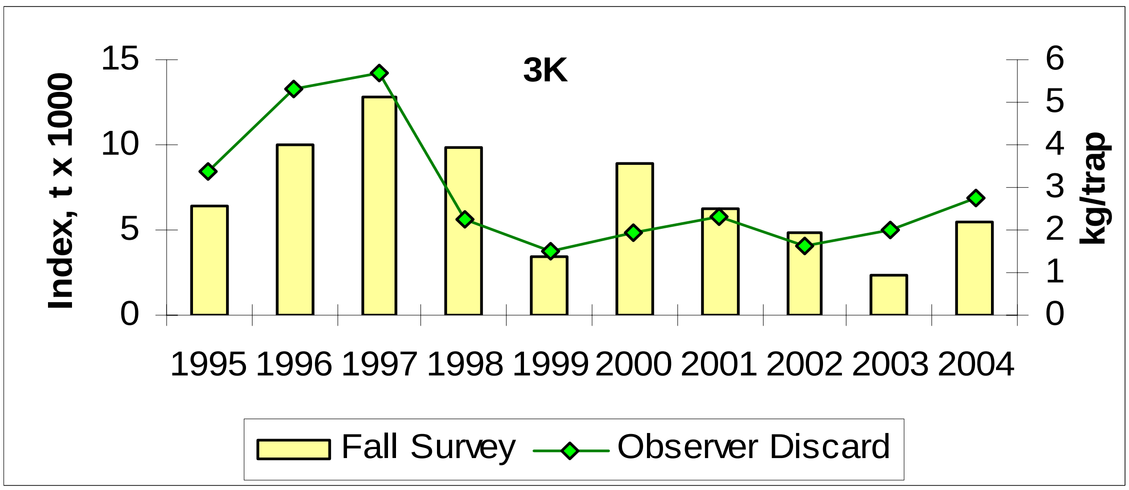

Figure 41. Annual trends in the Division 3K fall multi-species survey pre-recruit biomass index and the observer discard pre-recruit index.

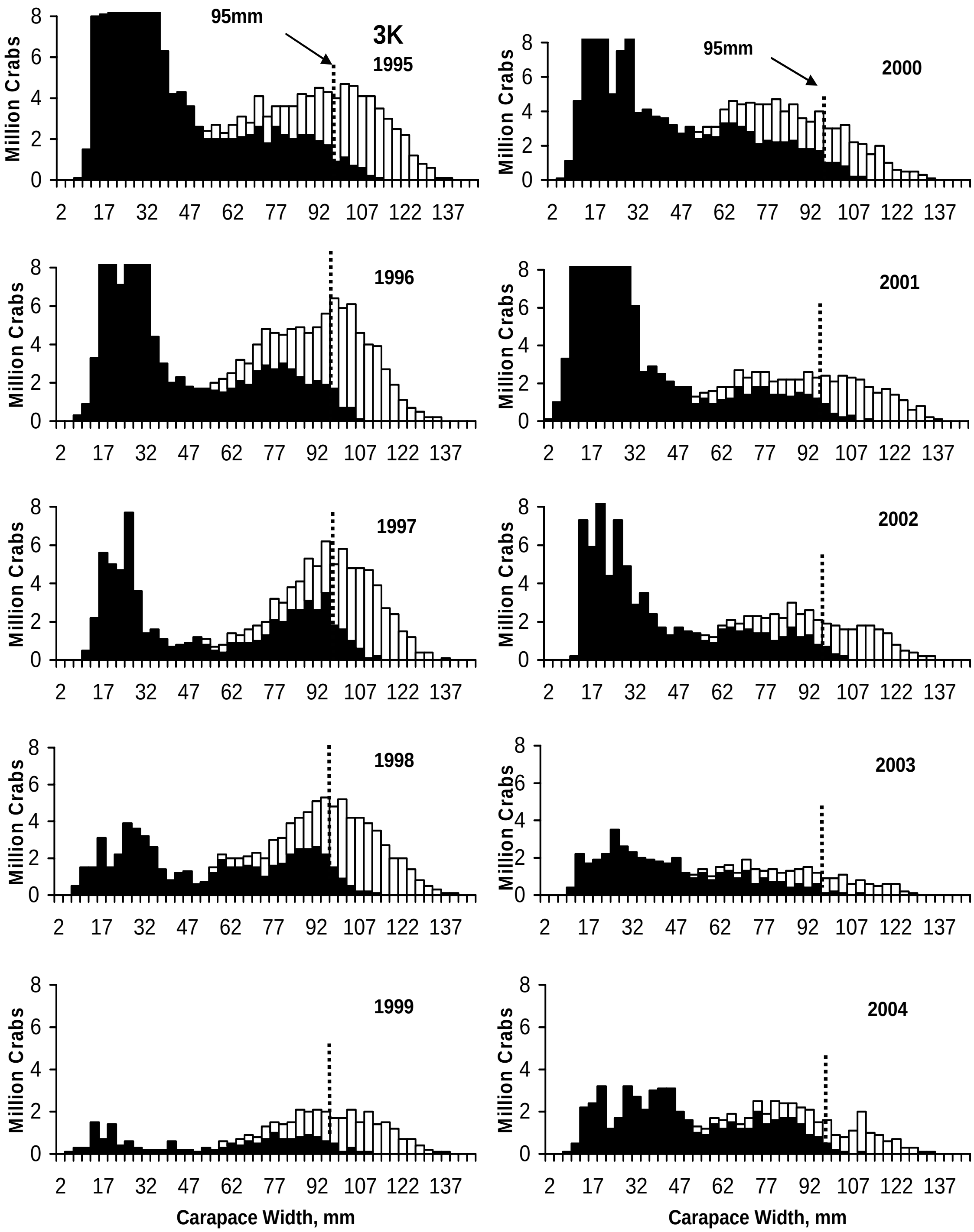

Figure 42. Truncated distribution of abundance (index) by carapace width for Division 3K juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

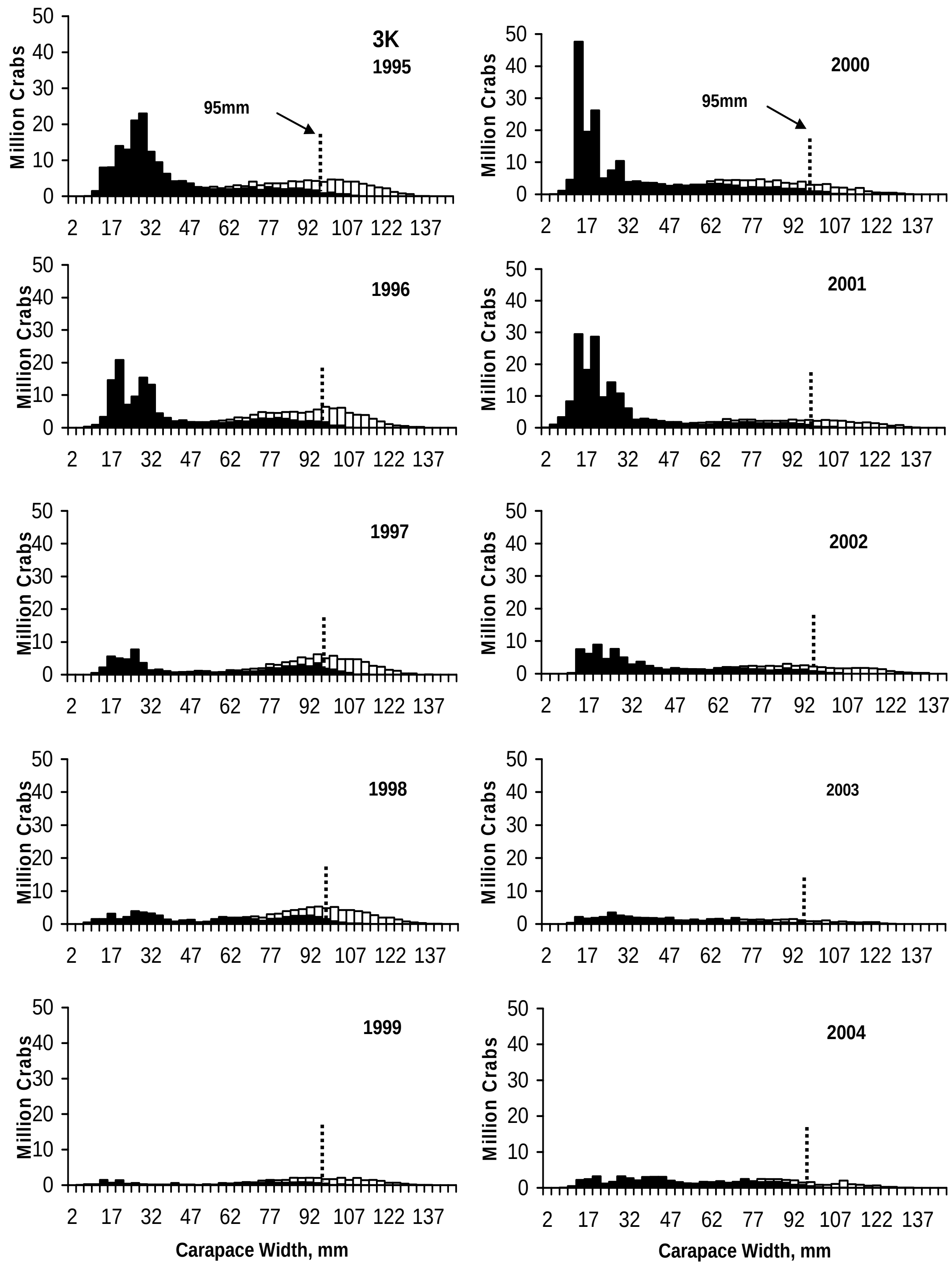

Figure 43. Distribution of abundance (index) by carapace width for Division 3K juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

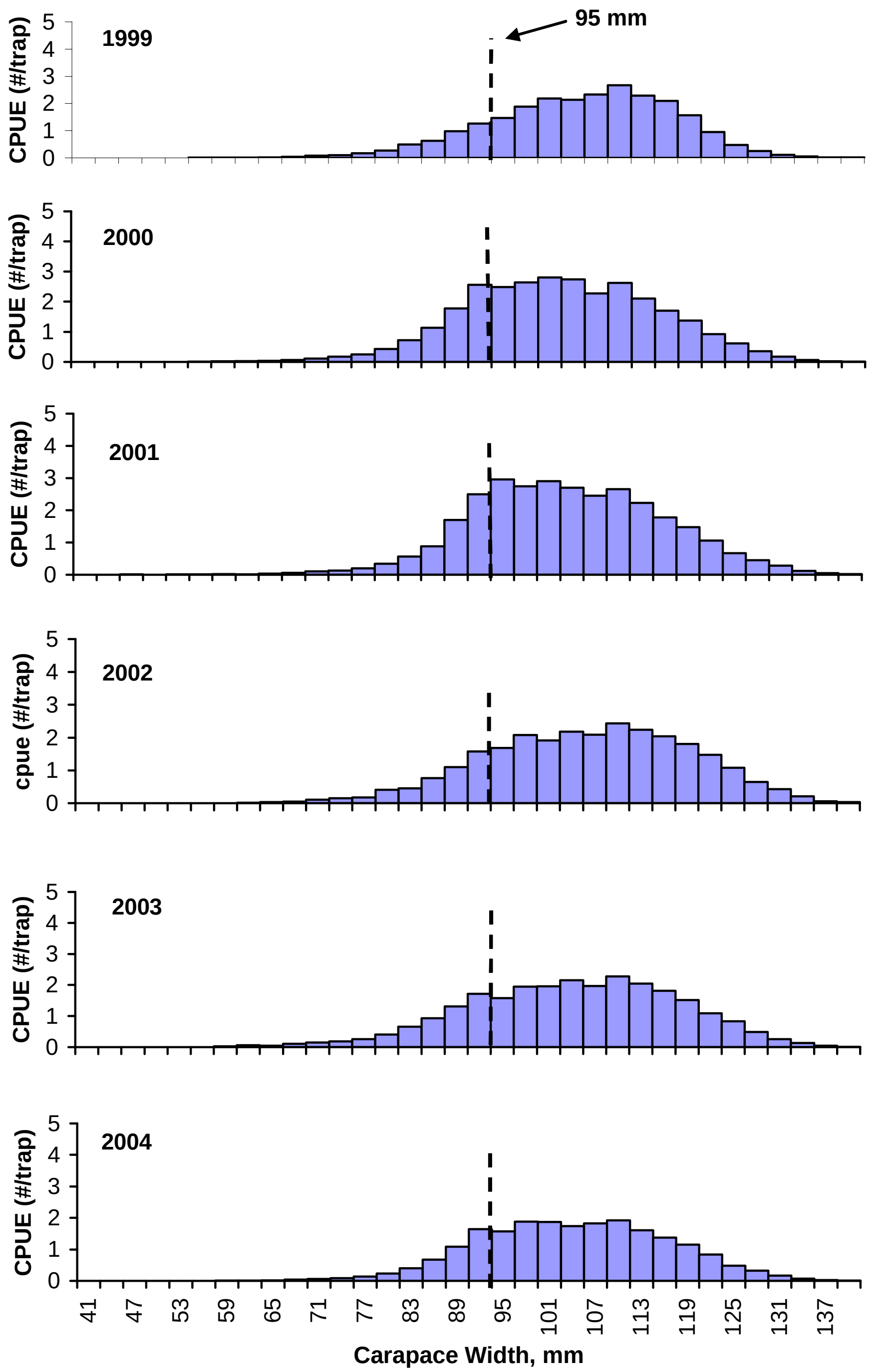

Figure 44. Annual trend in male carapace width distributions from observer at-sea sampling for Division 3K.

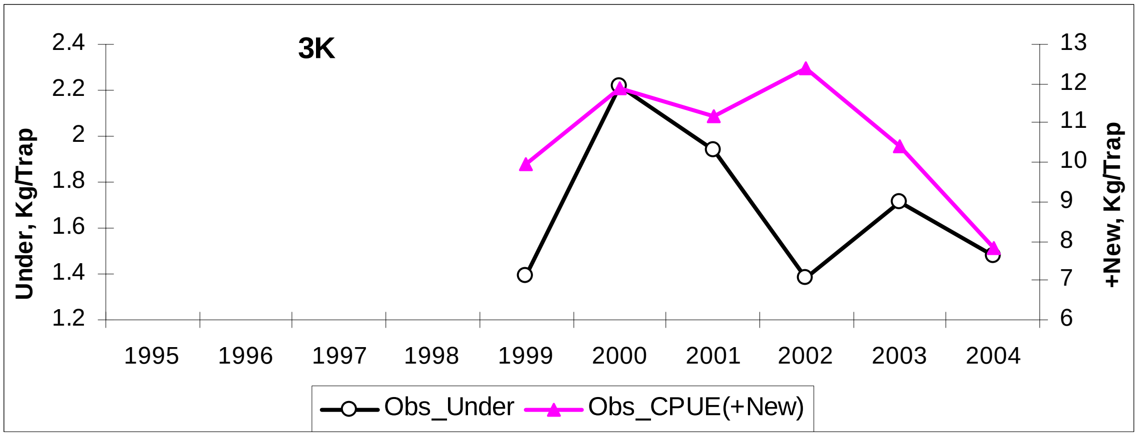

Figure 45. Annual trends in Division 3K observer-based CPUE of all legal-sized males, including new-shelled, from biological sampling, versus catch rates of sub-legal sized (under-sized) crabs.

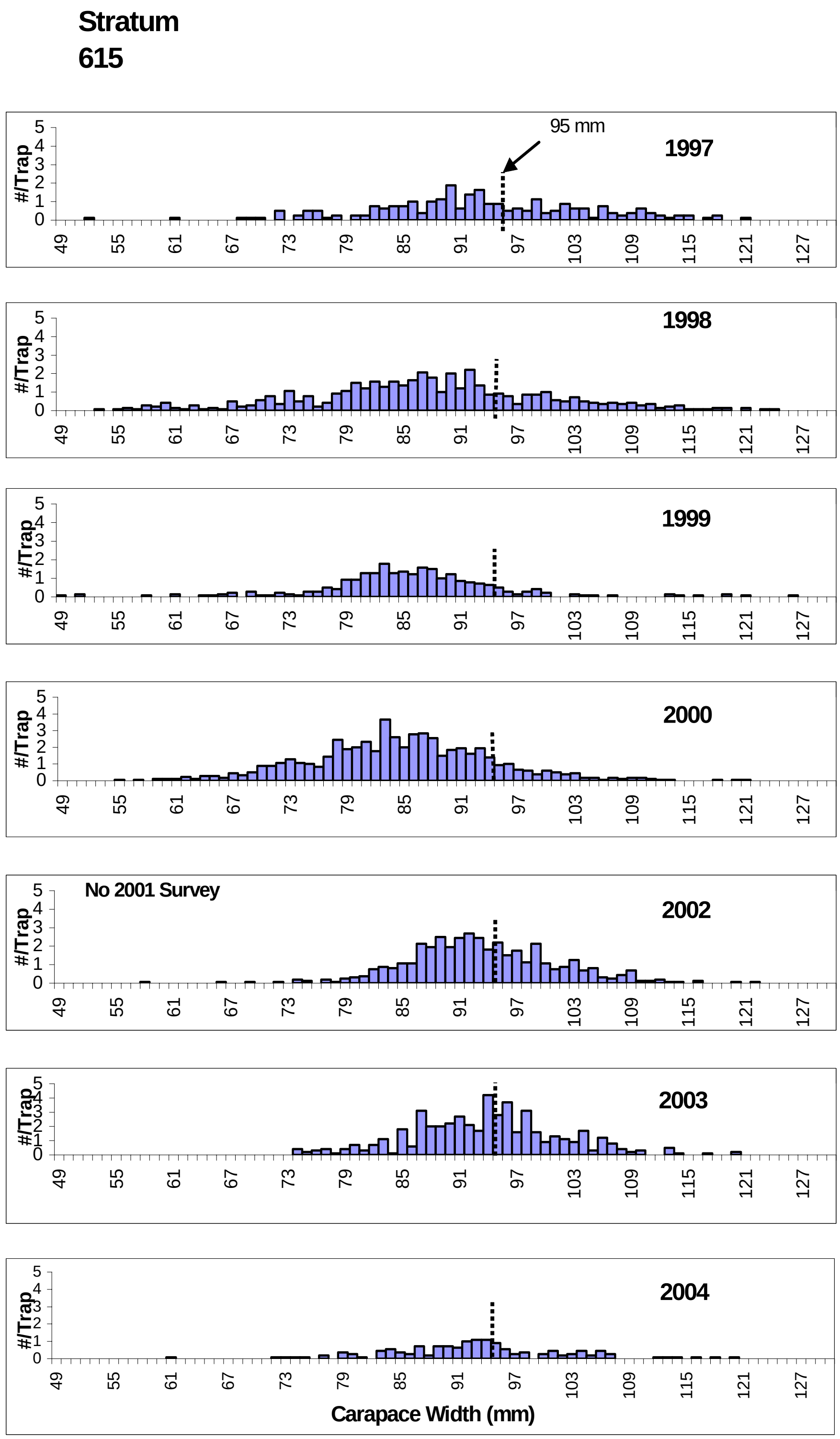

Figure 46. Inshore trap surveys; male size composition by year within White Bay Stratum 615 (200–299 m).

Stratum 614

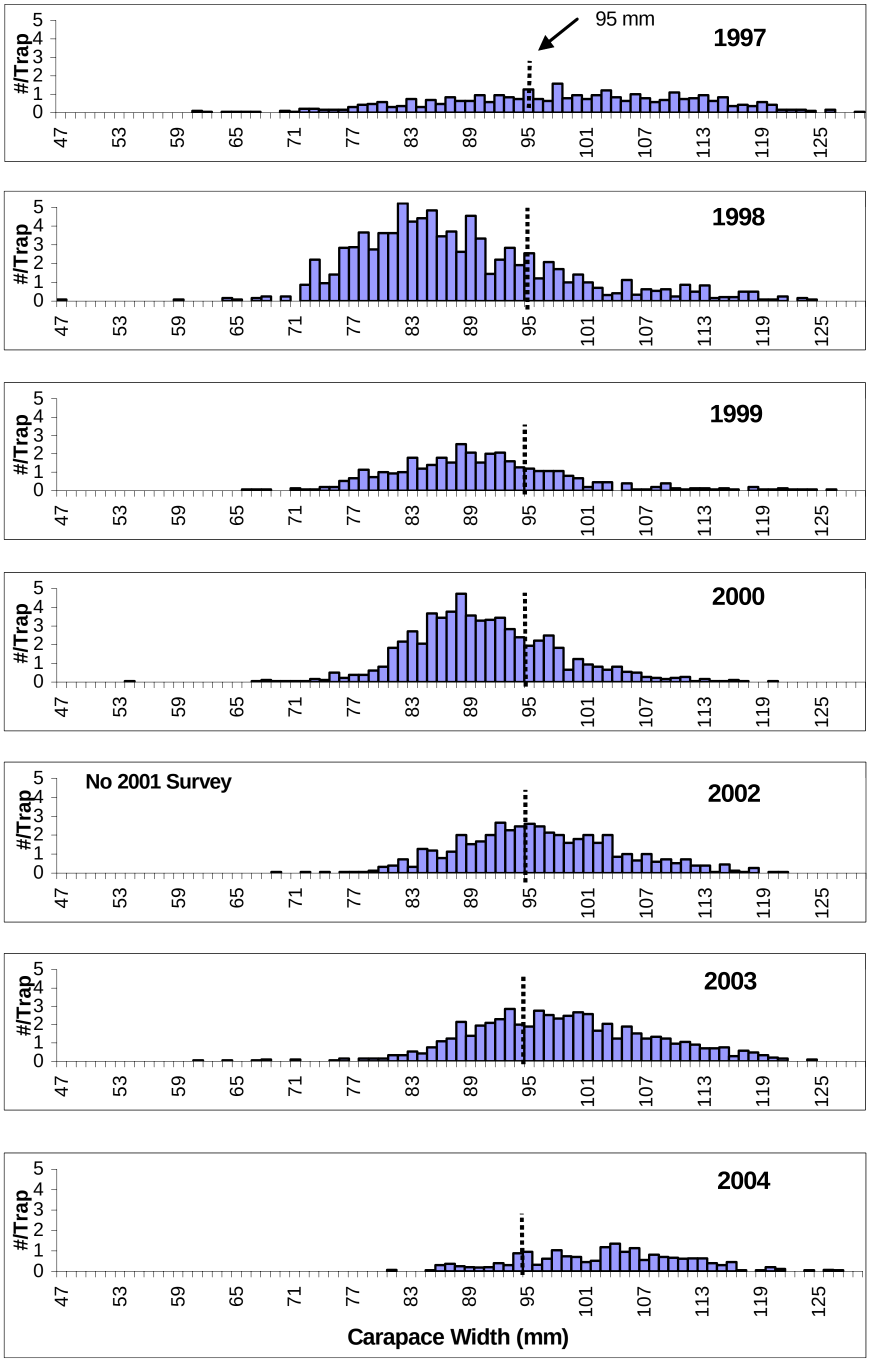

Figure 47. Inshore trap surveys; male size composition by year within White Bay stratum 614 (300–399 m).

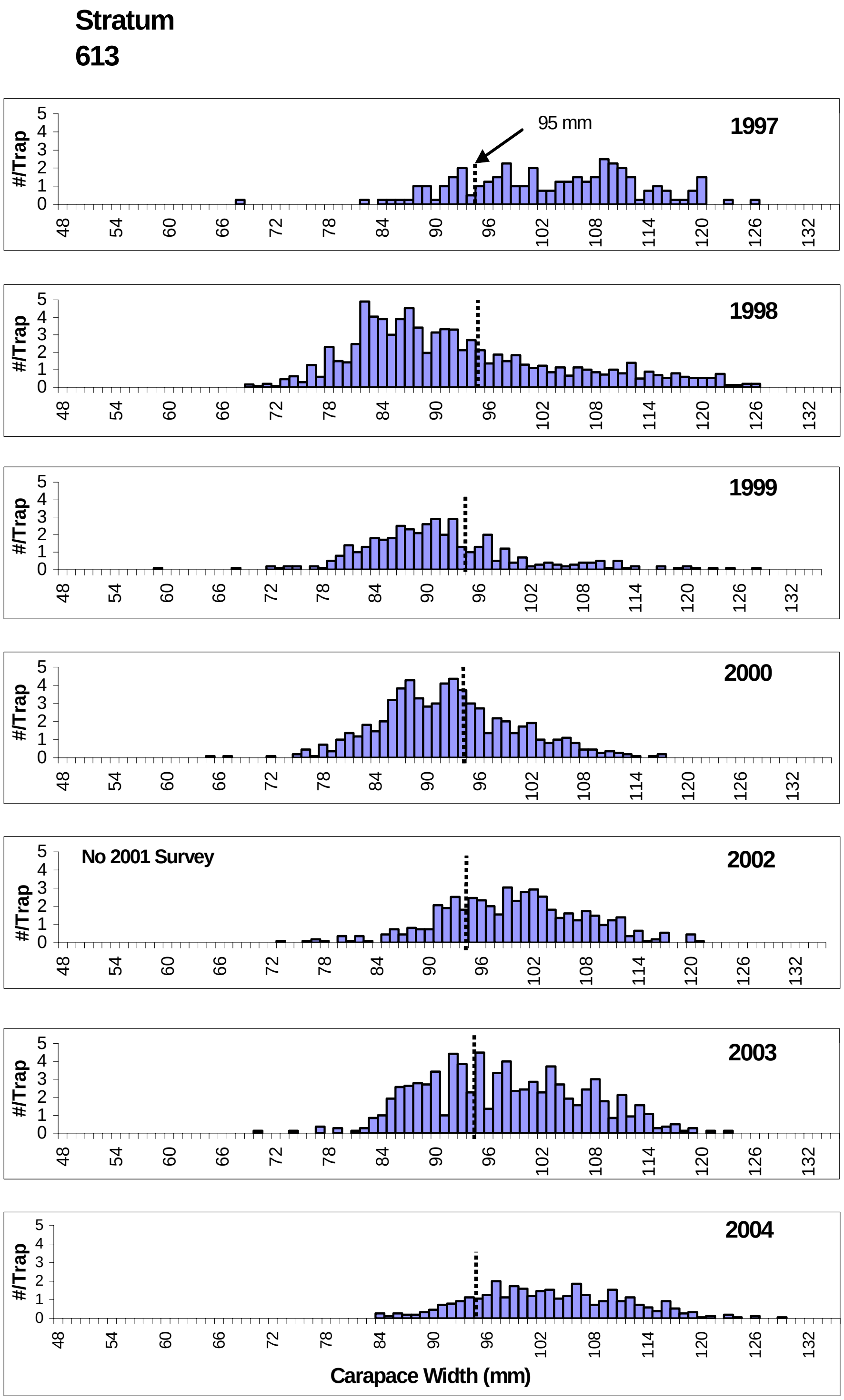

Figure 48. Inshore trap surveys; male size composition by year within White Bay stratum 613 (400–500 m).

Stratum 611

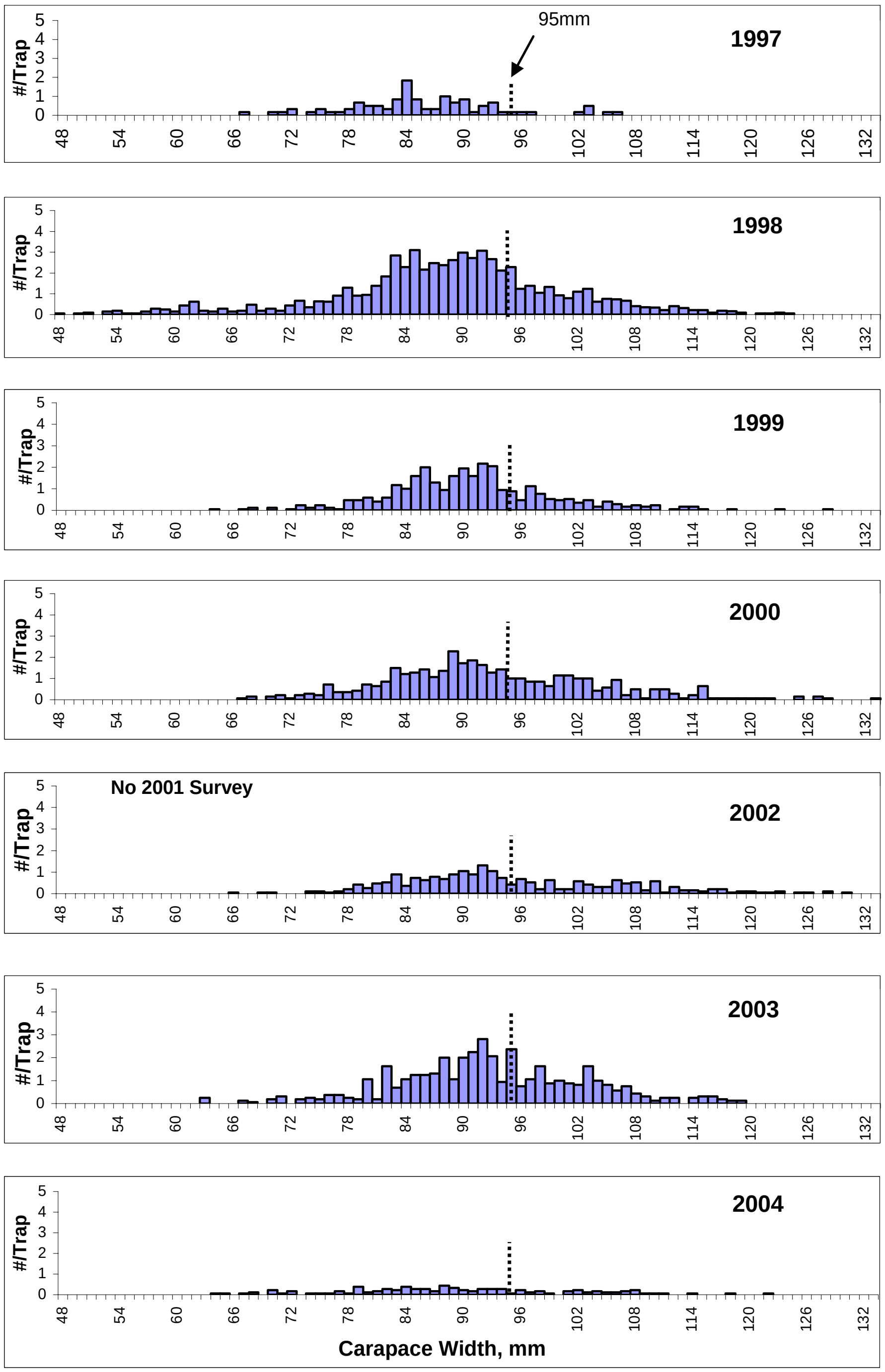

Figure 49. Inshore trap surveys; male size composition by year within Notre Dame Bay stratum 611 (200 –299 m).

Stratum 610

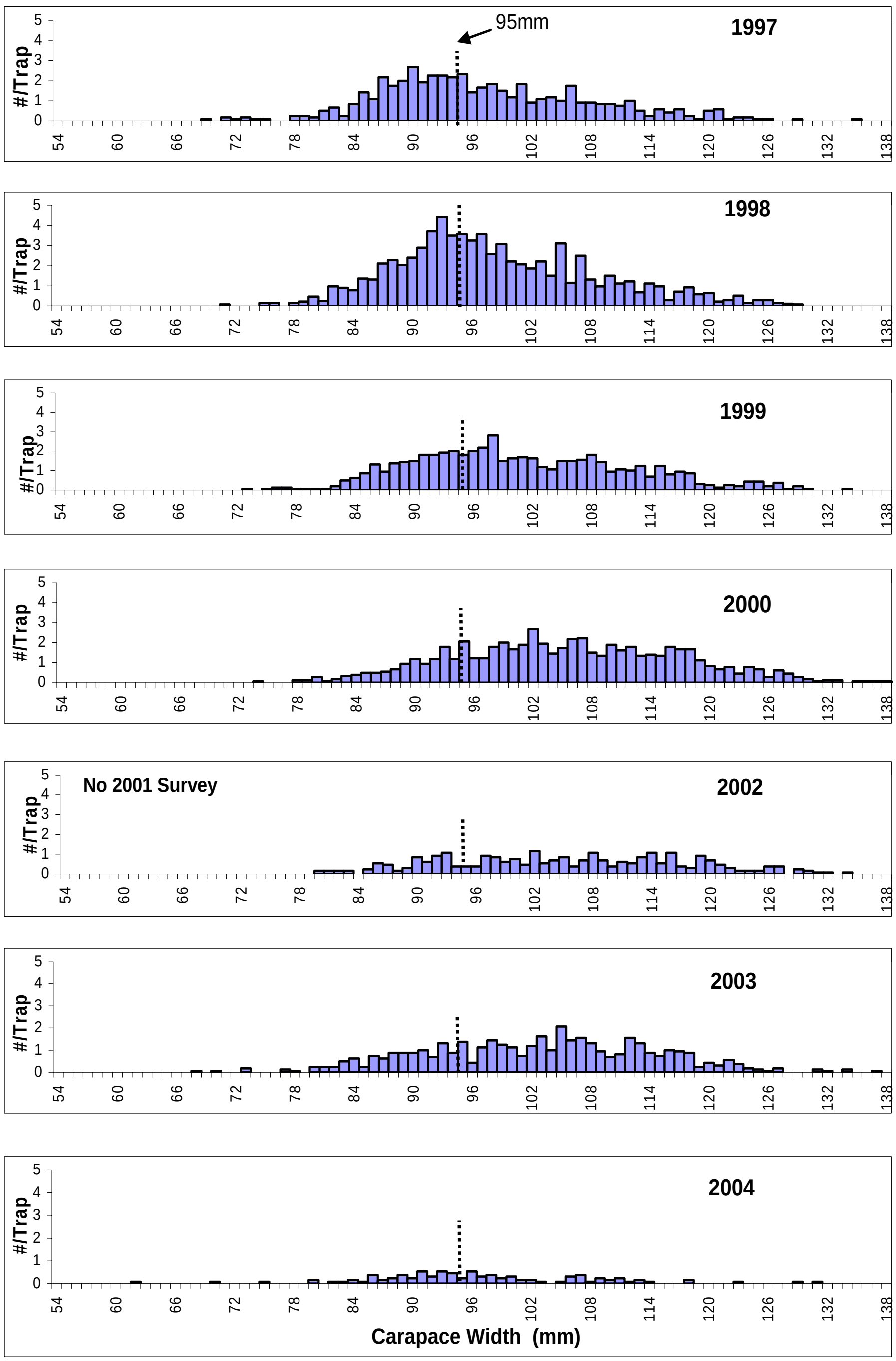

Figure 50. Inshore trap surveys; male size composition by year within Notre Dame Bay stratum 610 (300–400 m).

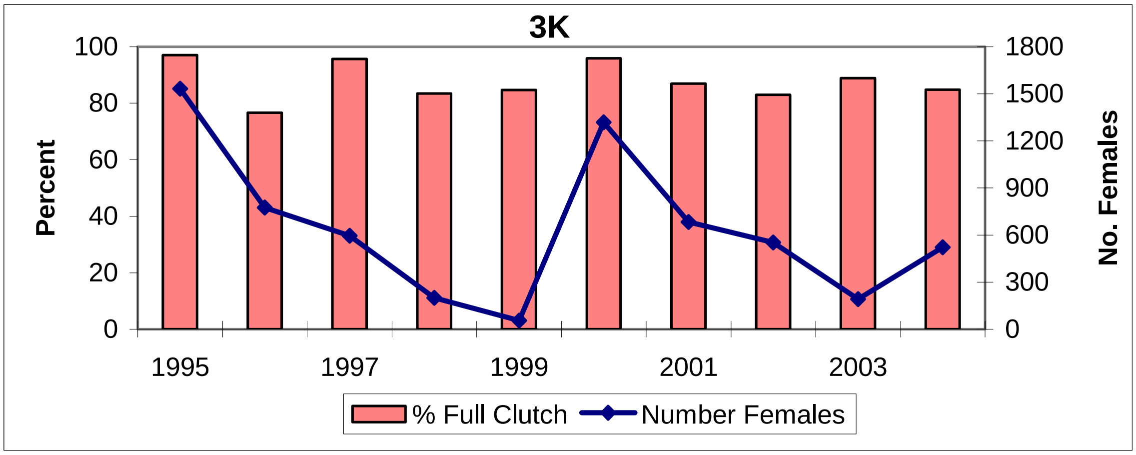

Figure 51. Annual trend in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3K from fall multi-species surveys.

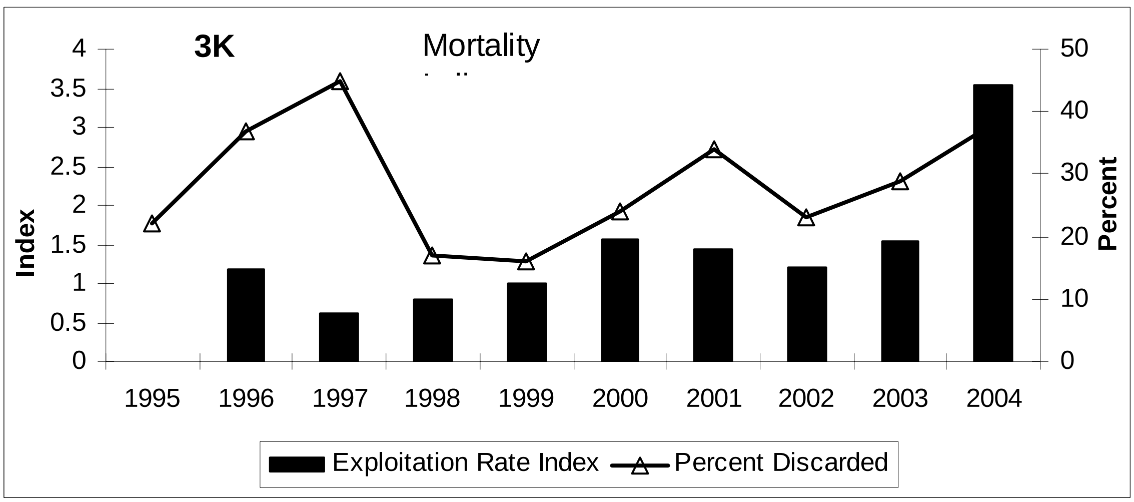

Figure 52. Annual trends in two Division 3K mortality indices.

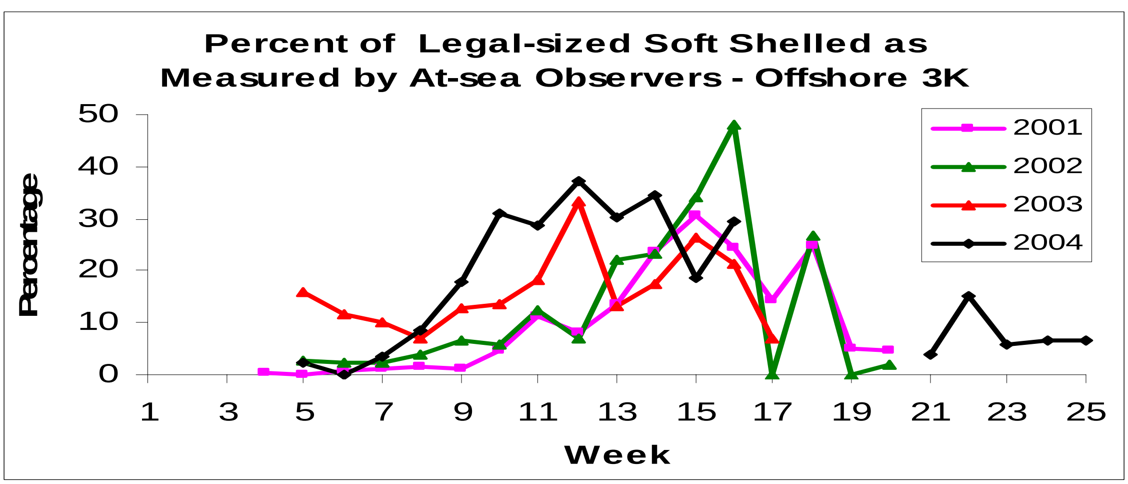

Figure 53. Seasonal trend (from April 1) in the percentage of legal-sized crabs that are soft-shelled by year (2001-04), from at-sea sampling by observers in Division 3K.

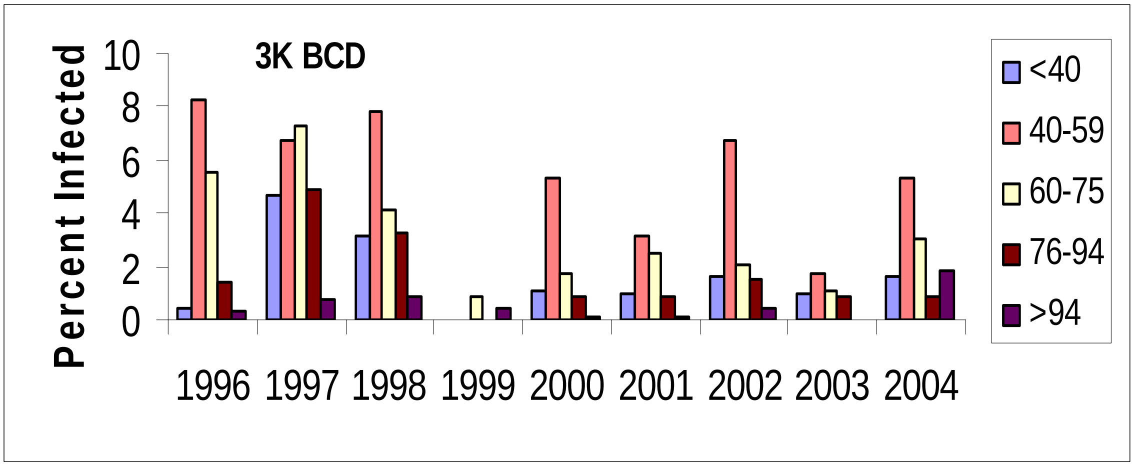

Figure 54. Annual trends in prevalence of BCD in Division 3K by male size group from fall multi-species surveys.

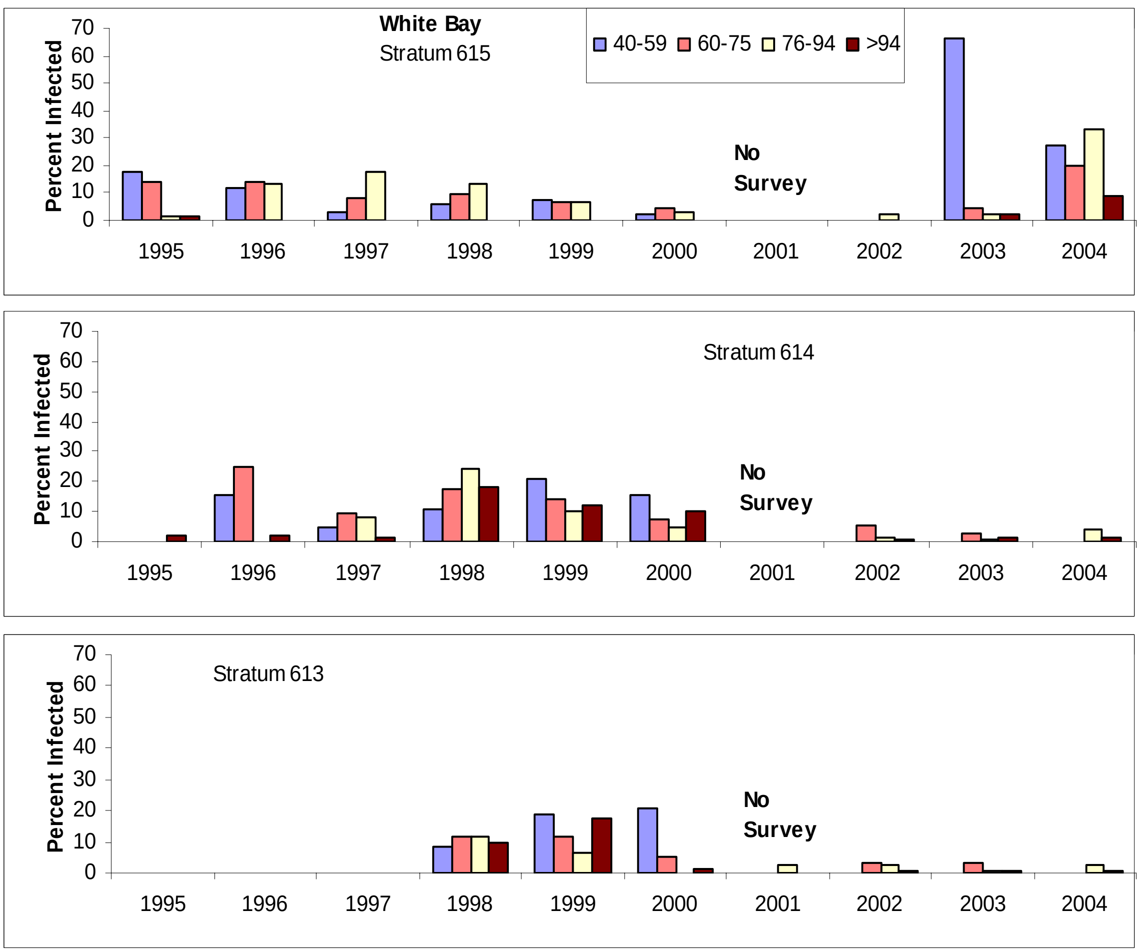

Figure 55. Incidence of BCD by stratum, year, and size group from trap surveys in White Bay; New-shelled males. (Stratum 615=200-299 m, stratum 614=300-399 m, stratum 613=400-500 m).

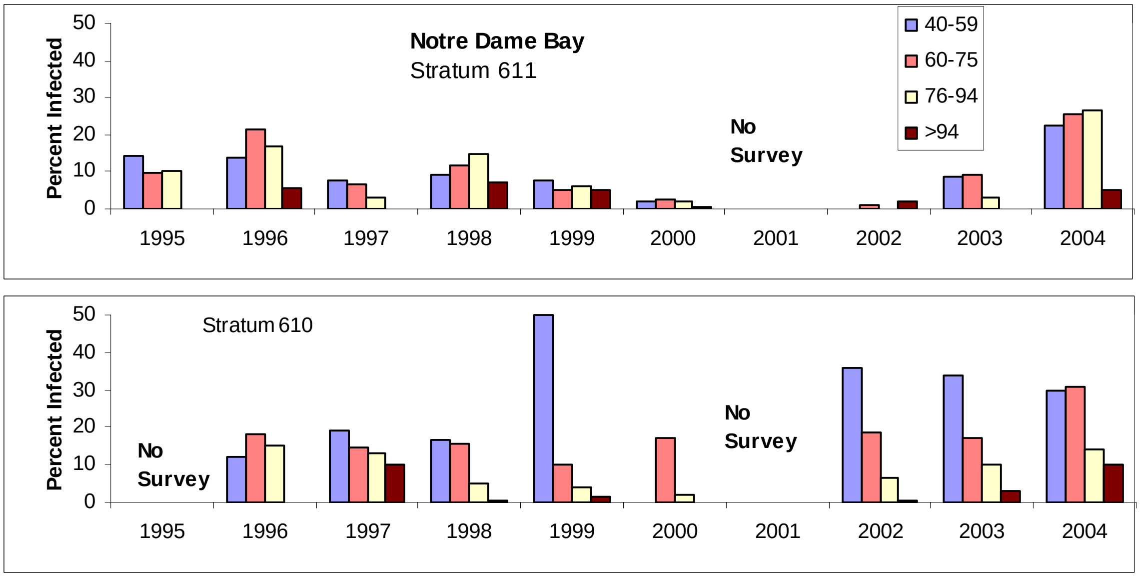

Figure 56. Incidence of BCD by stratum, year, and size group from trap surveys in Notre Dame Bay; New-shelled males. (Stratum 611=200-299 m, stratum 610=300-400 m).

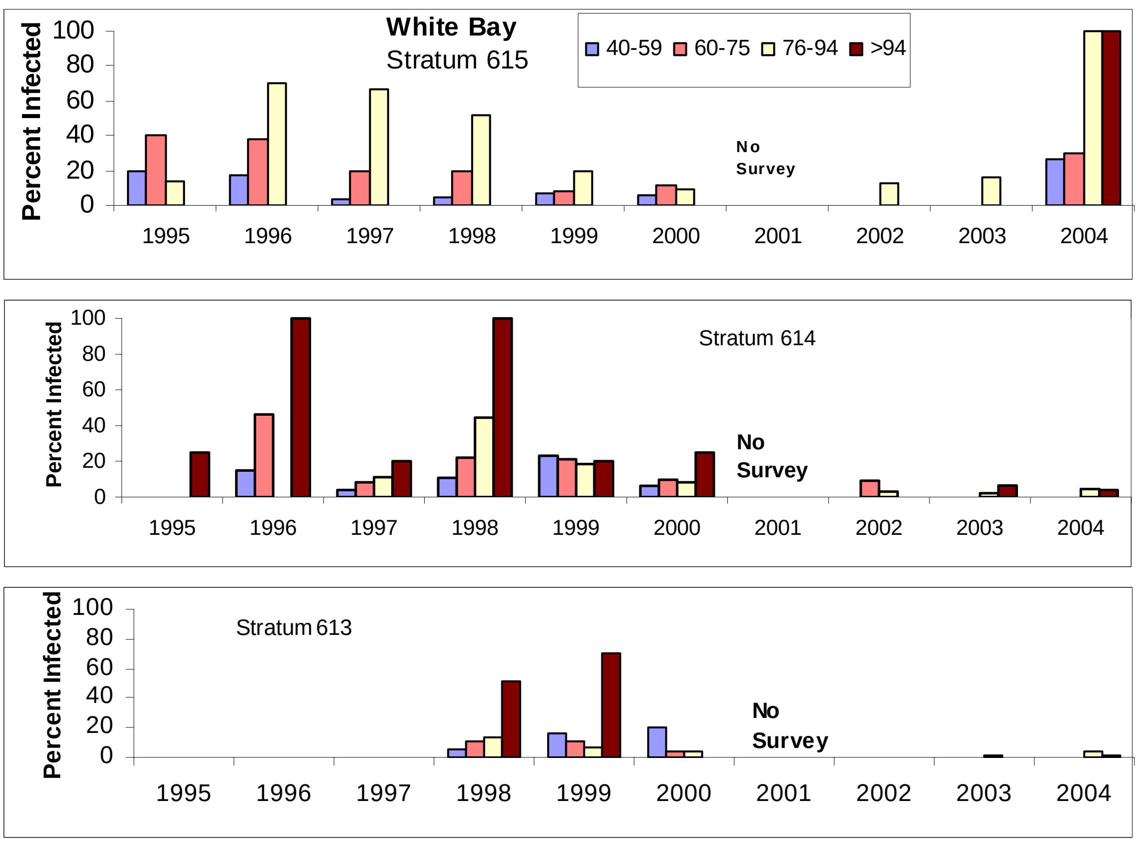

Figure 57. Incidence of BCD by stratum, year, and size group from trap surveys in White Bay; New-shelled, adolescent (small-clawed) males. (Stratum 615=200-299 m, stratum 614=300-399 m, stratum 613=400-500 m).

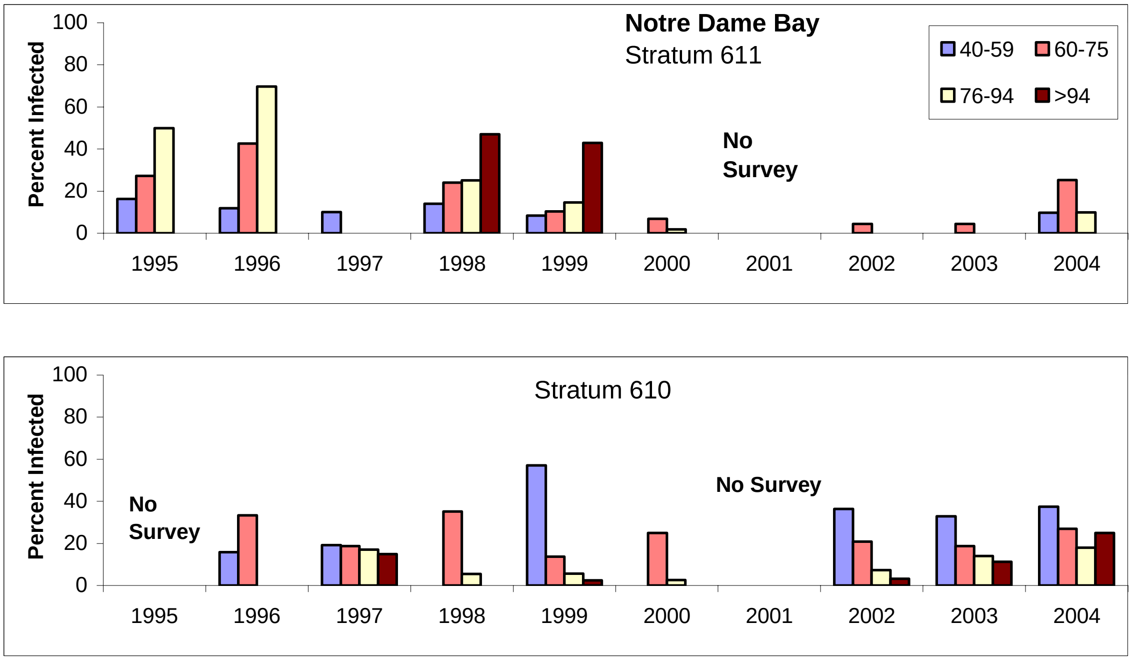

Figure 58. Incidence of BCD by stratum, year, and size group from trap surveys in Notre Dame Bay; New-shelled adolescent (small-clawed) males.

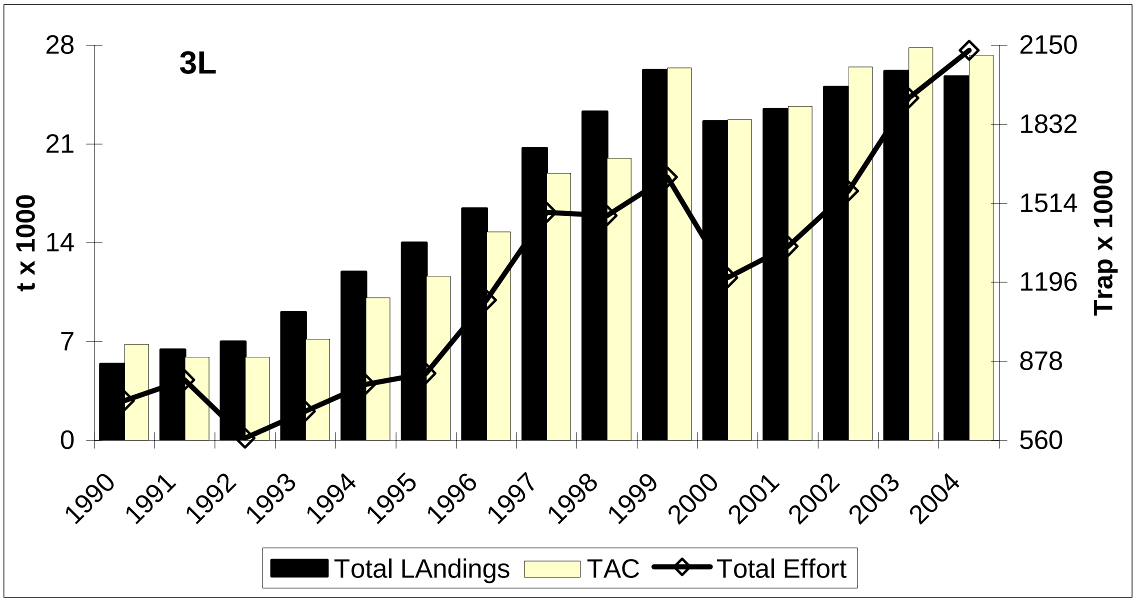

Figure 59. Annual trends in Division 3L Landings, TAC and fishing effort.

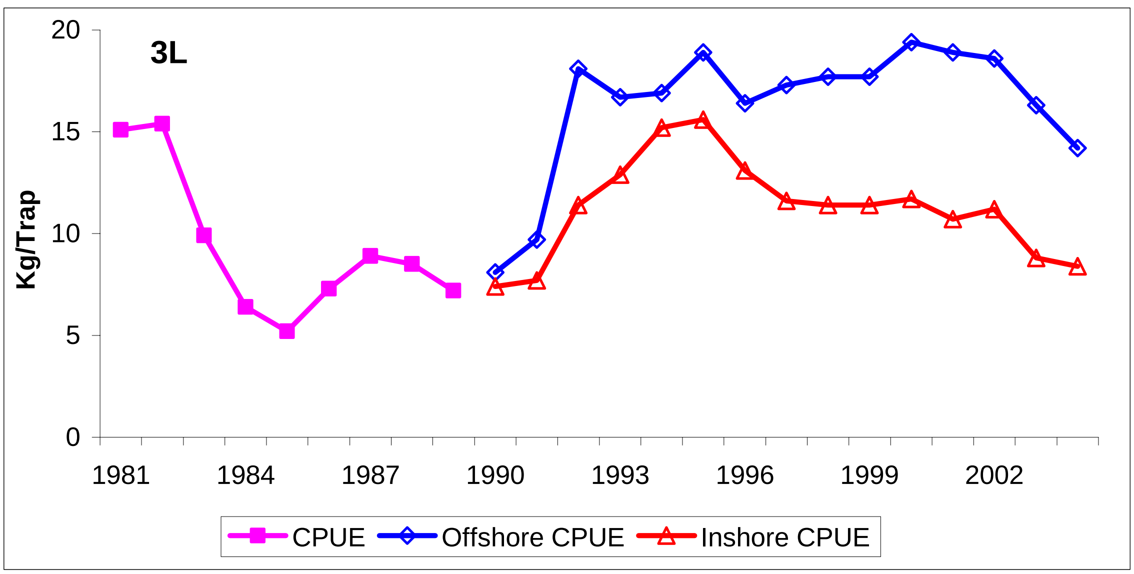

Figure 60. Annual trends in Division 3L commercial CPUE.

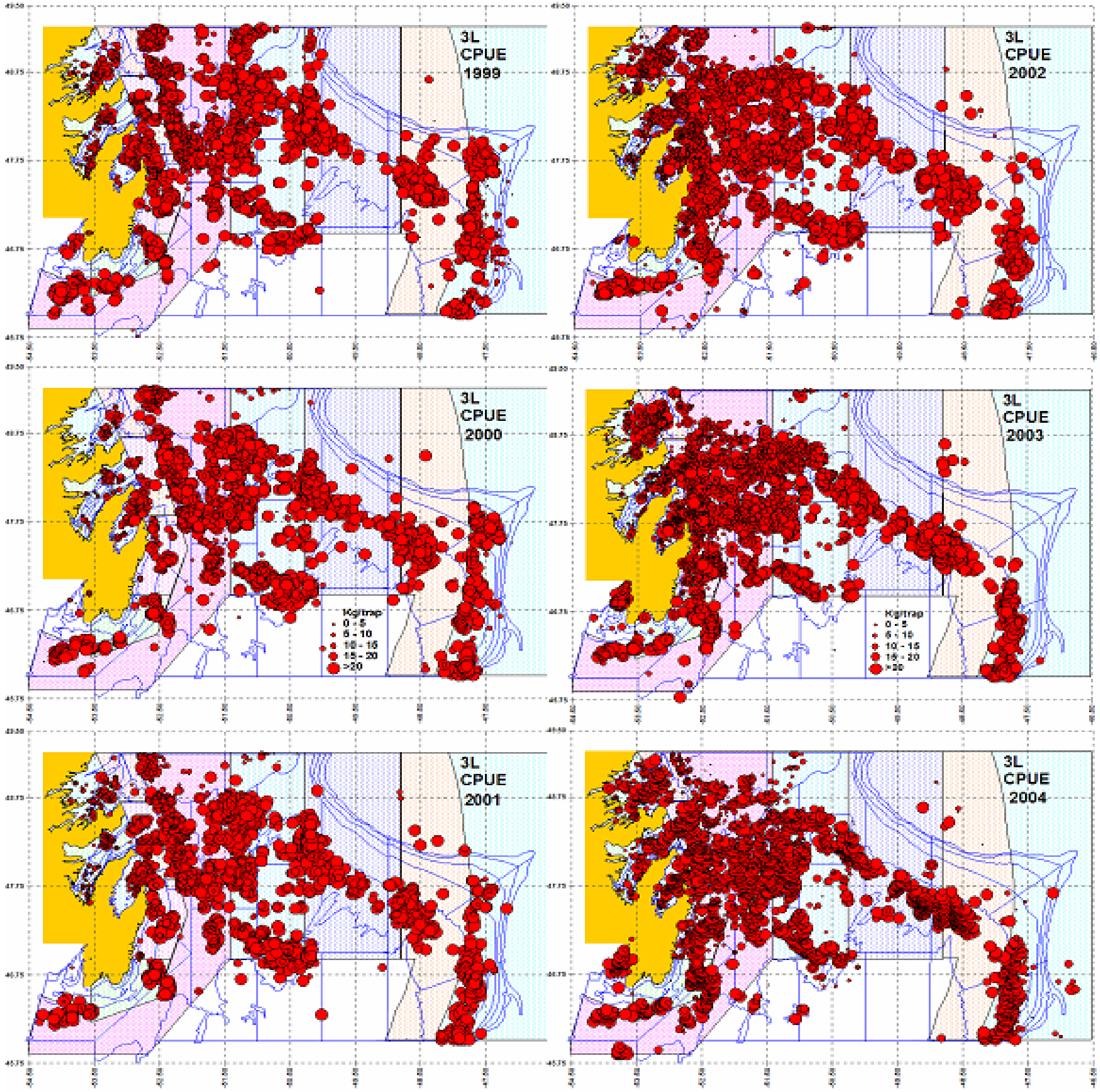

Figure 61. Spatial distribution of Division 3L commercial CPUE by year, 1999-2004.

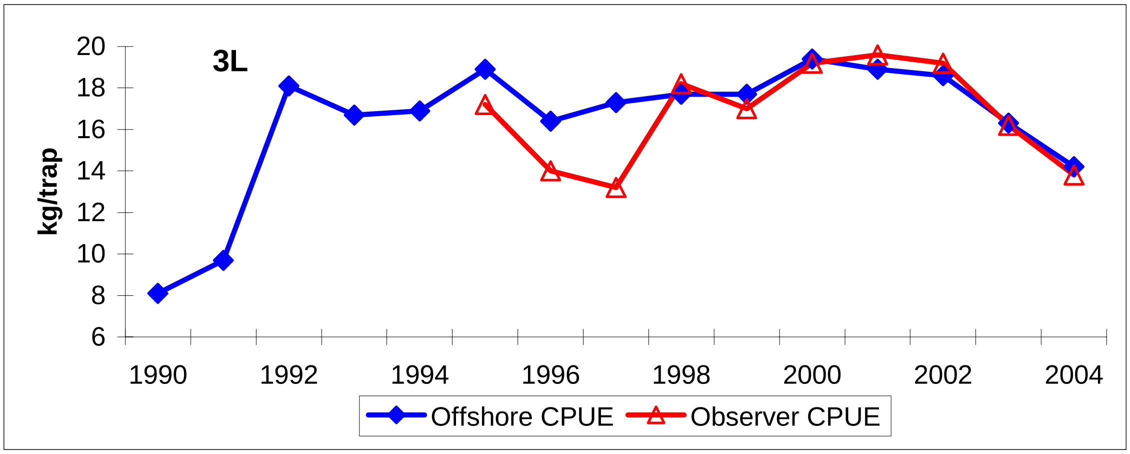

Figure 62. Annual trends in logbook- based offshore CPUE vs. observer - based CPUE in the Division 3L fishery.

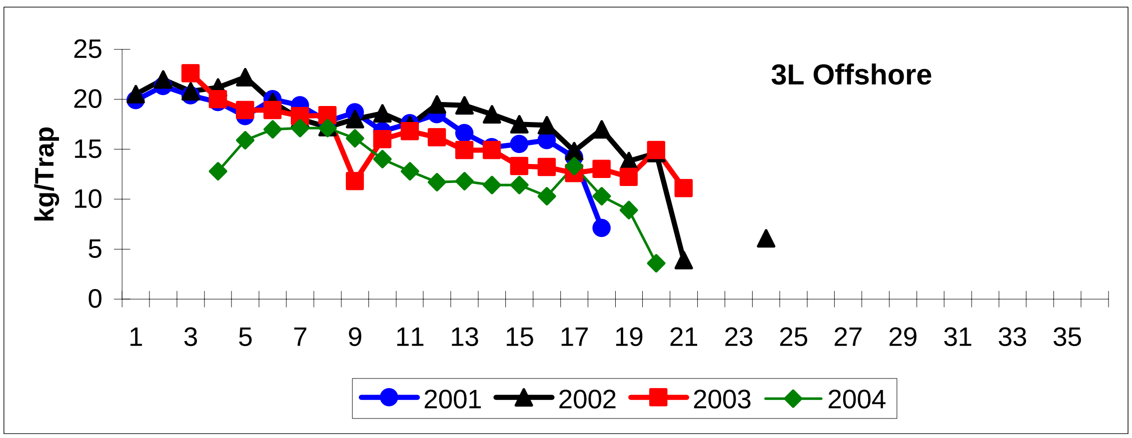

Figure 63. Seasonal trends in CPUE by week, for recent years for offshore Division 3L.

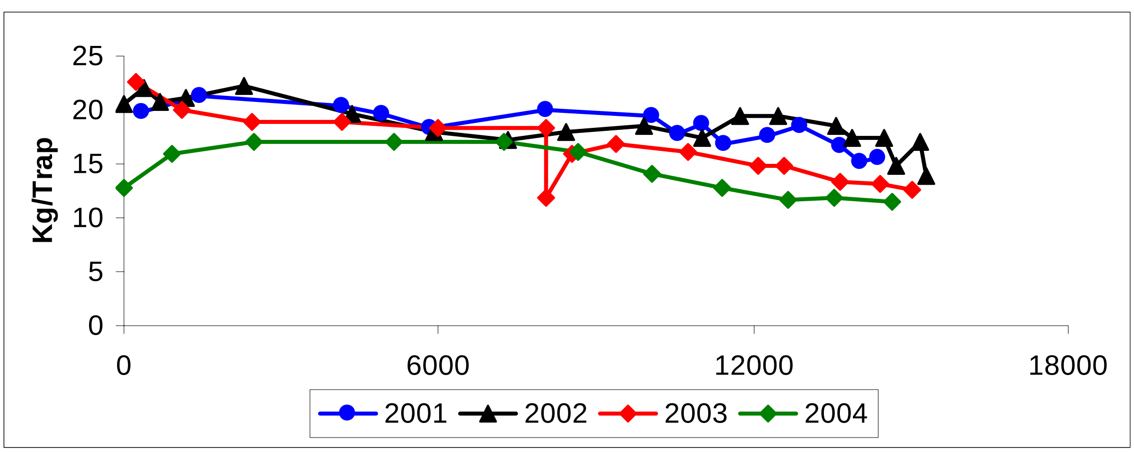

Figure 64. Seasonal trends in CPUE by cumulative catch for offshore Division 3L.

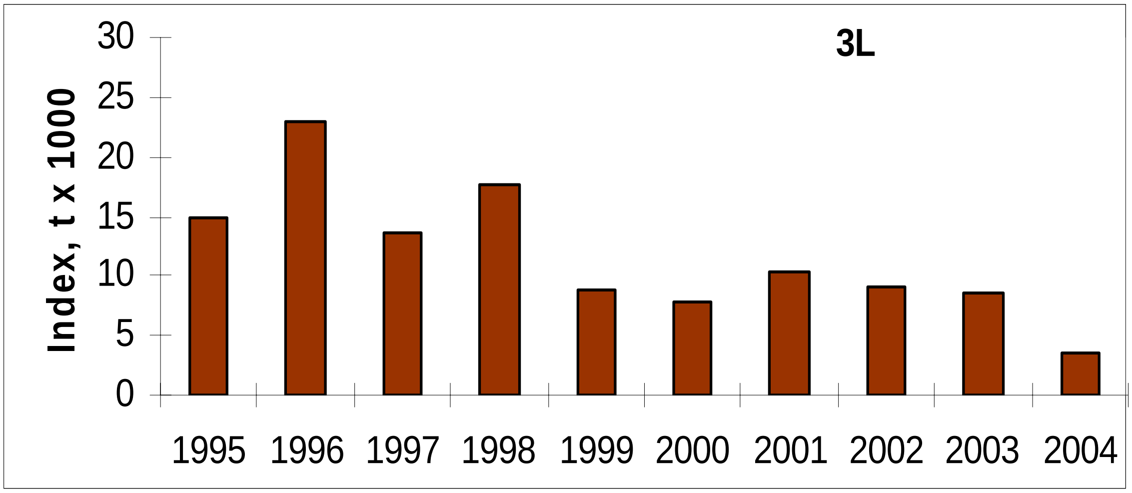

Figure 65. Annual trend in the Division 3L fall multi-species survey exploitable biomass index.

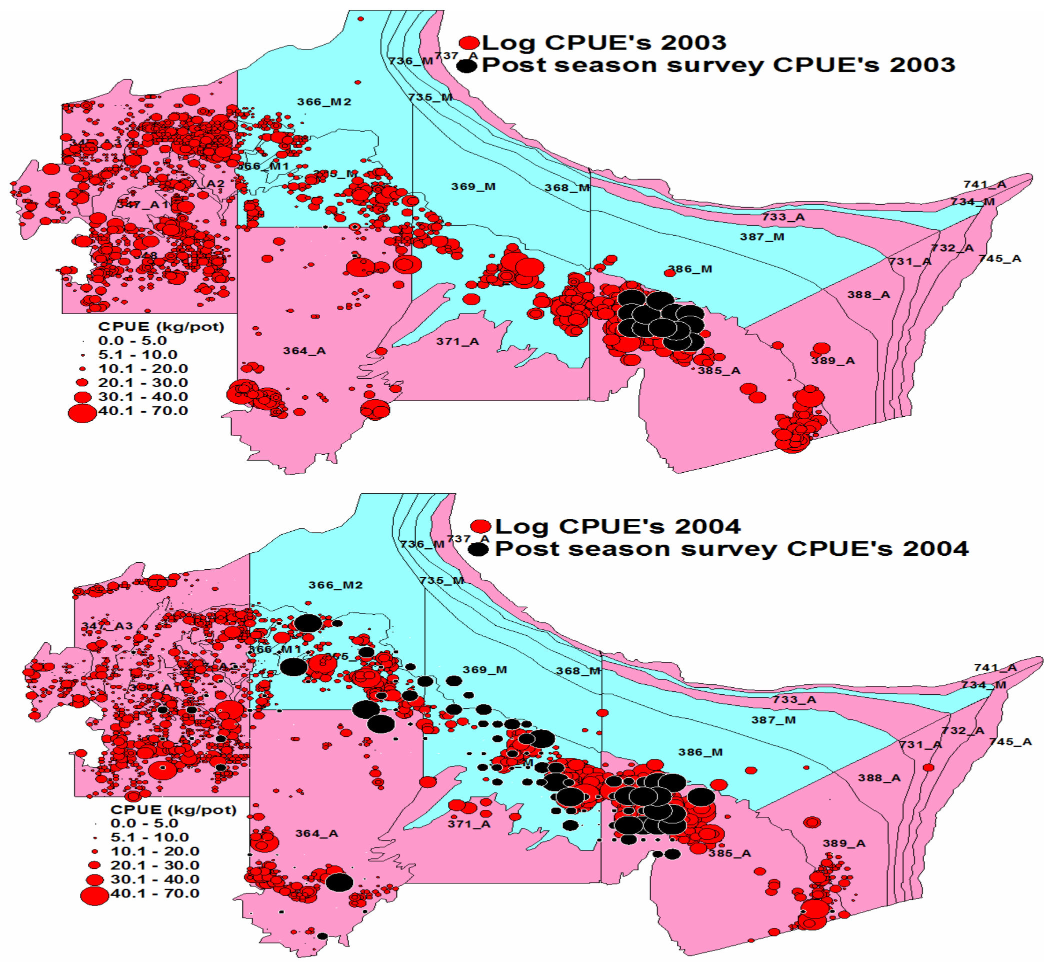

Figure 66. Offshore Division 3L spatial distribution of logbook CPUE and post-season trap survey CPUE for 2003 (above) and 2004 (below), in relation to strata that were not surveyed in 2004 (shown in blue).

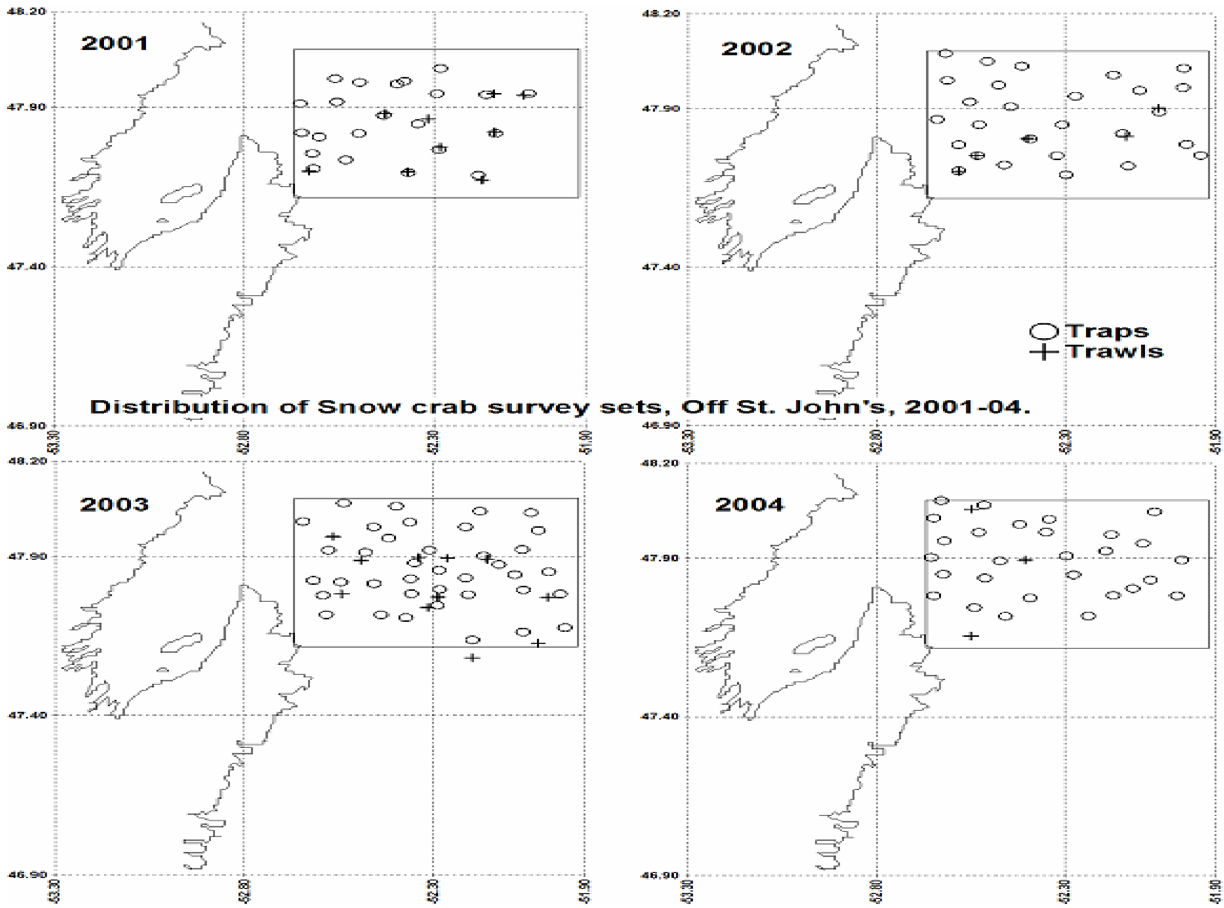

Figure 67. Set locations from inshore spring trap surveys for Northeast Avalon (NEA), 2001-04.

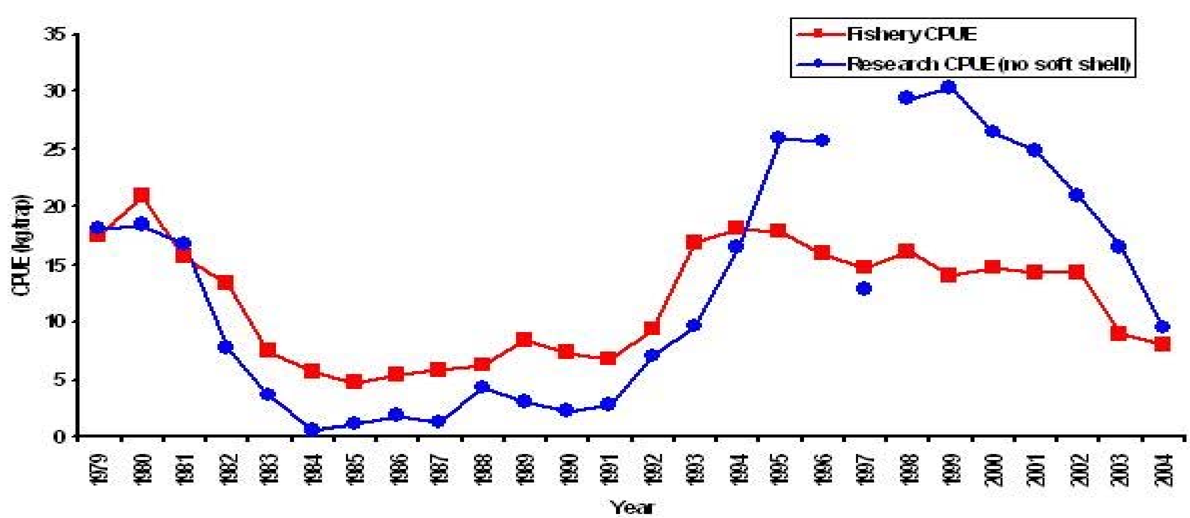

Figure 68. Comparison of fishery logbook CPUE with CPUE from inshore Division 3L spring trap surveys for North-east Avalon (NEA), 1979-2004.

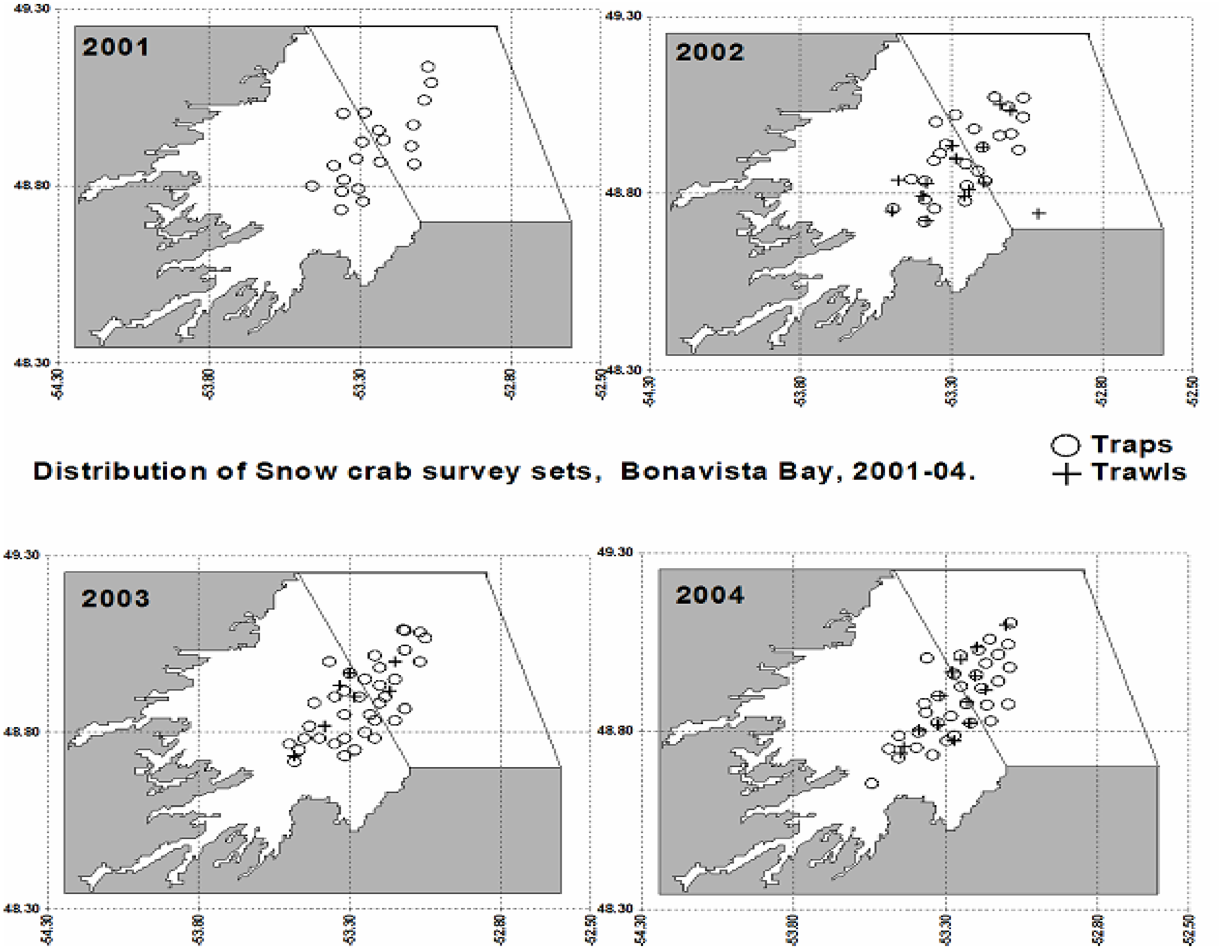

Figure 69. Set locations from inshore spring trap surveys for Bonavista Bay (BB), 2001-04.

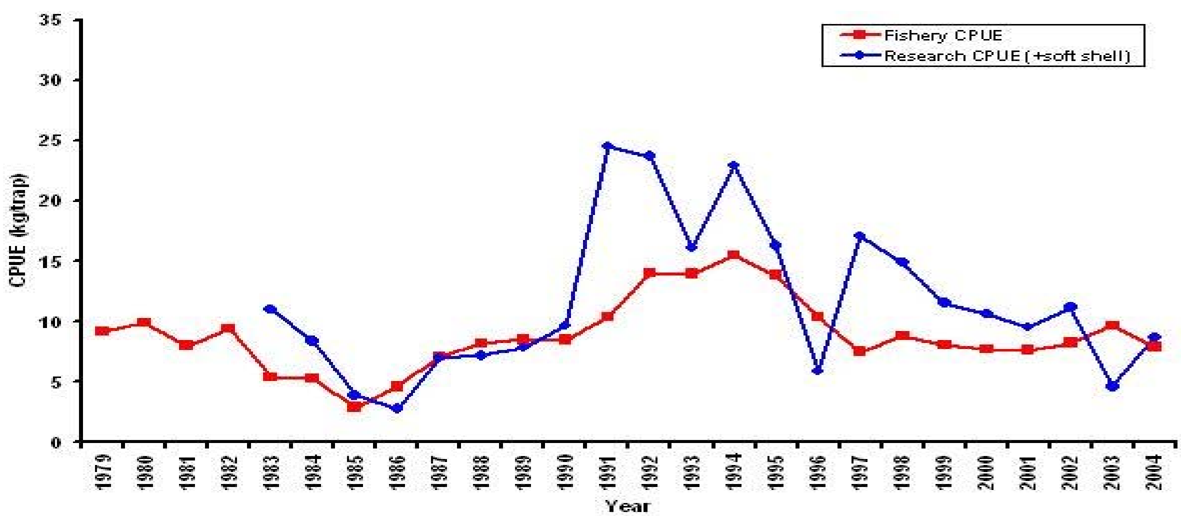

Figure 70. Comparison of fishery logbook CPUE with CPUE from inshore Division 3L spring trap surveys for Bonavista Bay (BB), 1979-2004.

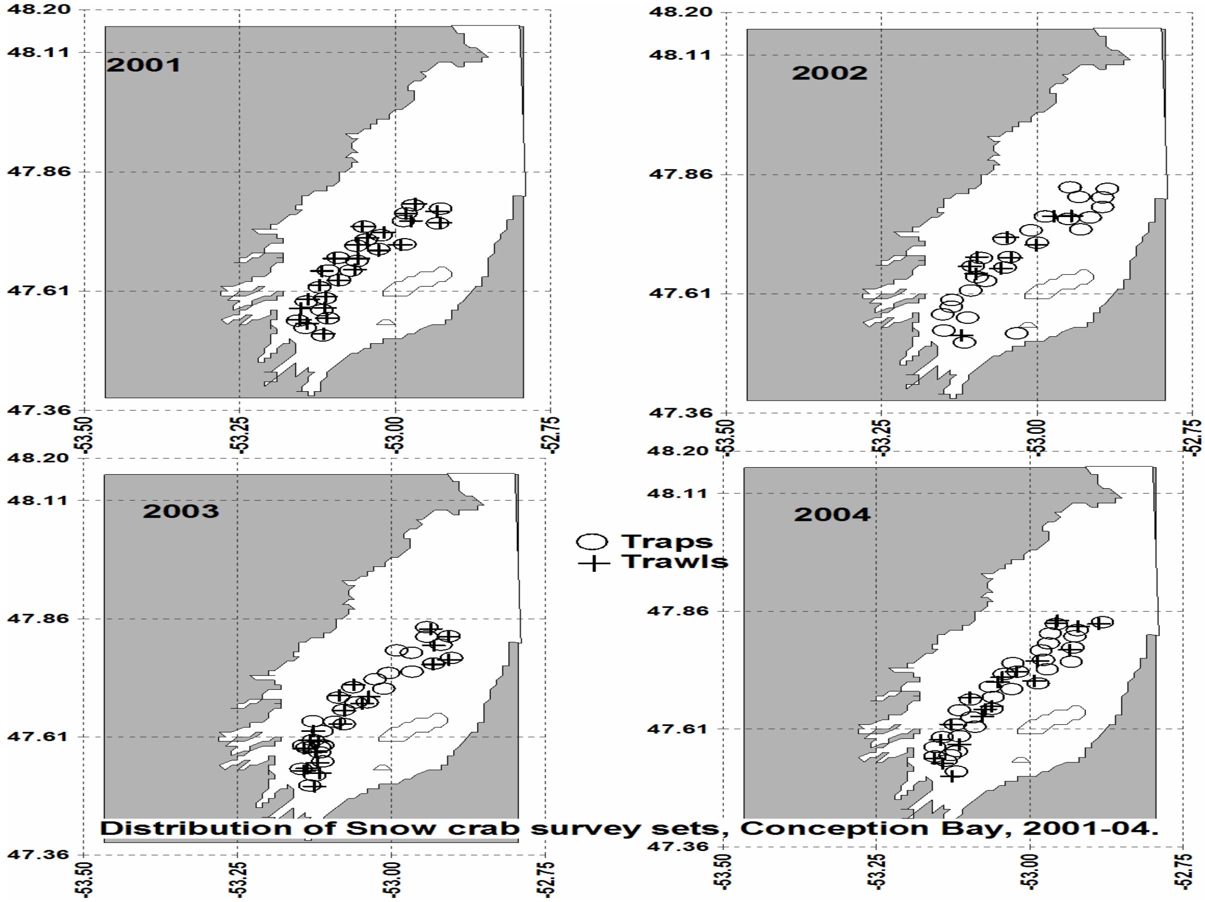

Figure 71. Set locations from inshore spring trap surveys for Conception Bay (CB), 2001-04.

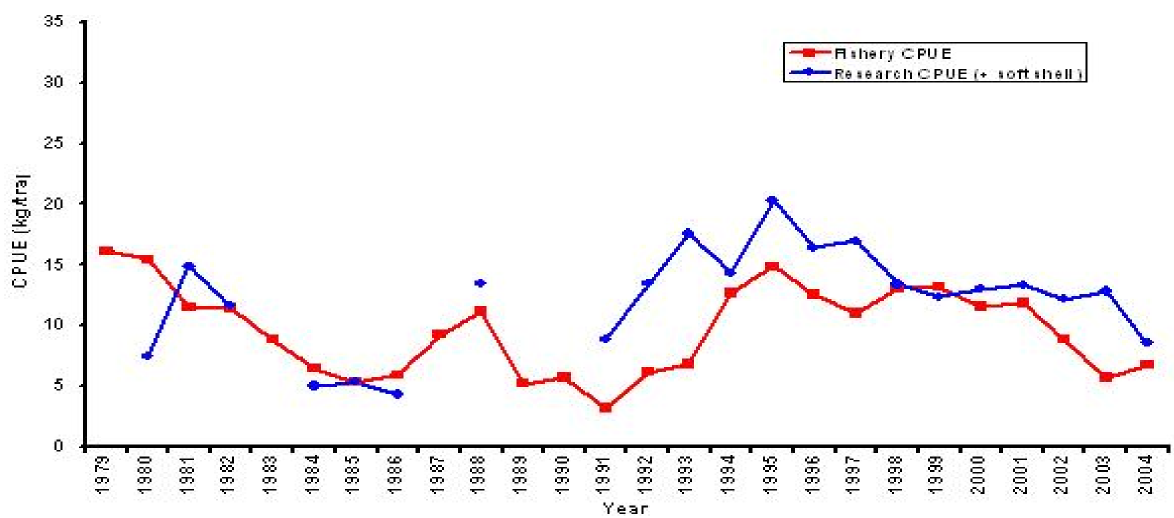

Figure 72. Comparison of fishery logbook CPUE with CPUE from inshore Division 3L spring trap surveys for Conception Bay (CB), 1979-2004.

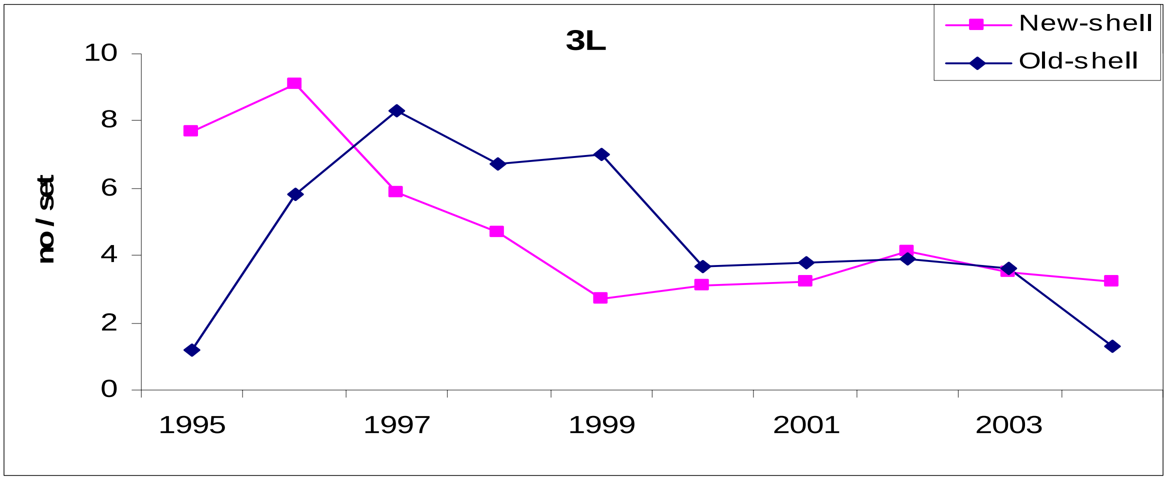

Figure 73. Annual trends, by shell condition, in abundance indices of legal-sized males for Division 3L from fall multi-species surveys.

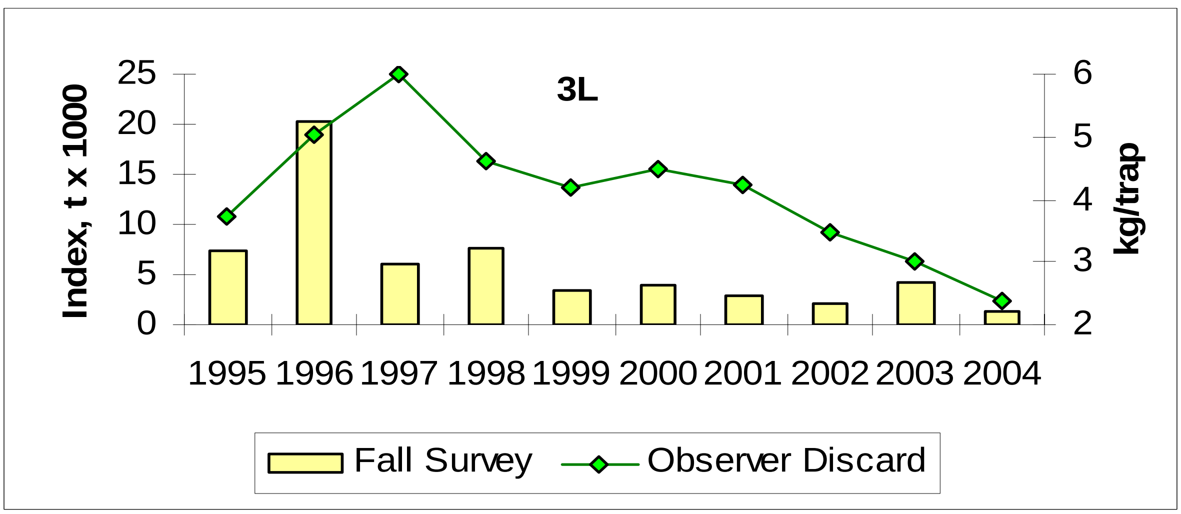

Figure 74. Annual trends in the Division 3L fall multi-species survey pre-recruit biomass index and the observer discard pre-recruit index.

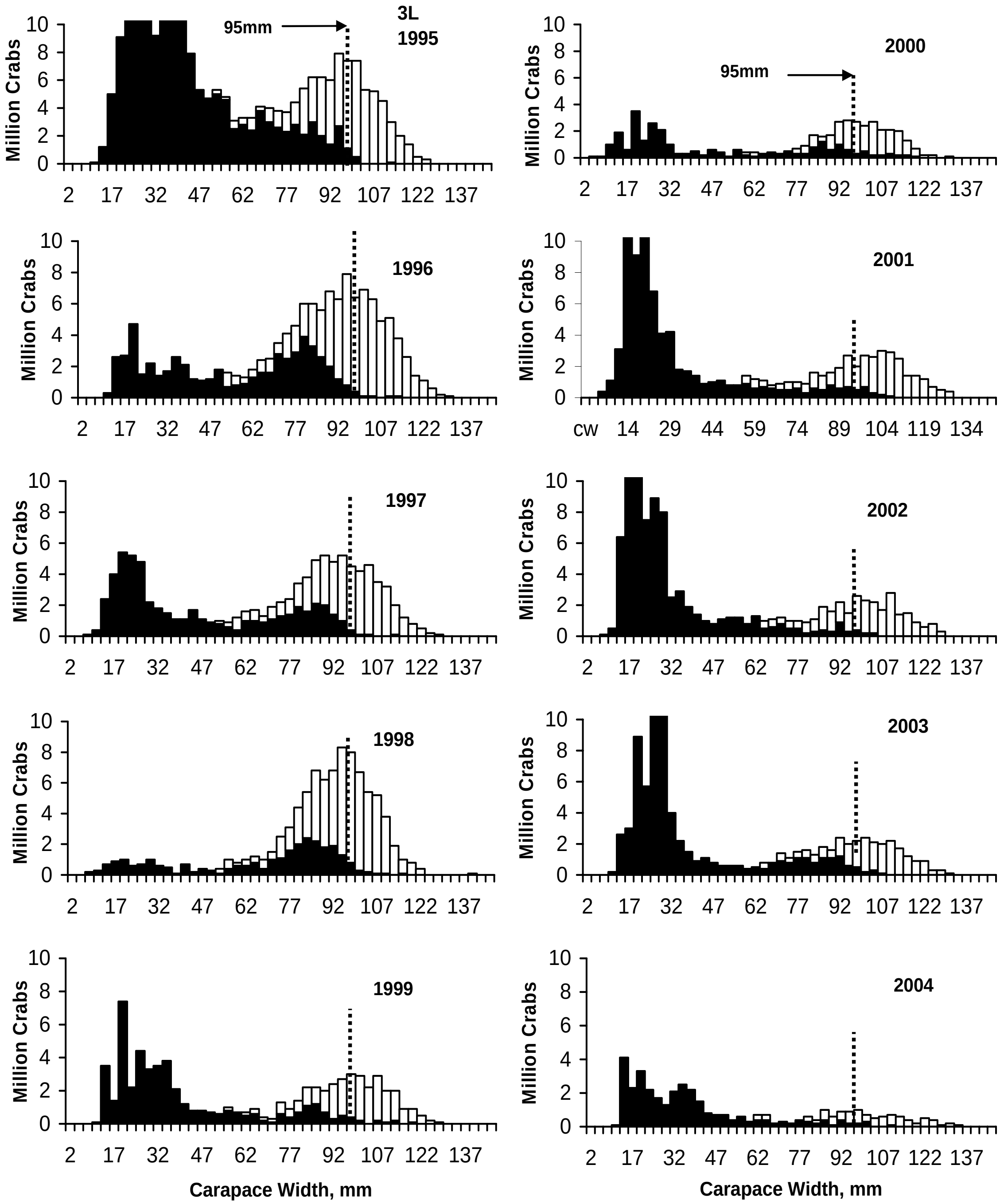

Figure 75. Truncated distribution of abundance (index) by carapace width for Division 3L juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

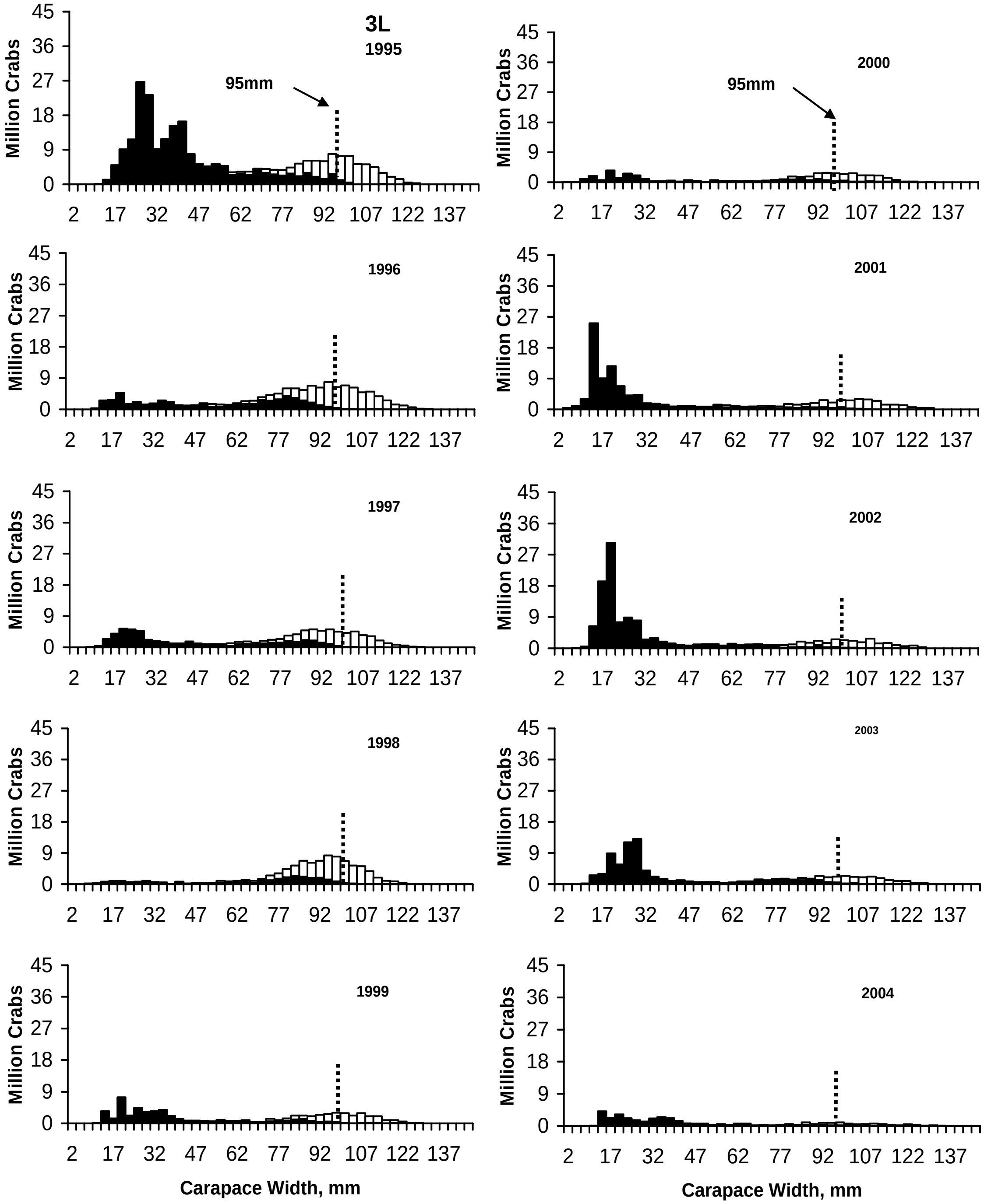

Figure 76. Distribution of abundance (index) by carapace width for Division 3L juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

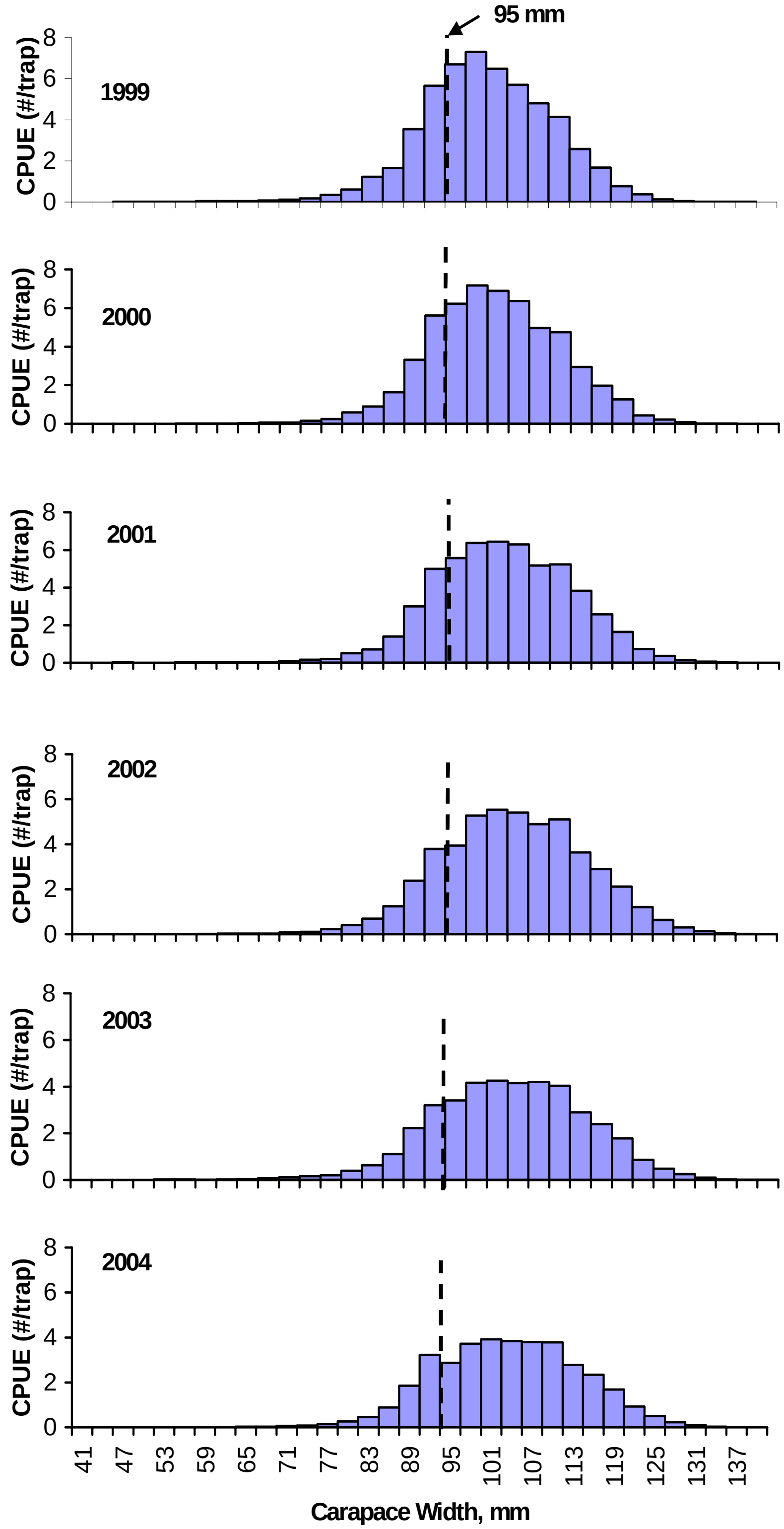

Figure 77. Annual trend in male carapace width distributions from observer at-sea sampling for Division 3L.

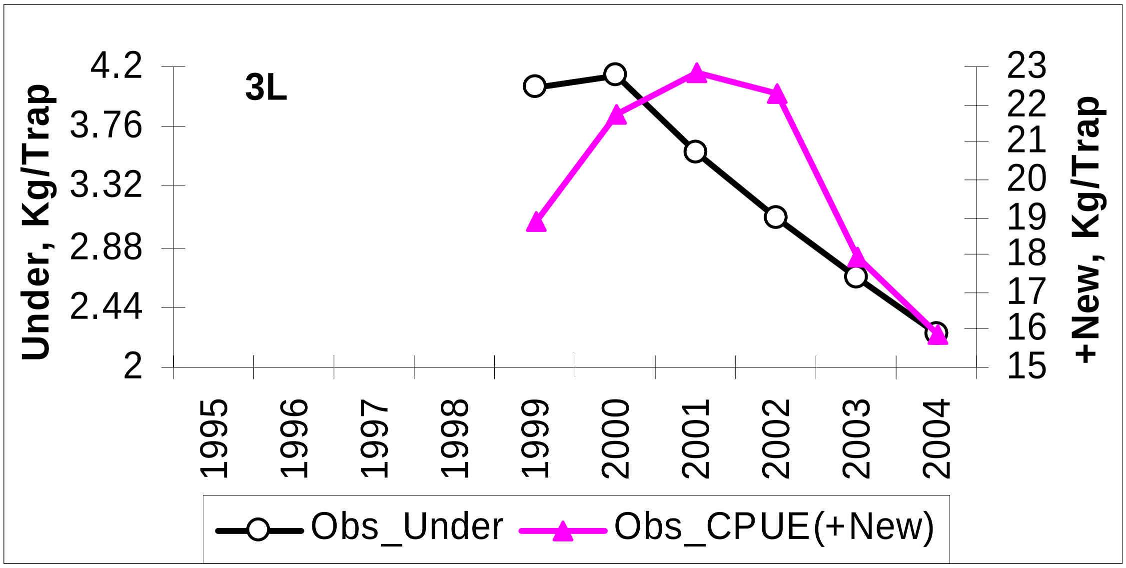

Figure 78. Annual trends in Division 3L observer-based CPUE of all legal-sized males, including new-shelled, from biological sampling, versus catch rates of sub-legal sized (under-sized) crabs.

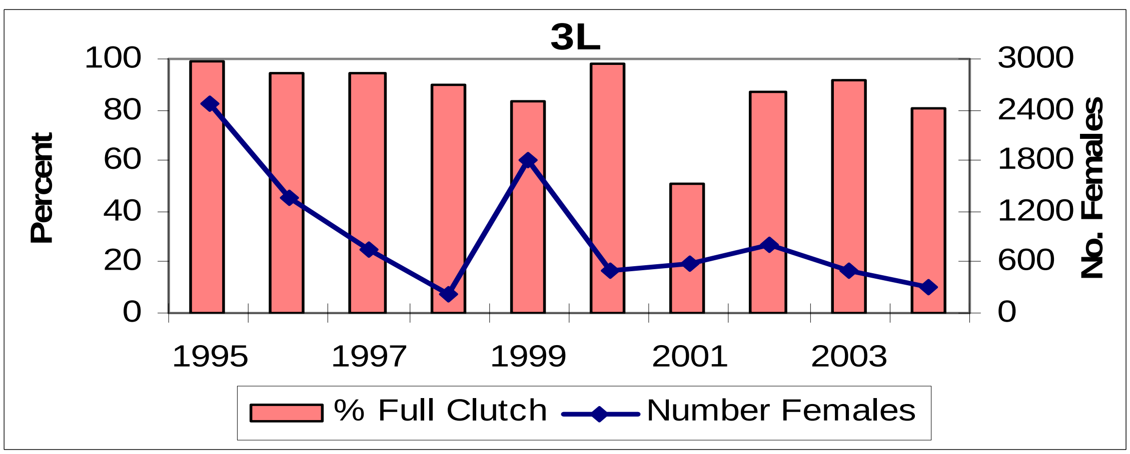

Figure 79. Annual trend in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3L from fall multi-species surveys.

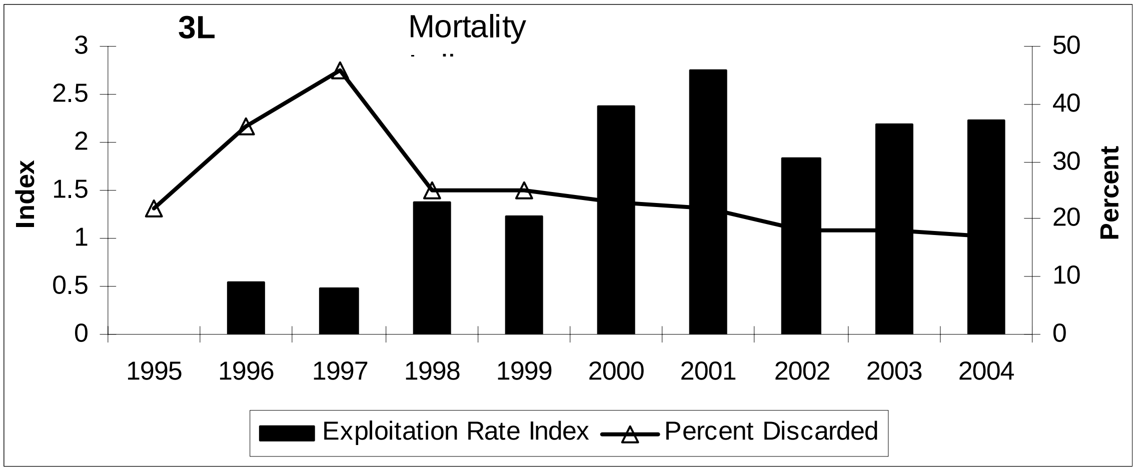

Figure 80. Annual trends in two Division 3L mortality indices.

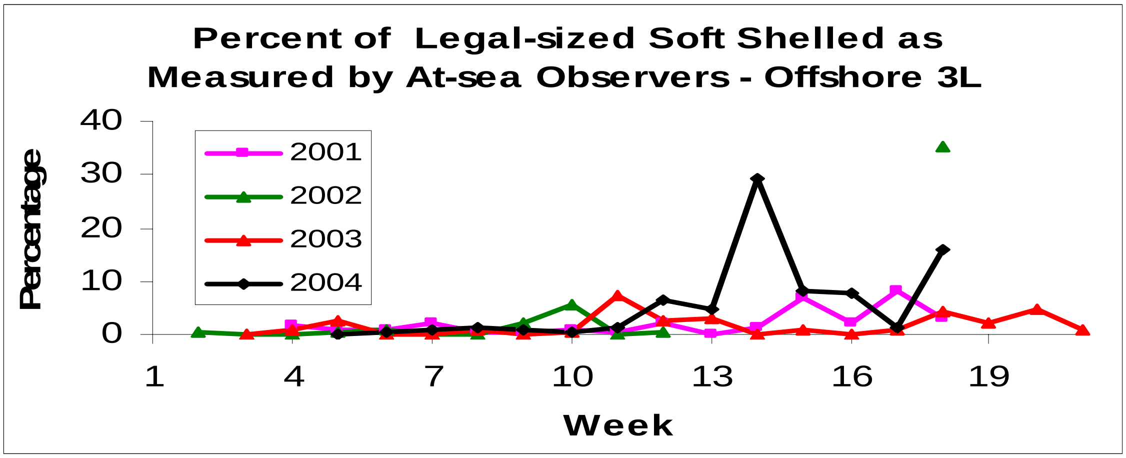

Figure 81. Seasonal trend (from April 01) in the percentage of legal-sized crabs that are soft-shelled by year (2001-04), from at-sea sampling by observers in Division 3L.

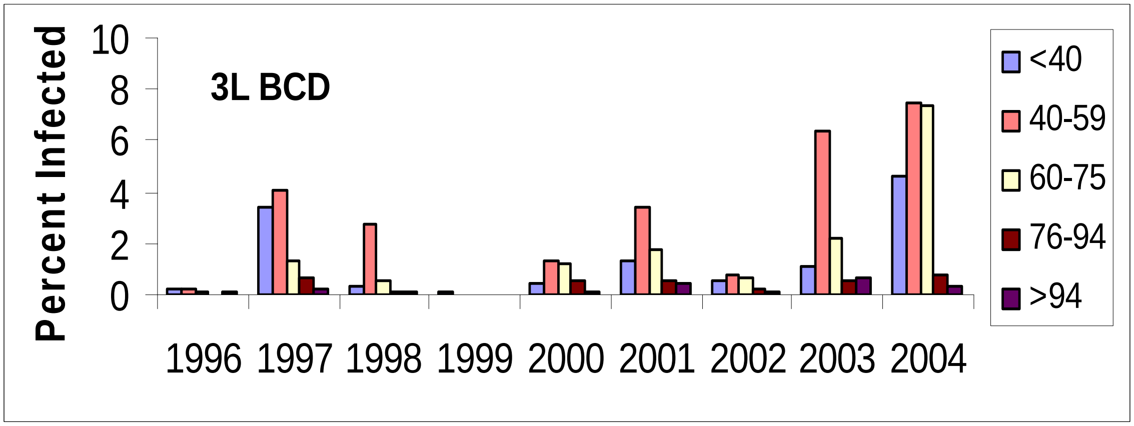

Figure 82. Annual trends in prevalence of BCD in Division 3L by male size group from fall multi-species surveys.

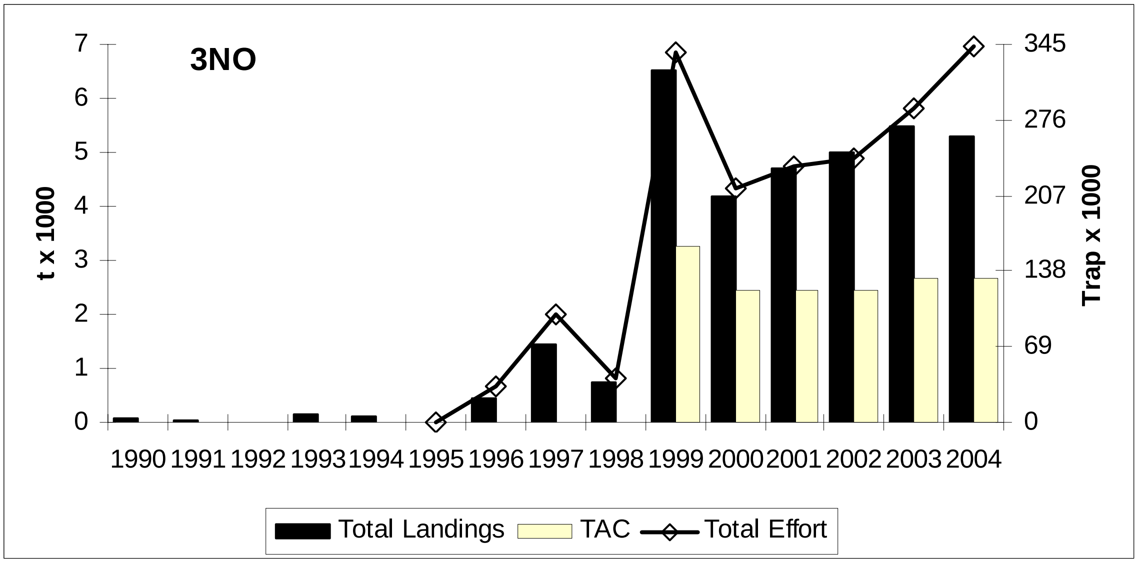

Figure 83. Annual trends in Division 3NO Landings, TAC and fishing effort.

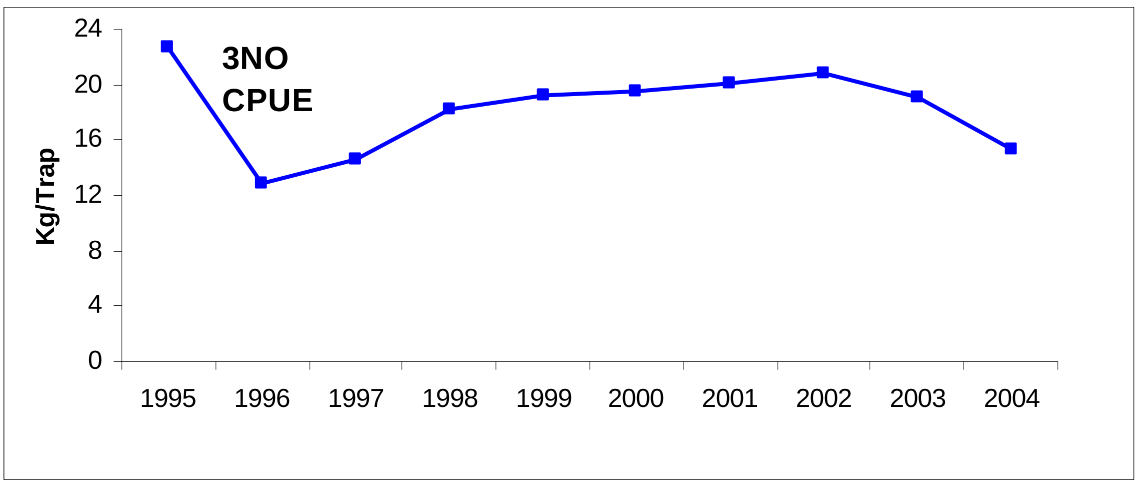

Figure 84. Annual trend in Division 3NO commercial CPUE.

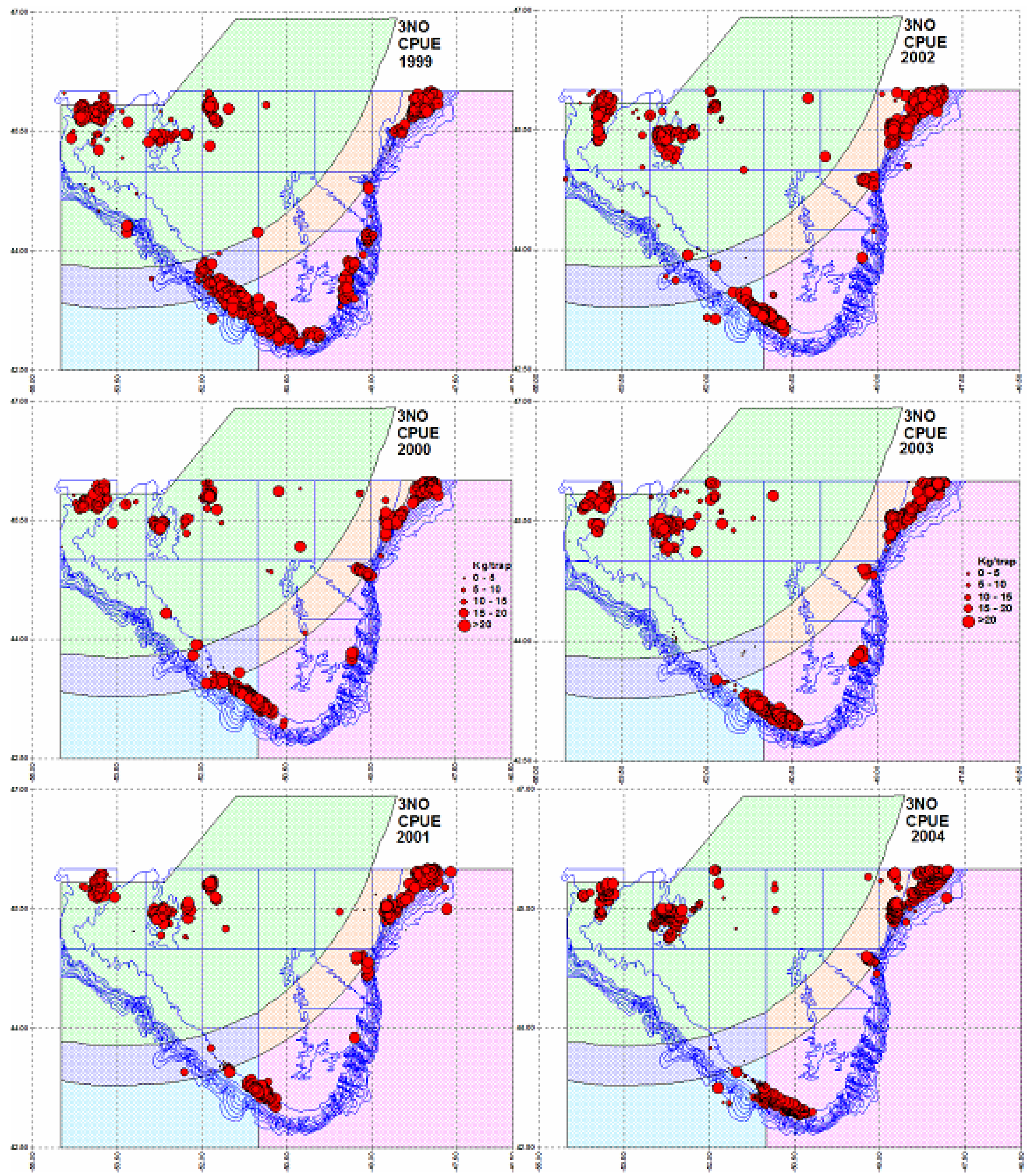

Figure 85. Spatial distribution of Division 3NO commercial CPUE for 1999-2004.

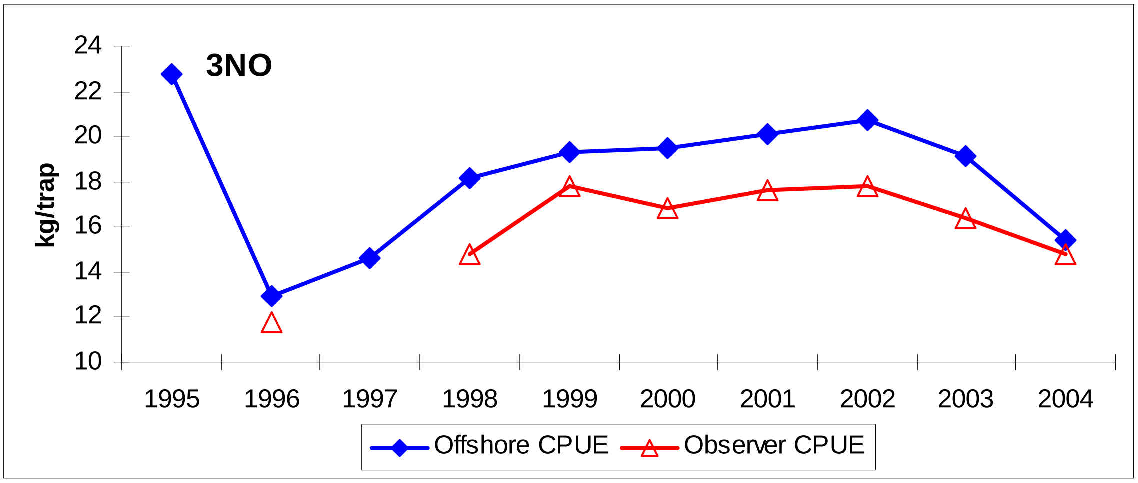

Figure 86. Annual trends in logbook- based offshore CPUE vs. observer - based CPUE in the Division 3NO fishery.

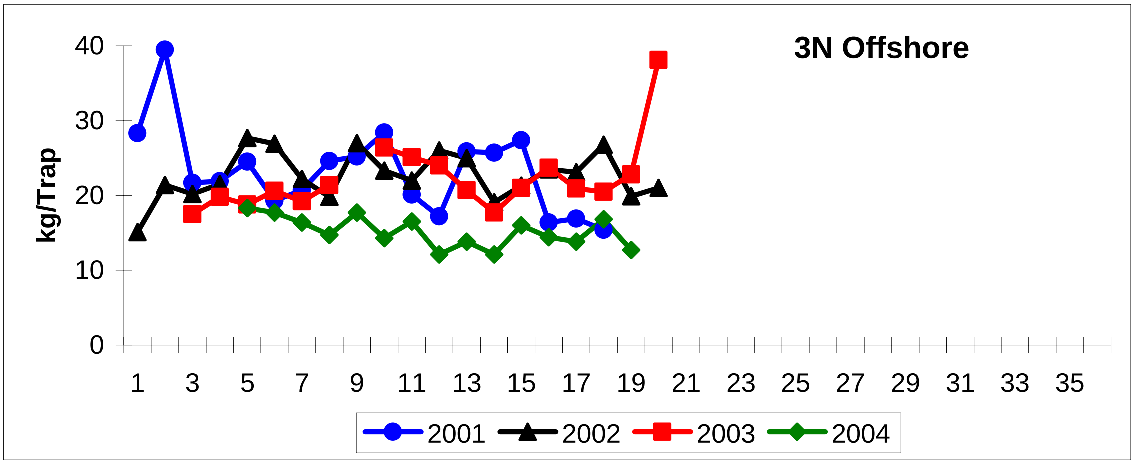

Figure 87. Seasonal trends in CPUE by week, for recent years for offshore Division 3N in recent years.

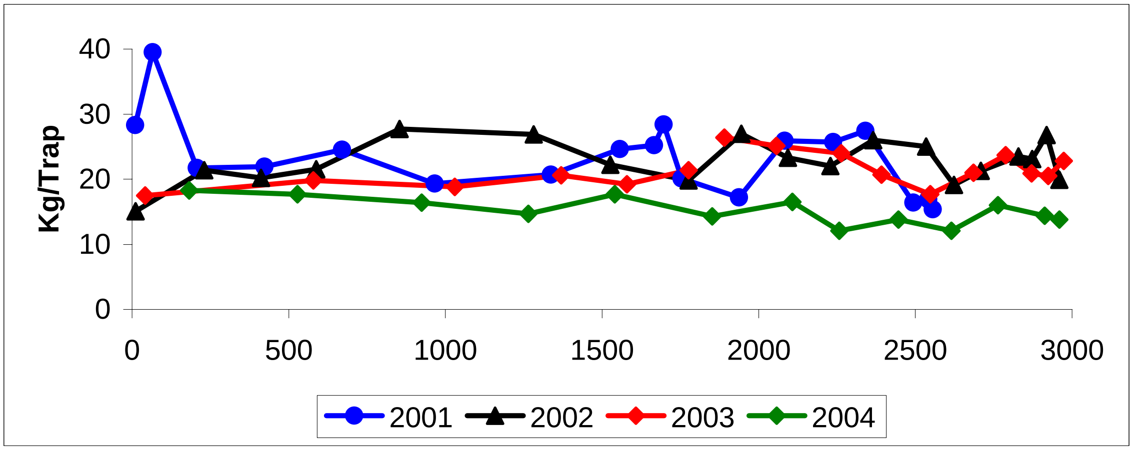

Figure 88. Seasonal trends in CPUE by cumulative catch for offshore Division 3N in recent years.

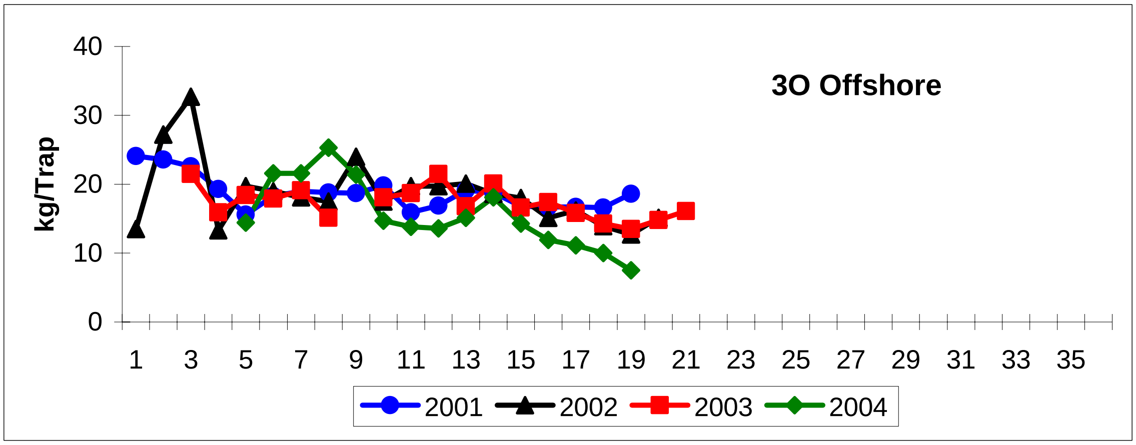

Figure 89. Seasonal trends in CPUE by week for offshore Division 3O in recent years.

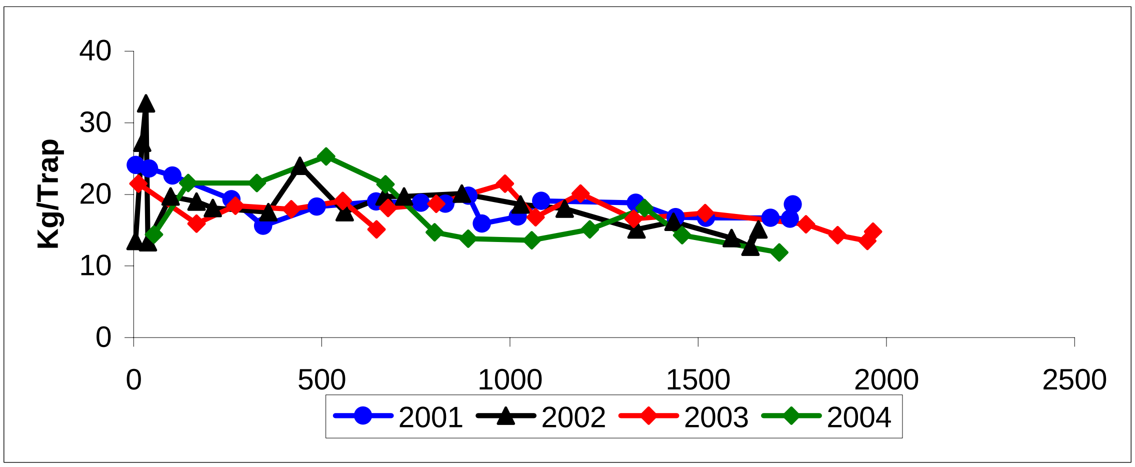

Figure 90. Seasonal trends in CPUE by cumulative catch for offshore Division 3O in recent years.

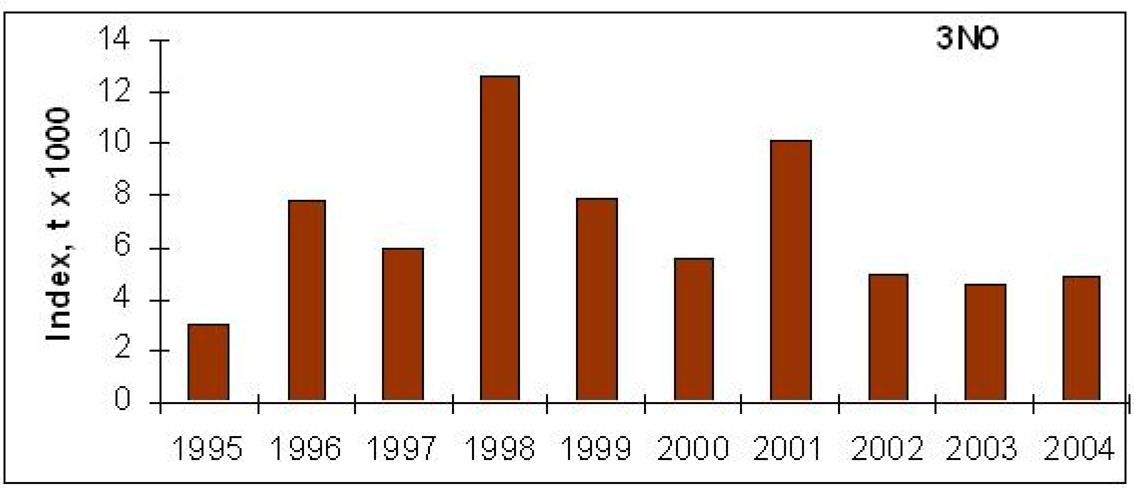

Figure 91. Annual trend in the Division 3NO fall multi-species survey exploitable biomass index.

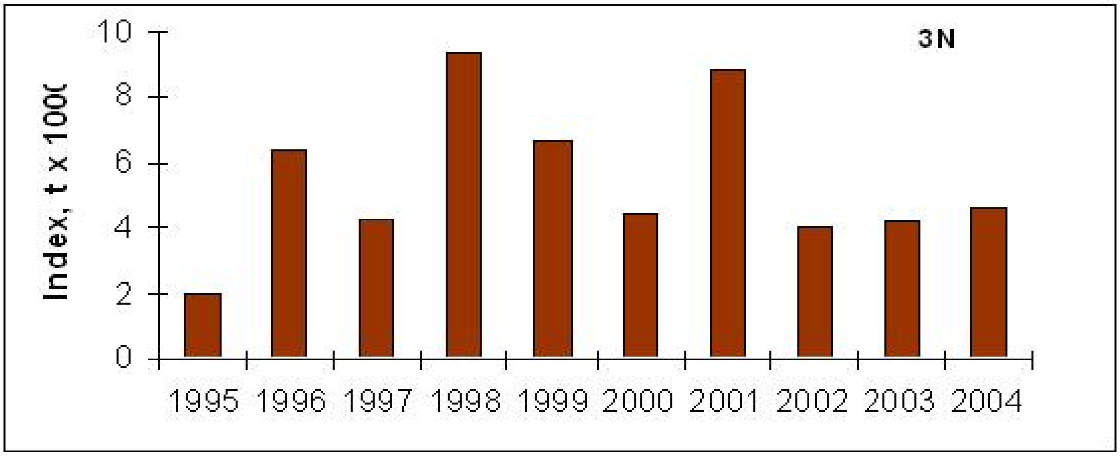

Figure 92. Annual trend in the Division 3N fall multi-species survey exploitable biomass index.

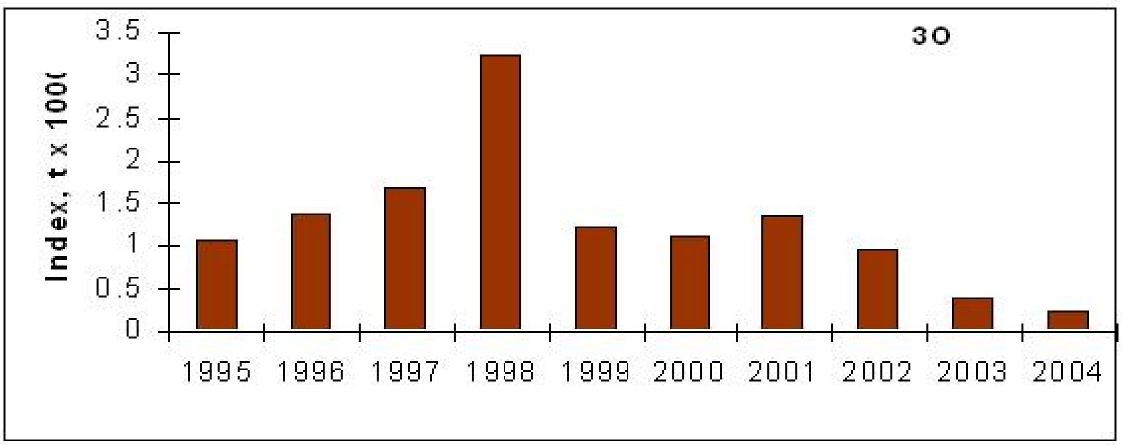

Figure 93. Annual trend in the Division 3O fall multi-species survey exploitable biomass index.

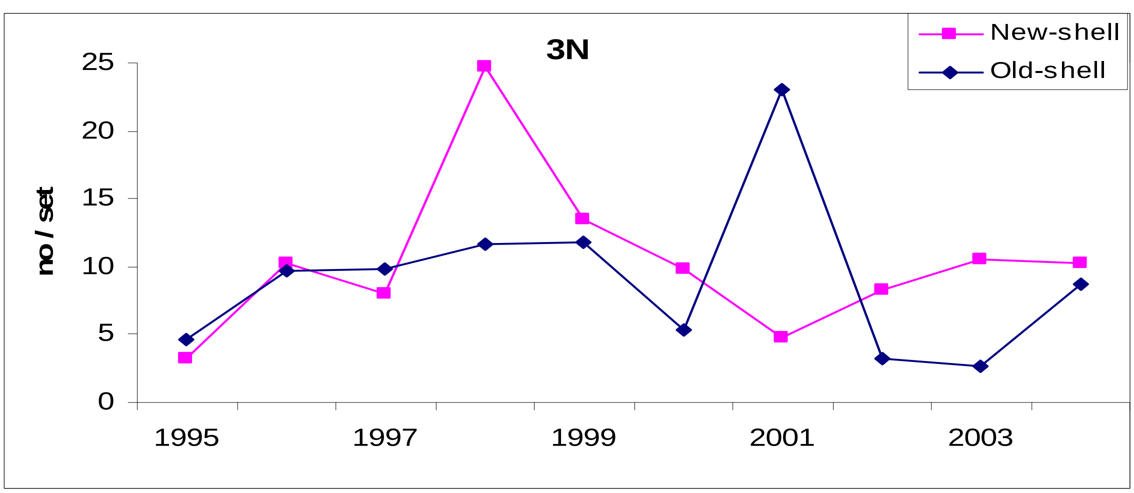

Figure 94. Annual trends, by shell condition, in abundance indices of legal-sized males for Division 3N from fall multi-species surveys.

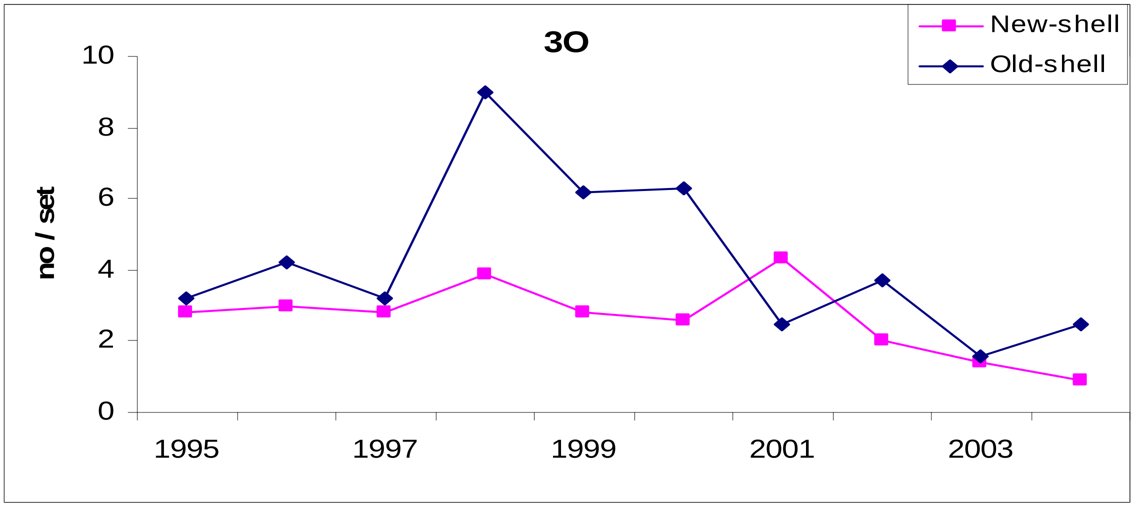

Figure 95. Annual trends, by shell condition, in abundance indices of legal-sized males for Division 3O from fall multi-species surveys.

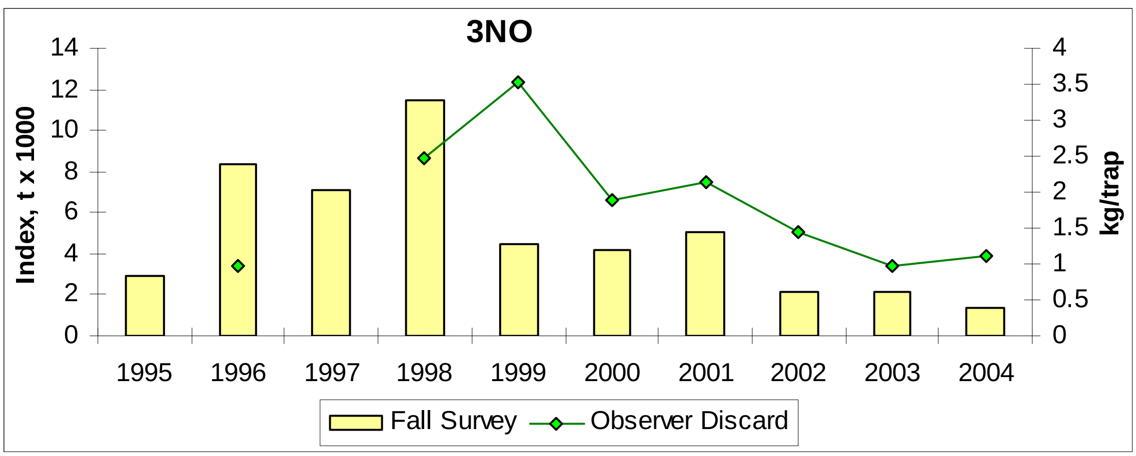

Figure 96. Annual trends in the Division 3NO fall multi-species survey pre-recruit biomass index and the observer discard pre-recruit index.

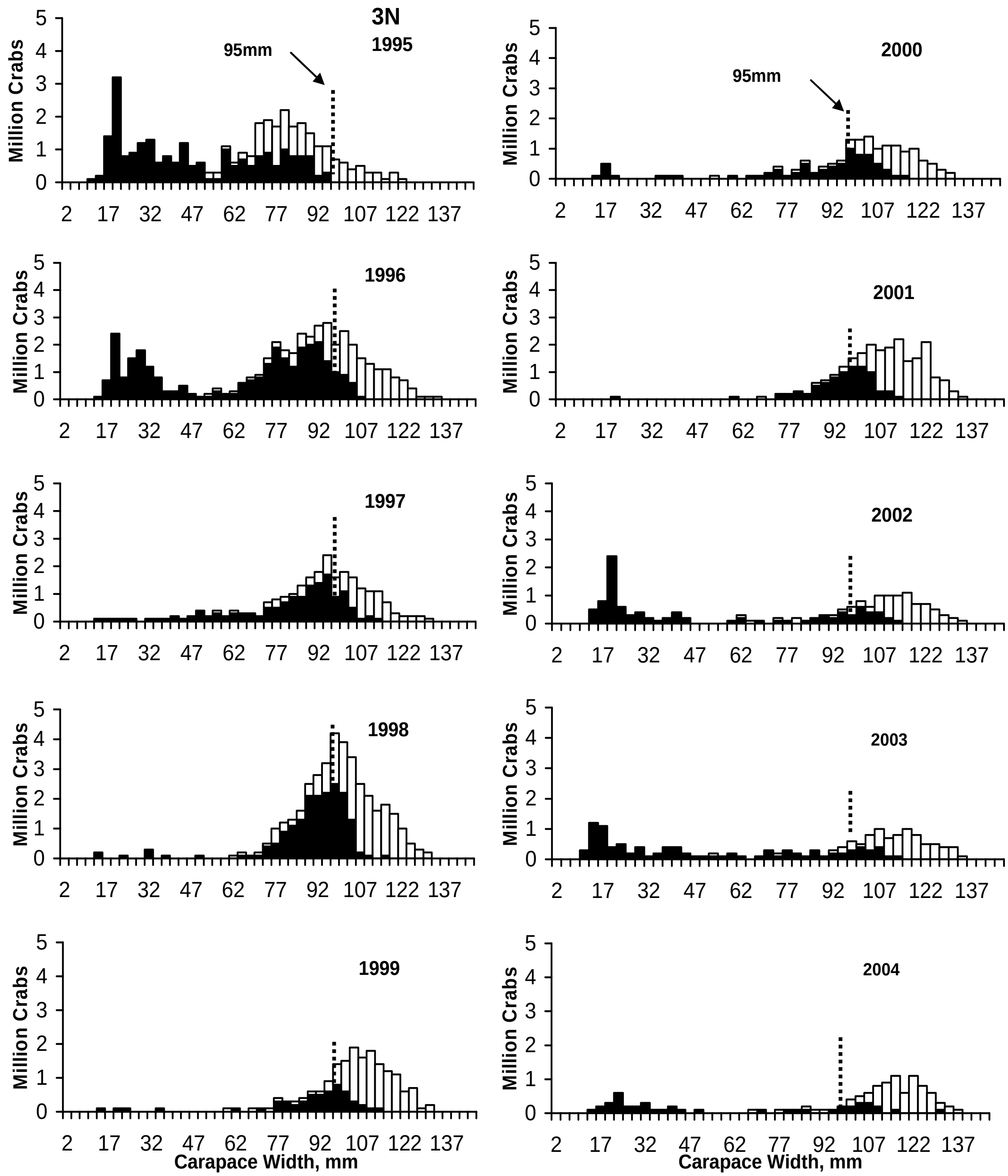

Figure 97. Distribution of abundance (index) by carapace width for Division 3N juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

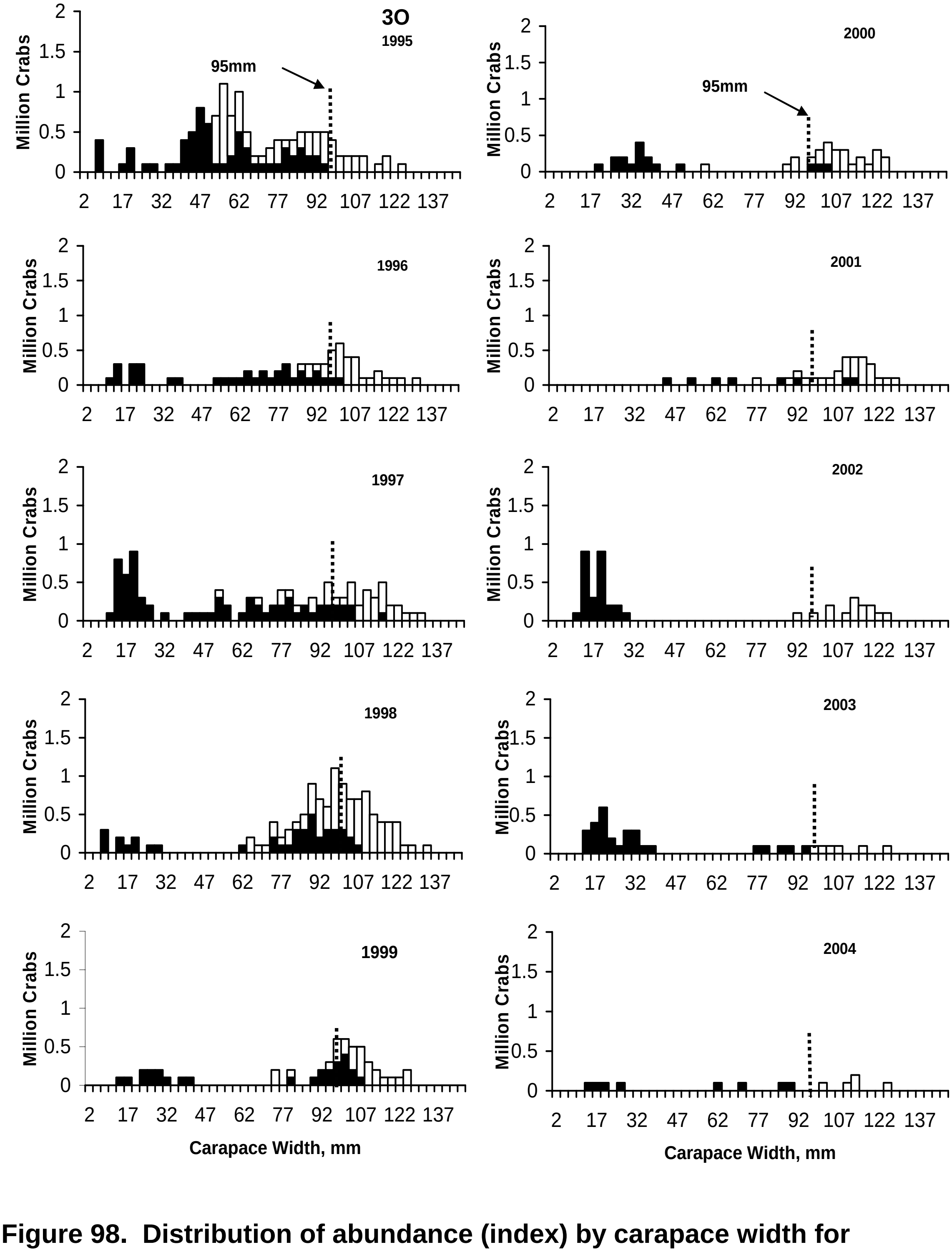

Figure 98. Distribution of abundance (index) by carapace width for Division 3O juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

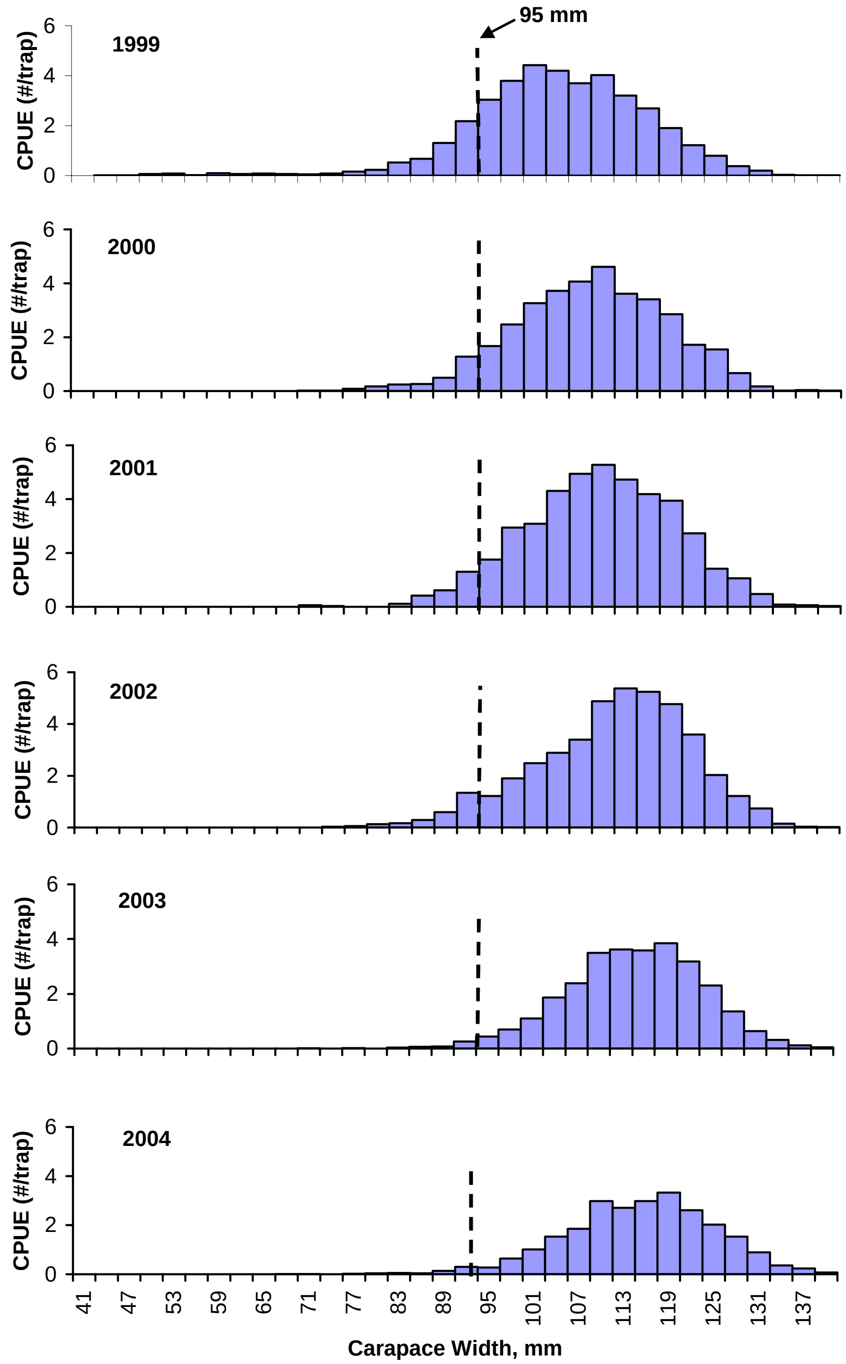

Figure 99. Annual trend in male carapace width distributions from observer at-sea sampling for Division 3N.

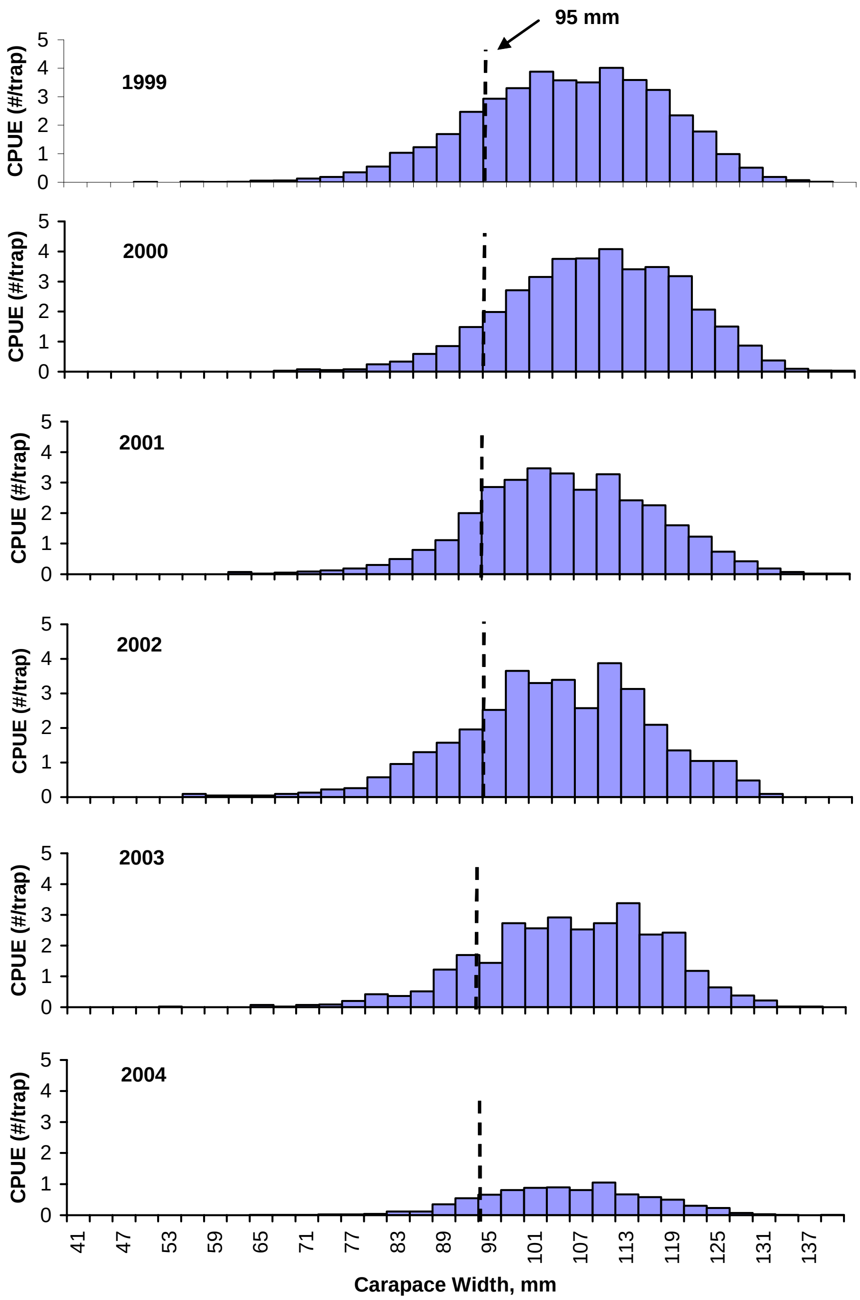

Figure 100. Annual trend in male carapace width distributions from observer at-sea sampling for Division 3O.

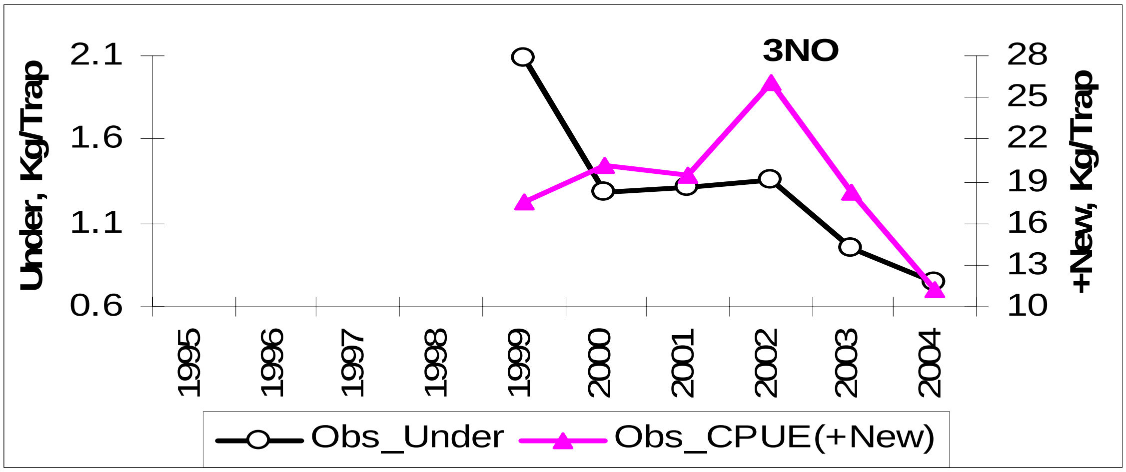

Figure 101. Annual trends in observer-based CPUE of all legal-sized males, including new-shelled, from biological sampling, versus catch rates of sub-legal sized (under-sized) males for Division 3NO.

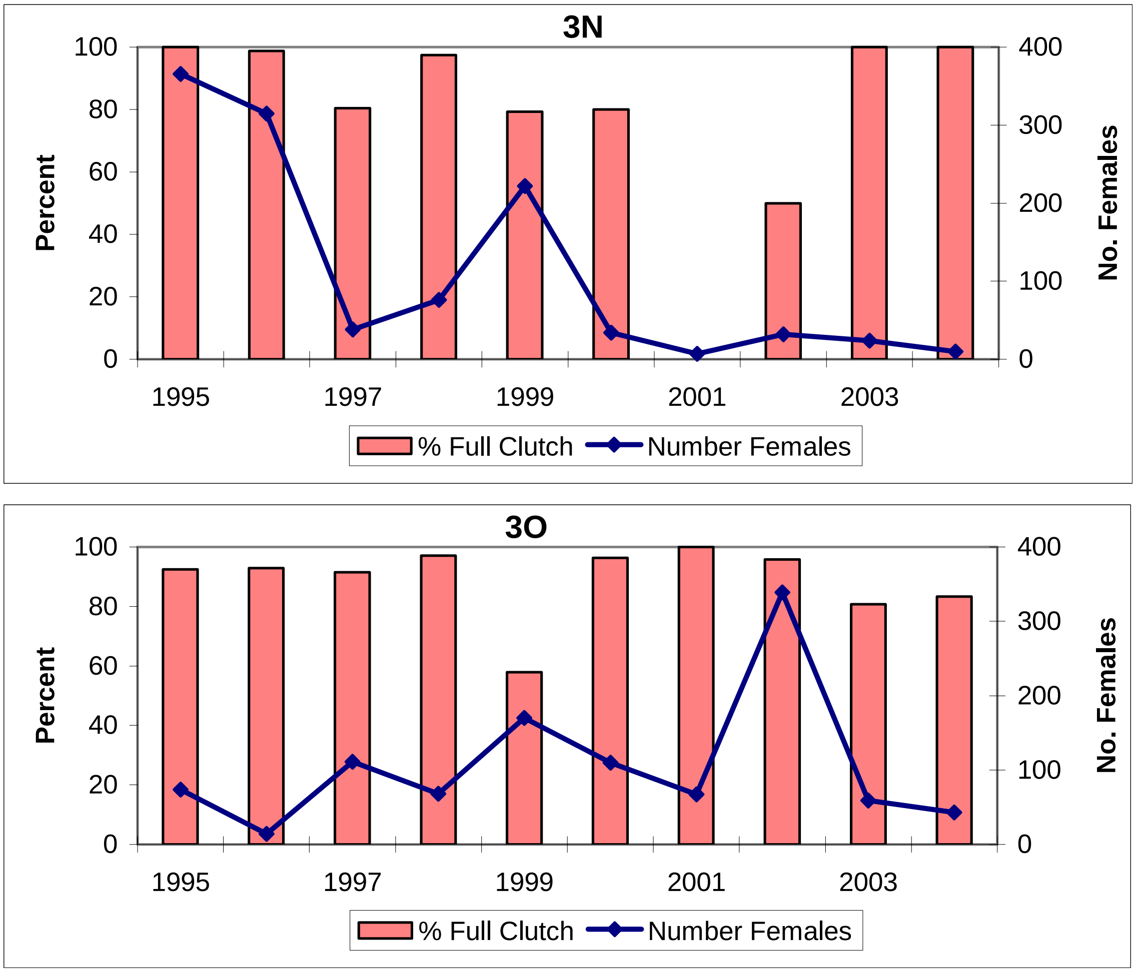

Figure 102. Annual trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3N and 3O from fall multi-species surveys.

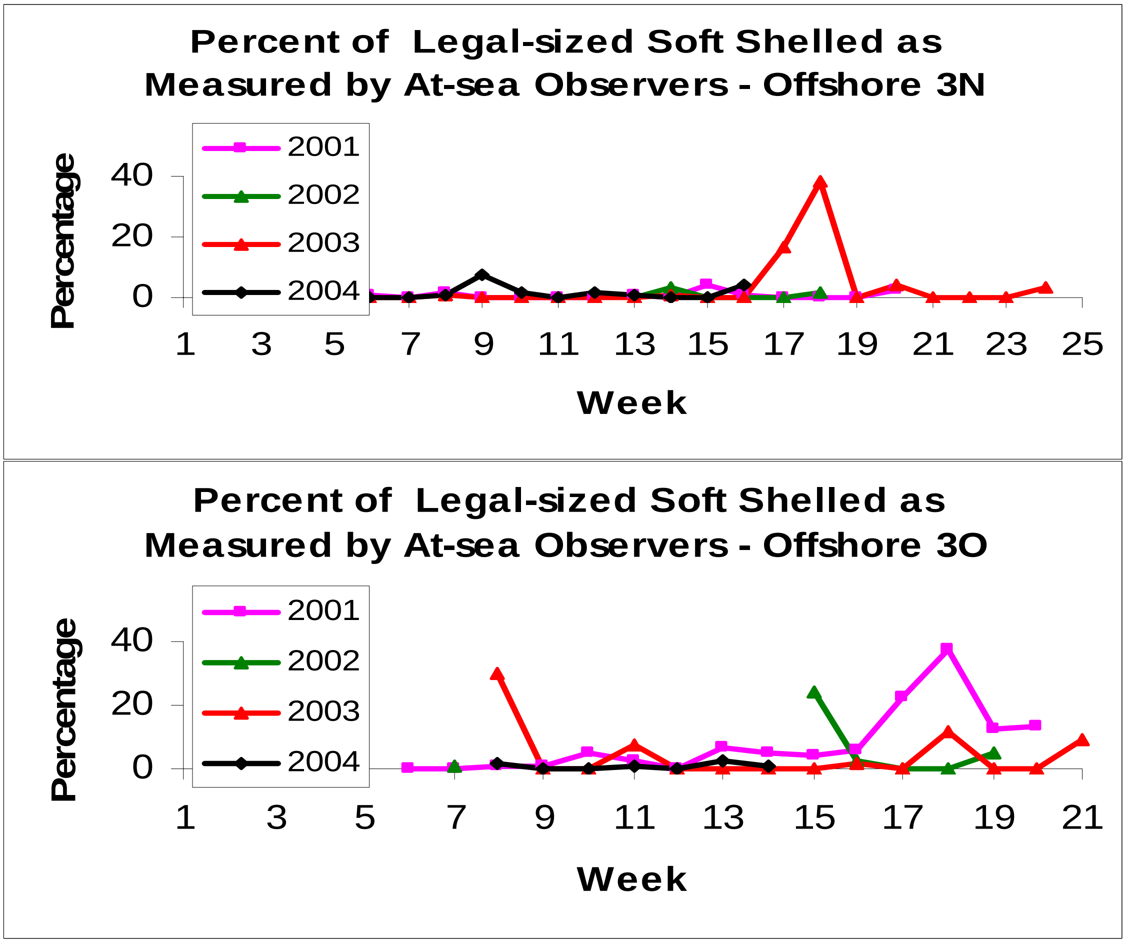

Figure 103. Seasonal trend (from April 1) in the percentage of legal-sized crabs that are soft-shelled by year (2001-04), from at-sea sampling by observers in Division 3N and 3O.

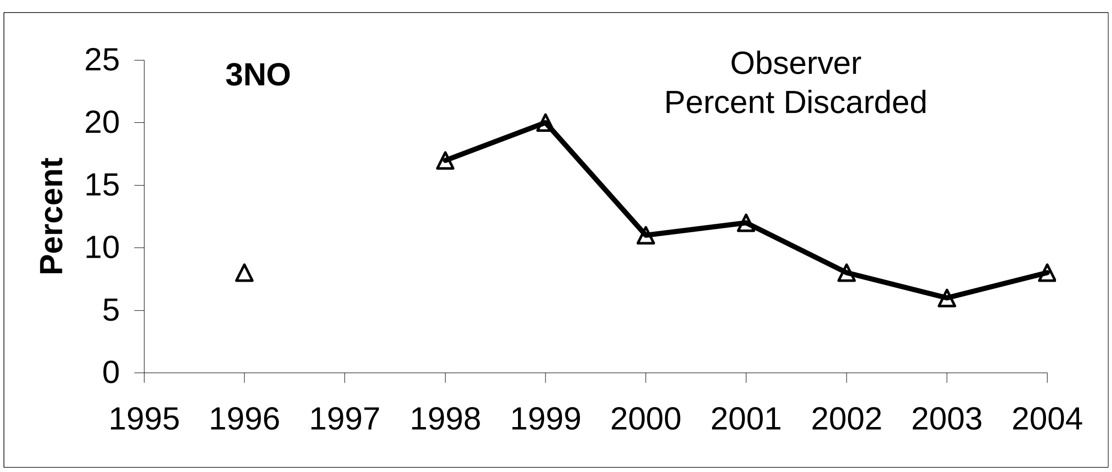

Figure 104. Annual trend in observer percent discarded in the Division 3NO fishery.

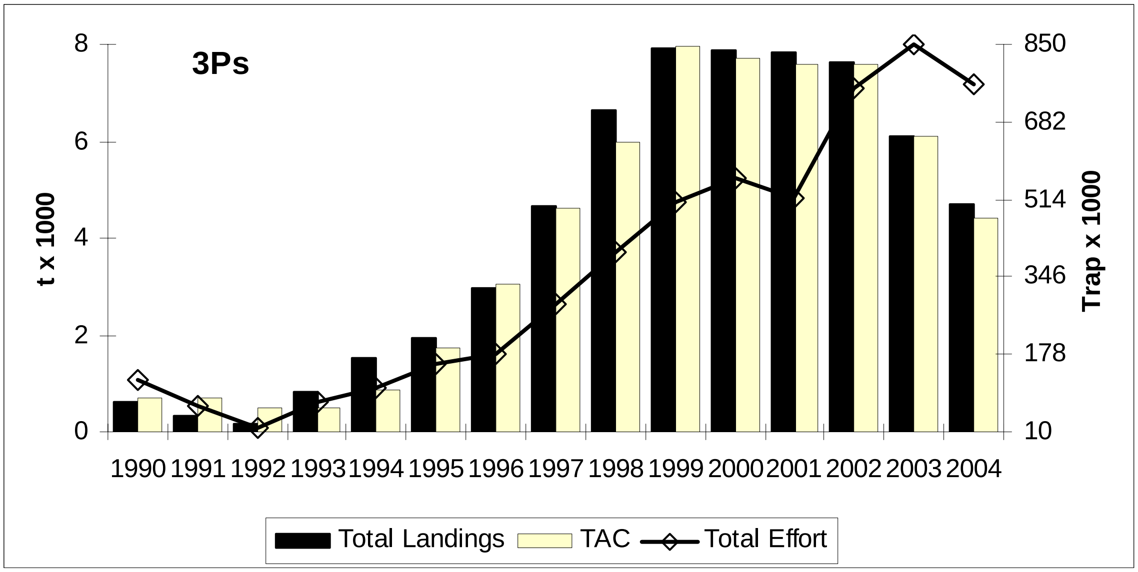

Figure 105. Annual trends in Subdiv. 3Ps landings, TAC and fishing effort.

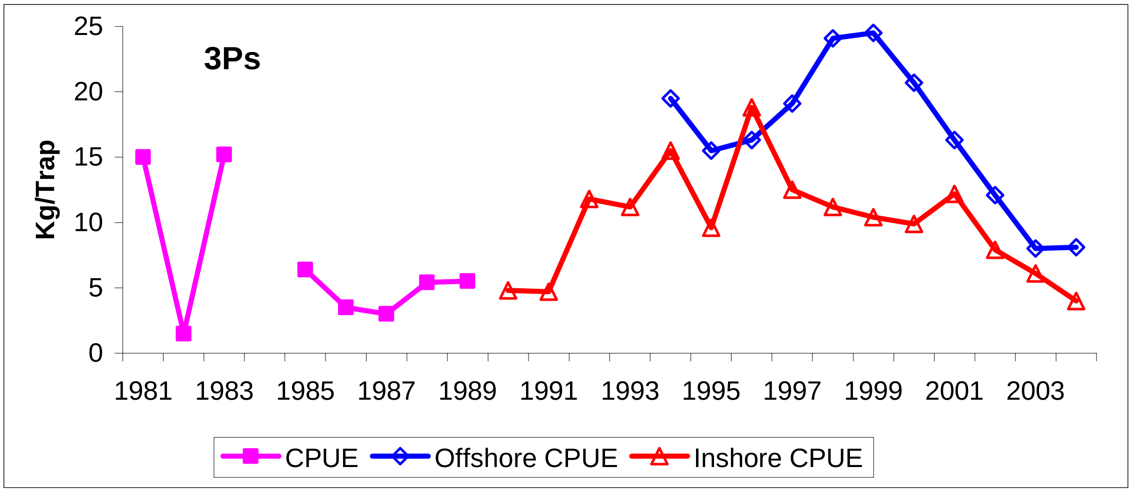

Figure 106. Annual trends in Subdivision 3Ps commercial CPUE.

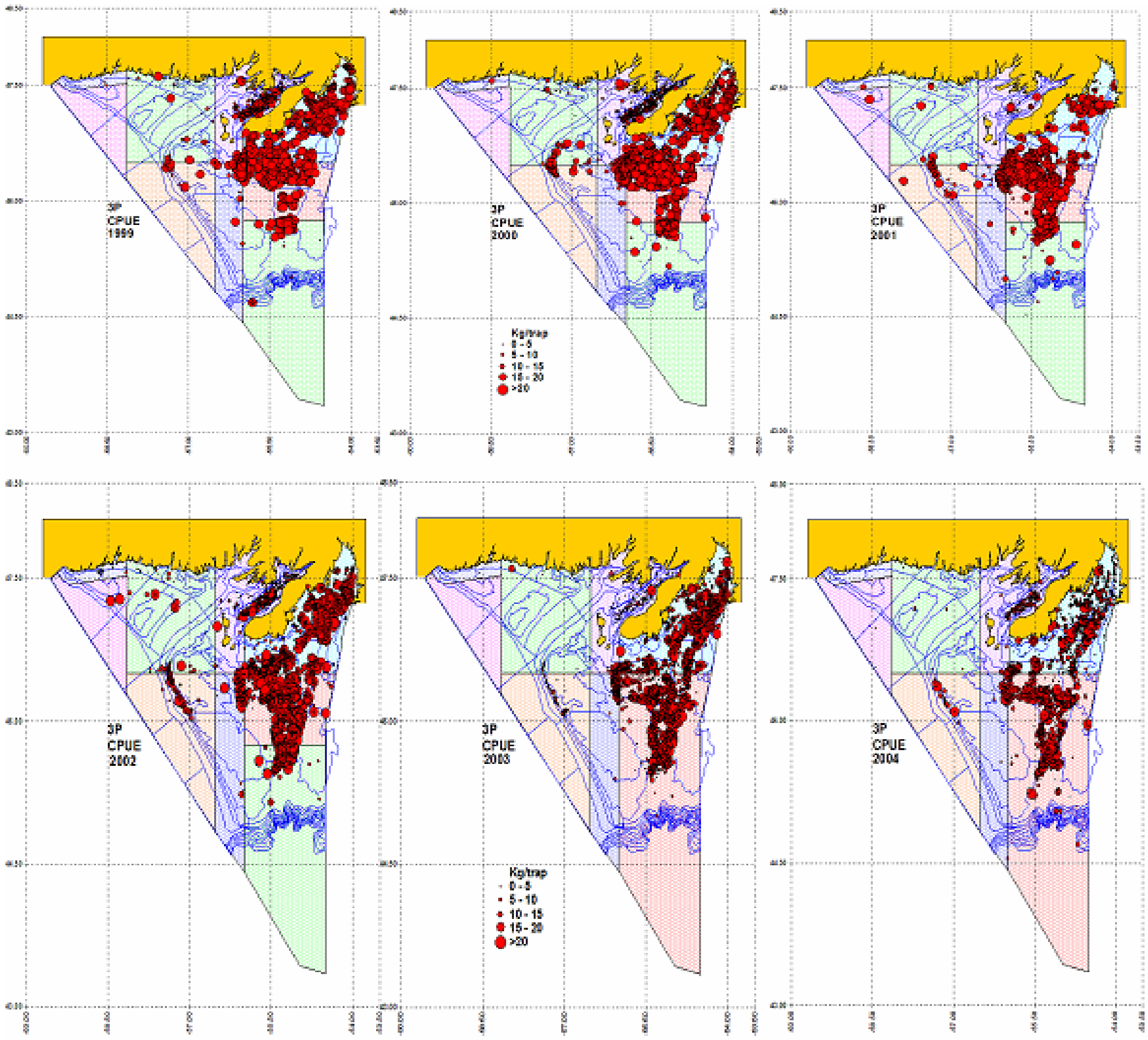

Figure 107. Spatial distribution of Subdivsion 3Ps commercial CPUE for 1999-2004.

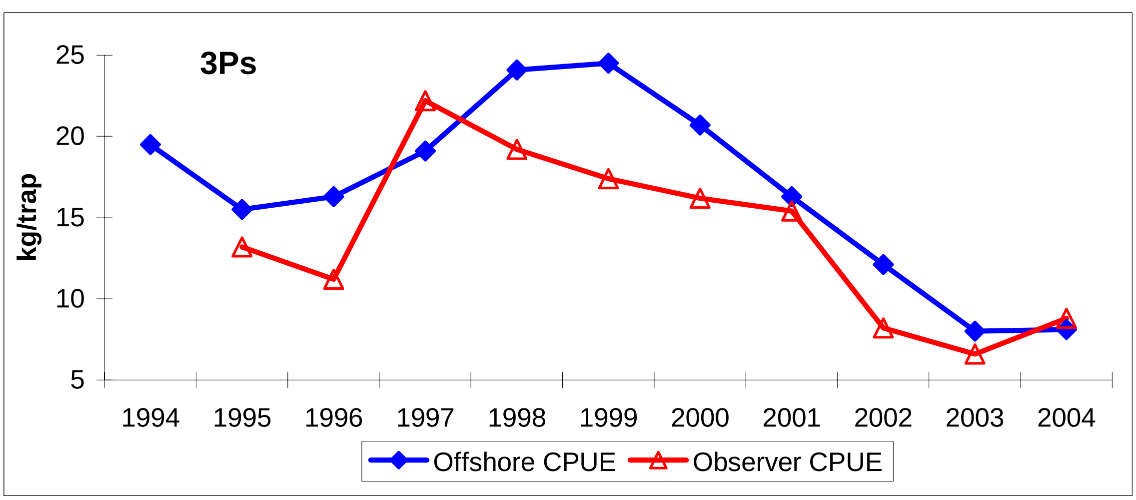

Figure 108. Annual trends in logbook- based offshore CPUE vs. observer - based CPUE in the Subdivision 3Ps fishery.

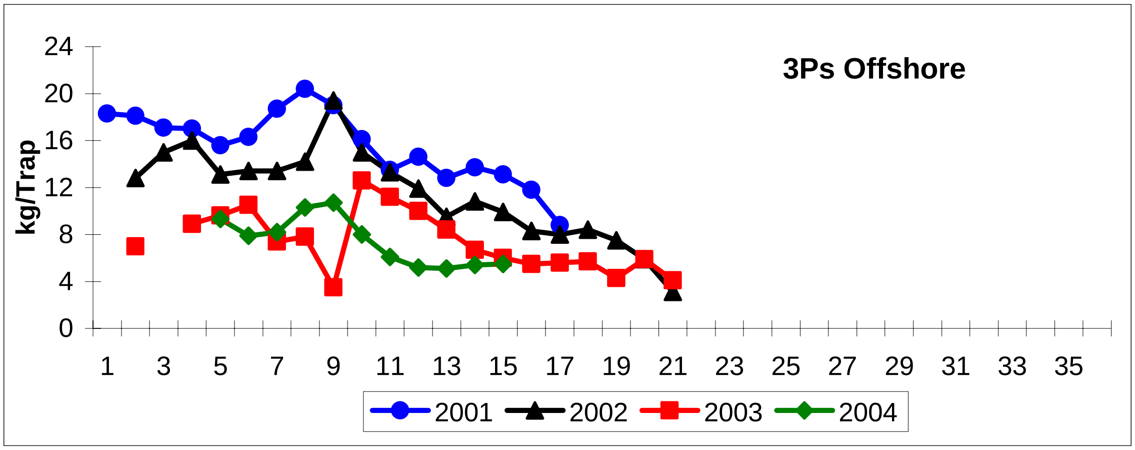

Figure 109. Seasonal trends in CPUE by week for offshore Subdivision 3Ps in recent years.

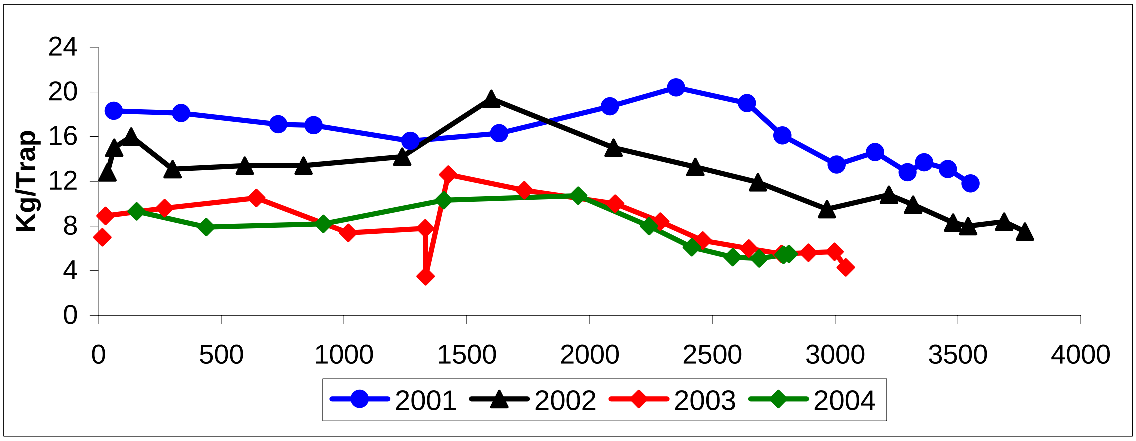

Figure 110. Seasonal trends in CPUE by cumulative catch for offshore Subdivision 3Ps in recent years.

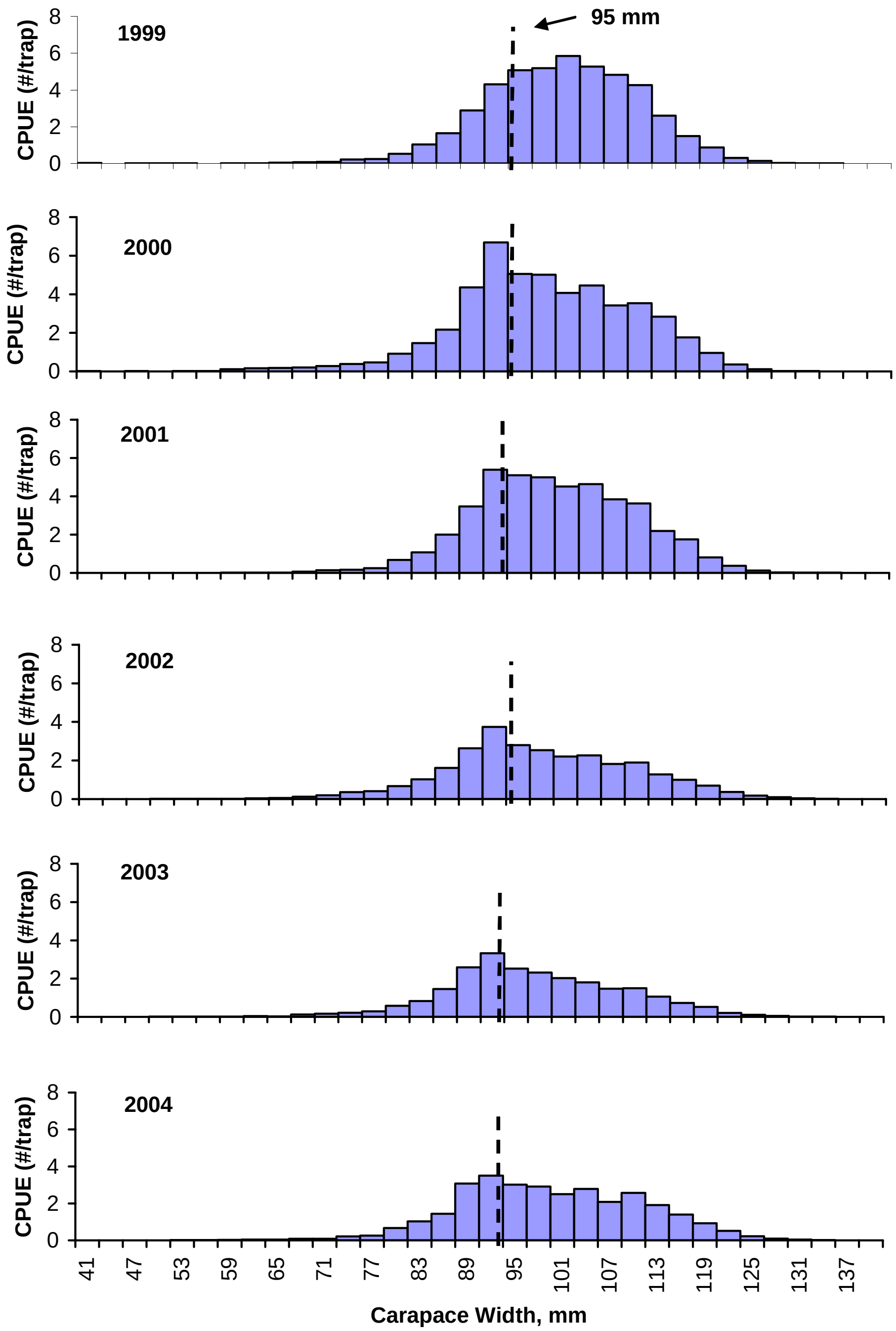

Figure 111. Annual trend in male carapace width distributions from observer at-sea sampling for Subdivision 3Ps.

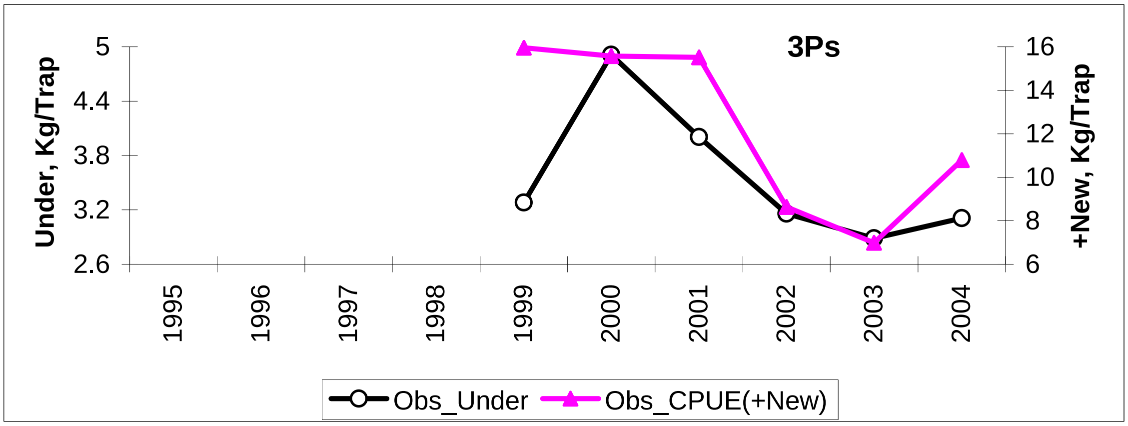

Figure 112. Annual trends in observer-based CPUE of all legal-sized males, including new-shelled, from biological sampling, versus catch rates of sub-legal sized (under-sized) males for Subdivision 3Ps.

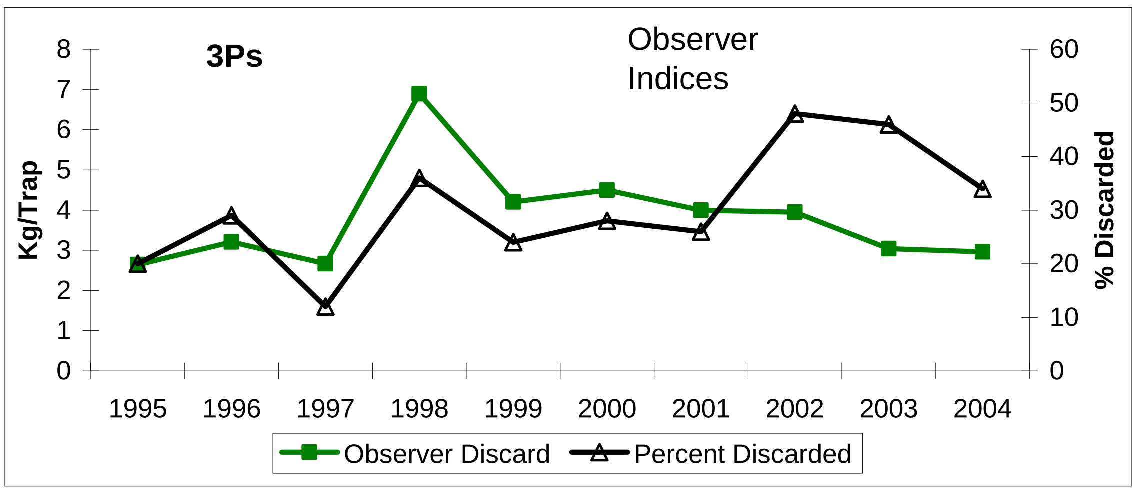

Figure 113. Annual trends in the Subdivision 3Ps observer discard pre-recruit index and percent discarded.

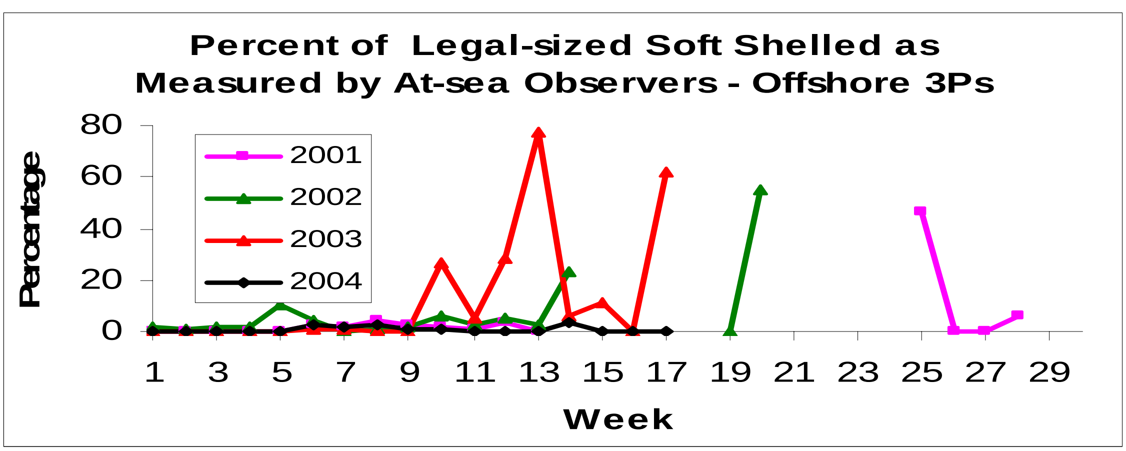

Figure 114. Seasonal trend (from April 01) in the percentage of legal-sized crabs that are soft-shelled by year (2001-04), from at-sea sampling by observers in Subdivision 3Ps.

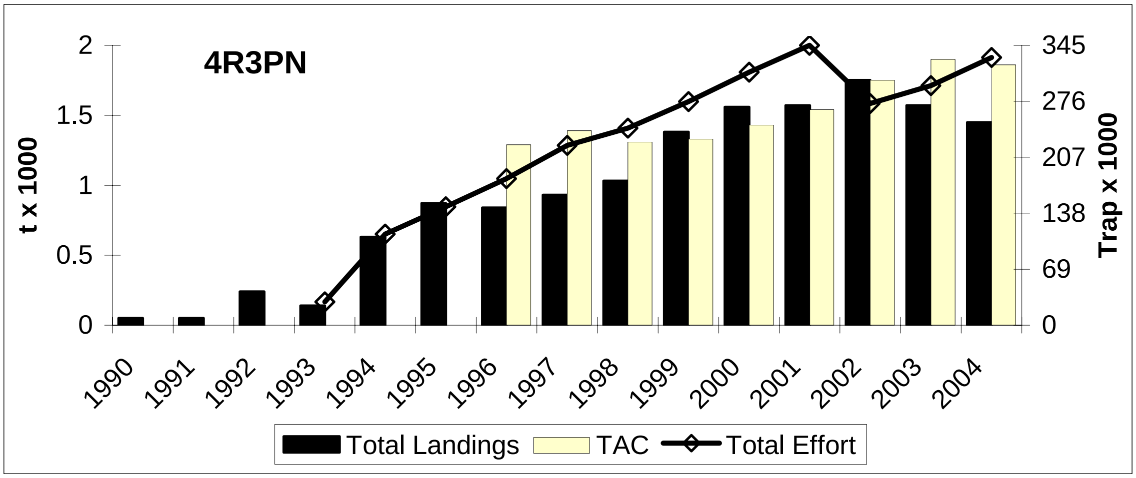

Figure 115. Annual trends in Division 4R and Subdivision 3Pn Landings, TAC and fishing effort.

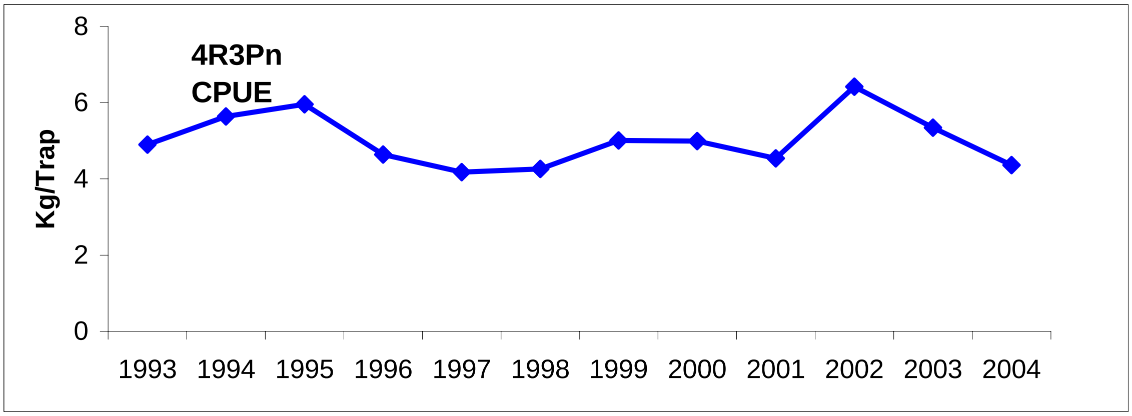

Figure 116. Annual trend in Division 4R and Subdivision 3Pn commercial CPUE.

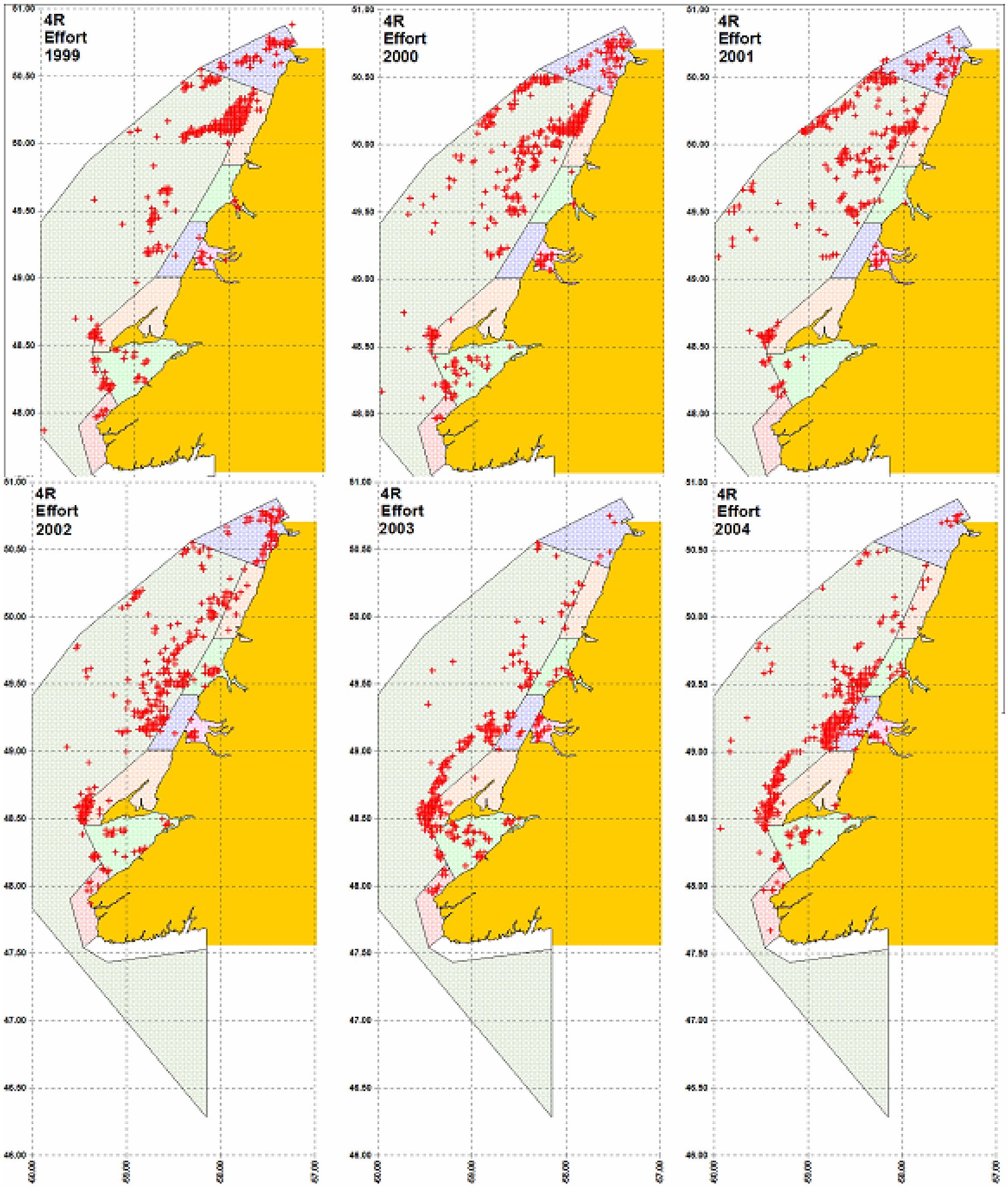

Figure 117. Division 4R and Subdivision 3Pn fishing effort distribution for 1999-2004.

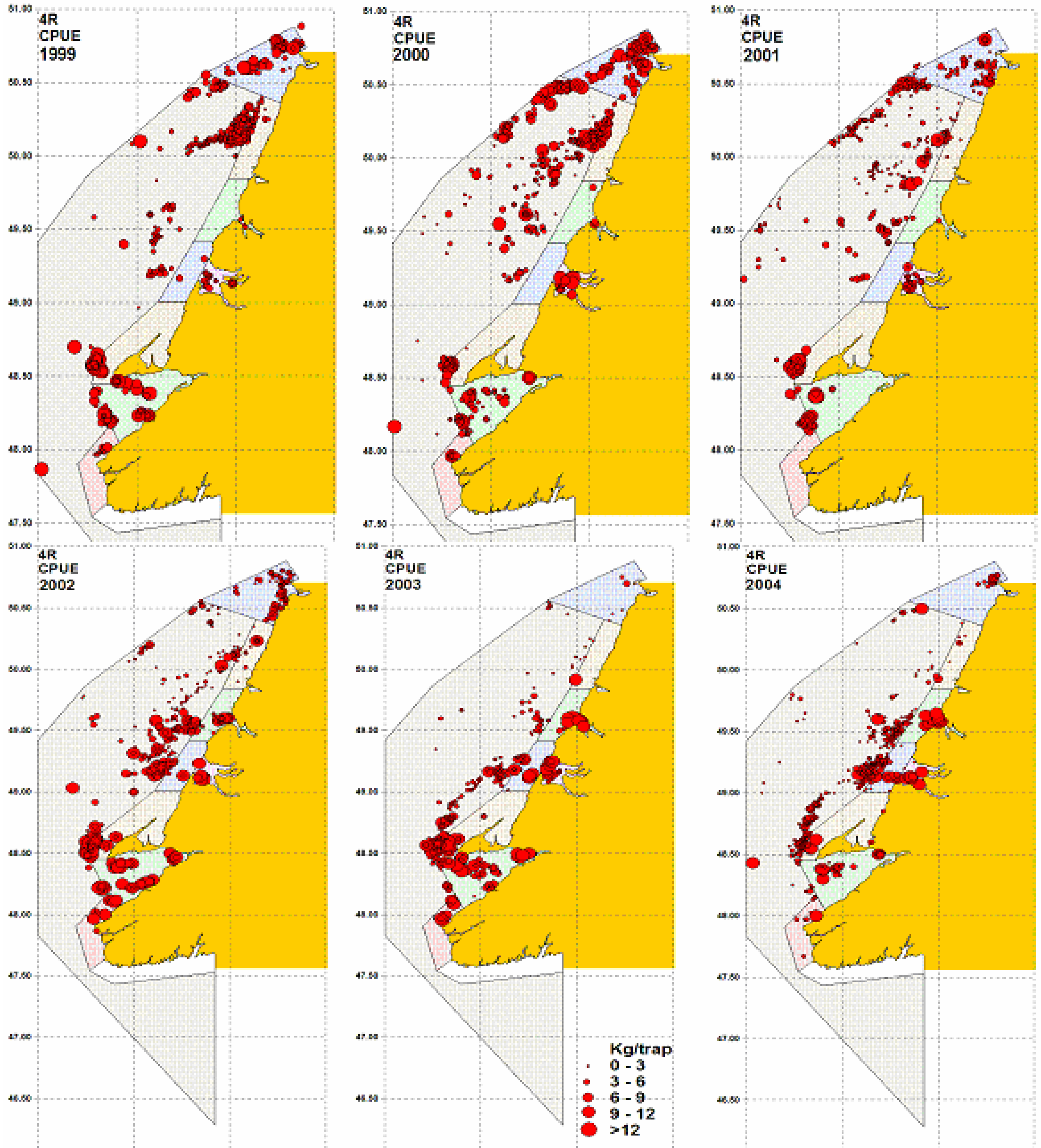

Figure 118. Spatial distribution of Division 4R commercial CPUE for 1999-2004.

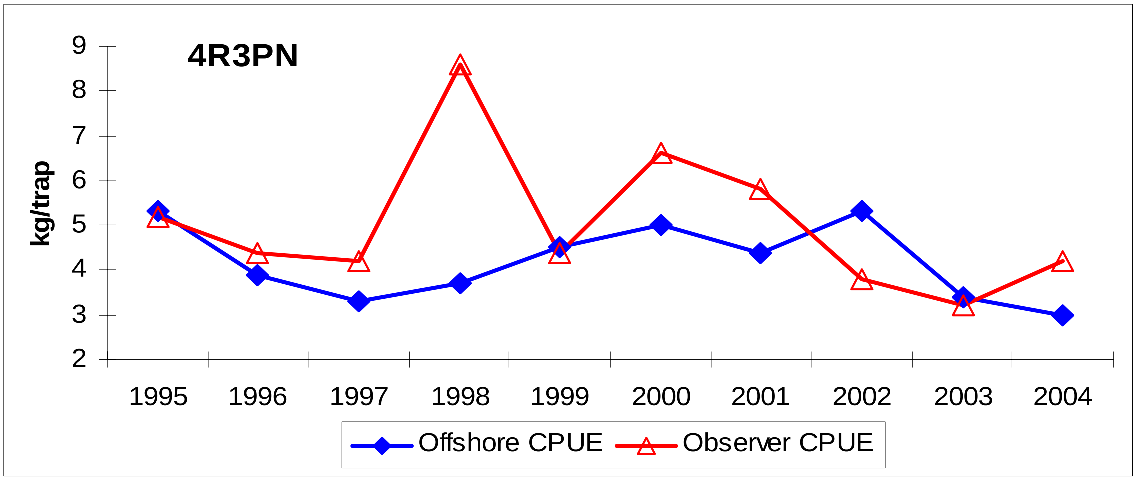

Figure 119. Annual trends in logbook- based offshore CPUE vs. observer - based CPUE in the Division 4R and Subdivision 3Pn fishery.

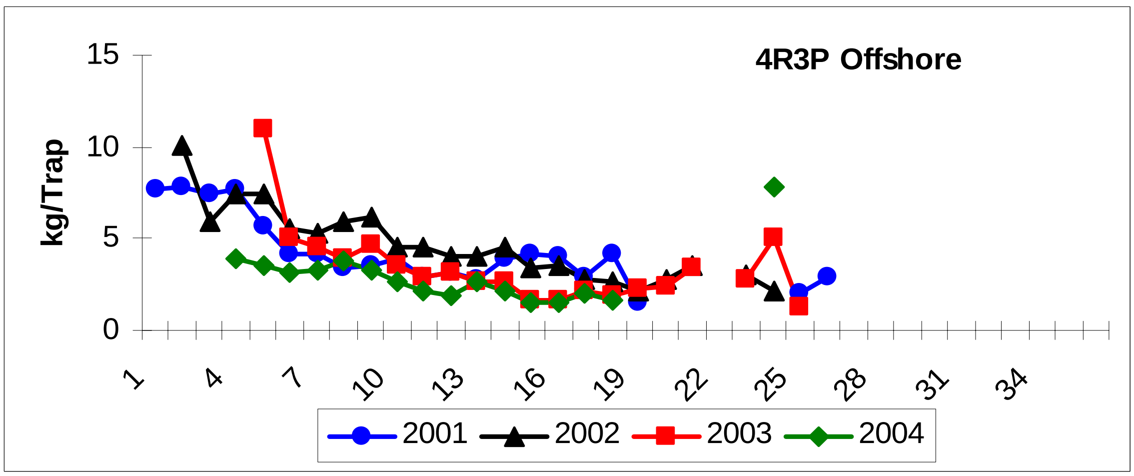

Figure 120. Seasonal trends in CPUE by week for offshore Division 4R and Subdivision 3Pn in recent years.

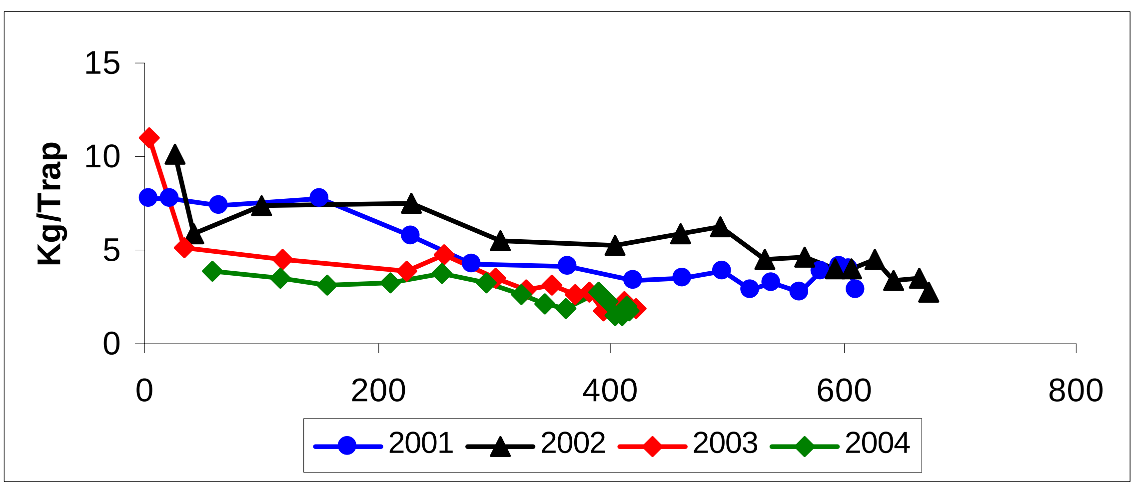

Figure 121. Seasonal trends in CPUE by cumulative catch for offshore Division 4R and Subdivision 3Pn in recent years.

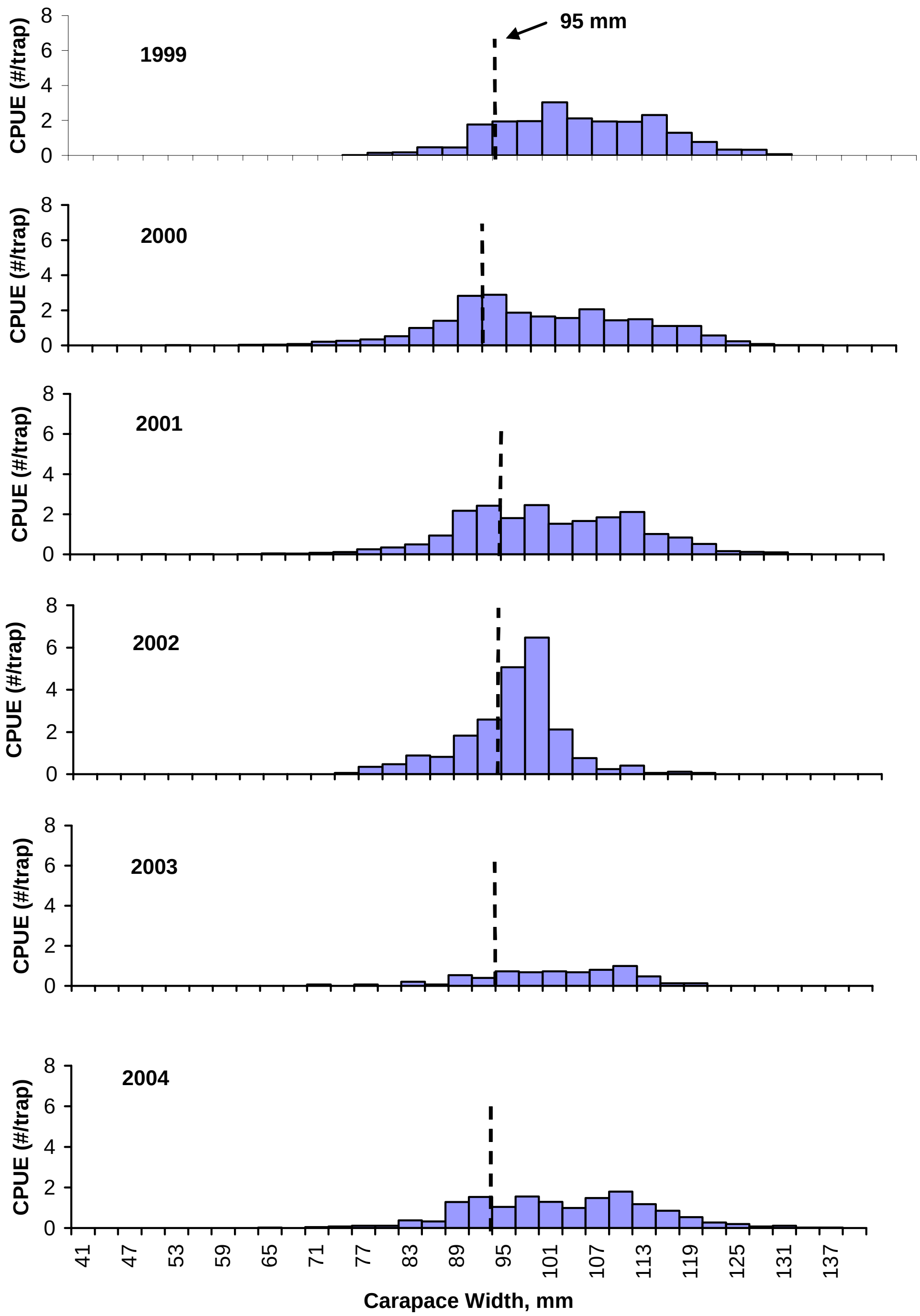

Figure 122. Annual trend in male carapace width distributions from observer at-sea sampling for Division 4R and Subdivision 3Pn.