Fisheries and Oceans Canada
Science

Pêches et Océans Canada
Sciences

C S A S

Canadian Science Advisory Secretariat

S C C S

Secrétariat canadien de consultation scientifique

Research Document 2008/009

Document de recherche 2008/009

Not to be cited without
permission of the authors *

Ne pas citer sans
autorisation des auteurs *

An Assessment of Newfoundland and Labrador Snow Crab (*Chionoecetes opilio*) in 2006

Évaluation du crabe des neiges (*Chionoecetes opilio*) de Terre-Neuve et du Labrador en 2006

E. Dawe, D. Mullowney, D. Stansbury, D. Taylor, E. Hynick, P. Veitch, J. Drew, P. O'Keefe,
K. Skanes, D. Fiander, R. Stead, D. Maddock Parsons, P. Higdon, T. Paddle,
B. Noseworthy, and S. Kelland

Science Branch
Fisheries and Oceans Canada
P O Box 5667
St. John's NL A1C 5X1

* This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

* La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

This document is available on the Internet at:

Ce document est disponible sur l'Internet à:

http://www.dfo-mpo.gc.ca/csas/

ISSN 1499-3848 (Printed / Imprimé)

Canada

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 multispecies bottom trawl surveys, inshore and offshore Div. 3KLPs4R trap surveys, and fishery data from logbooks as well as at-sea observer data. The fall multispecies survey is conducted near the end of the fishing season and 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 survey size frequency distributions. Mortality was inferred from exploitation rate indices, pre-recruit mortality indices and prevalence of Bitter Crab Disease (BCD). The fall multi-species surveys in Div. 2J3KLNO indicate a decline in exploitable biomass since 1998. However both the survey indices and commercial CPUE agree that the exploitable biomass has increased in the north (Div. 2J3K) in 2006 but continued to decline in the south. Recruitment has increased overall in 2006 due to increases in the north, while prospects have improved in the south. Longer-term recruitment prospects are uncertain but the persistence of a warm oceanographic regime implies poor prospects relative to the strong recruitment of the late 1990's. In Div. 2J the fall survey exploitable biomass index has increased over the past four years but remains low. Commercial CPUE doubled from a record low level in 2004 to about the long-term average in 2006. Recruitment has increased since 2004 and prospects remain promising for 2007. The exploitation rate index has declined since 2003 while the pre-recruit fishing mortality index decreased to a very low level. An increase in exploitation rate in the short term that results in increased pre-recruit mortality could impair further recovery. In Div. 3K, the fall survey exploitable biomass index has increased since 2003 to the long-term average. Both offshore and inshore commercial CPUE increased in 2006 to their long-term averages. Recruitment has increased in 2006 and prospects remain promising for 2007. The exploitation rate index was unchanged from 2005 at about the long-term average whereas the pre-recruit fishing mortality index decreased sharply to its lowest level. Any increase in exploitation rate in the short term that results in increased pre-recruit mortality could impair recovery of the exploitable biomass. In Div. 3L the fall survey exploitable biomass index was at its lowest level in 2006. Offshore commercial CPUE has changed little in the past three years and remains below the long-term average but high relative to other divisions. Inshore CPUE increased in 2006, approaching the long-term average. Recruitment is expected to remain low in the short term. The exploitation rate index has changed little since 2001 while the pre-recruit fishing mortality index was about average. Maintaining the current level of fishery removals, in the short term, will likely result in some increase in the fishery-induced mortality rate. In Div. 3NO, survey indices are unreliable. Commercial CPUE has changed little over the past three years and remains high relative to other areas. Recruitment has been low in recent years and short term prospects are uncertain. The effects of maintaining the current catch level on the fishery-induced mortality rate are unknown. In Subdiv. 3Ps offshore and inshore CPUE increased slightly in 2006 from record low levels in 2005. Recruitment should increase over the next three years. Increased removals, in the short term, would likely impair recovery of the exploitable biomass. In Div. 4R, there are insufficient data to assess resource status. Throughout Div. 2J3KLNO, the percentage of mature females bearing full clutches of viable eggs has remained high since 1995 with no clear trend.

RÉSUMÉ

On a évalué l’état des ressources par division de l’OPANO, d’après les tendances de la biomasse, les perspectives de recrutement et la mortalité. Les données utilisées proviennent du relevé plurispécifique d'automne au chalut de fond effectué dans ces divisions, de relevés au casier effectués dans les eaux côtières et hauturières des divisions 3KLPs4R, des journaux de bord des pêcheurs et des rapports des observateurs. Le relevé plurispécifique d'automne étant effectué vers la fin de la saison de pêche, il est considéré comme donnant un indice de la biomasse exploitable qui pourra être exploitée l'année suivante. Nous avons déduit les tendances de la biomasse dans 2J3KLNO en comparant les tendances des indices de biomasse exploitable issus des relevés d'automne aux tendances des captures par unité d'effort (CPUE) de pêche hauturière. De même, les perspectives de recrutement à court terme ont été obtenues en comparant les indices d'abondance des prérecrues provenant des relevés d'automne à un indice du nombre de crabes rejetés à la mer, établi par les observateurs. Les tendances à long terme du recrutement reposent sur l'entrée annuelle des groupes de taille des mâles dans les répartitions de fréquence des tailles provenant des relevés d'automne. Nous avons déduit le taux de mortalité à partir des indices du taux d'exploitation, des indices de mortalité chez les prérecrues et de la prévalence de la maladie du crabe amer. Les relevés plurispécifiques d’automne menés dans les divisions 2J3KLNO indiquent un déclin de la biomasse exploitable depuis 1998. Toutefois, les indices des relevés et les CPUE de la pêche commerciale indiquent tous les deux que la biomasse exploitable a augmenté dans le nord (divisions 2J3K) en 2006, mais continue de diminuer dans le sud. Le recrutement s’est accru dans l’ensemble en 2006 en raison des augmentations dans le nord, alors que les perspectives se sont améliorées dans le sud. Les perspectives de recrutement à long terme sont incertaines, mais la persistance d’un régime océanographique chaud laisse entrevoir des perspectives peu encourageantes par rapport au fort recrutement de la fin des années 1990. Dans la div. 2J, l’indice de la biomasse exploitable dérivé du relevé d’automne a augmenté depuis les quatre dernières années mais reste faible. Les CPUE de la pêche commerciale ont doublé, par rapport au creux record enregistré en 2004, pour atteindre à peu près leur moyenne à long terme en 2006. Le recrutement a augmenté depuis 2004 et les perspectives demeurent prometteuses pour 2007. L’indice du taux d’exploitation a diminué depuis 2003, alors que l’indice de la mortalité par la pêche chez les prérecrues a atteint un niveau très faible. Une augmentation du taux d’exploitation à court terme entraînant une mortalité accrue chez les prérecrues pourrait nuire davantage au rétablissement. Dans la div. 3K, l’indice de la biomasse exploitable dérivé du relevé d’automne a augmenté depuis 2003, atteignant la moyenne à long terme. En 2006, les CPUE de la pêche commerciale hauturière et côtière ont connu une hausse, jusqu’à leurs moyennes à long terme. Le recrutement a augmenté en 2006 et les perspectives demeurent prometteuses pour 2007. L’indice du taux d’exploitation reste inchangé depuis 2005, s’établissant à sa moyenne à long terme environ, alors que l’indice de la mortalité par la pêche chez les prérecrues a fortement diminué pour atteindre son niveau le plus faible. Toute augmentation du taux d’exploitation à court terme entraînant une mortalité accrue chez les prérecrues pourrait nuire davantage au rétablissement de la biomasse exploitable. Dans la div. 3L, l’indice de la biomasse exploitable issu du relevé d’automne était à son niveau le plus faible en 2006. Les CPUE de la pêche hauturière commerciale ont peu changé au cours des trois dernières années et restent inférieures à la moyenne à long terme, mais élevées par rapport à d’autres divisions. En 2006, les CPUE de la pêche côtière ont diminué, s’approchant des moyennes à long terme. Le recrutement devrait demeurer faible à court terme. L’indice du taux d’exploitation a peu changé depuis 2001, alors que l’indice de la mortalité par la pêche chez les prérecrues était à peu près dans la moyenne. Le maintien du niveau actuel de prises à court terme entraînera probablement

une certaine hausse du taux de mortalité par pêche. Dans la div. 3NO, les indices dérivés du relevé ne sont pas fiables. Les CPUE de la pêche commerciale ont peu changé au cours des trois dernières années et demeurent élevées par rapport à d'autres zones. Le recrutement a été faible ces dernières années et les perspectives à court terme sont incertaines. Les effets du maintien du niveau de prises actuel sur le taux de mortalité par pêche demeurent inconnus. Dans la sous-division 3Ps, les CPUE de la pêche commerciale hauturière et côtière ont légèrement augmenté en 2006 par rapport au creux record de 2005. Le recrutement devrait augmenter au cours des trois années à venir. L'augmentation des prises, à court terme, nuirait probablement au rétablissement de la biomasse exploitable. Dans la div. 4R, il n'y a pas suffisamment de données pour évaluer l'état des ressources. Dans toutes les div. 2J3KLNO, le pourcentage des femelles adultes portant de pleines couvées d'œufs viables est demeuré élevé depuis 1995, sans afficher de tendance particulière.

INTRODUCTION

The Newfoundland and Labrador snow crab (*Chionoecetes opilio*) fishery began in 1967 and was limited to NAFO Div. 3KL until the mid 1980's. It has since expanded throughout Div. 2J3KLNOP4R and is prosecuted by several fleets. 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 with a slight increase in the north (Div. 2J) in 2005 (Dawe et al. 2006). Management of the increasingly diverse fishery led to the development of many 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 those die.

This document presents research survey data and fishery data toward evaluating the status of the Newfoundland and Labrador snow crab resource throughout NAFO Div. 2J3KLNOP4R in 2006. Data from the Div. 2J3KLNOPs 1995-2006 multispecies bottom trawl surveys are presented to provide information on trends in biomass, recruitment, and mortality over the time series. The fall survey data have been used in annual snow crab assessments since 1997 (Dawe et al. 2006). Multispecies survey indices are compared with other relevant indices derived from fisher logbook data, observer data, and inshore and offshore Div. 3KLPs4R trap survey data, toward inferring changes in resource status for 2007 and beyond.

METHODOLOGY

MULTISPECIES SURVEY DATA

Data on total catch numbers and weight were acquired from the 1995-2006 fall stratified random bottom trawl surveys, which extended throughout NAFO Div. 2J3KLNO The 1996-98 fall 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 2000-06. These surveys utilized the Campelen 1800 survey trawl in standard tows of 15 min. duration. Survey data are selected from a standard set of strata common to all years, that does not include inshore or deep slope strata. However, the 2004 Div. 3L offshore survey was not fully completed and a sub-set of data has been used for analyses in that year.

Spring multi-species bottom trawl survey data for 1996-2005 were available for Div. 3LNOPs. Biomass indices from these surveys have not been used because of questionable reliability. However spring survey data for Subdiv. 3Ps were used specifically to infer recruitment prospects from annual size distributions.

Snow crab catches from each set were sorted, weighed and counted by sex. Catches were sampled in their entirety or sub-sampled by sex. Individuals of both sexes were measured in CW (mm) 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, in the current year, although it is recognized that some of these males are retained by the fishery late in the season (in fall). 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 was applied (Dawe et al. 1997) to classify each individual as either adult (large-clawed) versus adolescent or juvenile (small-clawed). This model is defined as:

$$CW = 0.0806CH^{1.1999}$$

Maturity status was determined for females and relative fullness and stage of development of egg clutches were assessed. Occurrence of advanced stages of Bitter Crab Disease (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 supported the classification of such specimens as infected.

We examined annual changes in abundance indices of legal-sized males, 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 they 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). It is assumed that all small-clawed males molt each year. 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 (>94mm CW adults) and pre-recruit (>75mm CW adolescents) males as described above.

The ratio of the annual landings to the exploitable biomass index (projected from the fall survey of the previous year) was calculated by NAFO Div. to provide an index of exploitation rate. This index underestimates absolute exploitation rate because the survey index underestimates absolute biomass. 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 plus 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 Division, Policy and Economics Branch, Newfoundland Region of the Department of Fisheries and Oceans. Catch per unit of effort (CPUE, kg/trap haul) was calculated by year and NAFO Div. CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (eg. soak time and mesh size). Long-term trends in logbook CPUE are presented, 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 at-sea Observer Program for the same time series as those from the fall multispecies surveys (1995-2006). The observer set and catch database included details about number of traps, landed catch (kg) and discarded catch (kg) for each set observed. An observer-based CPUE index (kg. landed/trap haul) was calculated for comparison with offshore logbook CPUE.

A discard pre-recruit index (DPI; kg. discarded/trap haul) was calculated to compare with the pre-recruit biomass index (PBI), 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 >75mm CW adolescents respectively) as well as by recently-molted males (‘soft’-shelled males >94 mm CW versus adolescents >75 mm CW).

A pre-recruit fishing mortality index (PFMI) was developed based on the ratio of the observed catch rate of pre-recruits discarded in the fishery to the fall survey pre-recruit index of the previous year. This index is defined as:

$$PFMI = S\left(\frac{DPI_t}{PBI_{t-1}}\right)$$

where DPI is the catch rate (kg/trap haul) of pre-recruits (undersized and soft-shelled) discarded in the fishery, in year *t,* calculated from observer data. PBI is the pre-recruit biomass index (*t* x 1000) from the fall survey of the previous year. S is a scaling factor to account for incomplete and annually variable levels of observer coverage, defined as:

$$S = \frac{Total\ Landings}{Observed\ Landings}$$

The PFMI underestimates pre-recruit mortality because the PBI underestimates pre-recruit biomass, as a result of low catchability of pre-recruits by the survey trawl. However we feel that long-term trends (since 1996) in this index provide a useful indication of trends in pre-recruit mortality. The percent discarded (by weight) is viewed as an index of wastage in the fishery. It provides an indication of the level of wastage associated with catching and releasing pre-recruits in the fishery and is not necessarily proportional to the mortality rate on the pre-recruit population.

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 (ie ‘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 implemented in 2004 to close specific small fishing areas when the percentage of soft-shell crab reached 20%.

TRAP SURVEYS

Data were available from an inshore Div. 3K trapping survey that was carried out in White Bay and Notre Dame Bay during 1994-2006, with the exception of 2001. The survey has consistently been conducted in September and it occupies 5 of the inshore fall multispecies survey strata 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) of legal sized males were calculated by shell category (new-shelled recently-molted versus older-shelled), and size distributions were described by claw type (small-clawed juveniles plus adolescents versus large-clawed adults).

Data were also available from three inshore trap surveys (1979-2006) within Div. 3L. These surveys were conducted in different seasons; spring (Northeast Avalon), summer (Bonavista Bay), and fall (Conception Bay). For each seasonal survey series, catch rate indices and size distributions were produced as described above for the inshore Div. 3K trapping survey.

In 2006, for the first time, data were examined from industry-DFO collaborative post-season trap surveys in Div. 3KLPs4R (Fig. 2). These surveys, funded by the Fisheries Science Collaborative Program (FSCP), were initiated following the 2003 fishery and have been conducted annually thereafter, beginning Sep. 1 each year. The surveys, conducted by snow crab harvesters accompanied by at-sea observers, focus on commercial fishing grounds within individual crab management areas (CMAs). Survey stations are fixed and generally follow a grid pattern, with maximum station spacing of 5' X 5' (Fig. 2). At each station, 6 (inshore) or 10 (offshore) commercial (135 mm mesh) crab traps are set in each fleet. All crab caught are sexed and counted. Biological sampling of male crab is conducted at sea, by observers, from two traps at each station. Sampling includes determination of carapace width, shell condition, leg loss and presence of BCD (bitter crab disease). Small mesh traps are included at selected stations to collect information on pre-recruits and females.

RESULTS AND DISCUSSION

THE FISHERY

The fishery began in Trinity Bay (Management area 6A, Fig.1) in 1967. 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 Div. 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. Mandatory use of the electronic vessel monitoring system (VMS) was fully implemented in all offshore fleets in 2004, to ensure compliance with fishing area regulations.

Landings for Div. 2J3KLNOP4R (Table 1, Fig. 3) 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 and declined to 55,700 t in 2004, due to changes in TAC's. They decreased by 21% to 43,900 t in 2005, primarily due to a sharp decrease in Div. 3K, where the reduced TAC was not taken. In 2006, landings increased to 48,000 t and the reduced TAC was achieved. Historically, most of the landings have been from Div. 3KL.

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 vessels <35 feet with temporary seasonal permits entering into the fishery. Effort has been broadly distributed in recent years (Fig. 4).

DIVISION 2J3KLNO

Spatial distribution from fall multispecies surveys

The fall distribution of exploitable males (legal-sized adults, Fig. 5) as well as immediate pre-recruits (>75 mm adolescents, Fig. 6) throughout NAFO Div. 2J3KLNO in 2006 was generally similar to the distribution pattern observed throughout 1997-2005, as previously described (Dawe et al. 2006; 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 2006 (Fig. 5) were higher in Div. 3K and lower in offshore Div. 3LNO than they were in 2005. Survey catches of pre-recruit males (Fig. 6) in 2006 were generally comparable to 2005 with increases observed in northern Div. 2J, throughout Div. 3K and along the Div. 3N slope.

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. 7) have both declined since 1998, by more than a factor of 3, to their lowest levels during 2003-06.

Recruitment

The fall survey pre-recruit biomass index (Fig. 8) 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.

We feel 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.

Low bottom temperatures promote terminal molt at small sizes in snow crab, resulting in relatively low recruitment from a given year class (unpublished data). However recruitment is more strongly affected by the positive effects of a cold regime on year class production than it is on the negative effects of a cold regime on size-at-terminal molt. Negative relationships between bottom temperature and snow crab CPUE have been demonstrated at lags of 6-10 years (Dawe et al. 2005) suggesting that cold conditions early in the life history are associated with the production of strong year classes and subsequent strong recruitment. 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. A warm oceanographic regime has persisted over the past decade (Colbourne et al. 2007) implying poor long-term recruitment prospects

Productivity of crab during early life history has also been linked to the winter and spring sea ice cover on the Newfoundland Shelf. 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. The model (Fig. 9) predicts a decline in CPUE up to 2006 and gradual recovery thereafter. However, uncertainty in the forecast, as illustrated by the 95% confidence intervals (C.I.), increases with time.

Mortality

BCD has been observed in snow crab, based on macroscopic observations, at low levels throughout 1996-2006. 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 shifted southward during 2001-06 (Fig. 10). Prevalence in Div. 2J has decreased over this period and the centre of distribution of infected crabs shifted slightly southward within Div. 3KL (Fig. 10). 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 represents true prevalence in the population, especially based on recognition of external characteristics in chronic cases. 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 (Fig. 11) peaked in 1999 at 5400 t. They then declined by 70% to 1600 t in 2005 due to reductions in TAC and increased by 25% in 2006 to 2000 t. Effort increased to a record high level in 2002-04 before declining by 58% to 2006. The fishery has occurred progressively earlier in recent years, especially in 2005 and 2006.

Biomass

Commercial catch rates (CPUE) have oscillated over the time series (Table 2, Fig. 12), initially decreasing during 1985-87, increasing to a peak in 1991, decreasing again to 1995, and increasing to another peak in 1998. They declined steadily by 76% during 1998-2004 to a record low level before doubling to about the long-term average in 2006. This increase can be attributed to improved catch rates in and around the Cartwright Channel in the north and the Hawke Channel in the south (Fig. 13).

An area of the Hawke Channel has been closed to all fisheries except snow crab from 2002 to 2006. The CPUE has increased similarly inside and outside the closed area since 2004 (Fig. 14). The logbook CPUE and observed CPUE agreed fairly well (Fig. 15). Trends in CPUE throughout the season (Fig. 16 and Fig.17) indicated that initial CPUE decreased during 2002-2004 but increased in 2005 and 2006. The late-season CPUE in 2006 was at the same level as the late-season CPUE of 2005 although it occurred earlier since the fishery has occurred progressively earlier with decreases in total effort in recent years (Fig. 18).

The fall multi-species survey exploitable biomass index (Table 3, Fig. 19) decreased steadily, by 94%, from 1998 to 2002. It has increased over the past four years but remains below levels observed prior to 2002.

Production

Recruitment: We examined annual changes in abundance indices of legal-sized males from fall multi-species surveys, by shell condition, toward evaluating the internal consistency of the data series (Fig. 20). Males enter the legal-size group as new-shelled crabs, after the spring molt, and they 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 in 1999, whereas abundance of old-shelled crabs declined steadily during 1999-2002. The abundance of new-shelled crabs has increased since 2002 to about the 1995-96 level while the abundance of old-shelled crabs has decreased further**.** This suggests that the resource has become increasingly dependent upon annual recruitment.

The fall survey pre-recruit index and observer discard pre-recruit index both decreased from 1998 to a lower level during 1999-2001 (Table 4, Fig. 21). Both indices increased to peak in 2004 and decreased in 2005. The observer index decreased further while the survey index almost doubled in 2006. The decline in the observer discard index in the past two years is related to a very early fishing season in those two years that resulted in reduced catches of new-shelled immediate pre-recruits.

The size compositions from fall multi-species surveys are examined initially with the abundance index (ordinate) truncated for smallest males (<50 mm CW), so as to focus on trends in abundance for larger males (Fig. 22). The decline in commercial-sized males from 1998 to 2004, 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 survey data indicate that most of the relatively abundant sub-legal sized adolescent males evident in 2004 achieved legal size in 2005, as new-shelled immediate pre-recruits. A portion of these recruited to the fishery as older-shelled crabs in 2006 and recruitment prospects remain promising for 2007.

The non-truncated size distributions (Fig. 23) 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 that developed into exploitable biomass in 2005 and 2006 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. 24) indicate that modal CW decreased from about 110-113 mm in 2002 to 92 mm in 2004, suggesting an increase in abundance of legal-sized new-shelled immediate pre-recruits in 2004. Modal CW then increased to 101 mm in 2005 and stayed at 101 mm in 2006, These observations suggest that a large portion of the modal group of sub-legal sized adolescents evident in the 2004 multi-species survey (but not evident at smaller size in the 2003 survey, Fig. 23) achieved legal size as exploitable crab in 2005 and 2006 (Fig. 24). This is consistent with increases in observed catch rates of old-shelled crab in the fishery in the past two years (Fig. 25). CPUE of under-sized crab closely matched CPUE of total discards in 2006 (Fig. 26), implying that discards were predominately of small crabs and there was a low incidence of soft-shelled discards in 2006.

Reproduction: The percentage of mature females carrying full clutches of viable eggs (Fig. 27) remained above 90% until 2000 (excepting the anomalous 1999 value). It declined from 94% in 2000 to 74-78% in 2001-03 before increasing back to 94% in 2004, but has since decreased to 59% in 2006. It is unknown whether declines in fecundity in recent years would affect subsequent abundance of settling megalopae.

Mortality

Exploitation: The exploitation rate index (Fig. 28) was low during 1996-2002, increased sharply in 2003, and has since declined to 2006. The pre-recruit fishing mortality index (Fig. 28) increased sharply from 2001 to 2004, decreased to the 1996-2001 level in 2005, and remained at a very low level in 2006.

Indirect fishing mortality: Fishery-induced mortality, on the exploitable as well as the pre-recruit populations, has decreased since 2003 and 2004 respectively. The percentage of the total catch discarded (Fig. 28) increased sharply in 2002, was unchanged in 2003, and further increased to a record high level in 2004. It declined sharply over the past two years to the pre-2002 level, implying reduced wastage of undersized and new-shelled pre-recruits in the fishery. The sharp decline over the past two years is related to very early fishing seasons in those years that resulted in reduced catches of new-shelled immediate pre-recruits.

Although wastage of pre-recruits (percent discarded) was high in the 2002-05 fisheries (Fig. 28), overall pre-recruit mortality has decreased sharply since 2004 due to an increase in the pre-recruit biomass in 2004, a reduction in landings in 2005, and an increased proportion of large, old-shelled crab in the population in 2005-06.

Snow crabs that are caught and released as under-sized or legal-sized soft-shelled males 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 cause increased 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).

Peaks in percentage of soft-shell occurred progressively earlier each year from 2002-2005 (Fig. 29). This trend may be related to annual changes in time of molting and abundance of pre-recruits. However it is likely also related to progressively earlier seasonal depletion of recruited (older-shelled) crabs in those years and resultant increased catchability of soft-shelled immediate pre-recruits. The percentage of soft-shelled crabs decreased in 2006 and the peak occurred later than in 2005 (Fig. 29), likely due, in part, to increased abundance of large older-shelled crabs (Fig. 24) and resultant decreased catchability of soft-shelled immediate pre-recruits. Regardless of the cause, this implies a decrease in wastage of new-shelled crabs in the 2006 fishery compared to the high levels of recent years.

The fishery has been occurring earlier each year, with the bulk of 2006 effort occurring from week 6 through week 10 (Fig. 30) with about 84% of the total trap hauls executed in those five weeks. Soft-shelled crab first exceeded 20% in week 12 when it comprised 50% of the observed catch. Before and after week 12, soft-shelled crab prevalence remained low until weeks 15-16, when it was at about 20% for the last two weeks of the fishery. Observer sampling was relatively well distributed in relation to total fishing effort throughout the fishing season (Fig. 30), with high sampling levels during the peak periods of soft-shell crab.

Natural mortality: (BCD): BCD in Div. 2J males has been most prevalent in small new-shelled adolescents of 40-59 mm CW (Fig. 31). Prevalence, in new-shelled adolescents, has generally been low in this area, usually about 2-3 percent occurrence for that size range, excepting 1999, when 18.2% of new-shelled adolescents in that size group were visibly infected. BCD prevalence increased in 2005, from a very low level in 2004, but was virtually absent in all males in 2006.

DIVISION 3K

The fishery

Landings (Fig. 32) peaked in 1999 at 21,400 t. They decreased to 15,400-16,500 t in 2000-04, due to reduction in TAC. Landings decreased by half to 8,700 t in 2005, not meeting the 12,900 t TAC. They increased by 23% to 10,700 t in 2006, achieving a reduced TAC. Effort increased by 33% in 2004 and declined by half to 2006. The TAC was not fully subscribed in 2005 because the fishery was closed prematurely due to high levels of soft-shelled crabs in the catch The fishing season occurred especially early in 2006 and most effort was concentrated in the southern portion of the Division. The percentage of the total landings derived from inshore increased from 8% to 37% over the past six years.

Biomass

Commercial catch rates have oscillated over the time series (Table 5, Fig. 33). Offshore CPUE declined since 1998 to its lowest level in 2005 before increasing sharply in 2006 to the long-term average. Inshore commercial CPUE declined during 2002-05 and increased in 2006 to the long-term average. Inshore CPUE has been consistently lower than offshore CPUE. Spatially, increases in CPUE occurred throughout the division in 2006 and an increase in effort occurred mostly in the south (Fig. 34). The areas fished changed little from 1999-2003 (Dawe et al. 2004), and remained similar in 2004, before a reduction in offshore effort in 2005 with the premature fishery closure. There has been little fishing since 1999 east of 51W along the slope and southeast of the Funk Island Bank.

An area of southern Div. 3K was closed to gillnet fisheries in 2002 and has been closed to all fisheries except snow crab during 2005-06 (Fig. 35). It would be premature to draw any conclusions regarding the impact of this closure on the snow crab resource but it is noted that the CPUE increased both inside and outside of the closed area in 2006 (Fig. 35).

The offshore logbook CPUE and observed CPUE agreed well for the third consecutive year in 2006 (Fig. 36). Both indices 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 maintained consistency. Observer CPUE increased in 2005 while logbook CPUE continued to decline and both similarly increased in 2006. In the offshore, there were clear annual differences in initial CPUE and trends throughout the season (Fig. 37 and Fig. 38). CPUEs were lower by week and cumulative catch in 2005 than in the three previous years despite the shortened season. In 2006, weekly CPUEs were similar to 2005 but there was an increase in CPUE back to 2002-03 levels, at comparable levels of cumulative catch (Fig. 38). Most of the 2006 offshore catch was taken during weeks 4 and 5 while CPUE remained relatively high. The offshore fishing season has occurred progressively earlier with declining total effort expenditure since 2004 (Fig. 39). Inshore, 2006 trends in weekly CPUEs reflected 2005 levels after declining since 2002 (Fig. 40). There was an improvement in CPUE in relation to cumulative catch from 2005 to 2006 with trends more closely resembling those of 2003-04 (Fig. 41). The inshore fishing season has also occurred progressively earlier with less total effort expenditure since 2004 (Fig. 42).

The fall survey exploitable biomass index (Fig. 43) decreased from its highest level by almost half in 1999. It changed little until it decreased again from 2001 to its lowest level in 2003 and has since increased to the long-term average. The industry-DFO collaborative offshore post-season trap survey showed that the catch rate of legal-sized crabs increased in 2006 (Fig. 44). The inshore collaborative post-season trap survey showed that the catch rate of legal-sized crabs increased slightly during 2004-06 (Fig. 45). Data from the DFO inshore post-season trap survey (Fig. 46) show similar results but indicate a high level of spatial variability (Fig. 47). Catch rates of old-shelled legal-sized crab have increased since 2003 in the two deepest strata of White Bay and since 2004 in both strata in Notre Dame Bay.

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. 48), as was evident in Div. 2J. This may be due to annual differences, particularly in 1998 and 1999, 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. 2002a). The decrease in both shell categories in 1999, followed by an increase suggests reduced catchability in the 1999 survey. This was reflected in spatial distributions that showed consistent relatively low 1999 catch rates across all size groups; most evident in small males (Dawe et al. 2006).

Both the fall survey pre-recruit index (Table 7, Fig. 49) and the observer discard pre-recruit index (Fig. 49) declined from 1997 to a lower level during 1999-2002. The survey index doubled since 2002, whereas the observer index doubled to 2005 before decreasing by more than half in 2006. The sharp decrease in the observer discard index in 2006 is related to a very early fishing season that resulted in reduced catches of new-shelled pre-recruits.

The truncated size compositions from fall multispecies surveys (Fig. 50) show a decline in commercial-sized males from 1996-2003, as well as of adolescent pre-recruits from 1997 to 2003. More recently, a group of adolescents in 2004 with modal CW at about 85 mm appears to have advanced in 2005 and 2006, to larger sizes. This group may have contributed to increased abundance of legal-sized adults in 2005 and 2006. A high proportion of males entering the legal size range in 2006 remained adolescent (Fig. 50) implying relatively relatively strong individual growth and recruitment in the short term.

The un-truncated size distributions (Fig. 51) 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.

The offshore collaborative post-season trap survey showed an increase in catch rate of new-shelled legal-sized crabs in 2006 (Fig. 45). Size distributions from this survey showed an increase in catch rates of new-shelled crab in 2006 (Fig. 52), including legal-sized crab (Fig. 45). This is consistent with the multispecies trawl survey data that indicates an increase in offshore recruitment in 2007.

Size distributions from at-sea sampling by observers (Fig. 53) 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, was unchanged in 2003-05 and increased to 119 mm CW in 2006, consistent with the recent trend in the fall survey pre-recruit index. Sampling by observers shows that CPUE of old-shelled animals decreased greatly from 2000 to 2003 but has increased each year since then (Fig. 54). The catch rate of total discards from observer set and catch records agreed well with the catch rate of under-sized discards from observer at-sea sampling during 2001-03 (Fig. 55), suggesting that discards were comprised mostly of under-sized crabs during that time. The catch rate of total discards increased from 2003 to 2005 while that of under-sized discards changed little, indicating an increase in discarding of soft-shelled crabs in 2004-05. The catch rate of total discards decreased sharply in 2006 and was almost equal to that of under-sized discards, implying that 2006 discards were comprised mostly of under-sized crabs. However, this is highly uncertain as it is not supported by the data on new-shelled immediate pre-recruits from observer sampling (Fig. 54), which has been unchanged since 2000.

Both offshore post-season surveys (collaborative trap survey and multispecies trawl surveys) indicate an increase in catch rates of new-shelled legal-sized crabs in 2006 that should result in increased recruitment in the short term. These pre-recruits include a substantial portion of large adolescents that will begin to recruit in 2008. Both surveys indicated that the post-season catch rate of older-shelled legal-sized crabs changed little in 2006, and was lower than that of new-shelled pre-recruits.

The industry-DFO collaborative inshore post-season trap survey showed that the catch rate of legal-sized older-shelled crabs increased during 2004-2006 but the catch rate of new-shelled legal-sized crabs remained higher (Fig. 45). Size frequencies from the survey show modal progression of new-shelled crabs from a primary mode of 92 mm CW in 2004 to 98 mm CW in 2006 and an increase in catch rates of legal-sized old-shelled crab in 2006 (Fig. 56).

Data from the DFO inshore post-season trap survey (Fig. 46) indicate a high level of spatial variability (Fig. 47). Catch rates of new-shelled legal-sized males (immediate pre-recruits) decreased in 2004 in all strata and for both trap types. Subsequently pre-recruit catch rates in all White Bay strata have changed little from large-meshed traps, but have continued to decline from small-meshed traps. Meanwhile, Notre Dame Bay pre-recruit catch rates have increased since 2004 in deeper stratum 610, but have changed little and remain low in stratum 611. Soft and new hard-shelled crab represented increasing proportions of catches in all three White Bay strata from 1997-2003 while the proportion of intermediate-shelled crab have increased in recent years (Fig. 57). In Notre Dame Bay, soft and new-shelled crabs have dominated catches in the shallower stratum 611 since 1998 and in the deeper stratum 610 since 1997 (Fig. 56).

Size frequencies from survey small-meshed traps (Fig. 58 and Fig. 59) show much clearer trends in White Bay than in Notre Dame Bay. Size frequencies from White Bay (Fig. 58) clearly show an abundant group of small crab in 1998 (especially in shallowest stratum 615) that progressed through the size range achieving legal size over the period 2000-2003 (especially in deepest stratum 613). A modal group of small crab in shallow stratum 615 in 2005 has partially progressed into the intermediate-depth stratum in 2006 but a large portion of this pulse appears to have terminally-molted to small adult crab in stratum 615 and 614. No indication of imminent recruitment is evident in the size frequencies from White Bay. In Notre Dame Bay, (Fig. 59) highest catch rates of sub-legal sized males occurred in 1998, especially in the shallower stratum, followed by a decline in catch rates of these small crabs during the next three years. However, there was no evidence of progression of these small crabs to recruitment in later years. Catch rates of legal-sized crabs was also highest early in this time series and recruitment appeared to be highest in 1998. High exploitation and mortality on pre-recruits could possibly account for this apparent lack of recruitment. Notre Dame Bay also showed a sharp decrease in catch rates across the entire size range in 2004 followed by a sharp increase in 2005 that remained around that level in 2006, reflecting changes in catchability. There was an apparent high abundance of sub-legal sized adult males in shallower stratum 611 in 2005 (Fig. 59), and a small pulse of sub-legal adolescent crab in stratum 610, but recruitment prospects are highly uncertain due to the recent changes in catchability by traps.

Recruitment in Div. 3K has increased in 2006 and prospects remain promising for 2007.

Reproduction: The percentage of mature females carrying full clutches of viable eggs (Fig. 60) varied at a high level from 1995 to 2004, exceeding 80% in all years but 1996, but fell to 61% in 2005 and 74% in 2006.

Mortality

Exploitation: The exploitation rate index (Fig. 61) has changed little throughout the time series and was unchanged in 2006 form the previous year at about the long-term average. The pre-recruit fishing mortality index (Fig. 61) decreased sharply to its lowest level in 2006. The high mortality indices for 2004 are likely due to anomalously low biomass indices from the 2003 survey.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 61) increased from 2002 to about 40% in 2005, reflecting increased wastage of under-sized and new-shelled pre-recruits. The high wastage in 2005 is consistent with a high incidence of soft-shelled immediate pre-recruits in the catch, which resulted in a premature closure of the fishery and failure to achieve the TAC. The percentage discarded decreased sharply in 2006 to its lowest level due to a very early fishing season that resulted in reduced catches of new-shelled pre-recruits. This implies greatly reduced wastage of pre-recruits in the 2006 fishery.

The percentage of soft-shelled crab in the catch by week followed a similar trend to that described for Div. 2J. It peaked progressively earlier each year from 2003 to 2005 (Fig. 62). In 2002, soft-shelled percentage of the catch did not approach 20% until week 11, seven weeks into the fishery, and peaked in week 14 at about 30%. In 2005, soft-shelled percentage approached 20% in week 6, two weeks into the fishery, and peaked in week 14 at around 70%. In 2006, the fishery started and ended early and soft-shelled percentage did not exceed 20% until week 10, the last week of the fishery. These trends may be due to depletion of recruited (older-shelled) crabs, earlier molting, or increased catchability of soft-shelled immediate pre-recruits from 2002 to 2005. Regardless of the cause, this implies a decrease in mortality on new-shelled crab in the 2006 fishery.

The bulk of the 2006 fishery occurred in the four weeks from week 3 through week 6 (Fig. 63) with 78% of the total trap hauls occurring in this period. Prevalence of soft-shelled crab exceeded 20% only in week 10, the last week of the fishery. Observer coverage was distributed throughout the season relatively proportional to total fishing effort (Fig. 63).

Natural mortality (BCD): Prevalence of BCD, from multispecies trawl samples, has overall been higher in this division than in any other division, with maximum levels during 1996-98 in the order of 8% in 40-75 mm CW new-shelled males (Fig. 64). Annual trends in BCD prevalence (across all sizes) were similar to those in the exploitable biomass and pre-recruit indices, featuring highest values in 1996-98, a sharp drop to minimum levels in 1999, and generally lower levels during 2000-06 than during 1996-98. In 2006, increases occurred in both biomass indices as well as in BCD prevalence in 76-94 mm CW adults. The very low prevalence levels, across all sizes, in 1999 may be an artefact related to the lower catchability of BCD-infected crabs by trawl than by traps, together with lower trawl efficiency (in Div. 3K) in 1999 than in other survey years. The relatively low prevalence in 2003 may also be an artefact of a later than normal trawl survey.

BCD has consistently occurred at much higher prevalence levels in the inshore Div. 3K trap survey samples (Fig. 65 – 66) than in the predominately offshore Campelen trawl samples. This may reflect low catchability of diseased animals by the survey trawl (based on comparative trap/trawl sampling), but it may also reflect higher prevalence in inshore than offshore areas. Prevalence of infection is higher in adolescent than adult crabs in all surveyed strata, a phenomenon that was not evident in the offshore trawl survey data (Fig. 64), suggesting that traps may select for diseased adolecents. 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. Between 1995 and 1999 there was a clear progression of BCD to successively larger crabs and successively greater depths, such that about 50% of legal-sized new-shelled adolescents in the deepest stratum were infected in 1999. This progression with size and depth until 1999 reflects both the observed size-related depth distribution pattern (Dawe and Colbourne 2002), as well as increasing recruitment over that time period. Prevalence in White Bay increased in 2003 in smallest new-shelled males within the shallowest stratum and subsequently increased in progressively larger crabs in this stratum during 2004-05 (Fig. 65). It also increased greatly in all sizes but especially in smallest adolescent males in the mid-depth White Bay strata in 2005 and has gradually increased in the deepest stratum since 2004. Prevalence in Notre Dame Bay was relatively high, especially in adolescent males within the deeper stratum during 2002-05, whereas it increased steadily during this period in the shallower stratum (Fig. 66). In 2006, prevalence in new-shelled adolescent males increased to the highest levels in the time series in large (>75 mm CW) crab in the shallowest stratum and in small (<60 mm CW) crab in the intermediate-depth stratum. In all strata, except stratum 610, BCD prevalence tends to increases with crab size in adolescents and decrease with increasing size in adults.

DIVISION 3L

The fishery

Landings (Table 8, Fig. 67) peaked at 26,200 t and decreased to 22,600 t in 2000 due to a reduction in TAC. They then increased to 26,000 t in 2003 due to TAC increases and changed little since, totalling 26,500 t in 2006. Effort (Fig. 67) increased by 73% during 2000-2004 and remained at that high level over the past three years. Inshore landings have represented about a quarter of the total in the past three years.

Biomass

Commercial CPUE has been consistently higher in the offshore than in the inshore. Offshore CPUE (Fig. 68) decreased by 22% between 2002 and 2004 and has changed little in the past 3 years to remain below the long-term average but high relative to other divisions. Inshore CPUE decreased by 21% in 2003, changed little to 2005, and increased in 2006, approaching the long-term average (Fig. 68). The spatial distribution of CPUE has changed little over the past three years (Fig. 69), as CPUE declined slightly.

The observer CPUE index agreed with the offshore logbook CPUE (Fig. 70). The two indices have agreed well since 1998. CPUE was lower in 2006 than in the previous four years during the first 9 weeks of the season (Fig. 71). However, late-season CPUE was similar to that in 2004-05 at comparable removal levels, but at a lower level than those in 2002 and 2003 (Fig. 72). A high proportion of the Div. 3L offshore fishery occurred earlier in 2006 than in previous years (Fig. 73) with almost half the total effort expended by week 6,. before the fishery began in 2005 The inshore 3L seasonal CPUE trends were generally similar to those during the 2003-05 fisheries (Fig. 74-75), at a lower level than during 2002. The inshore fishery started and ended earlier in 2006 than it did in the four preceding years (Fig. 76). About half the total fishing effort was expended by week 7 in 2006, before the fishery began in 2005

The fall survey exploitable biomass index (Table 9, Fig. 77) declined from 1996 to 2000 and remained at that low level until it further decreased to its lowest level in 2006. Disagreement between the exploitable biomass index and CPUE throughout most of the time series introduces uncertainty regarding trends in biomass. The differences between these indices may be due to spatial and temporal effects. The 3L fishery predominately occurs in a relatively fixed, shallow depth range in the summer and early fall whereas the survey occurs over a broader area and depth range later in the fall. The industry-DFO collaborative offshore post-season trap survey catch rates of legal-sized crabs declined during 2004-06 (Fig. 78) whereas the inshore post-season trap survey catch rates increased during 2004-06 (Fig. 79). Catch rates of legal-sized old-shelled crab from trap surveys in 3 localized inshore areas (Fig. 80) have declined since the late 1990's. Catch rates of old-shelled legal-sized crabs remained low in two areas in 2006, but have increased in Bonavista Bay during 2005 and 2006. Interpretation of year-to-year changes in these surveys is uncertain as catch rates have not agreed well with commercial CPUE from the local fisheries and have been highly variable in some areas (Dawe et al. 2006).

Production

Recruitment: Annual changes in the multi-species survey abundance index by shell condition (Fig. 82) reflected greater internal consistency than was evident in Div. 3K. Abundance of new-shelled legal-sized males declined from a peak in 1996, whereas old-shelled legal-sized males peaked a year later, in 1997. Abundance of new-shelled males continued to decline to 1999 before increasing gradually until 2005 and then declining sharply in 2006. The decline in old-shelled males extended one year later than new-shelled males, to 2000, before stabilizing until 2003, declining sharply in 2004 and continuing to increase since then. These trends show no clear evidence of strong changes in catchability or 'year effects', as were suggested in Div. 3K.

The fall survey pre-recruit index (Table 10, Fig. 83) has been low since 1999. The observer discard pre-recruit index declined from 1997 to 2004 and has changed little since (Fig. 83).

The truncated size compositions from fall multispecies surveys (Fig. 84) show a decline in commercial-sized males, as well as of adolescent pre-recruits since1998. The very low abundance-at-size in 2004, especially for legal-sized males, is largely due to the incomplete survey in that year that did not include some important commercial fishing grounds. There is no clear indication of any increase in recruitment in the short term, based on males larger than about 50 mm CW.

The un-truncated size distributions (Fig. 85) suggest that abundance indices of smallest males (<50 mm CW) were high during 2001-02, but abundance of this group has since decreased. 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.

The offshore collaborative post-season trap survey shows no clear trend in catch rates of new-shelled legal-sized males from 2004 to 2006, based on common stations (Fig. 78). Size distributions from the survey show a large decrease in abundance of legal-sized new-shelled crabs in 2004 with no change in catch rates of new-shelled crab of legal or sub-legal sizes since then (Fig. 86). However interpretation of this large decrease is uncertain as it is based on all stations, that are not common to all years.

Size distributions from at-sea sampling by observers (Fig. 87) became increasingly platykurtic over the past 7 years. Modal CW increased from 98 mm in 1999 to about 101-113 mm in 2006 as catch rates of small males decreased, suggesting declining recruitment. Observer sampling shows a gradual decline in catch rates of both new-shelled and old-shelled legal-sized crabs since 2000-01 (Fig. 88). The observer catch rate of total crabs discarded has declined since 1997 (Fig. 89). Most of these discards have been of under-sized crabs since 1999.

Data from at-sea sampling during the fishery and offshore collaborative post-season trap survey data show no change in catch rate of pre-recruits since 2004. Offshore recruitment is expected to remain relatively low in the short term.

The inshore collaborative post-season trap survey shows no clear trend in catch rates of new-shelled legal-sized males from 2004 to 2006 (Fig. 79). Size distributions from the survey show no clear change in size since 2003 (Fig. 90).

Data from inshore DFO trap surveys show increased catch rates of legal-sized new-shelled males since 1998 in all three areas (Fig. 81). In spring, off of the Northeast Avalon Peninsula (NEA), the abundance of new-shelled legal-sized males increased from 2001 to 2005 to the highest level since 1996, and changed little in 2006 (Fig. 81). Soft and new hard-shelled crabs have represented increased proportions of the survey catch since 2001 (Fig. 91). In summer, in Bonavista Bay (BB), catch rates of new-shelled legal-sized males have increased since 2003 to the highest level in the time series in 2005 and 2006 (Fig. 81). Intermediate and old-shelled crab represented the greatest proportions of catches from 1996 to 2001 but from 2001 to 2005 soft and new hard-shelled crabs were most common. The percentage of intermediate-shelled crabs increased with their catch rate in 2006 (Fig. 91). In fall, in Conception Bay (CB), catch rates of new-shelled legal-sized males changed little at a relatively high level from 2002 to 2005 before increasing sharply in 2006 to the highest level in the time series (Fig. 81). The percentage of intermediate and old-shell crab has declined since 1999 while the percentage of legal-sized new hard-shelled crab has increased (Fig. 91).

Male size distributions from the DFO inshore trap surveys (Fig. 92-94) show declining catch rates of adults (of all sizes) to 2004 in NEA (Fig. 92) and BB (Fig. 93), and to 2003 in CB (Fig. 94). There was a large increase in catch rate of both adolescents and adults, across a broad size range in CB in 2004 (Fig. 94) and to a lesser extent in NEA in 2005 (Fig.92). These increases were followed by decreases the following year. The large increase in adolescent catch rates in 2004 in Conception Bay did not result in increased catch rates of legal-sized adults in 2005 (Fig. 94).

Relatively high catch rates of new-shelled legal-sized crabs from DFO trap surveys in three localized inshore areas in 2006 suggest promising recruitment prospects in the short term.

Reproduction: The percentage of mature females carrying full clutches of viable eggs declined overall throughout the time series to 50% in 2001 but increased to about 90% in 2002-03. There was a slight decrease to about 80% in 2004-05 before increasing to 97% in 2006 (Fig. 95).

Mortality

Exploitation: The exploitation rate index (Fig. 96) increased from 1996 to 2001 and has since changed little. The pre-recruit fishing mortality index (Fig. 96) increased gradually to 2001, doubled to 2003, and has been lower since. It was about average in 2006. Maintaining the current level of fishery removals in the short term will likely result in some increase in the fishery-induced mortality rate.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 96) increased from 1995 to 1997 and decreased sharply in 1998. It then declined gradually until 2002, and changed little since, implying relatively little wastage of under-sized and new-shelled pre-recruits in the fishery in recent years.

The survey mortality indices (Fig. 96) and landings have changed little in recent years, Therefore the stable low pre-recruit wastage index, to 2006, implies that fishery-induced mortality has remained relatively low in recent years.

The prevalence of soft-shelled crab in the catch throughout the season was lower in Div. 3L than it was in Div. 2J or 3K (Fig. 97). The percentage of soft-shelled crab in 2006 gradually increased as the season progressed but remained low throughout the fishing season as in previous years. Soft-shell crab composed 0-10% of the weekly catch in 3L for most of the time series. Weekly effort was highest early in the season (weeks 4-5) with observer coverage being proportional to total effort in most weeks (Fig. 98). Incidence of soft-shelled crab did not approach 20% of the catch at any point in the season.

Natural mortality (BCD): BCD occurs almost exclusively in recently-molted crabs (Dawe, 2002) and generally occurs at lower levels in Div. 3L than in Div. 3K. In Div. 3L, BCD prevalence (in new-shelled males) from fall multi-species trawl surveys has been variable with highest incidence during 2002-05 (Fig. 99). Prevalence of infection increased from 2000 to 2005 and decreased considerably in 2006. In adolescents, prevalence progressed from 40 to 59 mm CW crabs in 2003 through successively larger sizes in 2004 and 2005. In adults, prevalence progressed from 60 to 75 mm CW crabs in 2003 through successively larger sizes in 2004 and 2005. Maximum prevalence was about 8% in 40-59 mm CW adolescents and 14% in 60-75 mm CW adults during 2004.

The trend in prevalence of BCD from Conception Bay trap surveys is similar to that from the multi-species surveys (at higher levels of prevalence), in that prevalence was highest in 2004-05 (Fig. 100). BCD has been monitored by survey traps in Conception Bay since 1996. Prevalence generally increased to 2000 before decreasing sharply in 2001. It increased during 2003-05 before decreasing considerably in 2006. Trends in prevalence of BCD within Conception Bay from trawled surveys have been similar to those from the trap surveys, but at lower levels.

DIVISION 3NO

The Fishery

The fishery began in the mid-1980's in Div. 3O and expanded along the shelf edge in 1999. It has since been concentrated along the shelf edge, and mostly in Div. 3N. Landings (Table 11, Fig. 101) decreased from 5600 t in 2003 to 4200 t in 2006. Effort has declined by about 20% since 2004.. Landings have consistently exceeded the TAC because some management areas extend into Div. 3L, and all landings from those areas are attributed to Div. 3NO.

Biomass

Commercial CPUE (Fig. 102) decreased by 26% between 2002 and 2004, It has changed little over the past three years and remains high relative to other divisions. The fishery has been concentrated along the shelf edge (Fig. 103) with no substantial change in areas fished from 2001-2006. A nearshore area of 3O (The Whale Deep) received less effort in 2006 than in the preceding 5 years.

Observed CPUE was consistently lower than logbook CPUE from 1996 to 2004, but showed a similar trend (Fig. 104). Both indices agreed well in 2004 and observed CPUE exceeded logbook CPUE in 2005 for the first time. The indices once again agreed well in 2006. The seasonal trend in Div. 3NO CPUE in 2006 was similar to that in 2004-05 with weekly CPUEs lower than those during 2002 and 2003 (Fig. 105). Late-season CPUE in 2006, at comparable catch levels, was lower than in previous four (Fig. 106). Fishing activity was similar to that during 2002 (Fig. 107). The 2006 fishery started in week 1, five weeks earlier than the previous years, and it ended in week 19 with uniform weekly expenditure of fishing effort.

Fall multi-species trawl survey indices (Table 12-13, Fig 108) may be unreliable because of a limited spatial distribution of the resource within these divisions that is poorly sampled by the multi-species survey.

Production

Recruitment: Annual changes in the multispecies survey catch rate by shell condition (Fig. 109) reflected poor internal consistency. Peaks in old-shelled abundance have generally not followed peaks in new-shelled abundance. This may reflect annual variability in catchability by the survey trawl.

The Div. 3NO observer discard pre-recruit index (Fig. 110) declined during 1999-2003 and has been unchanged since.

Truncated and untruncated size frequency distributions (Fig. 111 and Fig. 112) from the fall multi-species surveys show that very few legal-sized crabs were captured in 2005-06, but as noted, there is high uncertainty in interpreting these data.

Size distributions from observer sampling in Div. 3N (Fig. 113) showed a gradual increase in modal CW from 101 mm CW in 1999 to 113 mm in 2002. Size distributions from 2003 to 2006 have changed very little with a platykurtic distribution centered about a 110-119 mm CW range. Trends in catch rates of legal-sized old-shelled crab and observed CPUE do not agree, with the catch rate of old-shelled crabs under-estimating observed CPUE in most years (Fig. 114). This disagreement and under-estimation may reflect classification of some exploitable (intermediate-shelled) crabs as new-shelled or retention of some new hard-shelled crabs in the landed catch. The catch rate of legal-sized new-shelled crab declined during 2000-03 and has changed little since, suggesting little change in recruitment in the short term. Since 2002, trends in catch rates of discarded crabs have closely matched catch rates of under-sized crabs (Fig. 115), suggesting low incidence of soft-shelled crab in the Div. 3NO fishery.

Recruitment has been low in recent years and short term prospects are uncertain.

Reproduction: There was no clear trend in the percentage of females carrying full clutches of viable eggs in Div. 3NO (Fig. 116). Almost all females carried full clutches in 1995-96 before declining to about 70% in 1999 and returning to 100% in 2001. It again declined to about 70% in 2005 before increasing to almost 100% in 2006.

Mortality

Exploitation: The exploitation rate index and pre-recruit mortality index are not informative because of uncertainties associated with the survey biomass indices. Trends in fishery-induced mortality are unknown.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 117) declined by more than half from 1999 to 2002. It has remained steady during the last 5 years at a low level, implying little wastage of pre-recruits in the fishery in recent years.

Prevalence of soft-shelled crab was consistently low in the Div. 3NO fishery from 2002 to 2005 (Fig. 118). In 2006, maximum weekly soft-shelled crab prevalence throughout the season never exceeded 20% but was at about 15% for two weeks (weeks 16 and 18) late in the season.

The 2006 fishery occurred uniformly in weeks 7 through 18 with little effort in week 19 (Fig. 119), Observer coverage was relatively evenly dispersed throughout the season in 2006, as was total fishing effort.

Natural mortality: BCD: BCD has been virtually absent from Div. 3NO, based on fall multispecies survey trawl samples.

SUBDIVISION 3Ps

The fishery

The fishery began in 1985 with landings (Table 14, Fig. 120) not exceeding 1000 t until 1994 when the offshore fishery began. Landings were at their highest level of 7600-8000 t during 1999-2002. They declined by 59% to 3200 t in 2005, while the TAC was reduced by 46%. Landings changed little, at 3100 t, in 2006, achieving the reduced TAC. Effort peaked in 2003 before declining by 40% to 2006.. The percentage of the total catch taken inshore declined from 39% to 27% over the past 5 years.

Biomass

Offshore CPUE declined by 75% from 1999 to its historical low in 2005 and increased slightly in 2006 (Fig. 121). Inshore CPUE declined by 70% from 2001 to its historical low in 2005 and increased slightly in 2006 (Fig. 121). The 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 spatial distribution of effort has changed little since 2001. Little effort has been expended in Fortune Bay throughout 2001-06 and there has been little or no fishing along the western slope of the St. Pierre Bank since 2004 (Fig. 122). In all other areas fishing effort and CPUE have declined greatly since 2002.

Observed CPUE was generally lower than offshore logbook CPUE throughout 1995-2003. (Fig. 123). Both indices show that CPUE declined from 1999 to 2003 with the logbook CPUE remaining unchanged and the observed CPUE increasing slightly in 2004. These indices agreed well in the past three years and showed that offshore CPUE decreased to a record low level in 2005 and increased slightly in 2006. Trends in offshore CPUE throughout the season (Fig. 124-125) indicated that weekly CPUEs in 2006 were below levels of the previous four years (Fig. 124). However, late-season CPUE in 2006 was, at comparable catch levels (Fig. 125) similar to that of the previous year, but at a lower level than during 2002-04. The offshore fishery began and ended earlier than in previous years, with less total effort expended (Fig. 126). The fishery began in week 1 and finished in week 10, with 84% of trap hauls completed by week 6, the week in which the 2005 fishery began. Trends in inshore CPUE throughout the season indicated that weekly CPUEs were generally comparable to those of 2004-05 but lower than those of 2002-03 (Fig. 127). There was generally little evidence of seasonal depletion during the 2006 fishery (Fig. 127-128) and late season CPUE in 2006 was, at comparable catch levels, marginally higher than in 2005, but below 2002-04 levels (Fig. 128). The inshore fishery began and ended earlier in 2006, with less total effort expended than in previous four years (Fig. 129). The fishery began in week 1 and finished in week 14, with 90% of trap hauls completed by week 7, the week in which the 2005 fishery began.

No estimates of the exploitable biomass index are available as there are no reliable research survey data from this area. For unknown reasons, biomass and abundance indices from spring surveys are highly variable. The industry-DFO collaborative offshore post-season trap survey indices of legal-sized crabs showed a slight increase in catch rate since 2004 (Fig. 130). The inshore collaborative trap survey indices showed no trend (Fig. 131).

Production

Recruitment: The observer discard pre-recruit index (Fig. 132) changed little during 1999-2004 but almost doubled in 2005. It decreased in 2006, largely due to an early fishing season in 2006 that resulted in greatly reduced catches of soft-shelled crabs. Although spring survey biomass indices are considered unreliable, biological data from these surveys agreed with observer data in 2005 in suggesting that recruitment should increase over the next 3 years. However a spring survey was not conducted in this area in 2006 due to vessel breakdown.

The collaborative offshore post-season trap survey catch rate of sub-legal-sized crabs from common stations increased sharply in 2005 and was followed by an increase in catch rate of legal-sized new-shelled crabs in 2006 (Fig. 130), suggesting an increase in recruitment in the short term. Size frequencies from this survey (Fig. 133) showed an increase in soft-shelled crabs larger than about 70 mm CW in 2005 and a subsequent increase in new-shelled crabs of this size in 2006.

Size distributions from at-sea sampling by observers (Fig.134) in 2006 showed a sharp (‘knife-edge’) decrease in catch rate at 95 mm CW for the second consecutive year, reflecting effects of high exploitation on old-shelled legal sized crabs as well as new-shelled immediate pre-recruits. Catch rates of sub-legal sized (77-92 mm CW) new-shelled pre-recruits increased in 2005-06, likely reflecting the leading tail of a modal group of adolescent pre-recruits observed in spring trawl survey size distributions (Dawe et al. 2006). Trends in legal-sized old-shelled crab have reflected those of kept crabs since

2001, albeit at a higher level (Fig. 135). This could be attributable to spatial and/or temporal variability in the at-sea sampling. A decline in observer CPUE of new-shelled immediate pre-recruits since 2004 (Fig. 135) is due to a decline in average size of immediate pre-recruits (Fig. 134). Close agreement between catch rates of total discards and under-sized crabs (Fig. 136) indicates that most of the crabs released were under-sized as opposed to soft-shelled. The observer CPUE of under-sized crabs has increased steadily since 2003 (Fig. 136).

Observer and collaborative post-season trap survey data indicate recruitment should increase over the next three years in the offshore.

The collaborative inshore post-season trap survey (Fig. 131) showed no convincing trends in recruitment. Size frequencies from this survey showed higher abundance of new-shelled pre-recruits during 2004-06 than in 2003, but no clear modal progression has been evident (Fig. 137).

Long-term recruitment: no data.

Mortality

Exploitation: No pre-recruit fishing mortality index is available as there are insufficient fishery independent data from this area. CPUE trends indicate that the exploitable biomass has been greatly reduced.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 138) more than doubled to about 80% in 2005 and decreased, to its second highest level, in 2006 largely due to an early fishing season in 2006 that resulted in greatly reduced catches of soft-shelled crabs. Increased removals, in the short term, would likely impair recovery of the exploitable biomass.

The occurrence of soft-shelled crab in the weekly catch was much higher in 2005 than during 2002-04, and 2006 (Fig. 139). Soft-shelled crab represented 0-5% of the catch throughout the 2006 fishery.

The fishing season was early relative to preceding seasons, occurring most intensely from week 2 to week 6 (Fig. 140). Observer coverage matched fishing effort proportionately throughout the season.

Natural Mortality (BCD): Small-meshed trap data from the collaborative post-season trap survey indicates that BCD has been detected, at low prevalence levels in inshore Subdiv. 3Ps since 2004 (unpublished data).

DIVISION 4R AND SUBDIVISION 3Pn

The fishery

Landings (Table 15, Fig. 141) peaked in 2002 at 1850 t and since declined by 71% to their historic low of 540 t in 2006, while the TAC remained high. Effort decreased during 2005-06 to its lowest level since 1994.

Biomass

CPUE (Fig. 142) is higher in inshore than offshore areas but is low relative to other divisions. 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. 143). Fishing effort has decreased greatly since 2001 in the offshore and since 2002 in inshore` areas, such that in 2006 most of the fishing effort was concentrated in two inshore bays (Fig. 143)

Observed CPUE and logbook CPUE differed greatly and showed no common trend (Fig. 144), due to inadequate observer coverage. Offshore CPUE levels throughout the season in 2006 were at their lowest since 2002 (Fig. 145-146). They remained below 2 kg / trap haul for most of the season, but increased sharply late in the season. The 2006 offshore fishery occurred from weeks 1 through 14 with a lower number of trap hauls compared to the previous four years (Fig. 147). Inshore CPUE levels throughout the season in 2006 were comparable to those of 2005 and below 2002-2004 levels (Fig. 148). Initial CPUEs were the lowest in the time series in 2006. CPUEs in 2006, at comparable catch levels, were below those of earlier years except 2003 (Fig. 149). The inshore fishery was early relative to preceding seasons, starting in week 1 and finishing in week 14 (Fig. 150). In the first 4 weeks, 74% of the total effort was `expended.

The collaborative offshore post-season trap survey has not been conducted since 2003. The areas (CMAs) included in the inshore collaborative survey have decreased during 2003-2006 such that only two inshore areas were consistently surveyed in the past 3 years. Data from common stations (Fig. 151) show a decrease in inshore catch rates of all legal-sized crabs in 2006 and a decrease in catch rates of old-shelled legal-sized crabs since 2004.

Production

Immediate recruitment: The observer data for this area are insufficient to estimate a reliable pre-recruit index. Data from the inshore collaborative post-season trap survey (Fig. 151) shows that catch rates of under-sized crabs have declined since 2004 and the catch rate of new-shelled legal-sized immediate pre-recruits decreased sharply in 2006. However the implications are highly uncertain as these decreases are based on a very limited set of stations common to the past 4 years. Therefore, short-term recruitment prospects are unknown.

Long-term recruitment: no data are available.

Mortality

Trends in mortality on either the exploitable or pre-recruit population are unknown. The observer data are insufficient to estimate the percentage of the catch discarded in the fishery or to infer wastage of pre-recruits.

Observer data on weekly soft crab percentages were insufficient to interpret any trend. Observer coverage was not well distributed throughout the season in proportion to total fishing effort with observed sets occurring in only one week of the 2006 fishery.

There are no data on BCD from this area.

REFERENCES

Colbourne, E., Craig, J., Fitzpatrick, C., Senciall, D., Stead, P., and Bailey, W. 2007. An assessment of the physical oceanographic environment on the Newfoundland and Labrador Shelf during 2006. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/030.

Dawe, E.G. 2002. Trends in prevalence of bitter crab disease caused by *Hematodinium* sp. in Snow Crab (*Chionoecetes opilio*) throughout the Newfoundland and Labrador Continental Shelf. pp. 385-400 *In*: Crabs in Cold Water Regions: Biology, Management, and Economics. Edited by A.J. Paul, E.G., Dawe, R. Elner, G.S. Jamieson, G.H. Kruse, R.S. Otto, B. Sainte-Marie, T.C. Shirley, and D. Woodby University of Alaska Sea Grant, AK-SG-02-01, Fairbanks, 786 p.

Dawe, E.G., and Colbourne, E.B. 2002. Distribution and demography of snow crab (*Chionoecetes opilio*) males on the Newfoundland and Labrador shelf. pp. 577-594 *In*: Crabs in Cold Water Regions: Biology, Management, and Economics. Edited by A.J. Paul, E.G. Dawe, R. Elner, G.S. Jamieson, G.H. Kruse, R.S. Otto, B. Sainte-Marie, T.C. Shirley, and D. Woodby University of Alaska Sea Grant,AK-SG-02-01, Fairbanks, 876 p.

Dawe, E.G., Drew, H.J., Veitch, P.J., Turpin, R., O'Keefe, P.G and Beck, P.C. 2002b. An assessment of Newfoundland and Labrador snow crab in 2001. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/050, 51 p.

Dawe, E.G., Drew, H.J., Veitch, P.J., Turpin, R., Seward, E. , Beck, P.C. 2003. An Assessment of Newfoundland and Labrador Snow Crab in 2002. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/025, 67p.

Dawe, E.G., McCallum, B.R., Walsh, S.J., Beck, P.C., Drew, H.J., and Seward, E.M. 2002a. A study of the catchability of snow crab by the Campelen 1800 survey trawl. DFO Can. Sci. Advis. Sec. Res. Doc. 51/02.

Dawe, E.G., Orr, D., Parsons, D., Stansbury, D., Taylor, D.M., Drew, H.J., Veitch, P.J., O'Keefe, P.G., Seward, E., Ings, D., Pardy, A., Skanes, K., and Beck, P.C. 2004. An Assessment of Newfoundland and Labrador Snow Crab in 2003. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/024, 110p.

Dawe, E.G., Taylor, D.M., Stansbury, D., Drew, H.J., Pardy, A., Veitch, P.J., Hynick, E., O'Keefe, P.G., Beck, P.C., Mullowney, D., and Skanes, K. 2005. An Assessment of Newfoundland and Labrador Snow Crab in 2004. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/013, 114 p.

Dawe, E.G., Mullowney, D., Stansbury, D. Parsons, D.G., Taylor, D.M., Drew, H.J., Veitch, P.J., Hynick, E., O'Keefe, P.G., and Beck, P.C. 2006. An Assessment of Newfoundland and Labrador Snow Crab in 2005. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/031, 129 p.

Dawe, E.G., Taylor, D.M., Veitch, P.J., Drew, H.J., Beck, P.C., and O'Keefe, P.G. 1997. Status of Newfoundland and Labrador Snow Crab in 1996. DFO Can. Sci. Advis. Sec. Res. Doc. 97/07, 30p.

Dufour, R., Bernier, D., Brêthes, J.-C. 1997. Optimization of meat yield and mortality during snow crab (*Chionoecetes opilio* O. Fabricius) fishing operations in Eastern Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2152 : viii + 30p.

Hoenig, J.M., Dawe, E.G., and O'Keefe, P.G. 1994. Molt indicators and growth per molt for male snow crabs (*Chionoecetes* *opilio*). J. Crust. Biol. 14(2): 273-279.

Miller, R.J. 1977. Resource Underutilization in a Spider Crab Industry. Fisheries, Vol. 2 No. 3 : 9 – 13.

Smith, S.J., and Somerton, G.D. 1981. STRAP: A user-oriented computer analysis system for groundfish research trawl survey data. Can. Tech. Rep. Fish. Aquat. Sci. 1030: 66 p.

Table 1. TAC (t) and Landings (t) by year for Division 2J3KLNOPs4R.

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
2005	49,978	43,946
2006	46,233	47,051

Table 2. TAC (t), Landings (t), Effort (trap hauls), and CPUE (kg/trap) by year for Division 2J.

Year	TAC	Landings	Effort	CPUE Total
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	47,031	12.8
1991	1,420	1,003	68,231	14.7
1992	1,420	1,494	121,463	12.3
1993	2,300	2,267	190,504	11.9
1994	2,900	2,971	330,111	9
1995	3,050	3,189	393,704	8.1
1996	2,800	3,102	326,526	9.5
1997	2,800	3,183	286,757	11.1
1998	3,500	4,098	284,583	14.4
1999	4,655	5,428	402,074	13.5
2000	3,411	3,673	303,554	12.1
2001	3,340	3,738	424,773	8.8
2002	3,381	3,521	577,213	6.1
2003	2,265	2,532	588,837	4.3
2004	1,780	1,925	550,000	3.5
2005	1,425	1,581	298,302	5.3
2006	1,425	1,975	240,854	8.2

Table 3. Fall multispecies survey exploitable Biomass by Year for Division 2J.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	2,956	4,109	1,803	2.28
1996	5,811	8,049	3,573	2.91
1997	10,861	16,895	4,826	4.13
1998	13,369	19,173	7,565	4.92
1999	6,215	8,098	4,332	3.08
2000	4,172	5,155	3,190	2.13
2001	3,318	4,107	2,528	1.88
2002	463	552	374	0.89
2003	658	1,046	270	0.97
2004	828	1,695	-39	1.26
2005	1,393	9,404	-6,617	3.36
2006	2,582	3,332	1,829	1.53

Table 4. Fall multispecies survey pre-recruit index by Year for Division 2J.

YEAR	BIOMASS (t)	Confidence Intervals (+/-)		MEAN kg/set
		Upper	Lower	
1995	1,339	4,078	-1,400	3.66
1996	2,139	3,513	766	2.07
1997	2,618	3,231	2,004	1.68
1998	3,747	5,061	2,433	2.65
1999	6,86	3,607	-223	2.2
2000	1,434	6,606	-3,738	2.09
2001	917	5,787	-3,954	2.96
2002	352	2,598	-1,894	1.77
2003	327	1,106	-452	2.4
2004	3,888	32,832	-25,056	7.89
2005	1,015	6,602	-4,571	3.36
2006	1,850	3,707	-8	2.04

Table 5. TAC (t), Landings (t), Effort (trap hauls), and CPUE (kg/trap) by Year for Division 3K.

Year	TAC	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	9.9	9.2
2002	15,378	16,352	1,619,010	10.7	8.2
2003	15,608	16,502	1,755,532	10.3	6.7
2004	15,593	16,460	2,351,429	7.6	5.3
2005	12,860	8,685	1,423,770	6.9	4.8
2006	10,430	10,717	1,116,354	11.5	6.4

Table 6. Fall multispecies survey Biomass index for Division 3K.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	12,686	39,246	-13,873	3.57
1996	21,057	25,314	16,801	5.38
1997	19,789	23,922	15,656	4.87
1998	21,398	32,146	10,650	5.54
1999	11,976	15,259	8,694	3.56
2000	13,052	16,511	9,593	3.49
2001	12,519	16,935	8,104	4.58
2002	10,236	12,930	7,542	3.06
2003	4,031	4,983	3,079	1.62
2004	6,813	9,317	4,310	2.52
2005	8,271	10,339	6,202	2.87
2006	12,602	15,363	9,841	4.4

Table 7. Fall multispecies survey pre-recruit index for Division 3K.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	8,722	14,124	3,320	3.45
1996	10,998	14,467	7,528	3.16
1997	18,871	24,283	13,459	5.35
1998	11,652	16,247	7,057	3.89
1999	4,079	5,747	2,411	2.64
2000	12,626	17,427	7,824	5.25
2001	7,307	10,083	4,532	3.09
2002	5,846	7,977	3,715	2.25
2003	4,161	14,317	-5,995	1.93
2004	8,501	16,500	502	3.88
2005	7,852	10,516	5,189	2.81
2006	12,216	17,379	7,053	5.08

Table 8. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) 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	1,958,346	16.6	8.1
2004	27,288	25,746	2,163,529	14.2	7.7
2005	27,078	24,909	2,075,750	13.8	8.2
2006	27,128	26,479	2,152,764	13.4	9.6

Table 9. Fall multispecies survey exploitable Biomass index by Year for Division 3L.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	22,845	29,632	16,058	6.24
1996	34,160	41,585	26,735	7.97
1997	21,479	29,960	12,998	5.15
1998	23,809	29,886	17,732	5.43
1999	15,264	25,601	4,927	3.85
2000	9,942	15,343	4,541	2.64
2001	14,157	19,285	9,030	3.35
2002	12,876	20,875	4,878	3.47
2003	13,639	21,337	5,940	3.58
2004				
2005	11,327	20,104	2,549	2.97
2006	5,750	7,550	3,950	1.85

Table 10. Fall multispecies survey pre-recruit Biomass index by Year for Division 3L.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	12,904	18,227	7,580	3.67
1996	25,934	33,972	17,896	6.21
1997	10,126	38,935	-18,682	2.81
1998	9,318	12,044	6,592	3.08
1999	6,284	11,200	1,367	2.07
2000	5,945	9,552	2,338	2.36
2001	3,594	5,912	1,276	1.63
2002	3,050	3,788	2,312	1.21
2003	6,689	12,039	1,338	2.21
2004				
2005	3,529	7,904	-846	1.64
2006	3,390	4,564	2,216	1.16

Table 11. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) by Year for Division 3NO.

Year	TAC	Landings	Effort	CPUE Total
1985		7		
1986				
1987				
1988		327		
1989		531		
1990		78		
1991		19		
1992				
1993		148		
1994		106		
1995		14	615	22.8
1996		427	33,101	12.9
1997		1,454	99,589	14.6
1998		730	40,110	18.2
1999	3,250	6,506	337,098	19.3
2000	2,425	4,173	216,218	19.3
2001	2,425	4,697	239.643	19.6
2002	2,425	5,023	246,225	20.4
2003	2,670	5,592	292,775	19.1
2004	2,670	5,283	343,052	15.4
2005	2,670	4,740	336,170	14.1
2006	2,670	4,238	273,419	15.5

Table 12. Fall multispecies survey exploitable Biomass index by Year for Division 3NO.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	2,140	4,837	-556	3.23
1996	8,264	20,344	-3,816	11.29
1997	3,670	5,405	1,934	5.61
1998	7,178	10,007	4,349	10.87
1999	7,138	10,138	4,138	7.47
2000	3,804	14,070	-6,461	4.71
2001	9,767	18,977	556	14.3
2002	4,170	9,970	-1,629	6.05
2003	4,024	6,249	1,800	2.61
2004	4,883	12,836	-3,070	8.24
2005	9,102	3,200	-1,380	1.77
2006	2,621	14,338	-909	1.22

Table 13. Fall multispecies survey pre-recruit Biomass index by Year for Division 3NO.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	2,539	18,041	-12,964	4.4
1996	6,694	17,683	-4,295	10.71
1997	2,954	5,174	734	3.98
1998	6,699	55,824	-42,426	11.29
1999	3,576	9,364	-2,212	5.73
2000	2,081	3,568	595	3.19
2001	3,875	6,940	809	7.52
2002	649	4,324	-3,026	6.35
2003	2,153	4,069	236	2.29
2004	1,506	12,479	-9,466	3.74
2005	91	284	-101	0.96
2006	420	2,252	-1,412	1.09

Table 14. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) by Year for Division 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	849,028	8.3	5.7
2004	4,395	4,720	749,206	8.2	3.7
2005	4,100	3,169	597,525	6.2	3.3
2006	3,045	3,099	516,500	7.5	3.8

Table 15. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) 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	113,214		5.6
1995		869	144,835	5.3	7.4
1996	1,289	838	178,298	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	294,717	3.7	9.4
2004	1,864	1,462	340,000	3.2	7.6
2005	1,845	862	200,465	3.1	7.4
2006	1,535	543	115,532	2.9	6

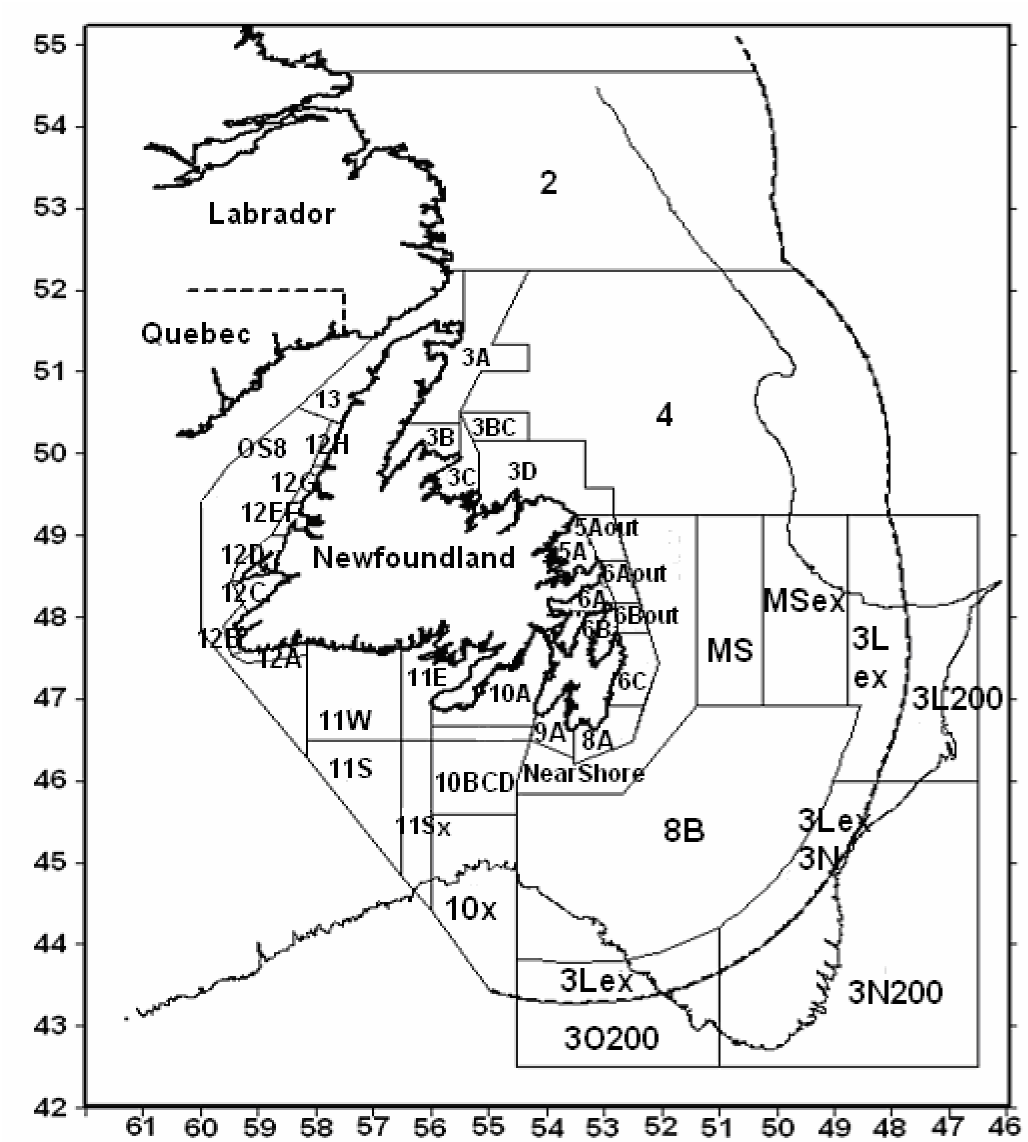


Figure 1. Newfoundland and Labrador Snow Crab Management areas.

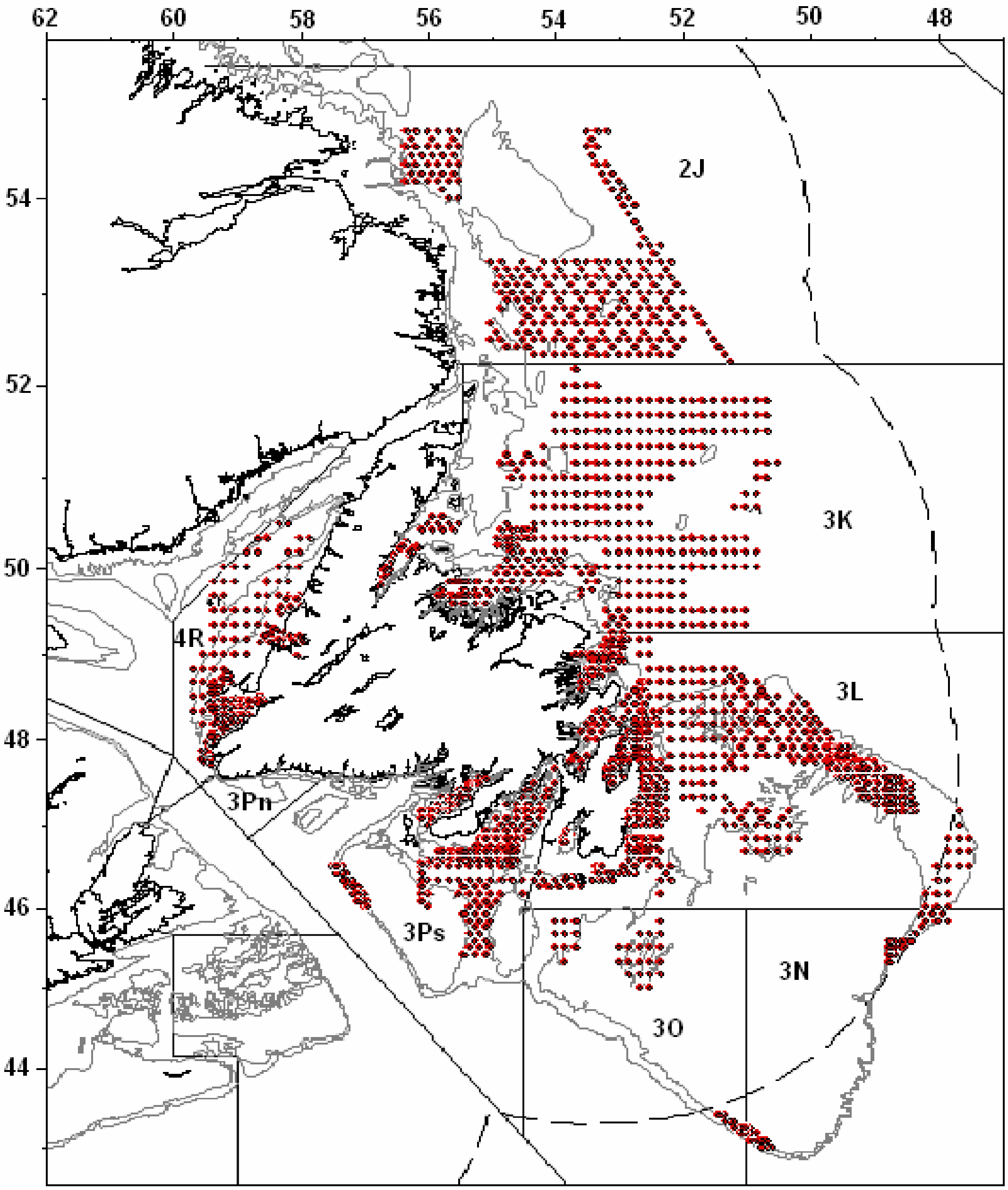


Figure 2. FSCP post-season trap survey stations.

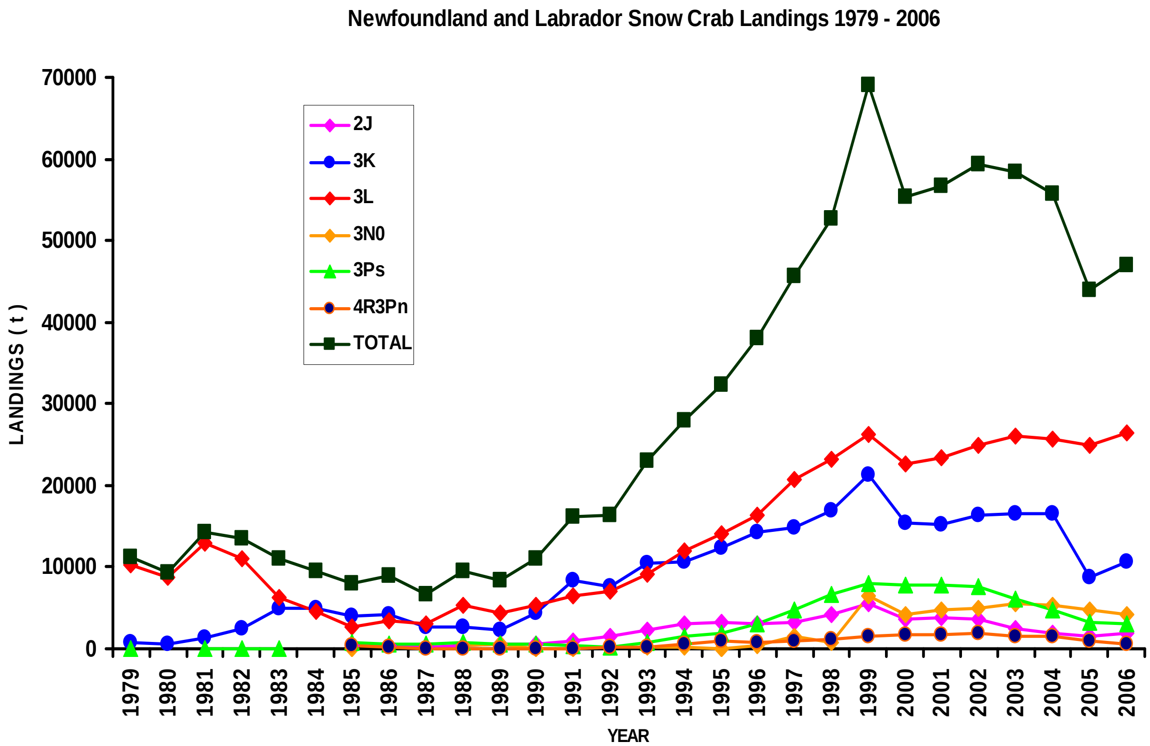


Figure 3. Trends in landings by NAFO Division and in total.

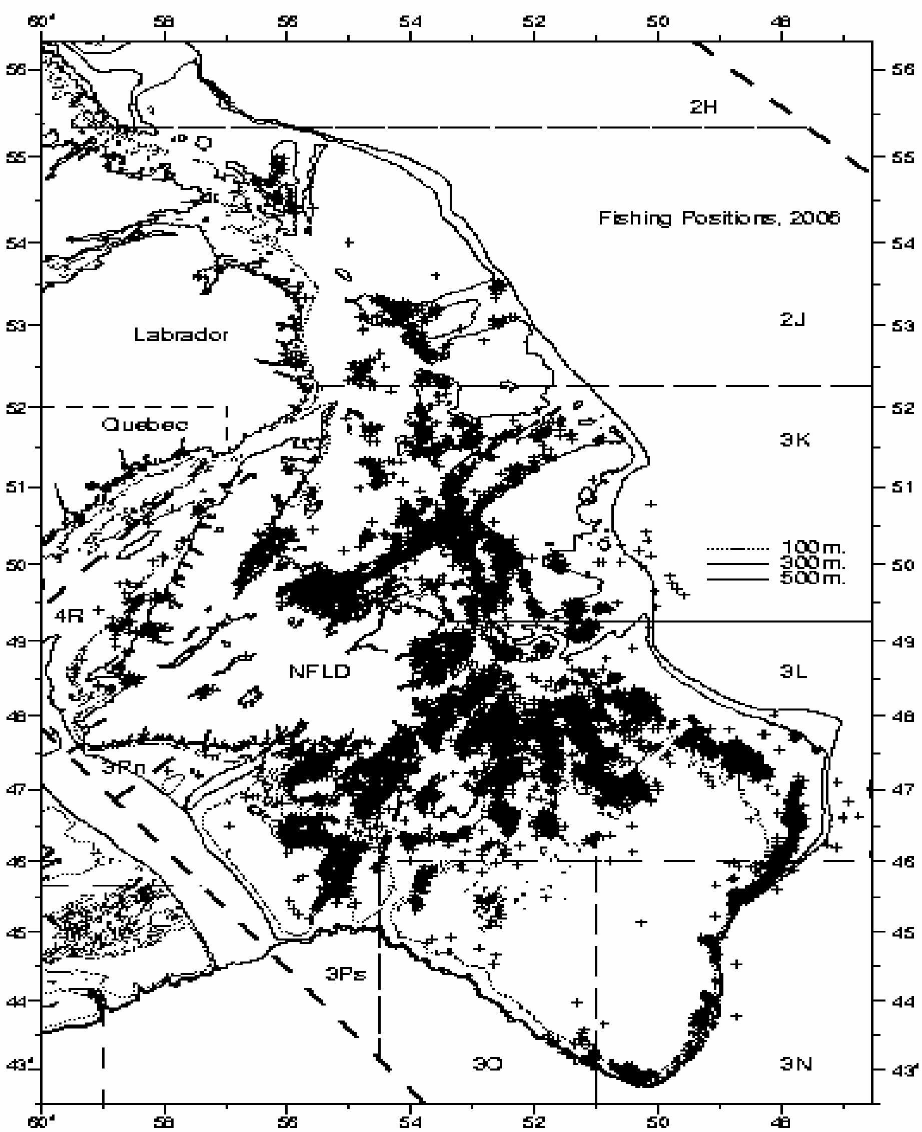


Figure 4. Spatial distribution of commercial fishing effort during 2006.

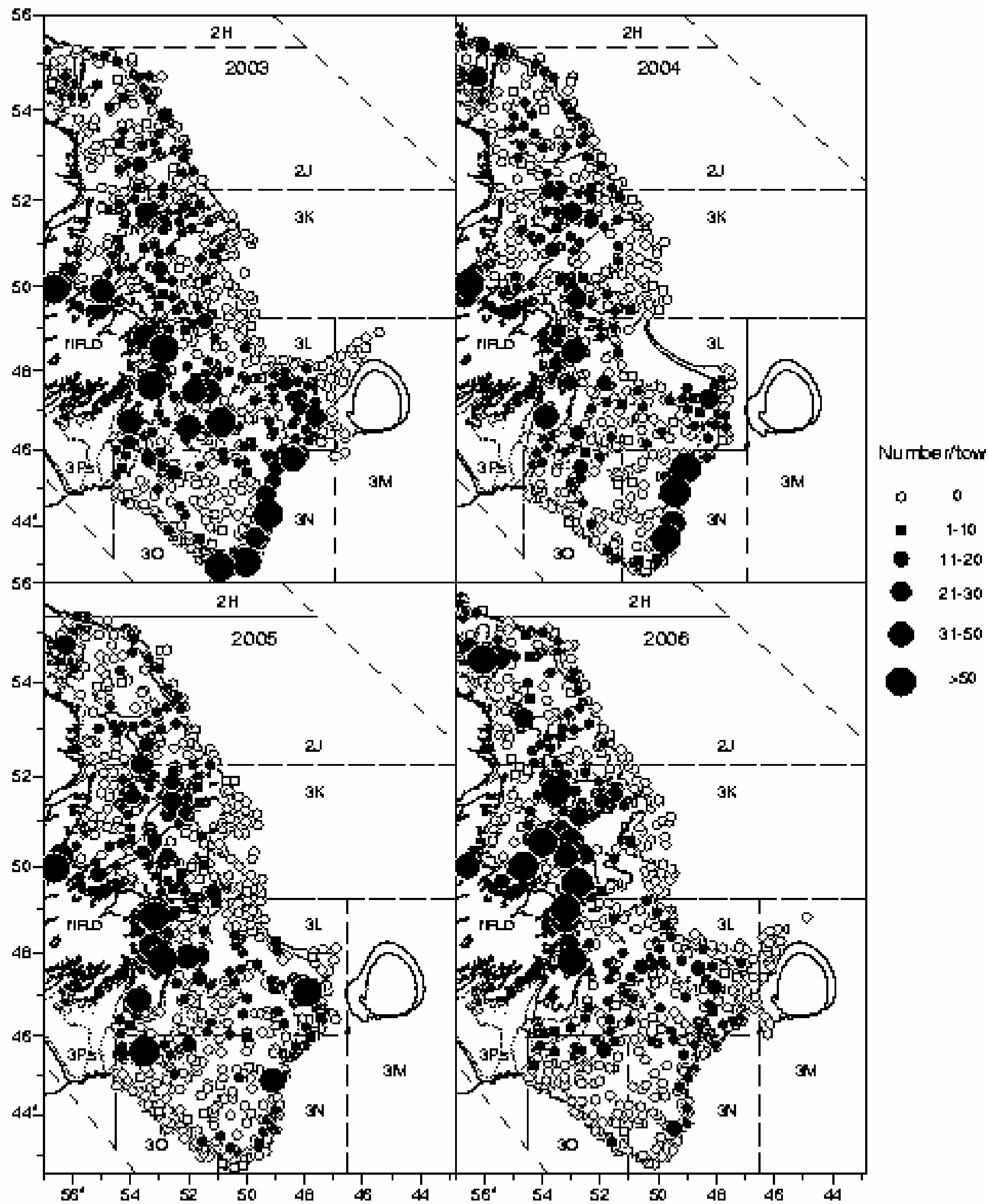


Figure 5. Distribution of exploitable males (>94 mm CW adults) from fall Division 2J3KLNO multi–species bottom trawl surveys from 2003 to 2006.

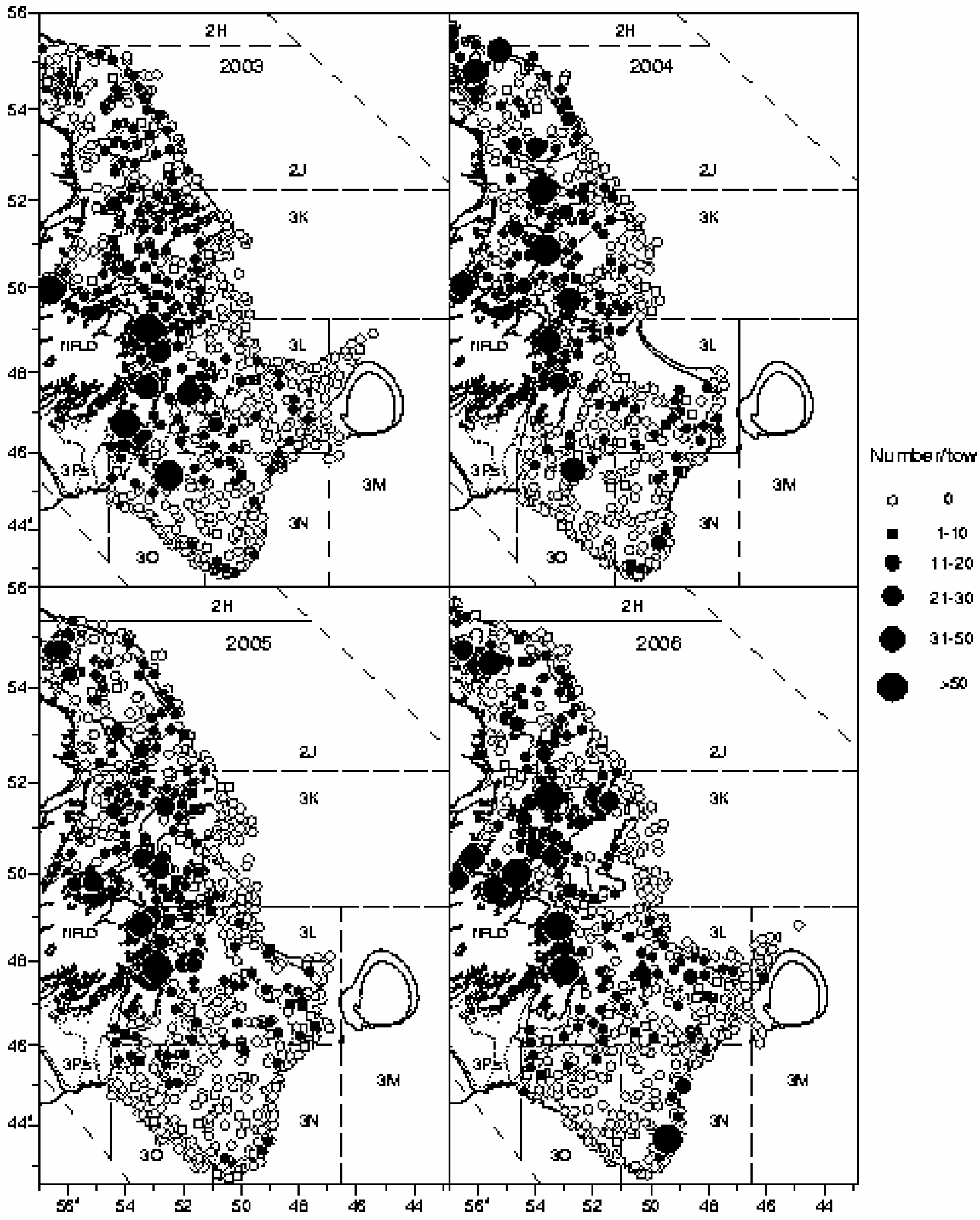


Figure 6. Distribution of pre-recruit males (>75 mm CW adolescents) from fall Division 2J3KLNO multi–species bottom trawl surveys from 2003 to 2006.

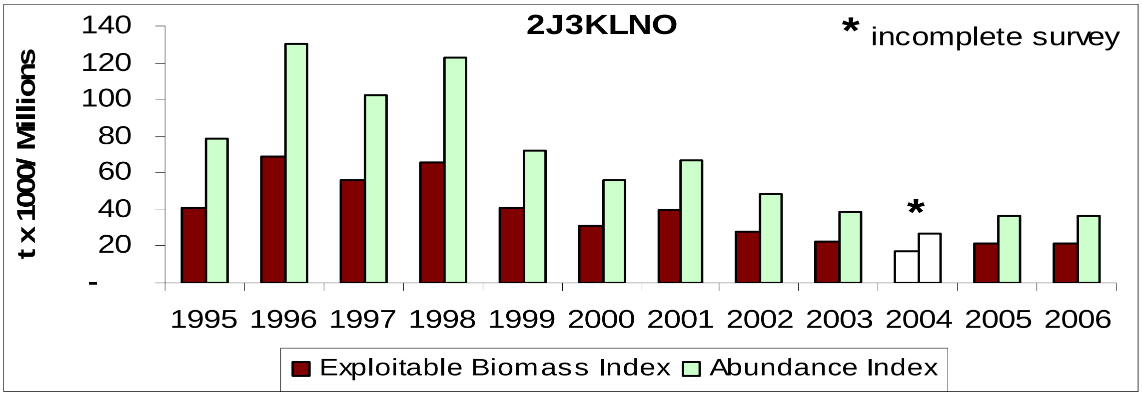


Figure 7. Trends in the fall multi-species survey exploitable biomass and abundance indices, for Division 2J3KLNO.

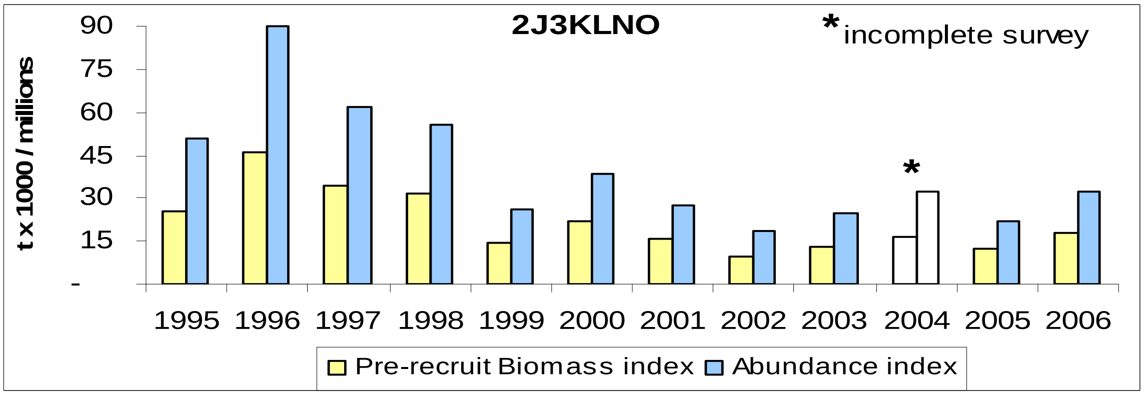


Figure 8. Trends in the fall multi-species survey pre-recruit biomass and abundance indices, for Division 2J3KLNO.

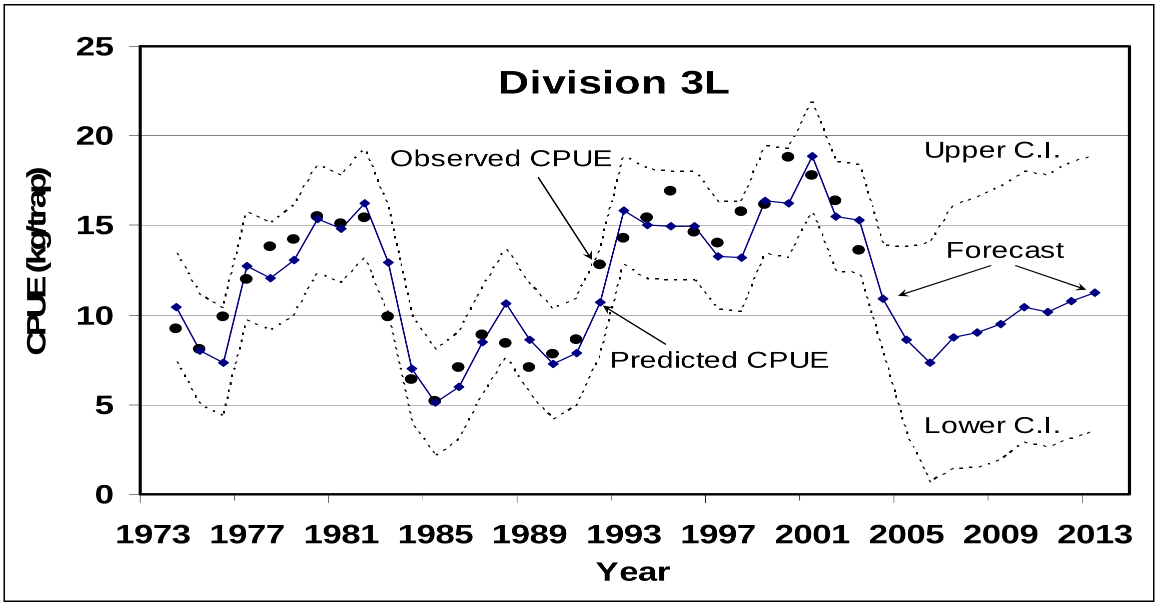


Figure 9. Comparison of observed Division 3L CPUE values with those predicted by a model that includes ice cover 10 years earlier as an explanatory variable.

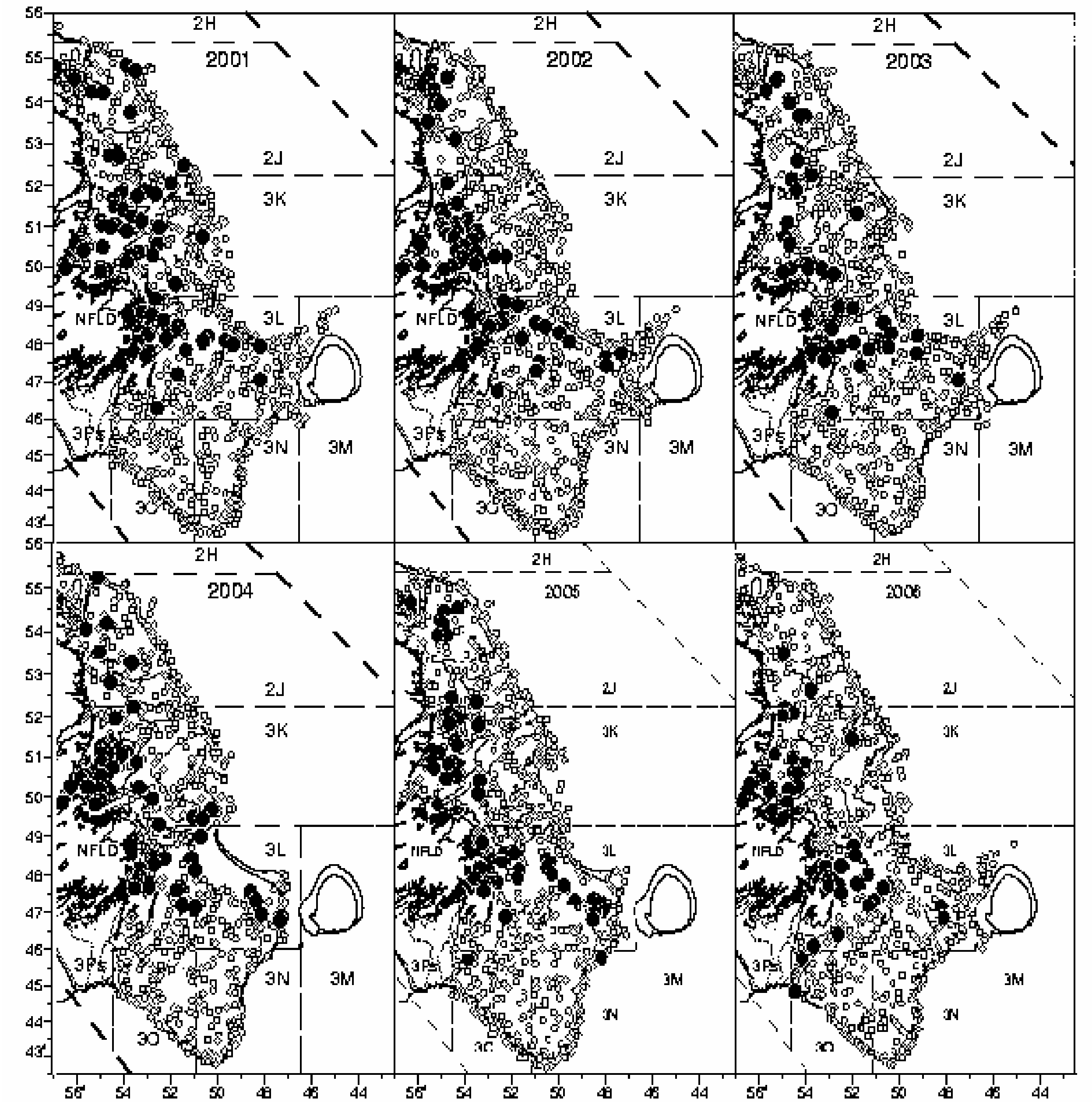


Figure 10. Distribution by year of survey sets where BCD was encountered (closed circles) versus all other sets (open circles) from 2001 to 2006.

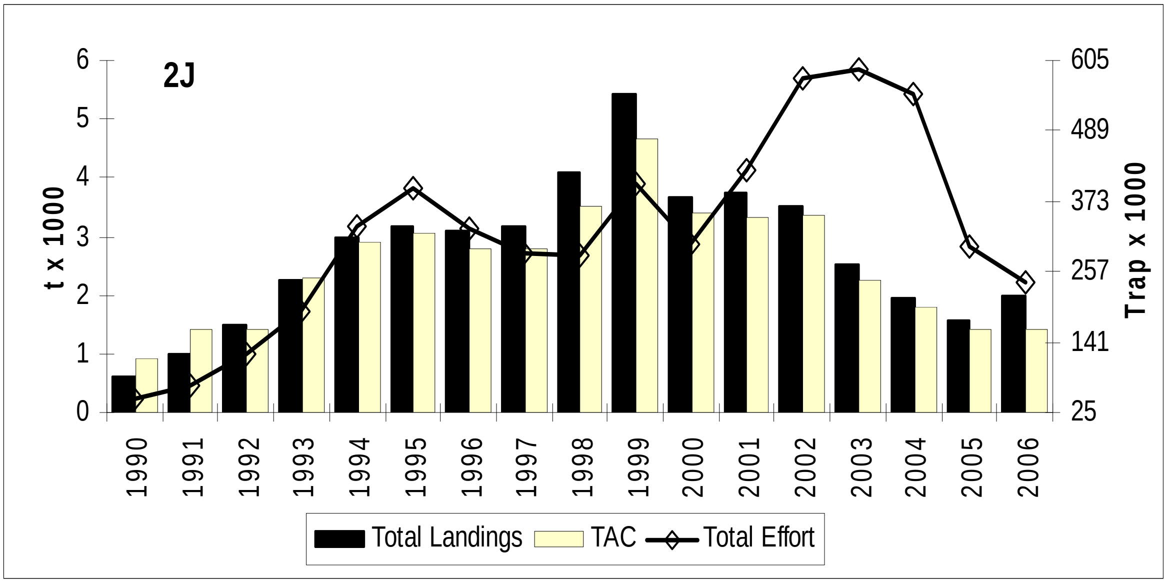


Figure 11. Trends in Division 2J landings, TAC, and fishing effort.

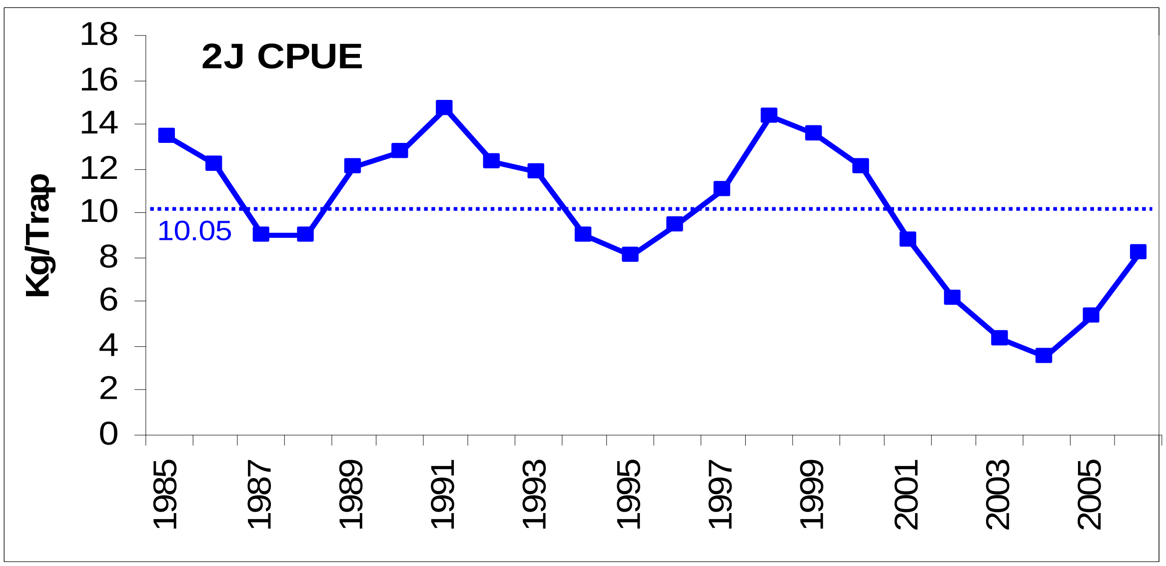


Figure 12. Trends in Division 2J commercial CPUE in relation to the long-term average (dotted line).

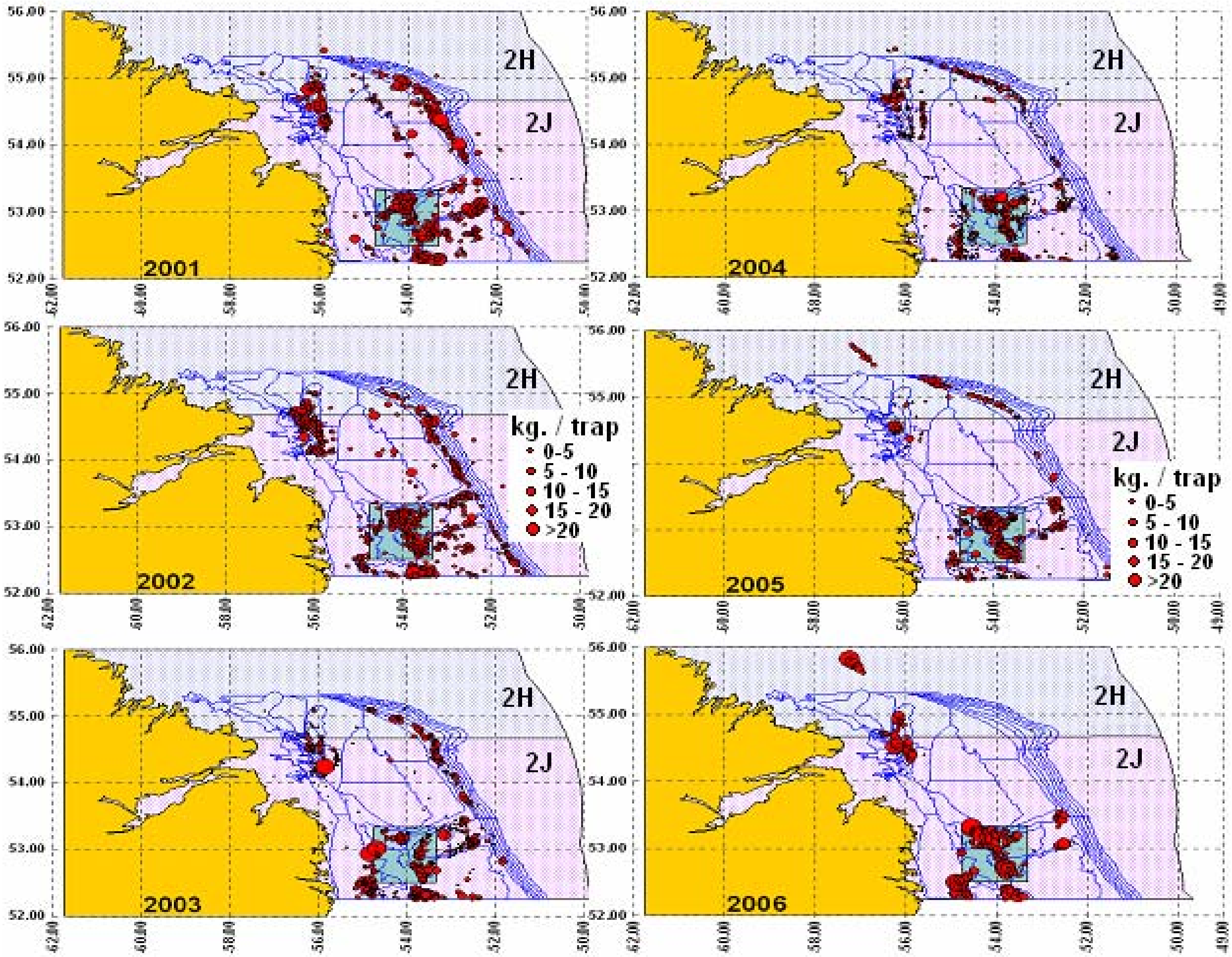


Figure 13. Spatial distribution of Division 2J commercial CPUE by year showing the Hawke channel closed area.

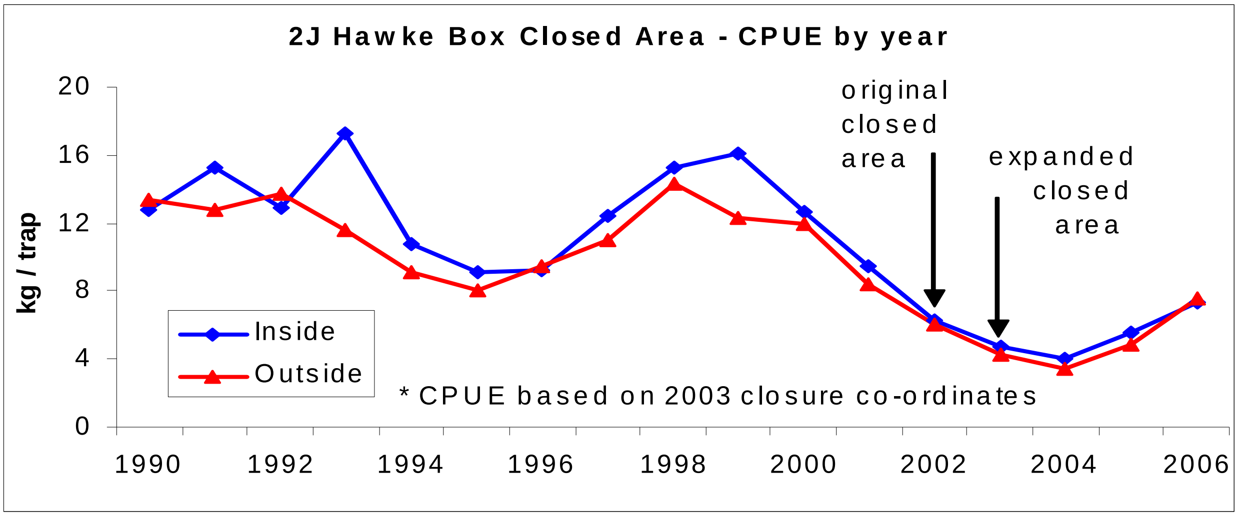


Figure 14. Division 2J commercial CPUE; inside vs. outside the Hawke Channel closed area.

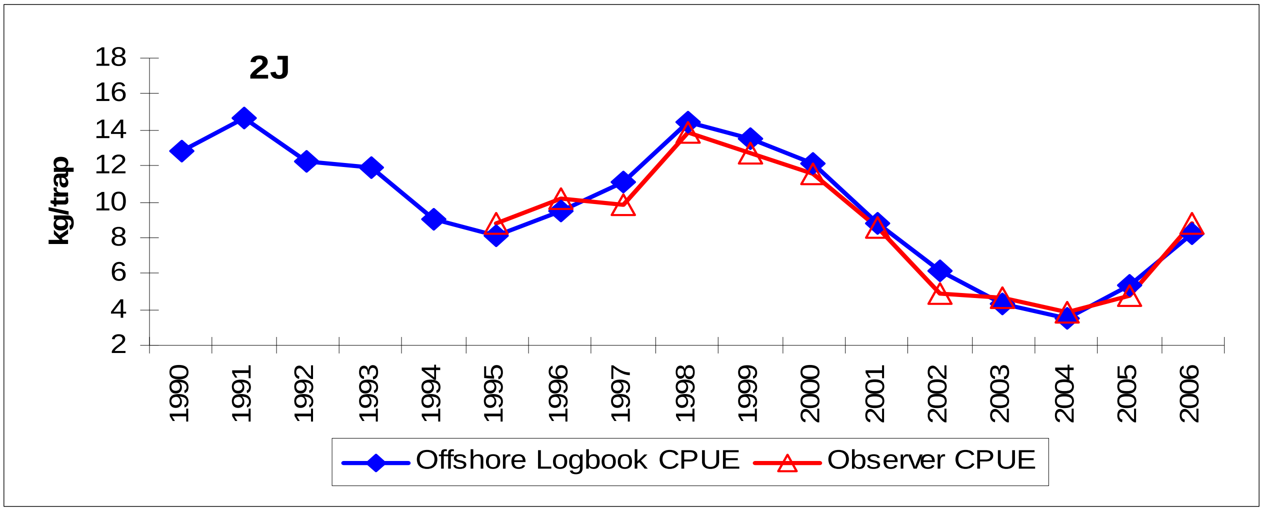


Figure 15. Trends in logbook-based CPUE vs. observer-based CPUE in the Division 2J fishery.

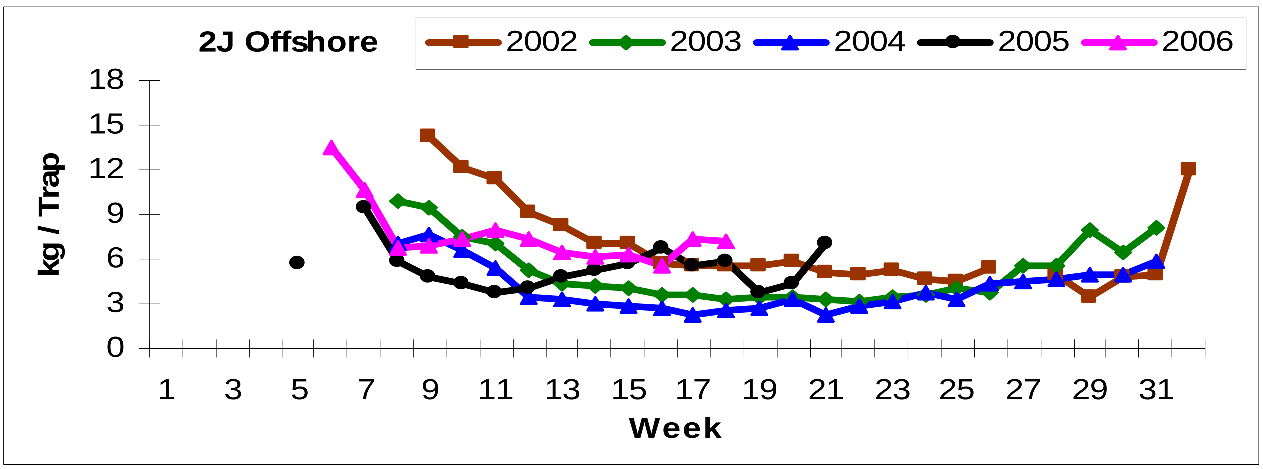


Figure 16. Seasonal trends in CPUE, by week, for Division 2J during 2002-06.

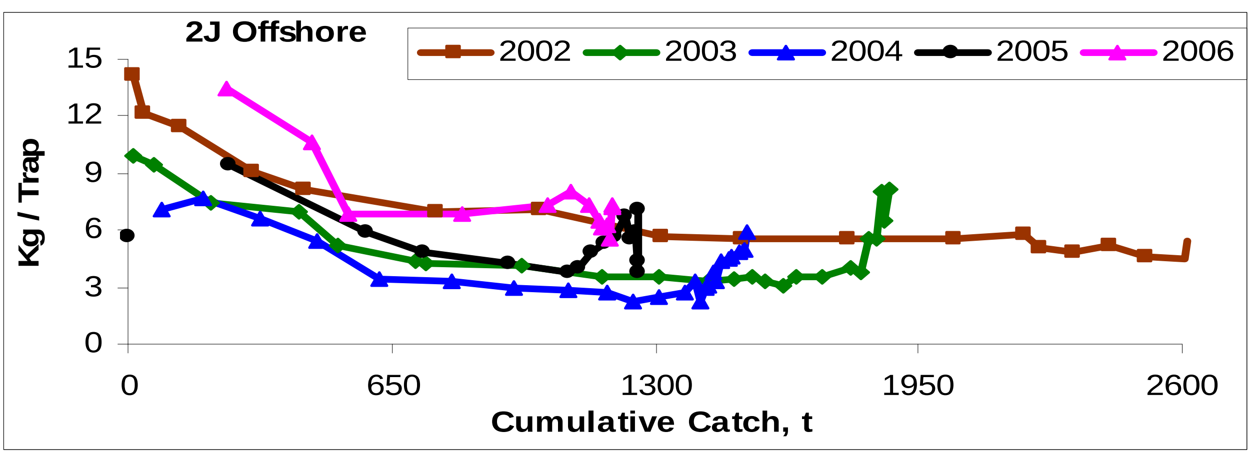


Figure 17. Seasonal trends in CPUE, in relation to cumulative catch, for Division 2J during 2002-06.

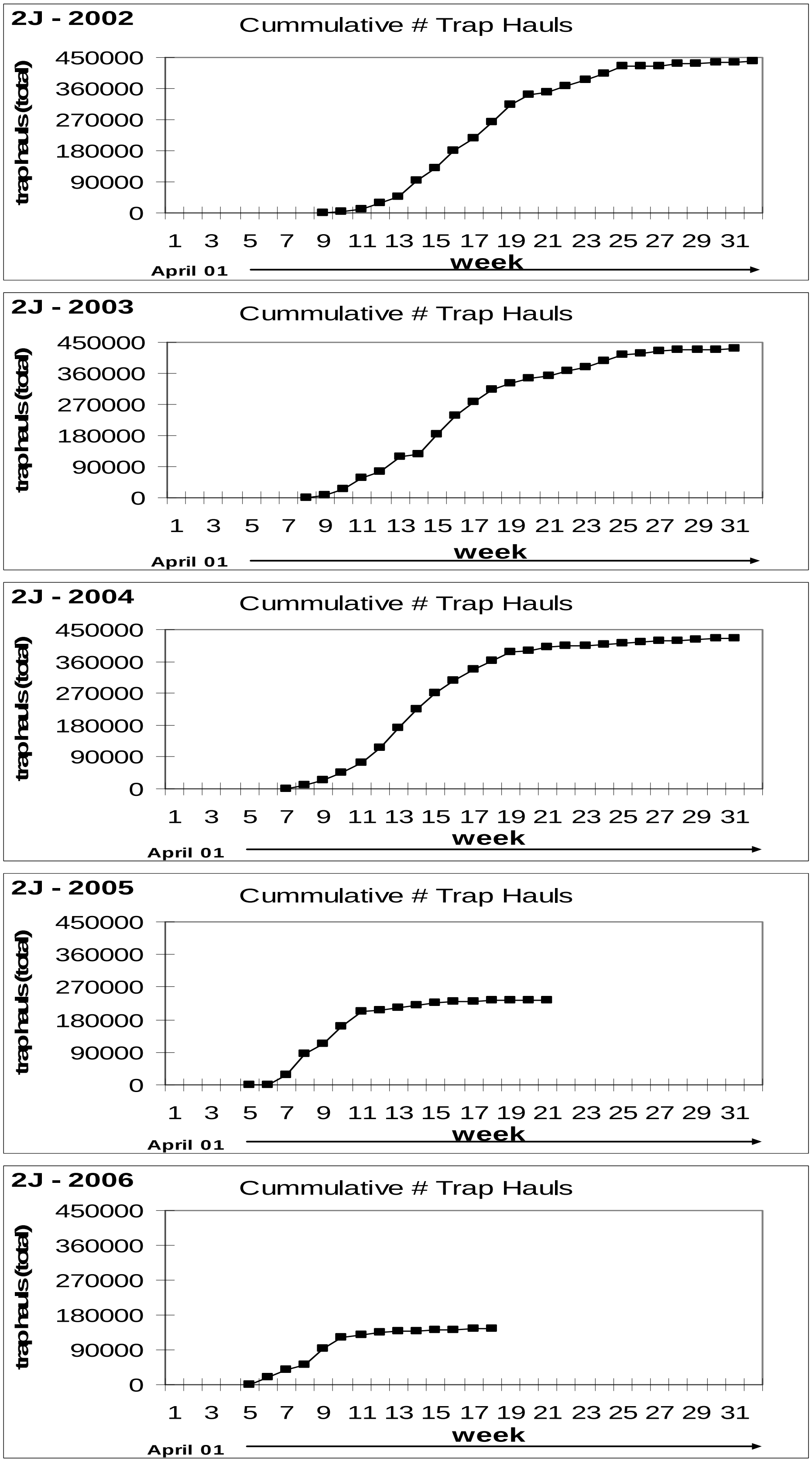


Figure 18. Seasonal trends in fishing effort, by week, for Division 2J during 2002-06.

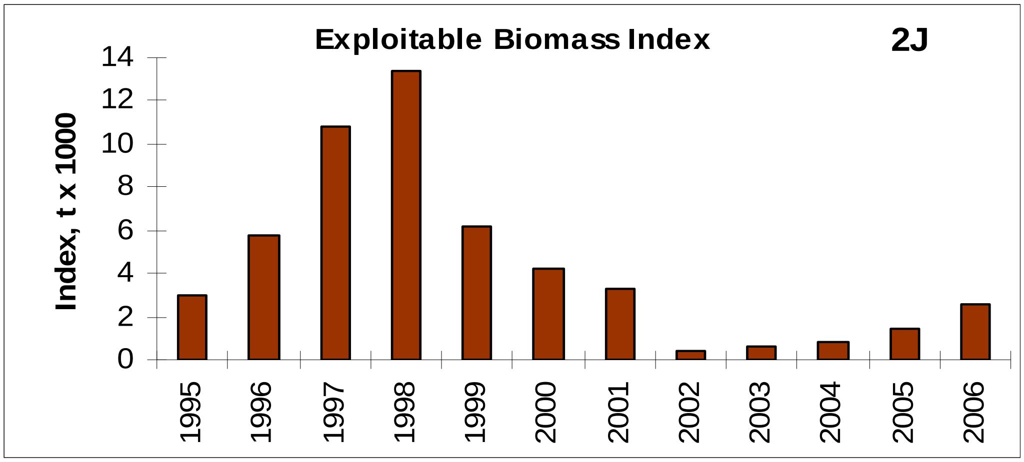


Figure 19. Trends in the Division 2J fall multi-species survey exploitable biomass index.

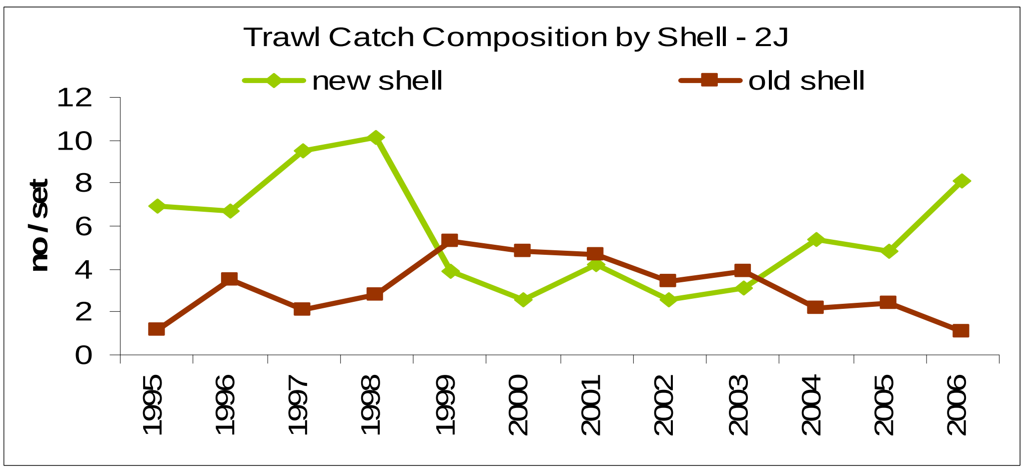


Figure 20. Trends, by shell condition, in abundance indices of legal-sized males for Division 2J from fall multi-species surveys.

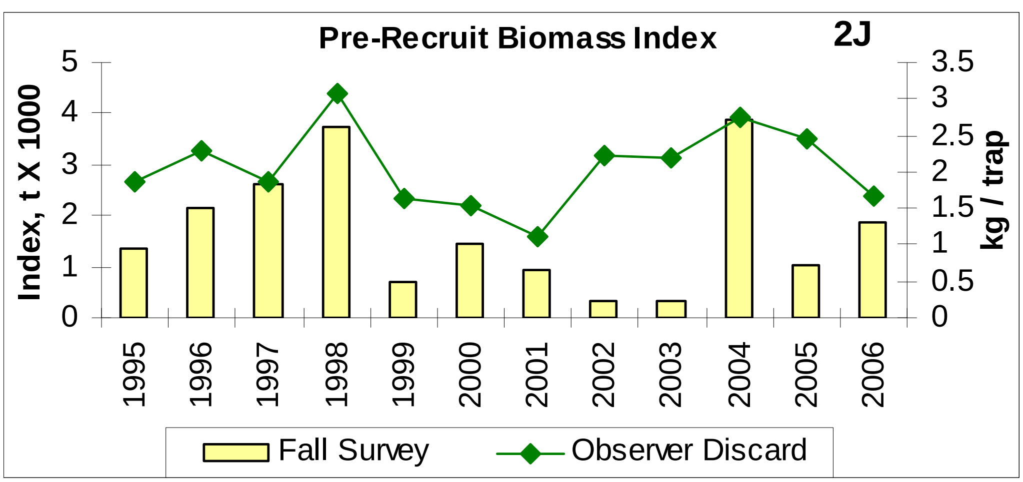


Figure 21. Trends in the Division 2J fall multi-species survey pre-recruit biomass index and the observer discard catch rate index.

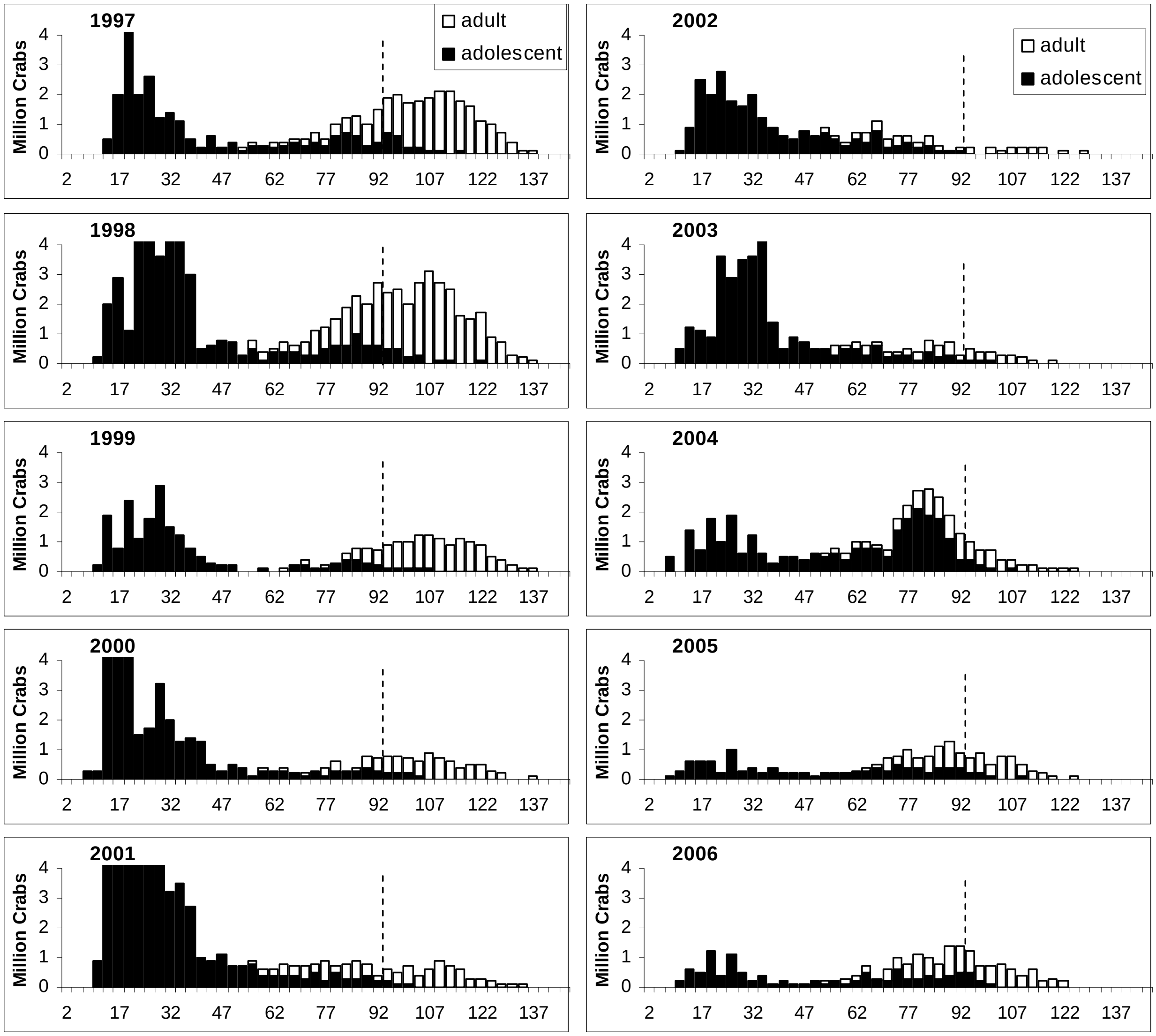


Figure 22. Truncated distribution of abundance (index) by carapace width for Division 2J juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

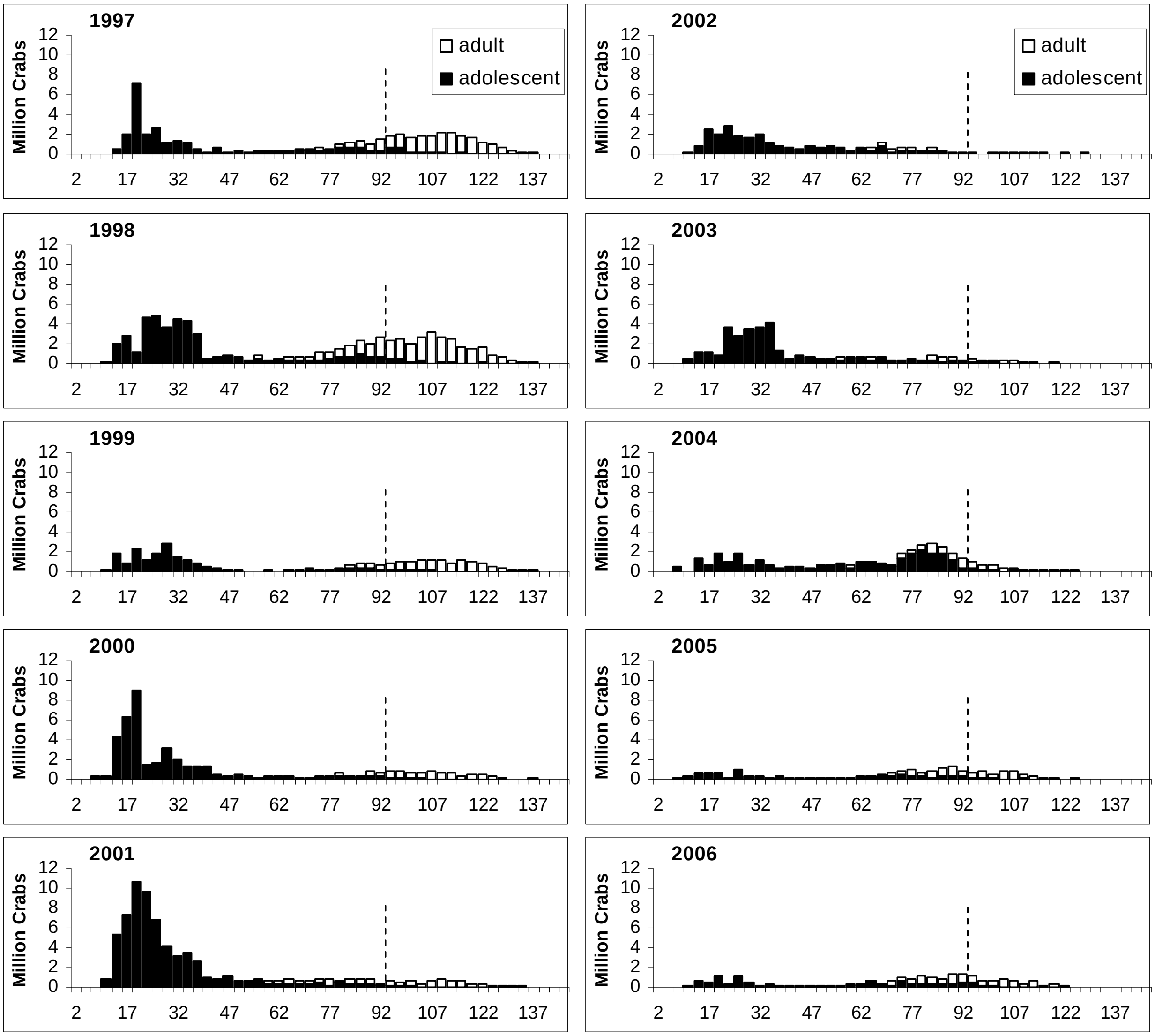


Figure 23. Distribution of abundance (index) by carapace width for Division 2J juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

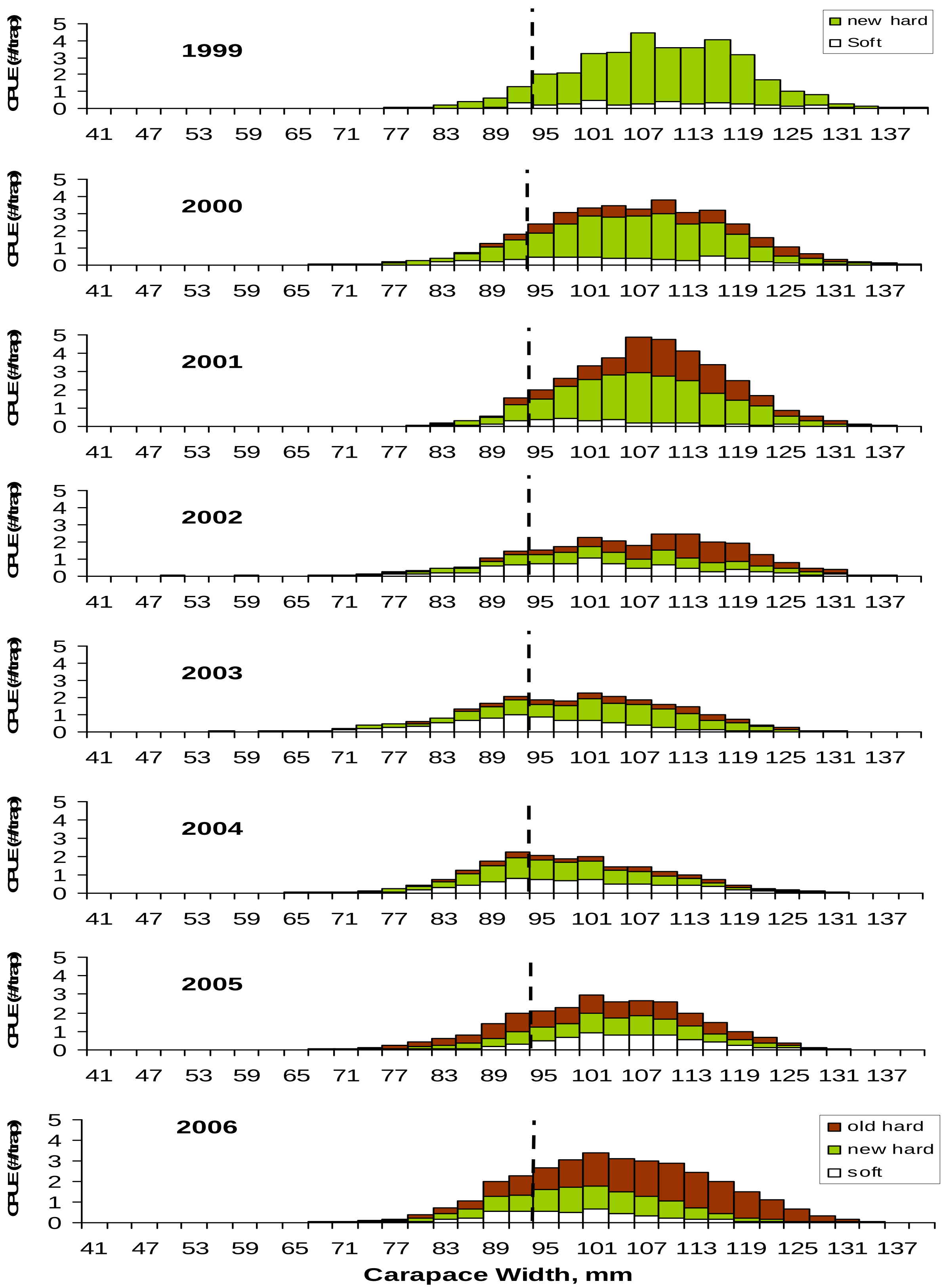


Figure 24. Trends in male carapace width distributions from observer at-sea sampling for Division 2J.

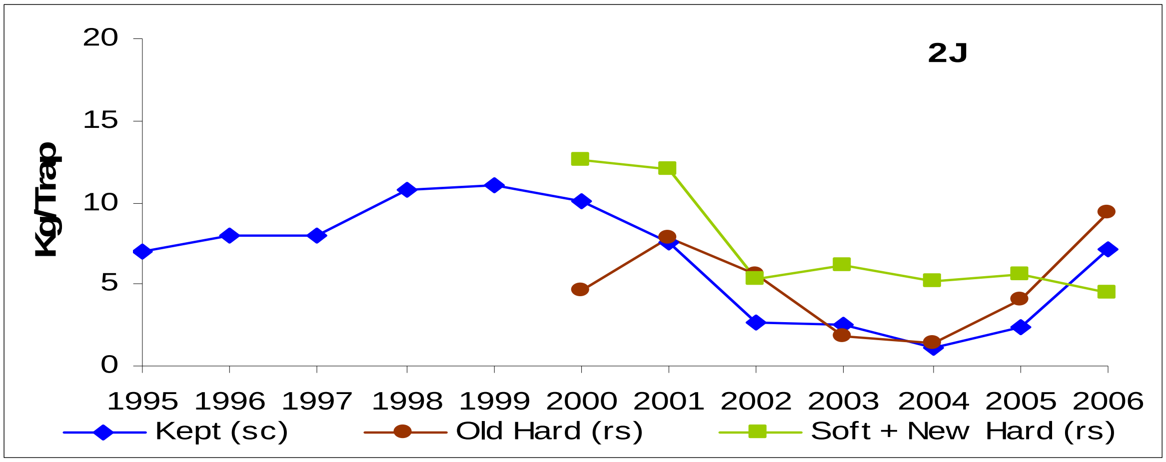


Figure 25. Trends in Division 2J observer catch rates of exploitable crabs since 1995 from set and catch records and of legal-sized crabs by shell category since 2000 from at-sea sampling.

Figure 26. Trends in Division 2J observer catch rates of total discards since 1995 from set and catch records and of sub-legal sized crabs since 1999 from at-sea sampling.

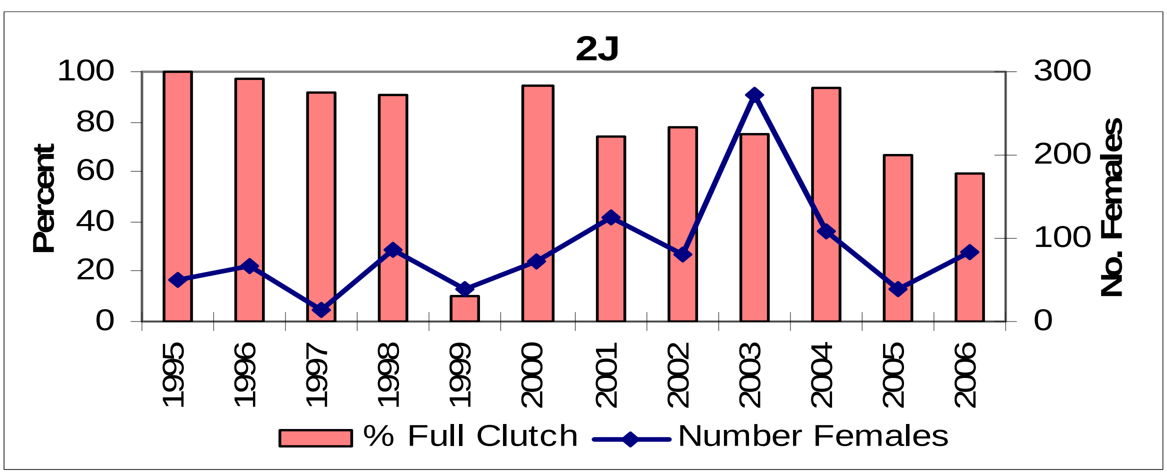


Figure 27. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 2J from fall multi-species surveys.

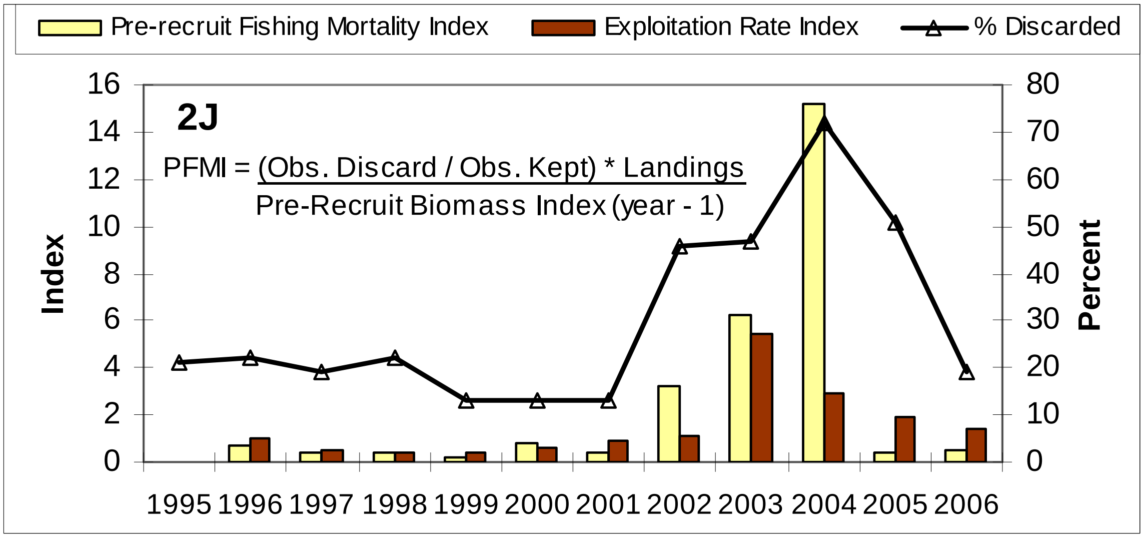


Figure 28. Trends in Division 2J mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery.

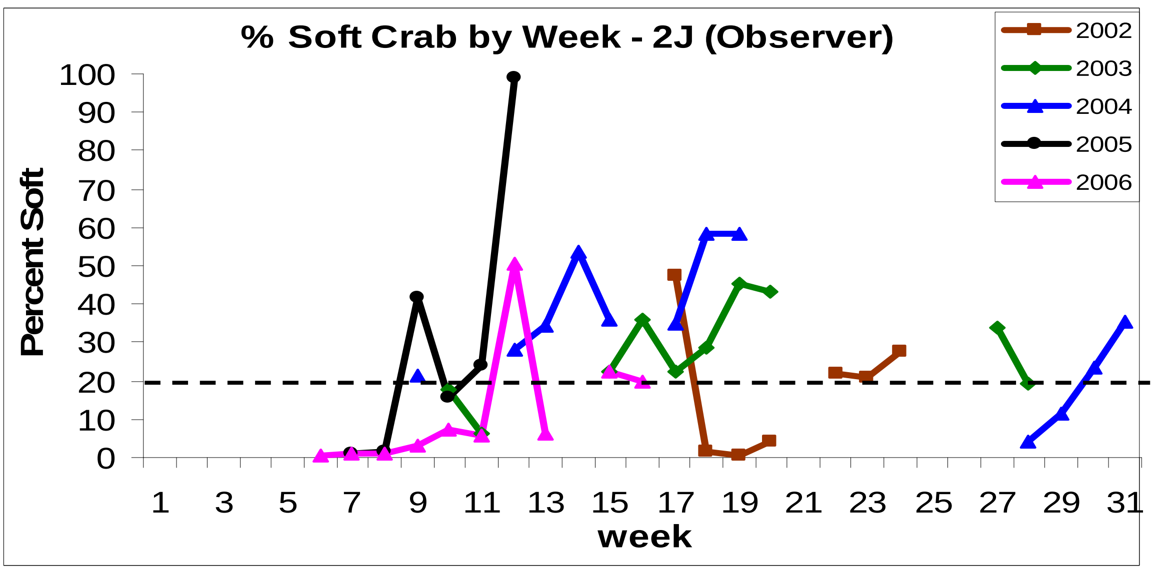


Figure 29. Seasonal trends (from April 1st) in the percentage of legal-sized crabs that are soft-shelled by year (2002-06), from at-sea sampling by observers in Division 2J. (Sample sizes of <10 observed sets/week removed)

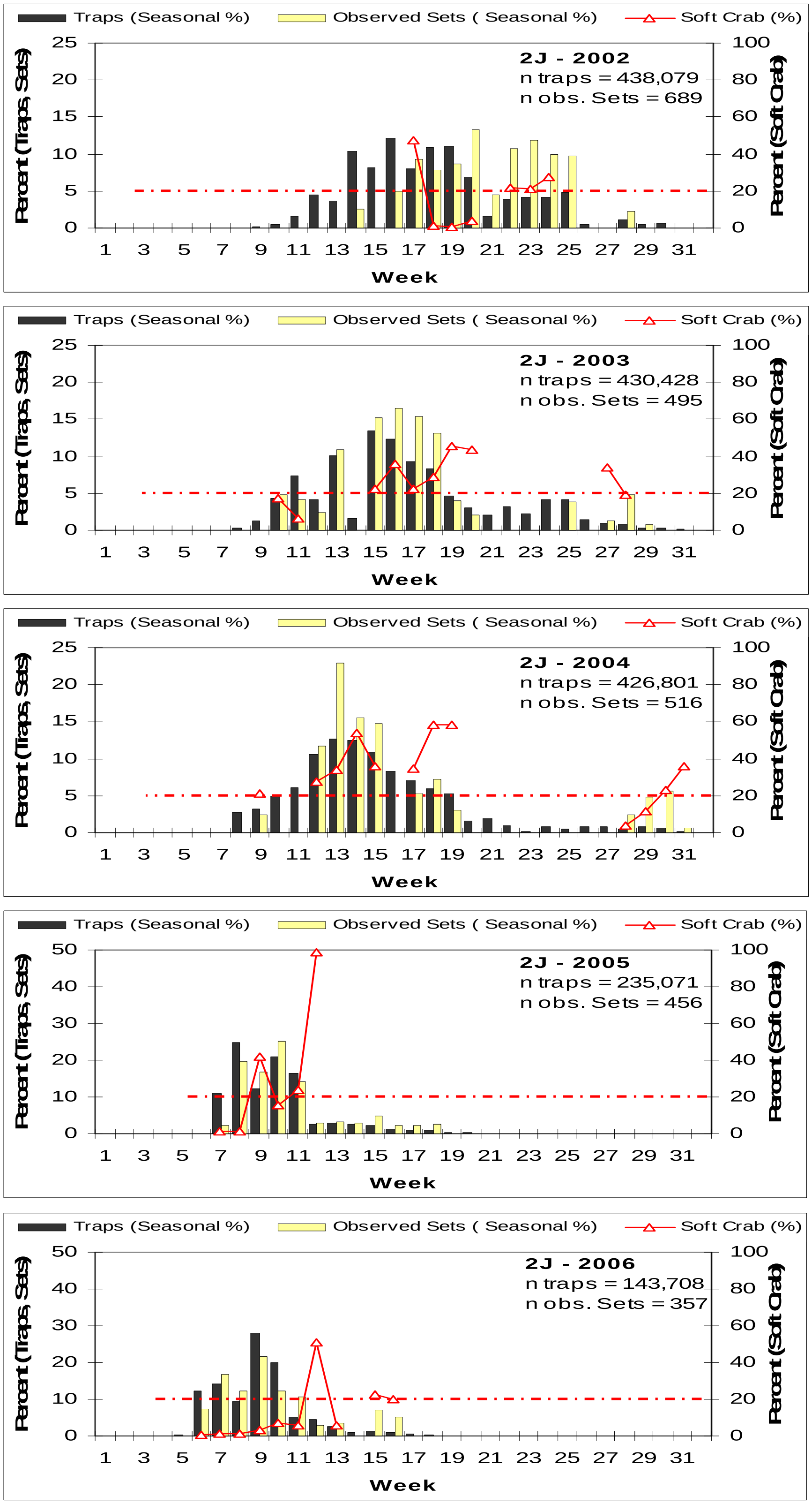
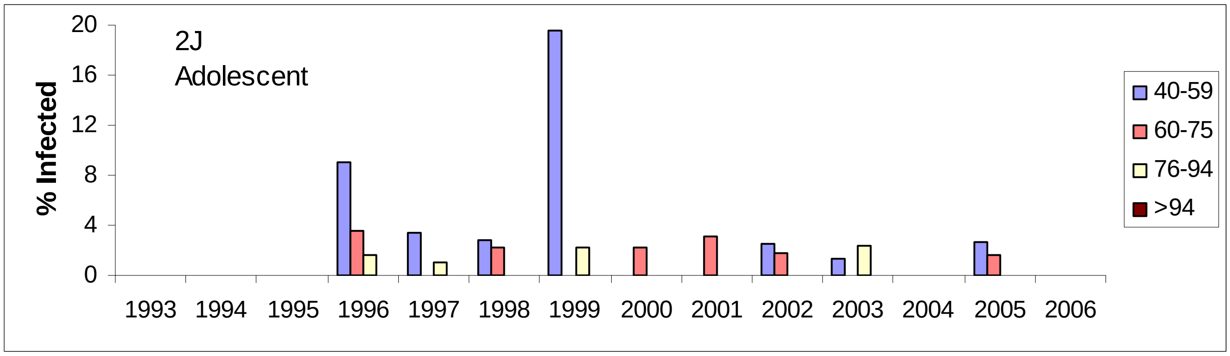


Figure 30. Trends in percentages of weekly effort by trap hauls in Division 2J versus percentages of weekly sets observed and soft-shell (shell type 1) discards from 2002 to 2006. (Sample sizes of <10 observed sets/week removed)



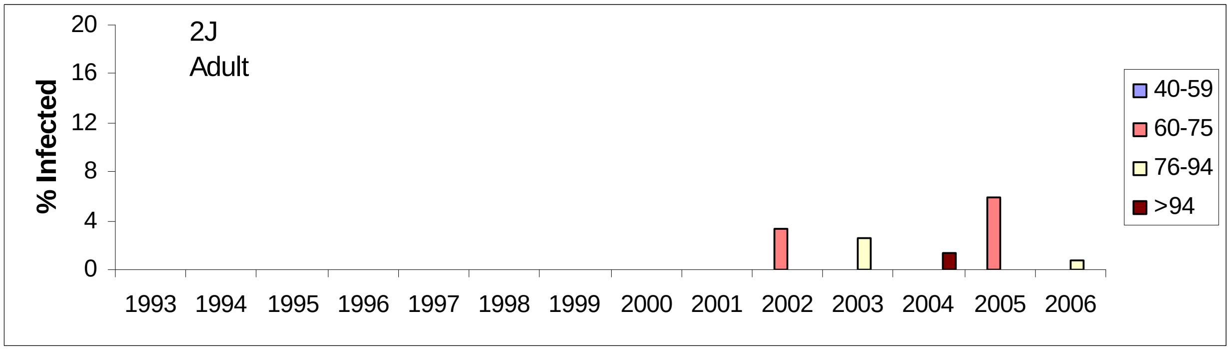


Figure 31. Trends in prevalence of BCD in Division 2J by male size group from multi-species surveys in new-shelled adolescents (above) and new-shelled adults (below).

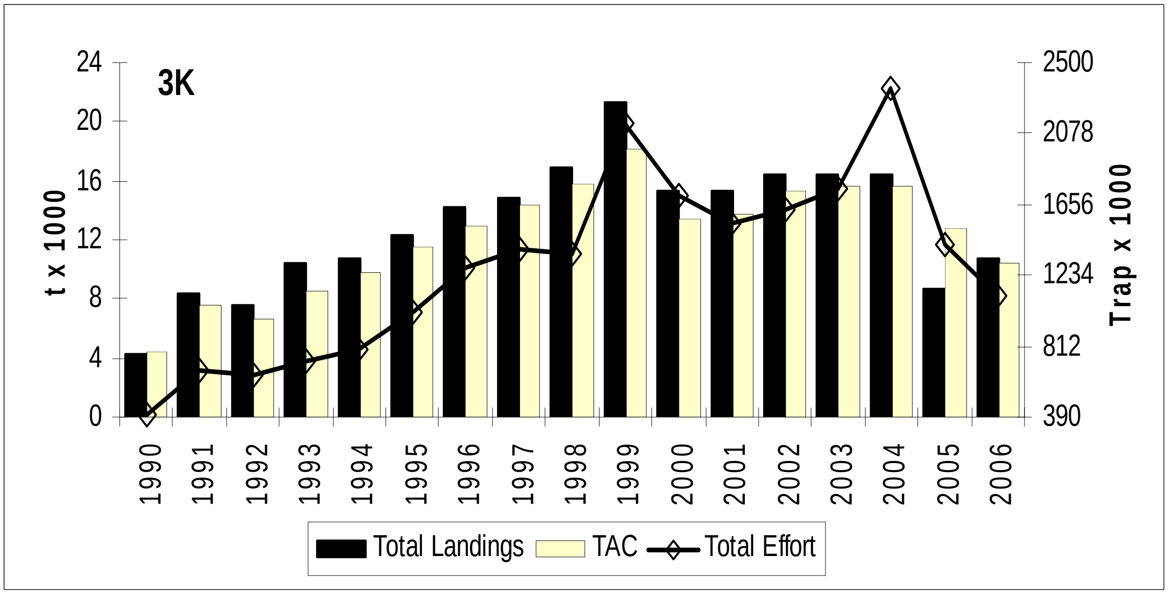


Figure 32. Trends in Division 3K landings, TAC, and fishing effort.

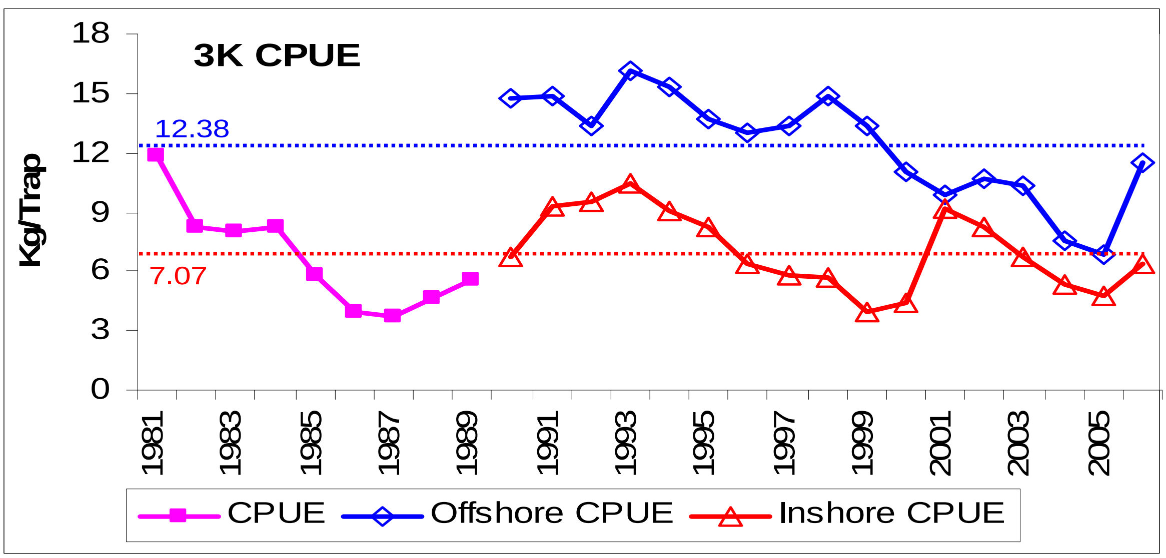


Figure 33. Trends in Division 3K inshore and offshore commercial CPUE in relation to their long-term averages (dotted lines).

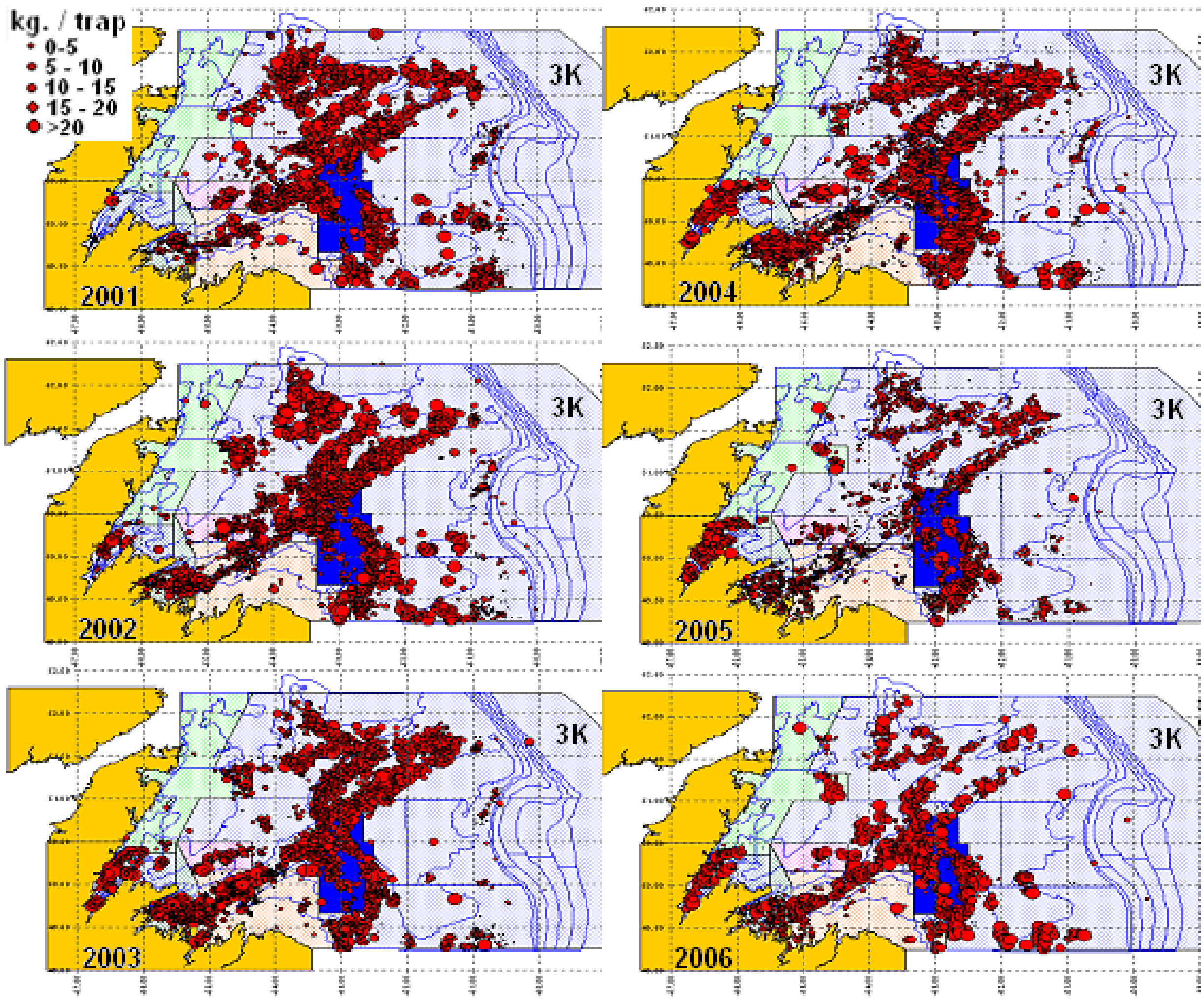


Figure 34. Spatial distribution of Division 3K commercial CPUE by year showing the Funk Island Deep closed area.

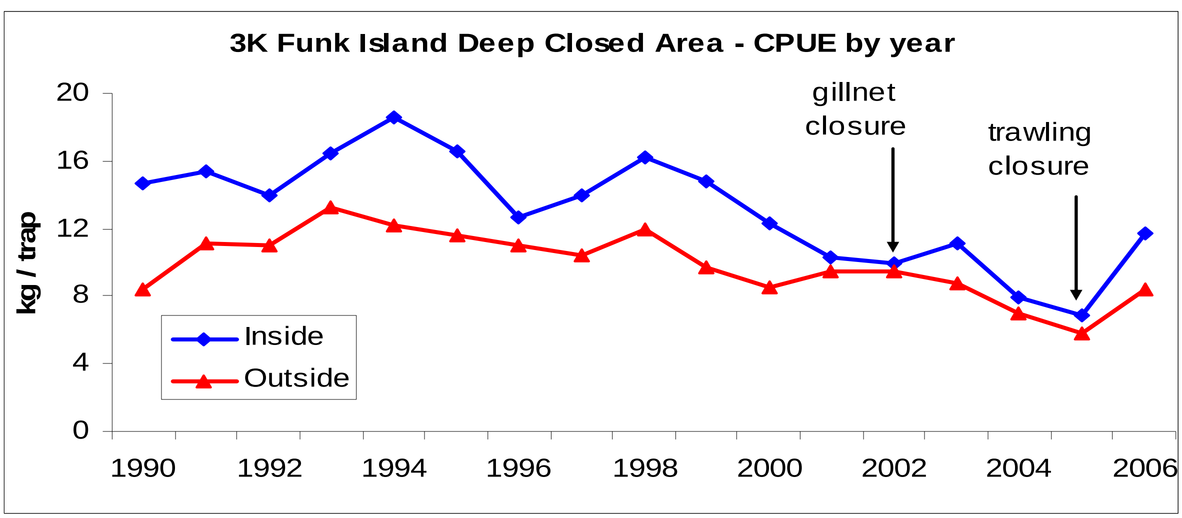


Figure 35. Division 3K commercial CPUE; inside vs. outside the Funk Island Deep closed area.

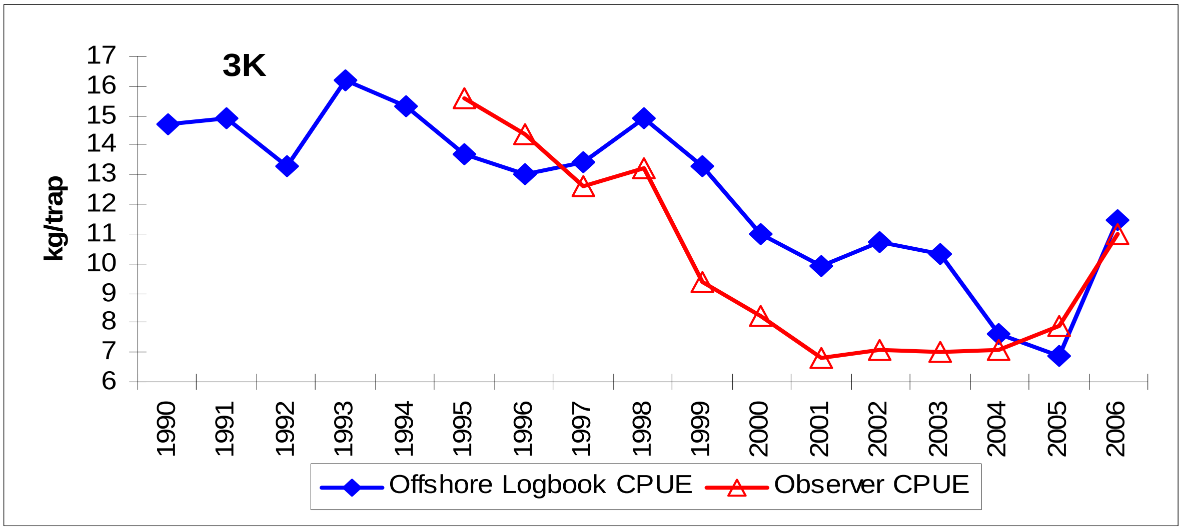


Figure 36. Trends in logbook-based CPUE vs. observer-based CPUE in the Division 3K fishery.

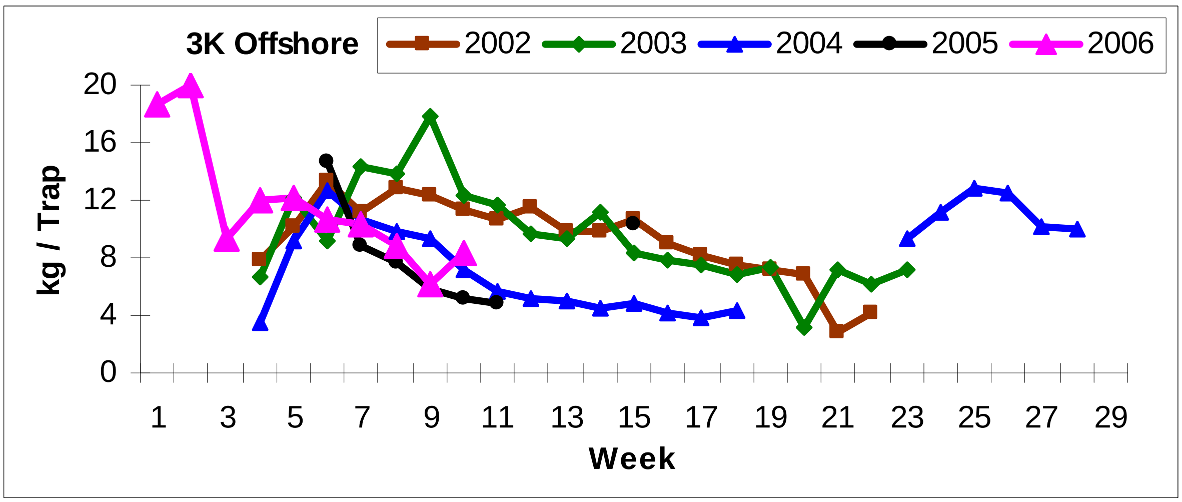


Figure 37. Seasonal trends in CPUE, by week, for Division 3K offshore during 2002-06.

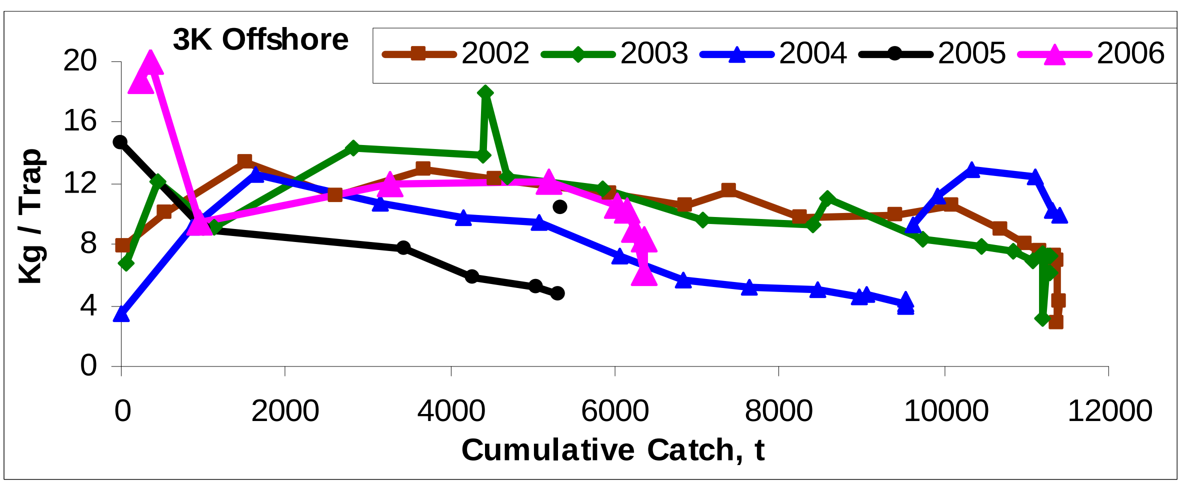


Figure 38. Seasonal trends in CPUE, in relation to cumulative catch, for Division 3K offshore during 2002-06.

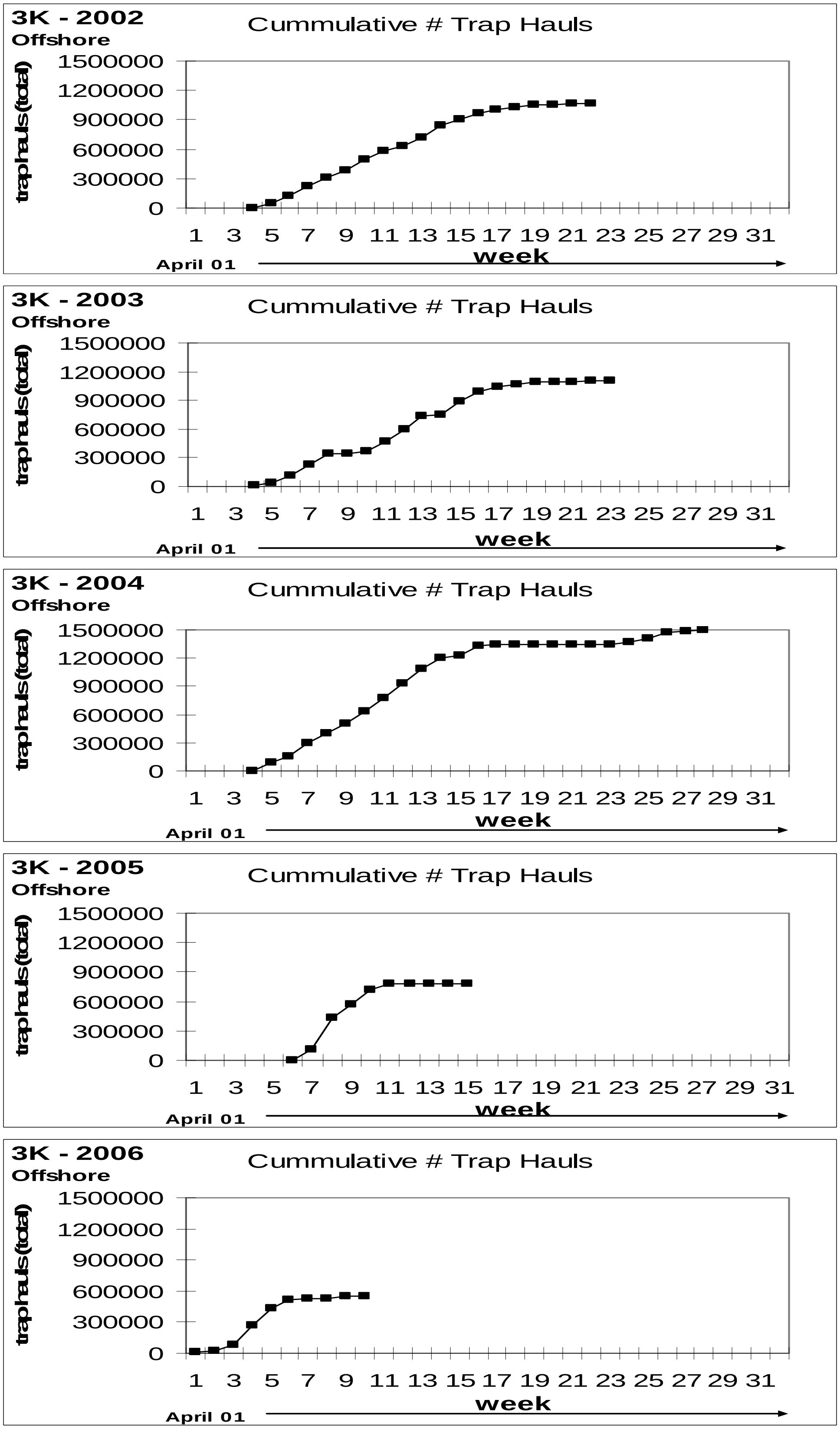


Figure 39. Seasonal trends in fishing effort, by week, for Division 3K offshore during 2002-06.

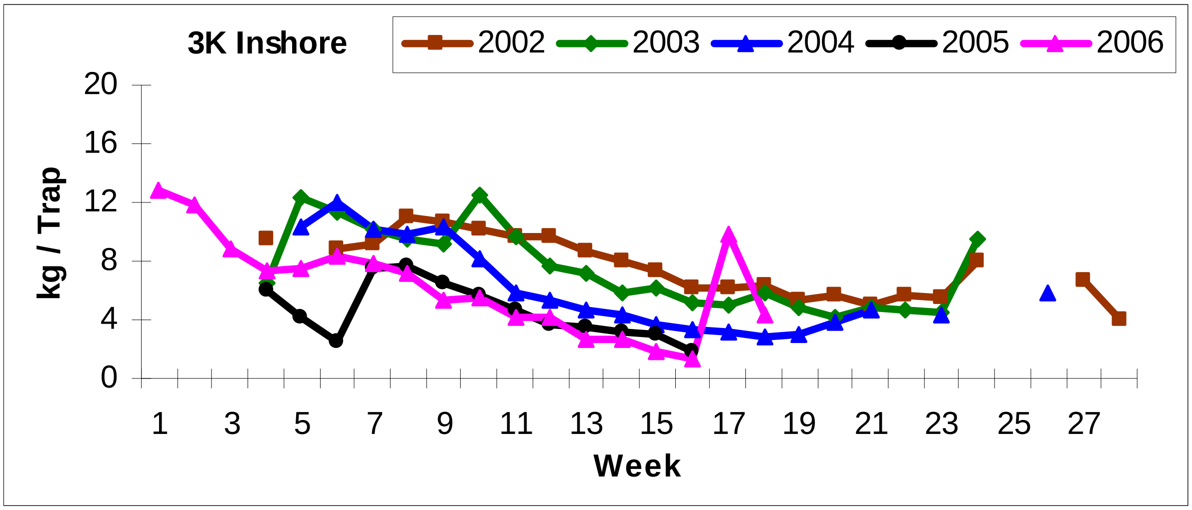


Figure 40. Seasonal trends in CPUE, by week, for Division 3K inshore during 2002-06.

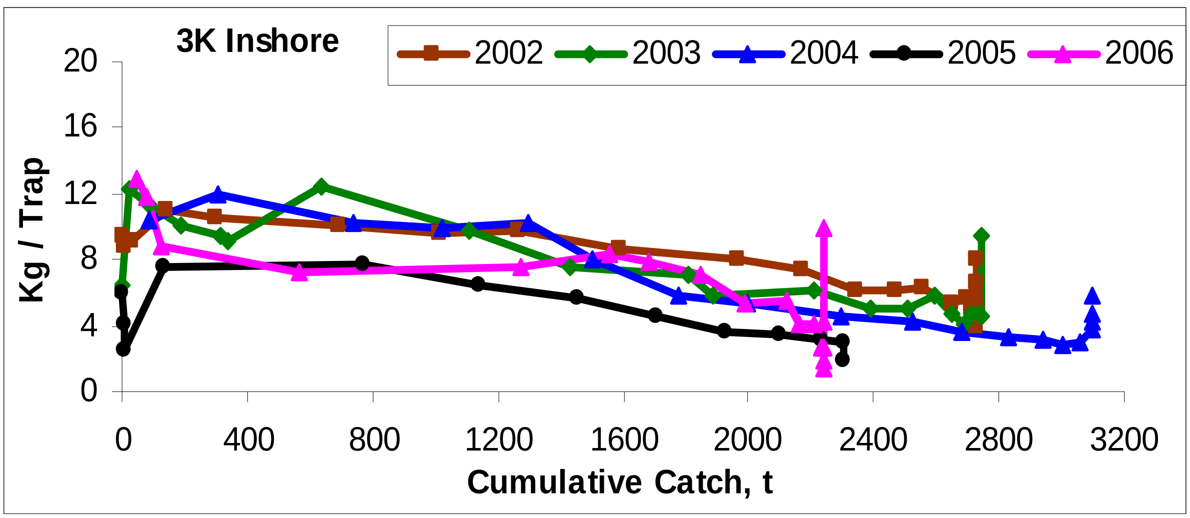


Figure 41. Seasonal trends in CPUE, in relation to cumulative catch, for Division 3K inshore during 2002-06.

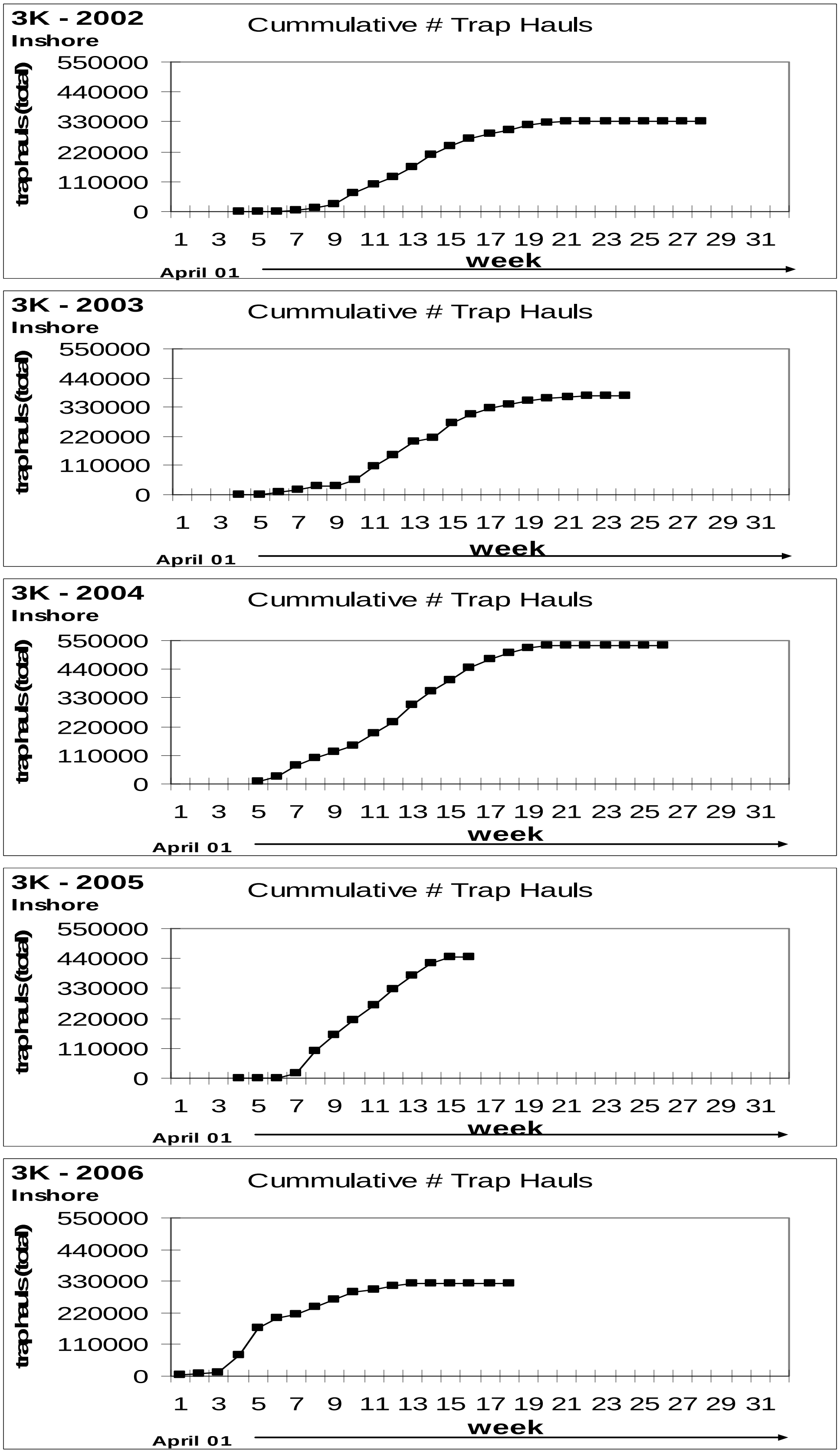


Figure 42. Seasonal trends in fishing effort, by week, for Division 3K inshore during 2002-06.

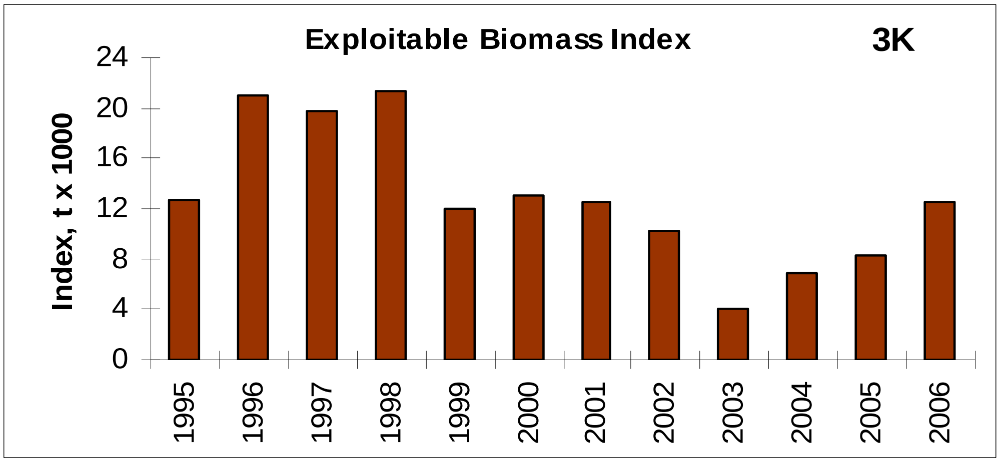


Figure 43. Trends in the Division 3K fall multi-species survey exploitable biomass index.

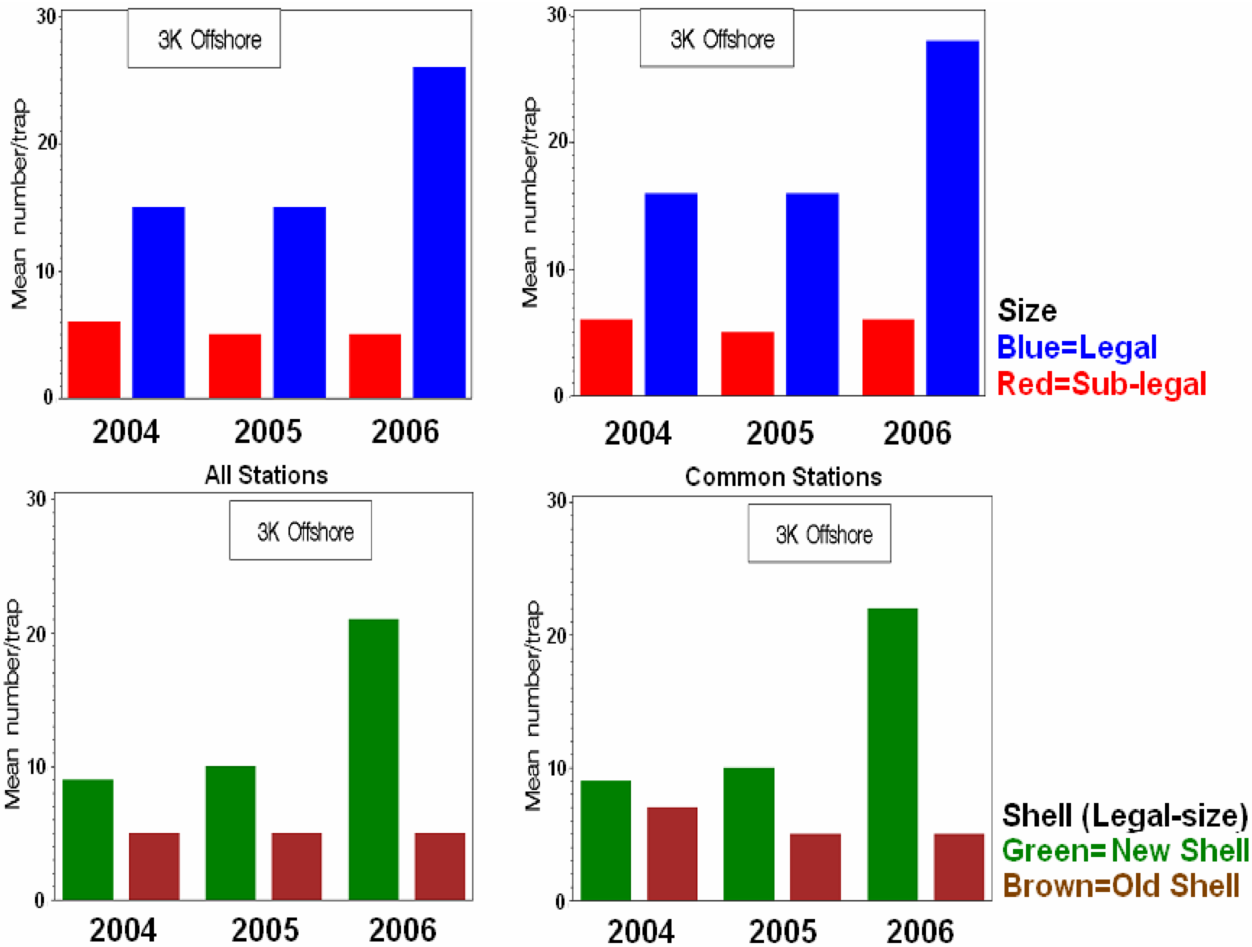


Figure 44. Trends in CPUE for size composition (above) and shell condition (below) from FSCP post-season trap surveys for Division 3K offshore from all stations (left) and common stations (right).

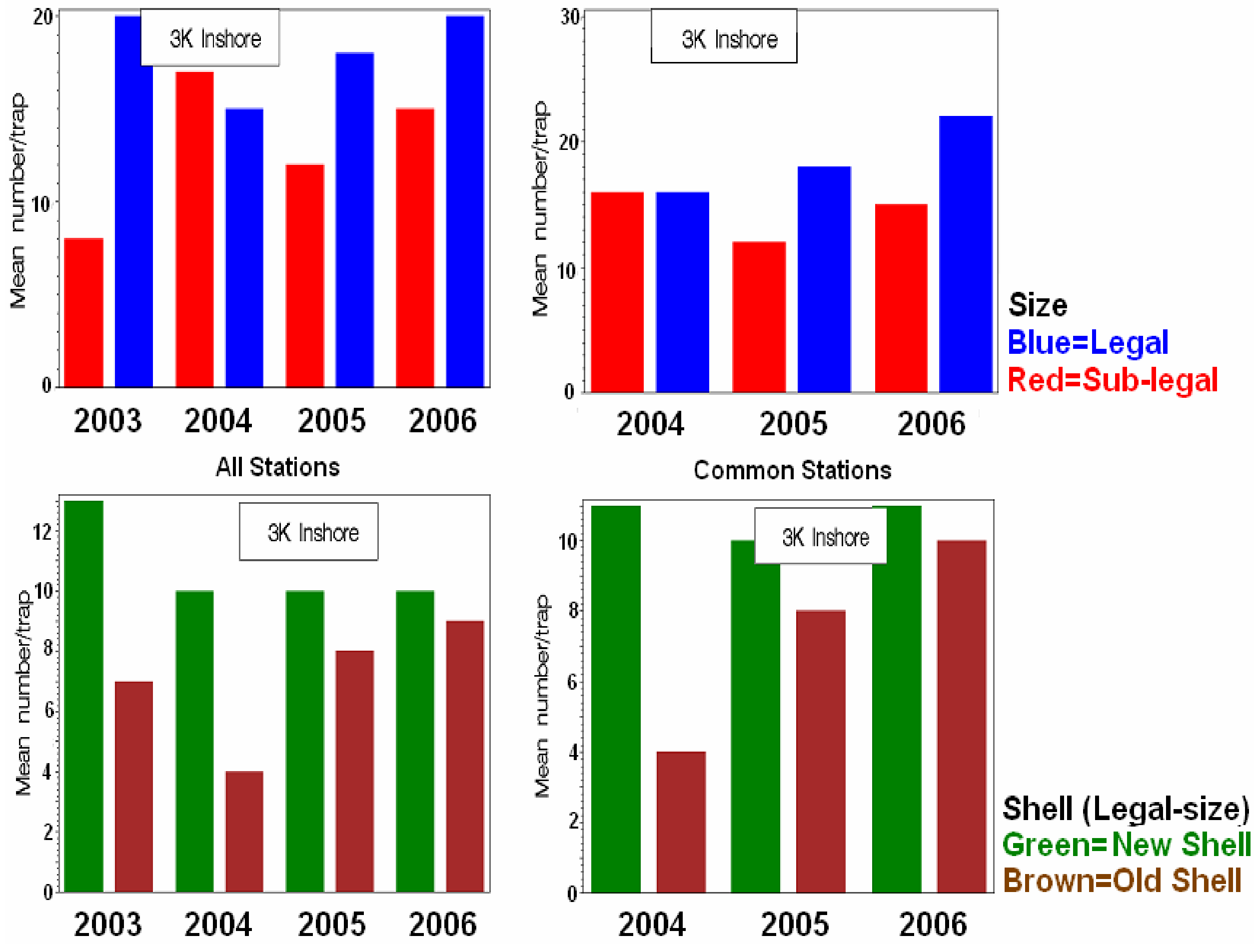


Figure 45. Trends in CPUE for size composition (above) and shell condition (below) from FSCP post-season trap surveys for Division 3K inshore from all stations (left) and common stations (right).

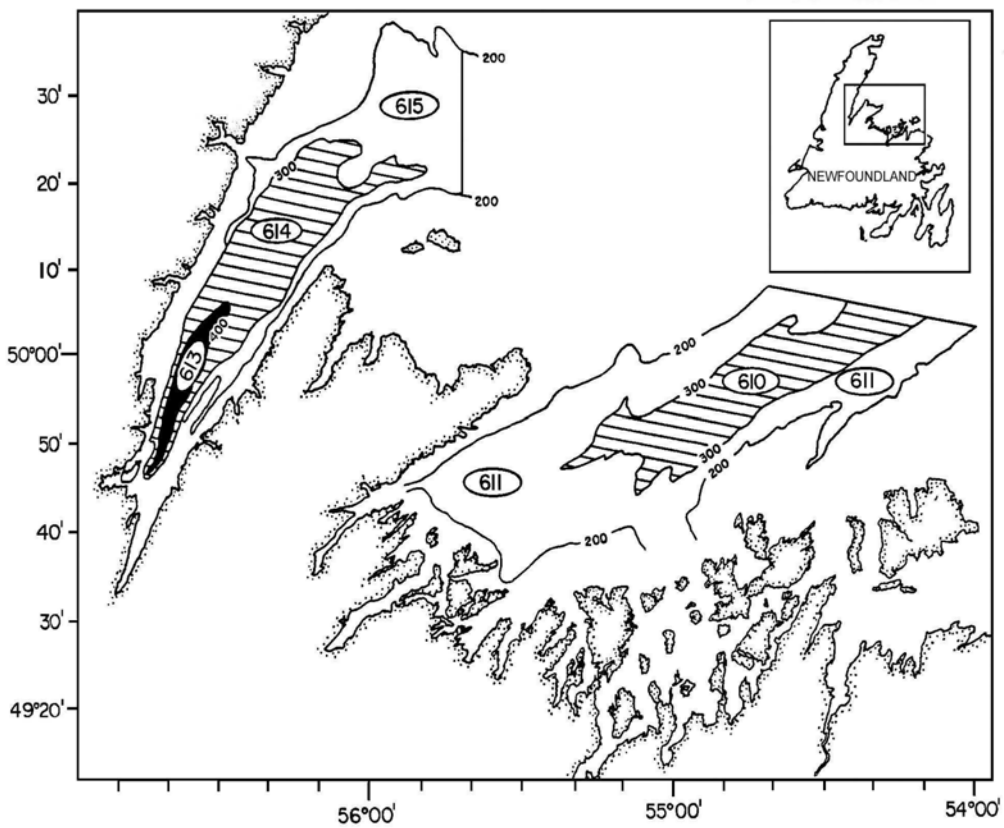


Figure 46. Location map showing inshore Division 3K strata sampled during White/Notre Dame bays September trapping surveys.

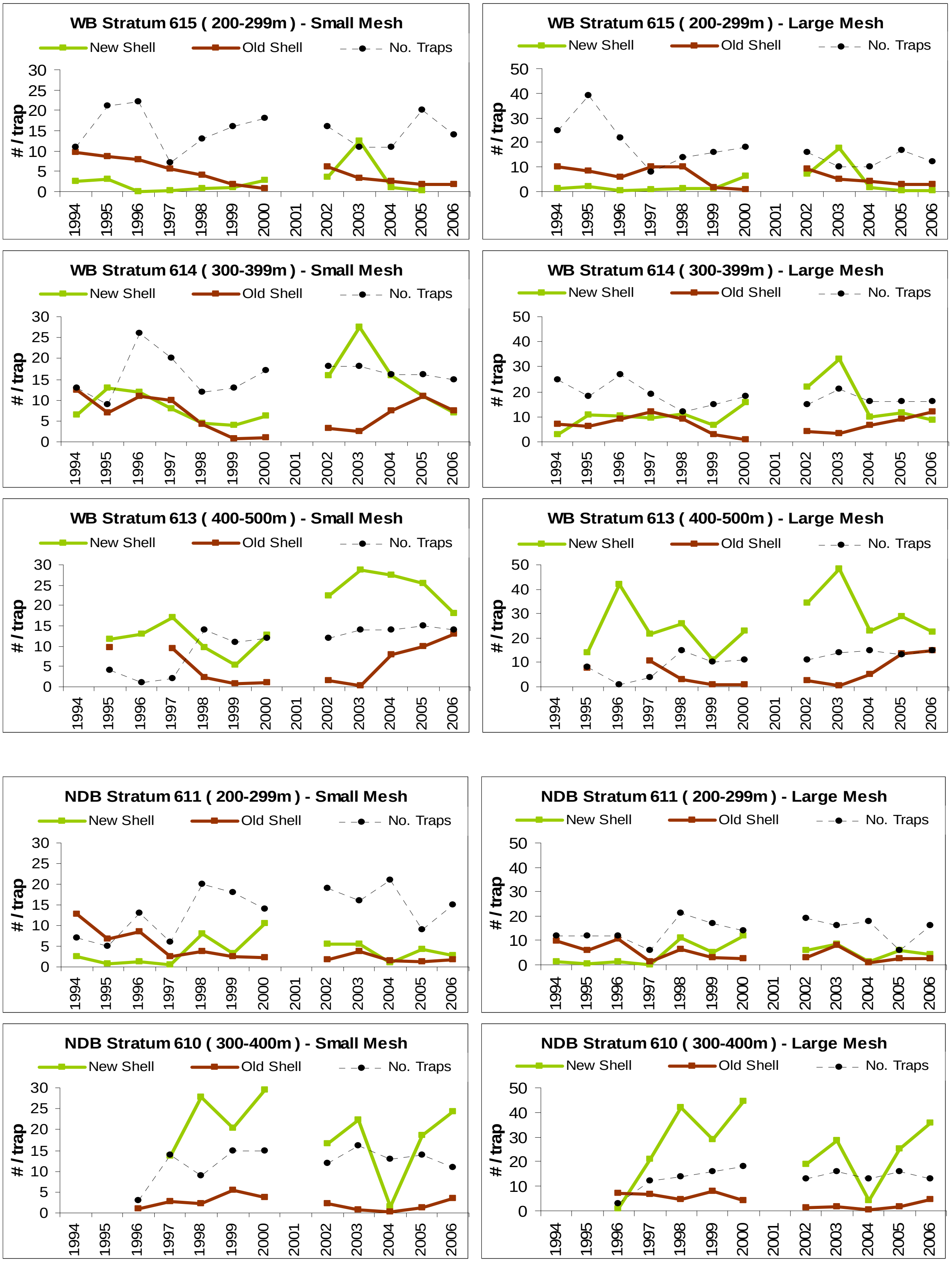


Figure 47. Trends in catch rates by shell category and stratum from inshore Division 3K trap surveys in White and Notre Dame bays, 1994-2006; no survey was conducted in 2001.

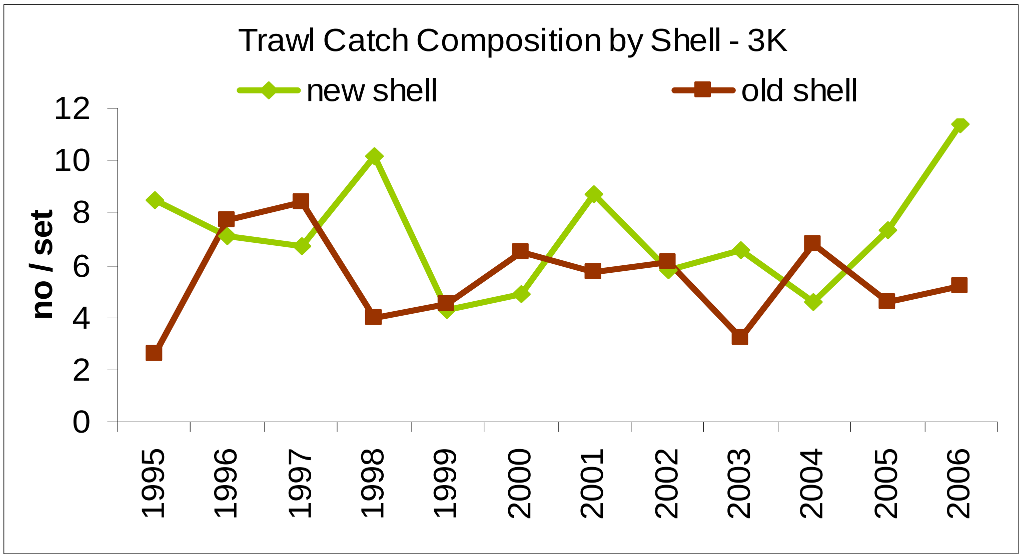


Figure 48. Trends, by shell condition, in abundance indices of legal-sized males for Division 3K from fall multi-species surveys.

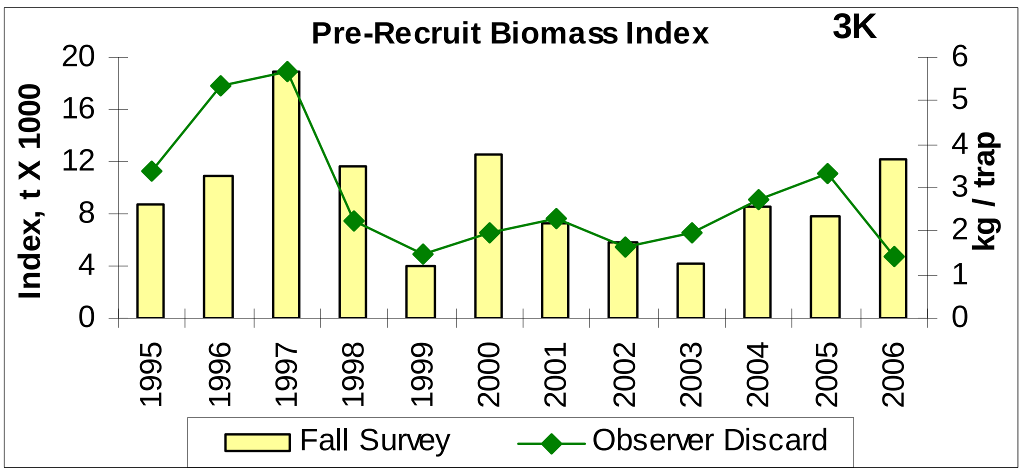


Figure 49. Trends in the Division 3K fall multi-species survey pre-recruit biomass index and the observer discard catch rate index.

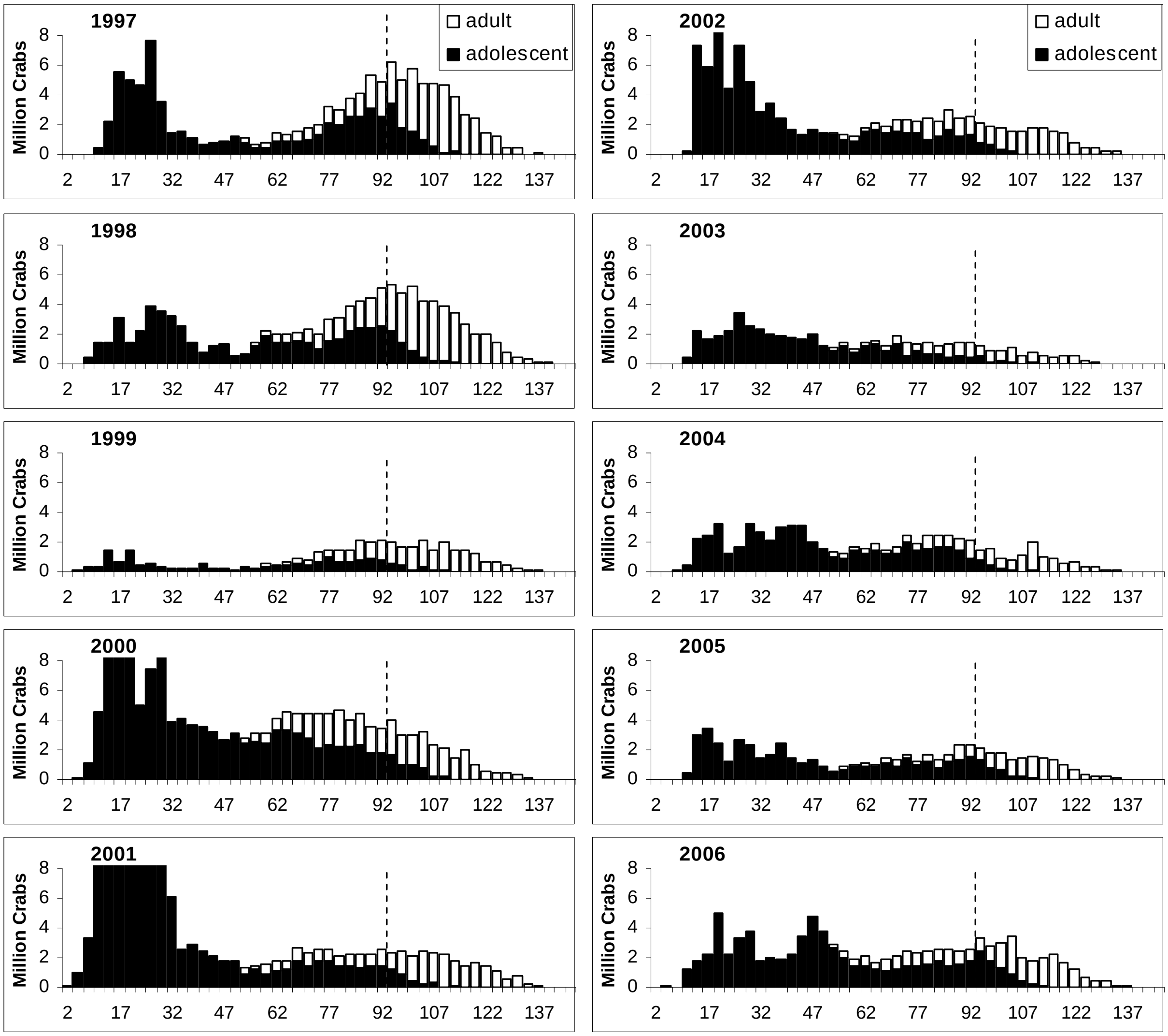


Figure 50. Truncated distribution of abundance (index) by carapace width for Division 3K juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

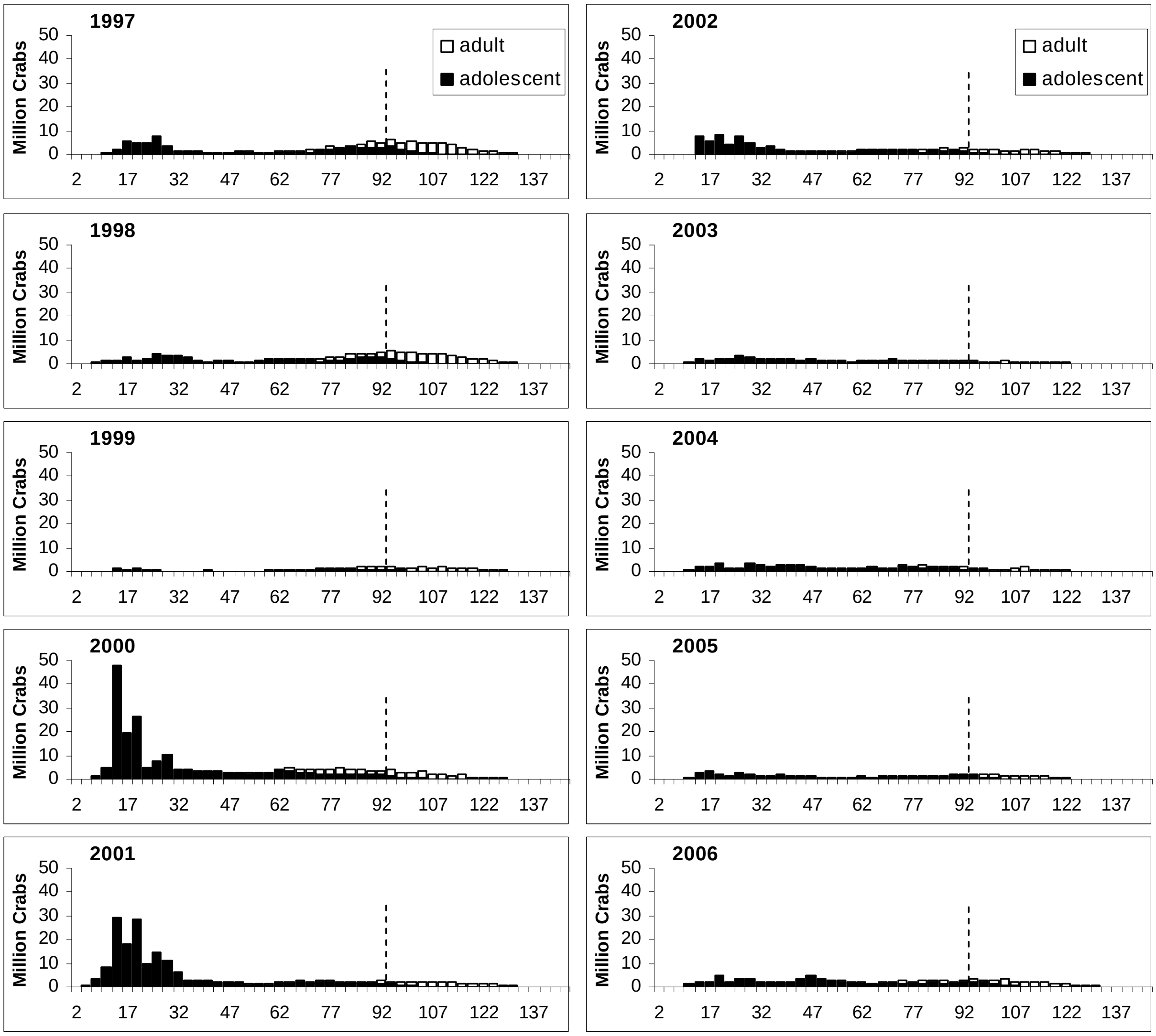


Figure 51. Distribution of abundance (index) by carapace width for Division 3K juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

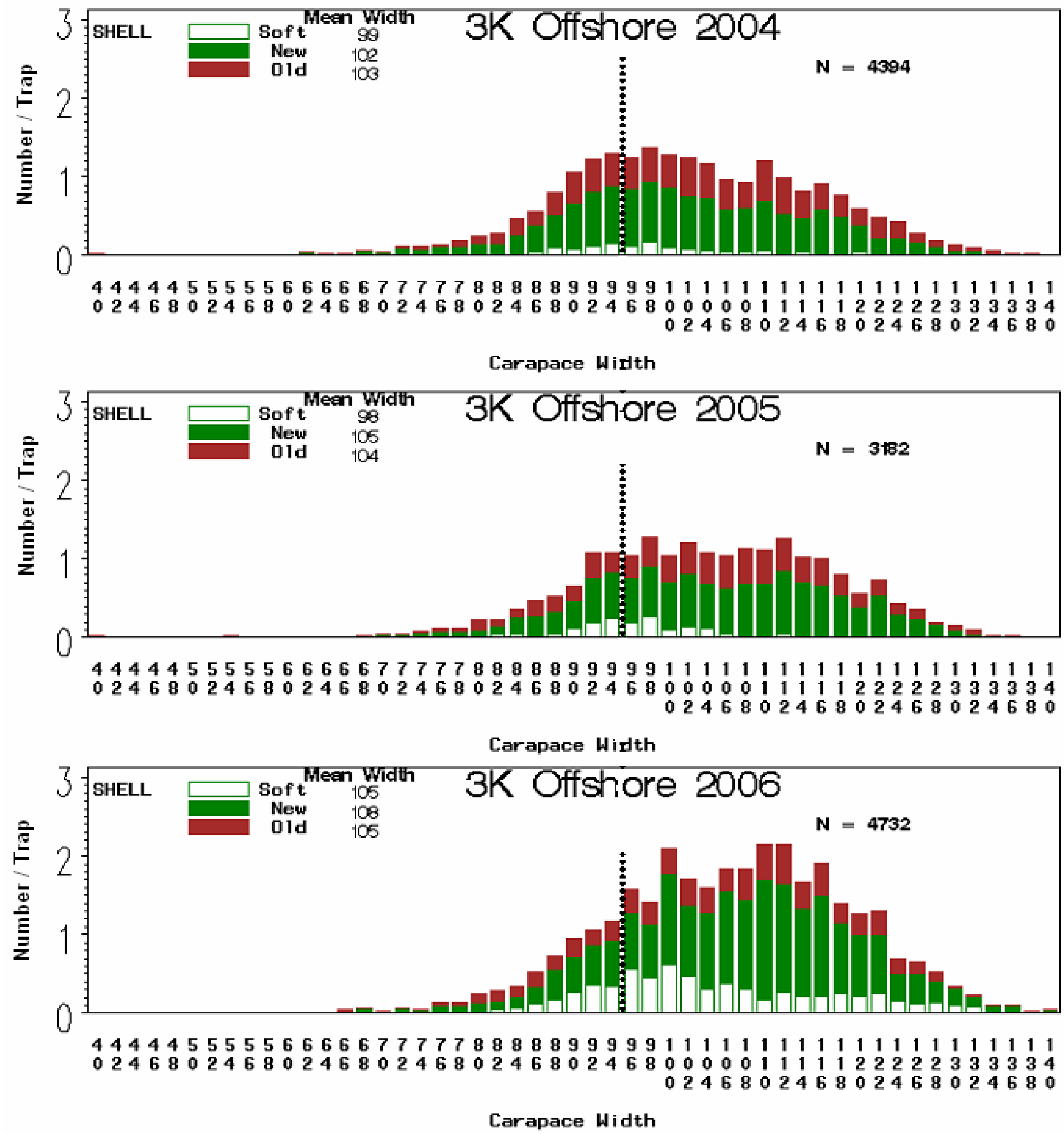


Figure 52. Trends in male carapace width distributions from FSCP post-season trap surveys for Division 3K offshore.

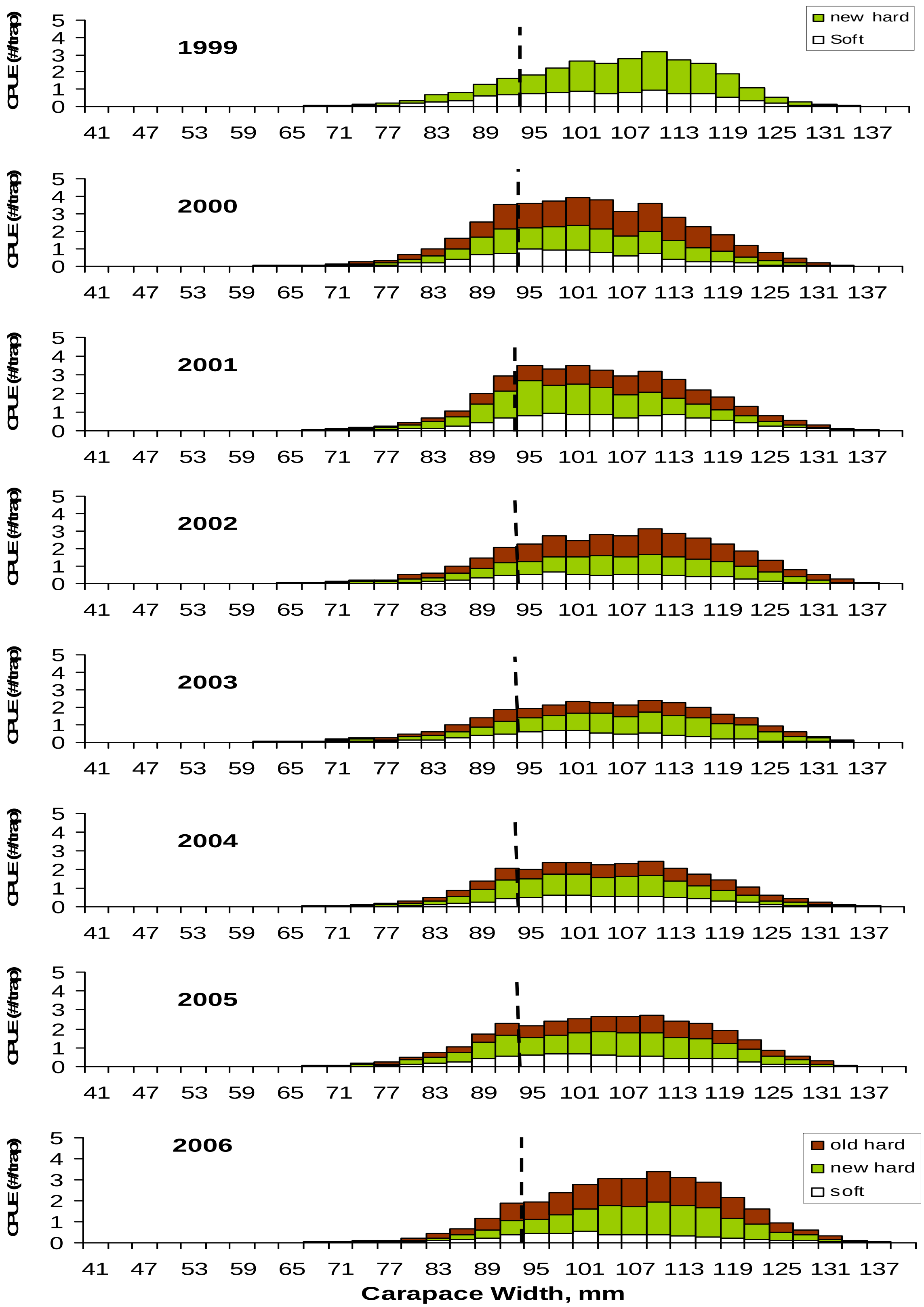


Figure 53. Trends in male carapace width distributions from observer at-sea sampling for Division 3K.

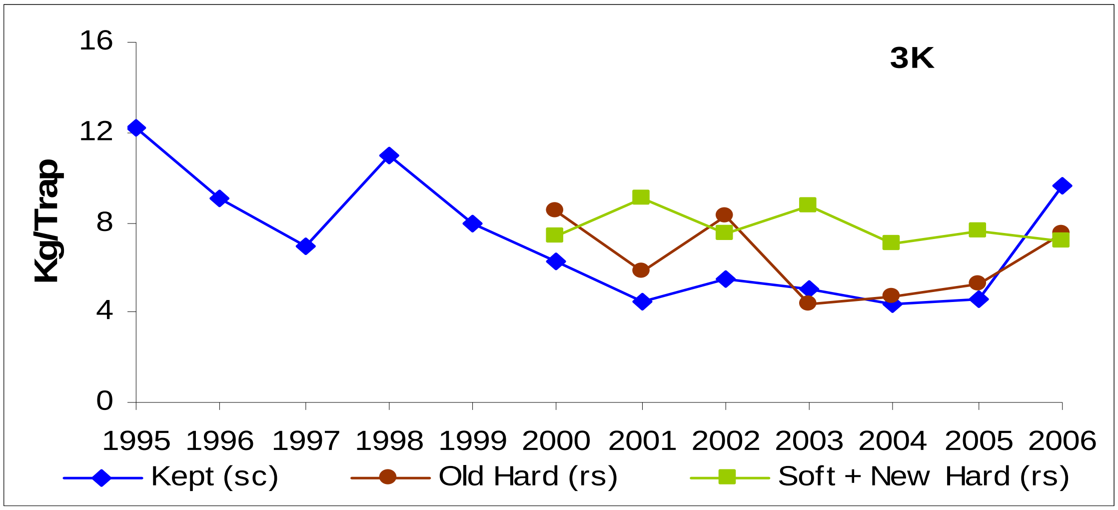


Figure 54. Trends in Division 3K observer catch rates of exploitable crabs since 1995 from set and catch records and of legal-sized crabs by shell category since 2000 from at-sea sampling.

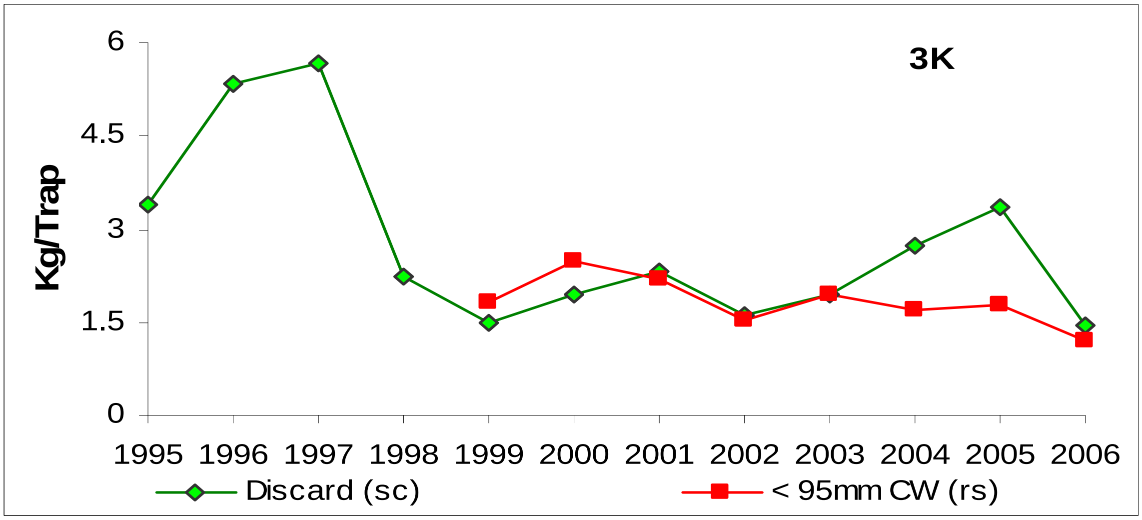


Figure 55. Trends in Division 3K observer catch rates of total discards since 1995 from set and catch records and of sub-legal sized crabs since 1999 from at-sea sampling.

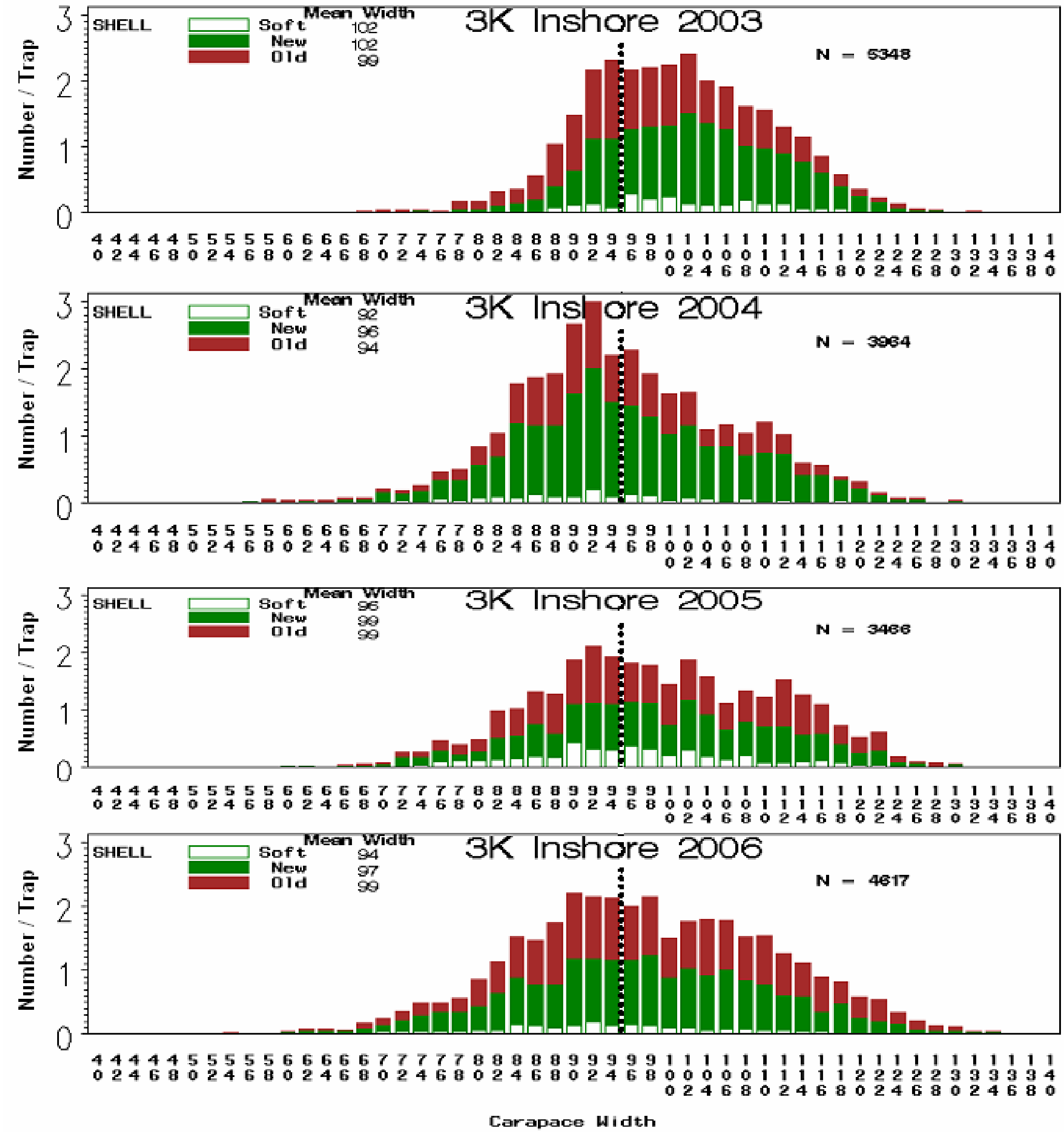


Figure 56. Trends in male carapace width distributions from FSCP post-season trap surveys for Division 3K inshore.

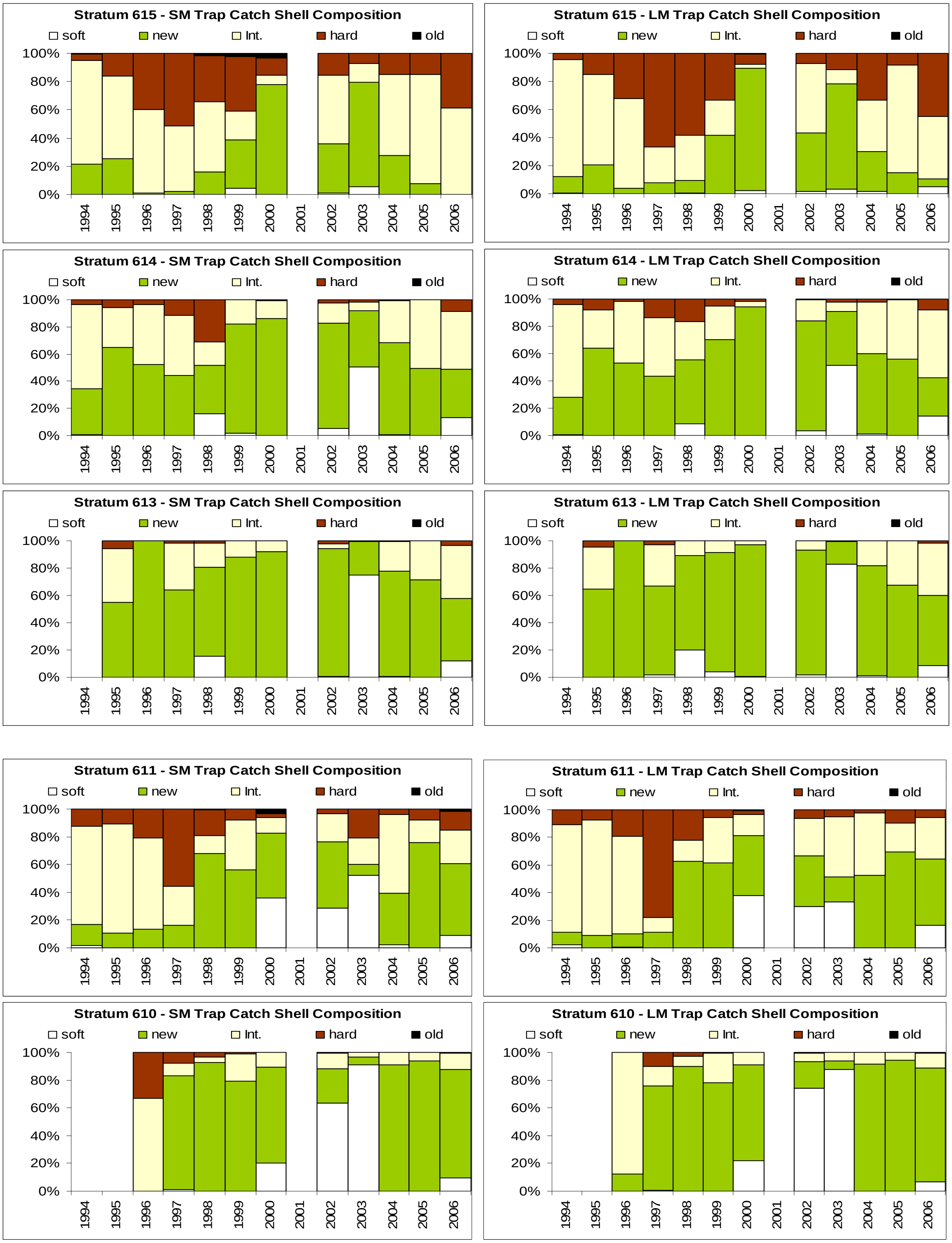


Figure 57. Trends in shell condition of catches by stratum from inshore Division 3K trap surveys in White and Notre Dame bays, 1994-2006; no survey was conducted in 2001.

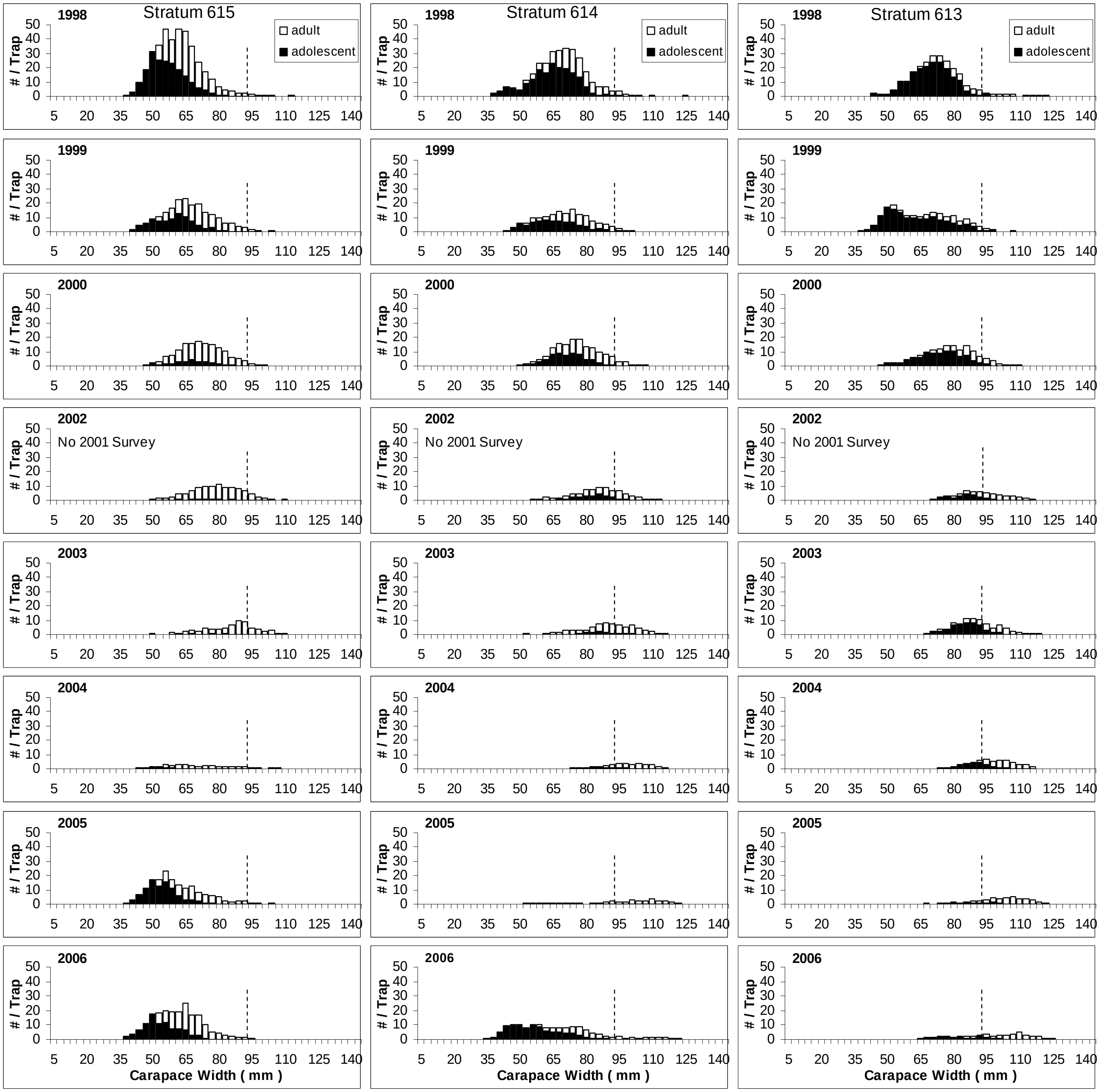


Figure 58. Inshore 3K trap surveys; small-claw (adolescent) vs. large-claw (adult) male crab size compositions by year from small-mesh traps within White Bay; Stratum 615 (200 – 299 m), Stratum 614 (300-399 m) and Stratum 613 (400-500 m).

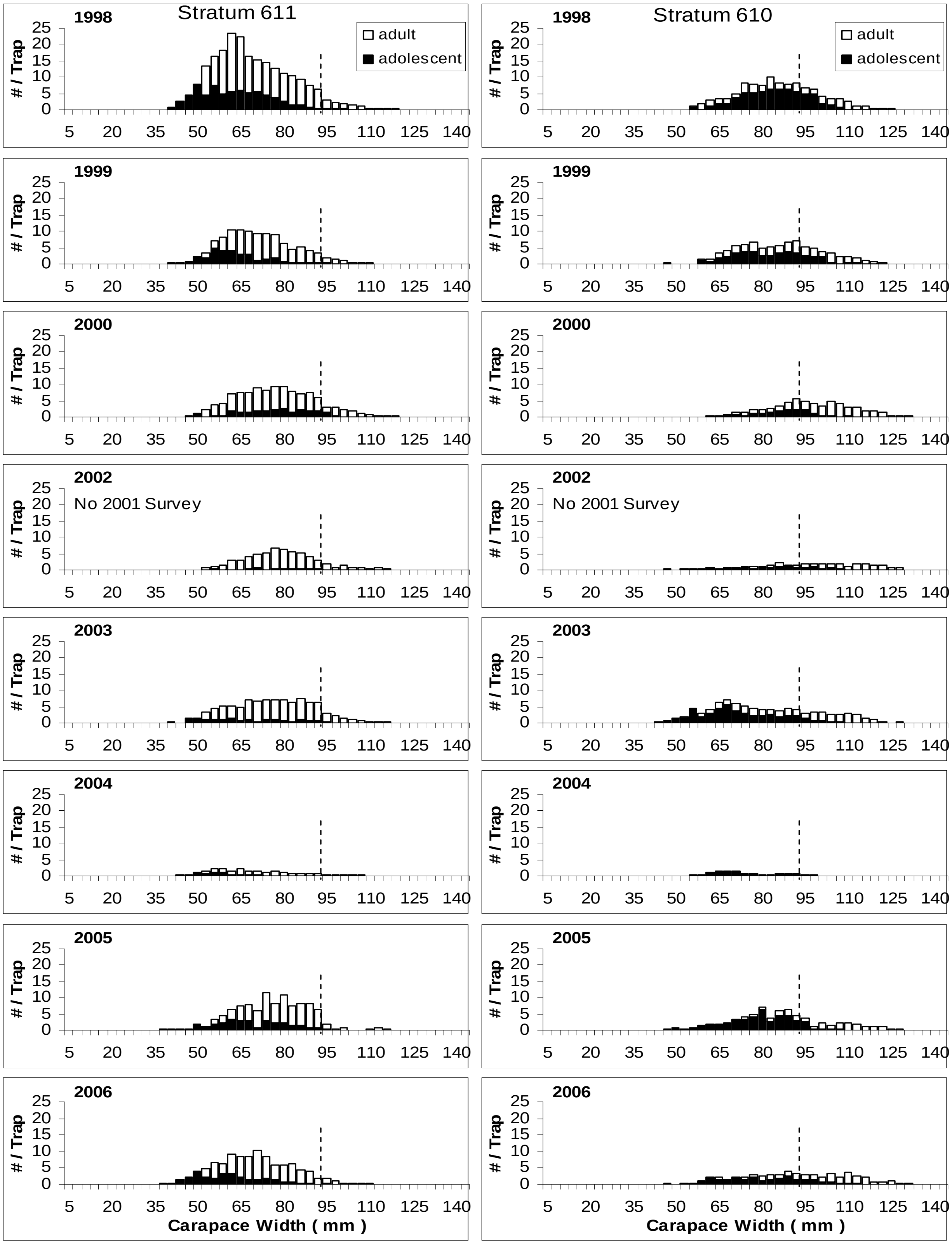


Figure 59. Inshore 3K trap surveys; small-claw (adolescent) vs. large-claw (adult) male crab size compositions by year from small-mesh traps within Notre Dame Bay; Stratum 611 (200-299 m) and Stratum 610 (300-399 m).

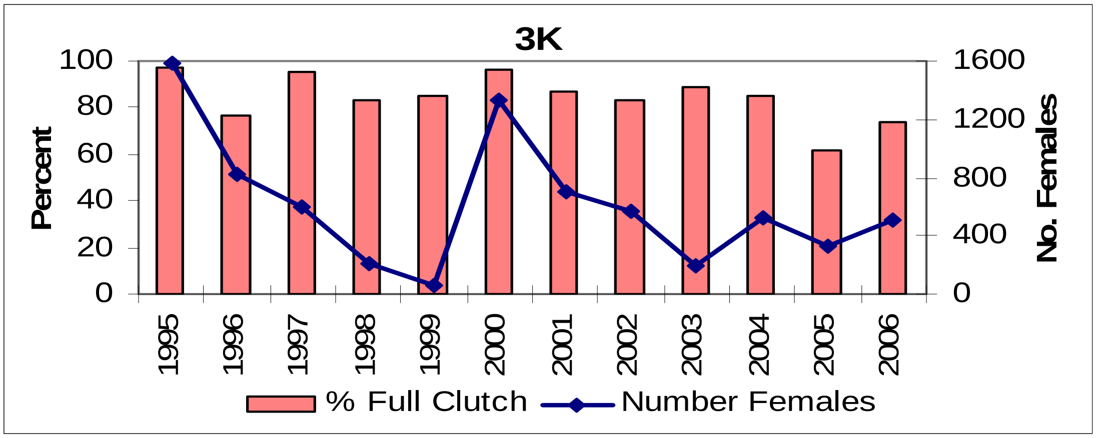


Figure 60. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3K from fall multi-species surveys.

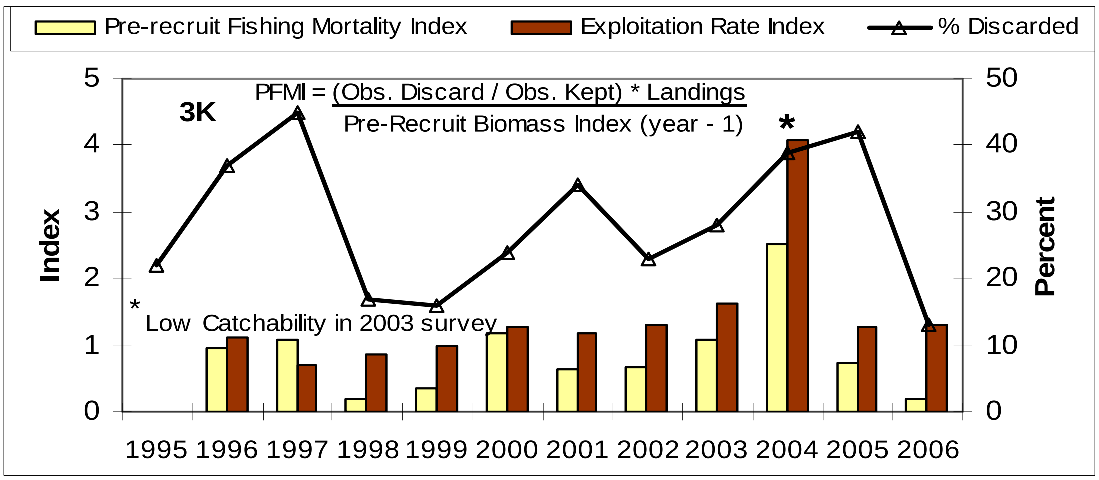


Figure 61. Annual trends in Division 3K mortality indices (the exploitation rate index and the pre-recruit mortality index) and in the percentage of the catch discarded in the fishery. (* low catchability in 2003 survey)

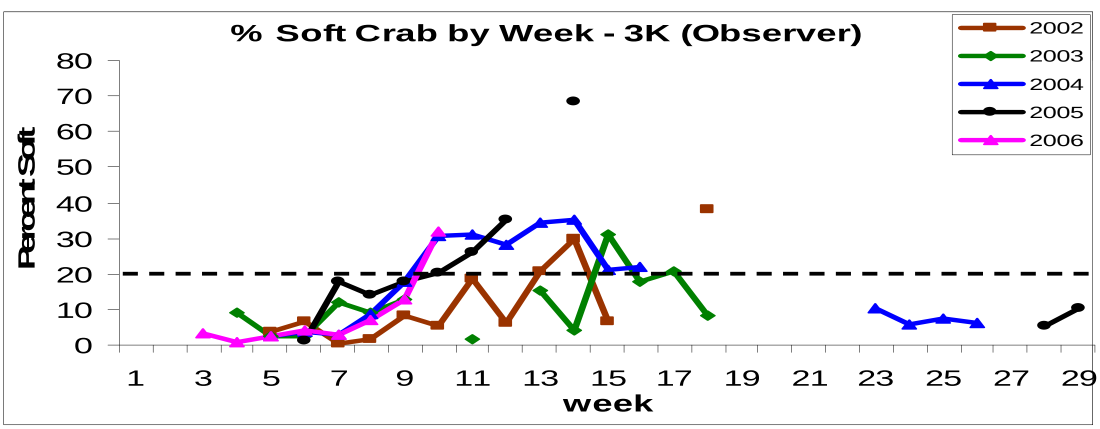


Figure 62. Seasonal trend (from April 1st) in the percentage of legal-sized crabs that are soft-shelled by year (2002-06), from at-sea sampling by observers in Division 3K. (Sample sizes of <10 observed sets/week removed)

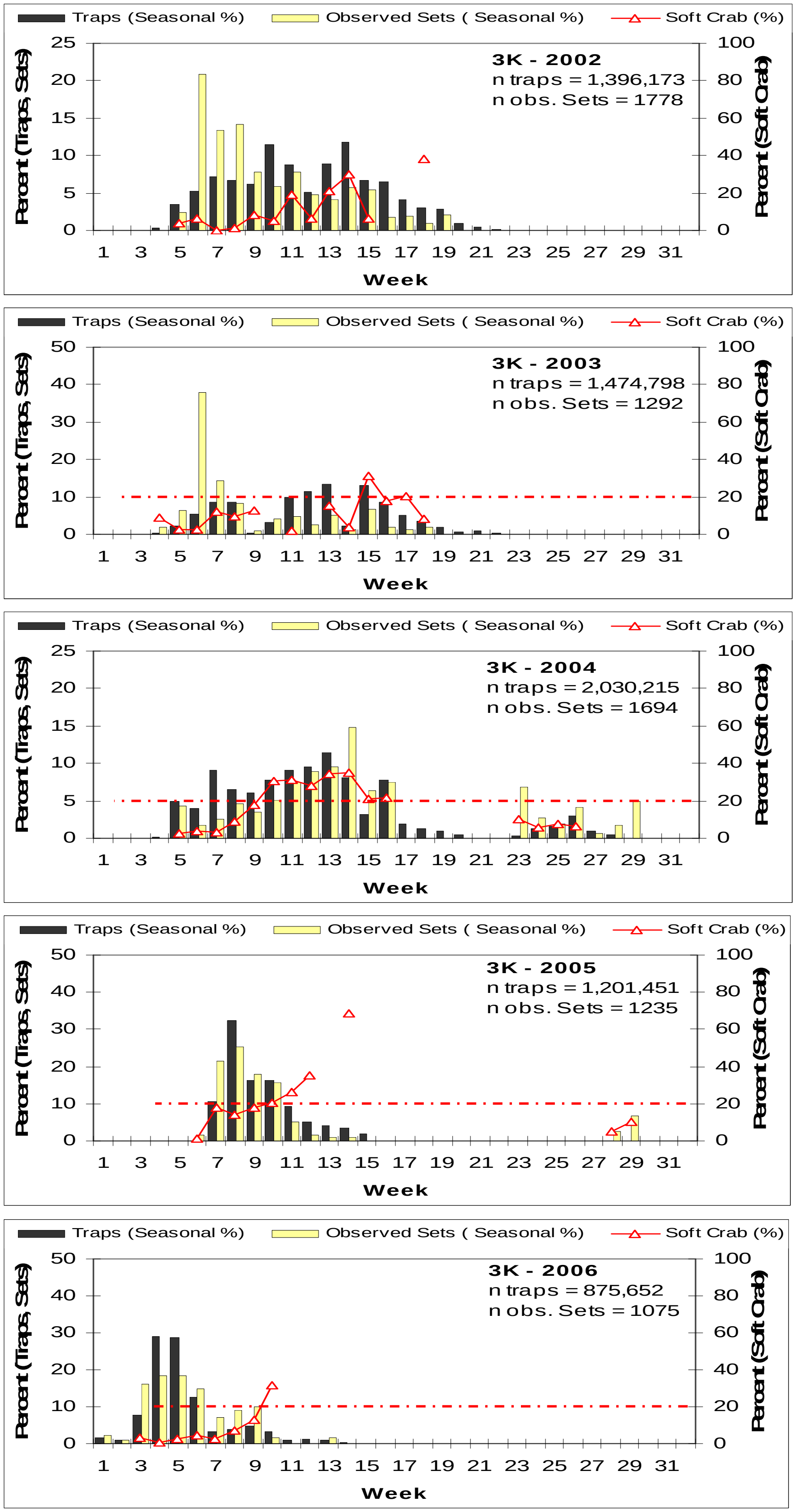


Figure 63. Trends in percentages of weekly effort by trap hauls in Division 3K versus percentages of weekly sets observed and soft shell (shell type 1) discards. (Sample sizes of <10 observed sets/week removed)

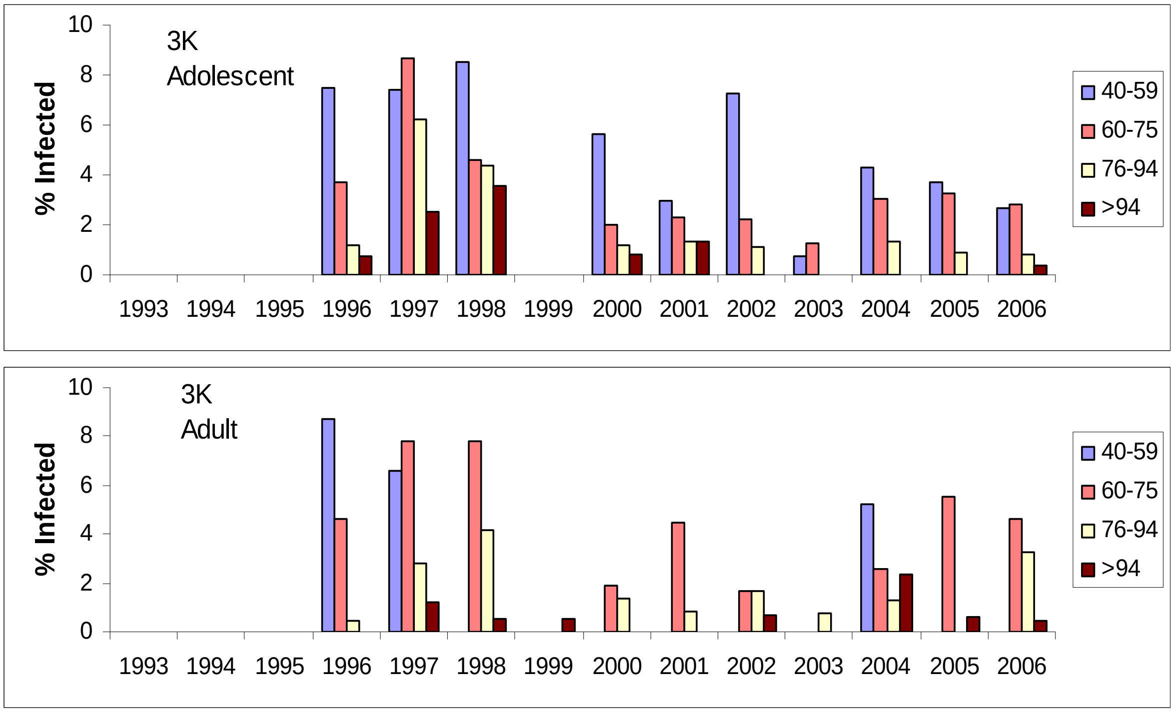


Figure 64. Trends in prevalence of BCD in Division 3K by male size group from multi-species surveys in new-shelled adolescent males (above) and adult males (below).

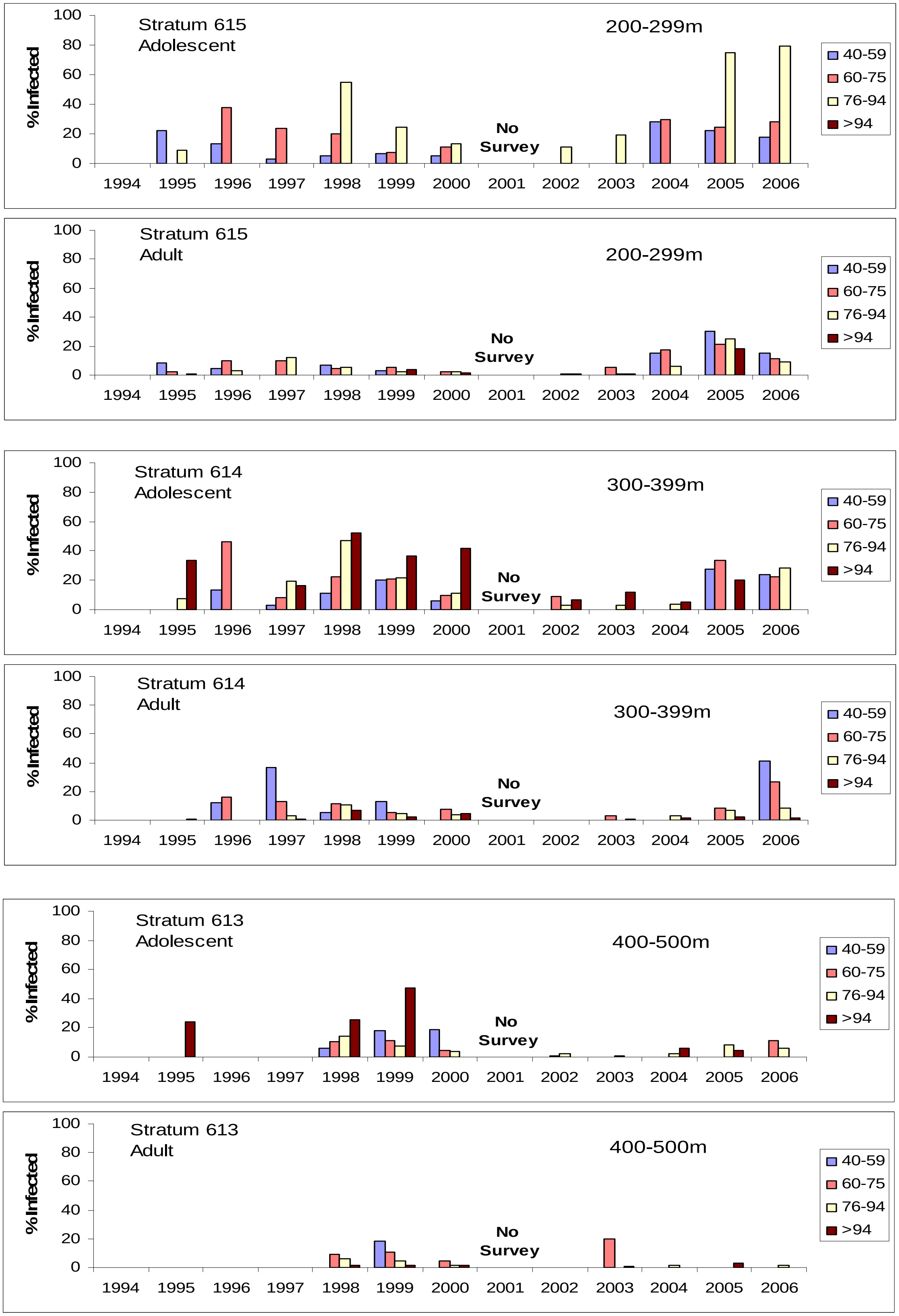


Figure 65. Incidence of BCD by stratum, year, and size group from trap surveys in White Bay; New-shelled males in adolescents (above) and adults (below).

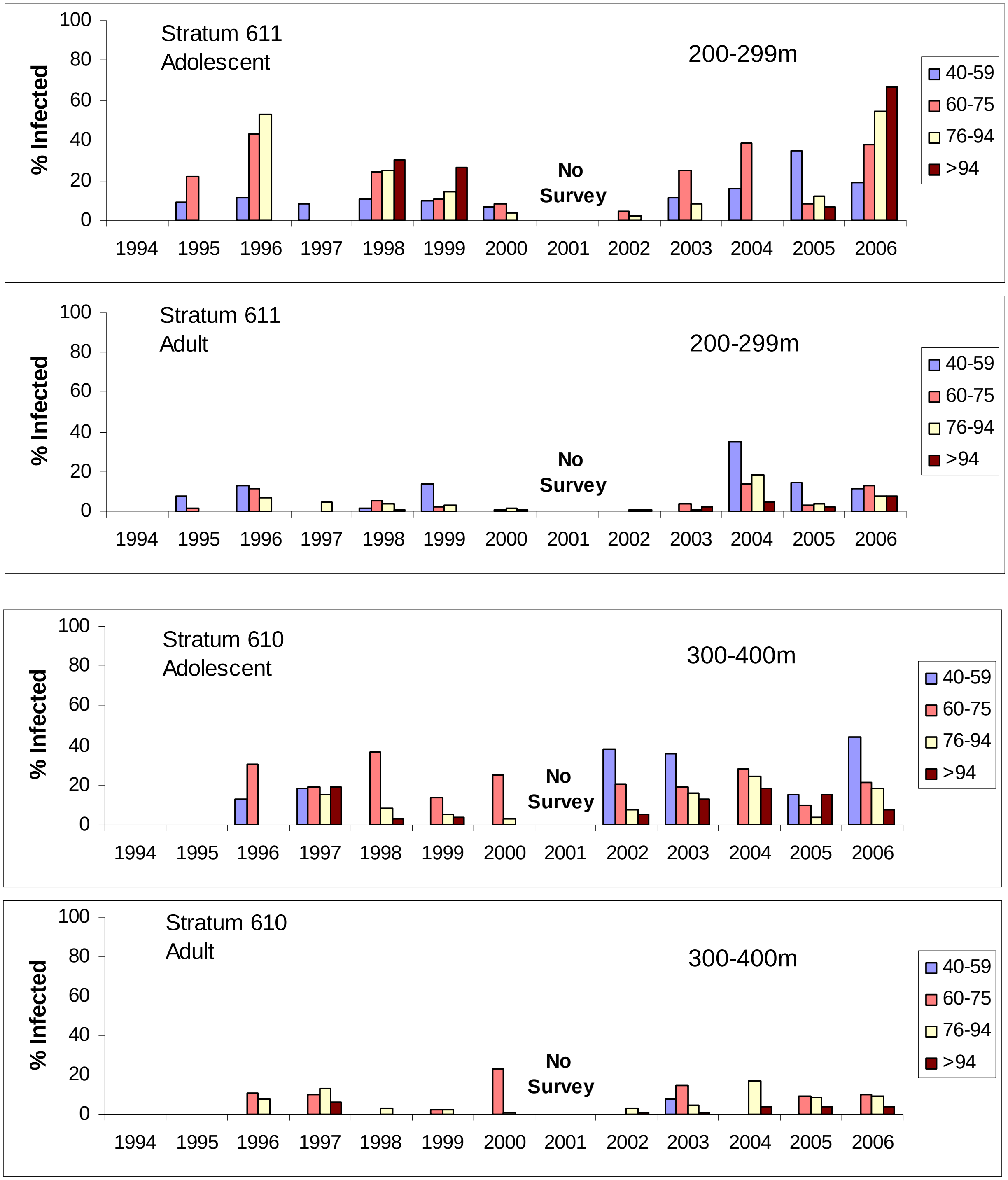


Figure 66. Incidence of BCD by stratum, year, and size group from trap surveys in Notre Dame Bay; New-shelled males in adolescents (above) and adults (below).

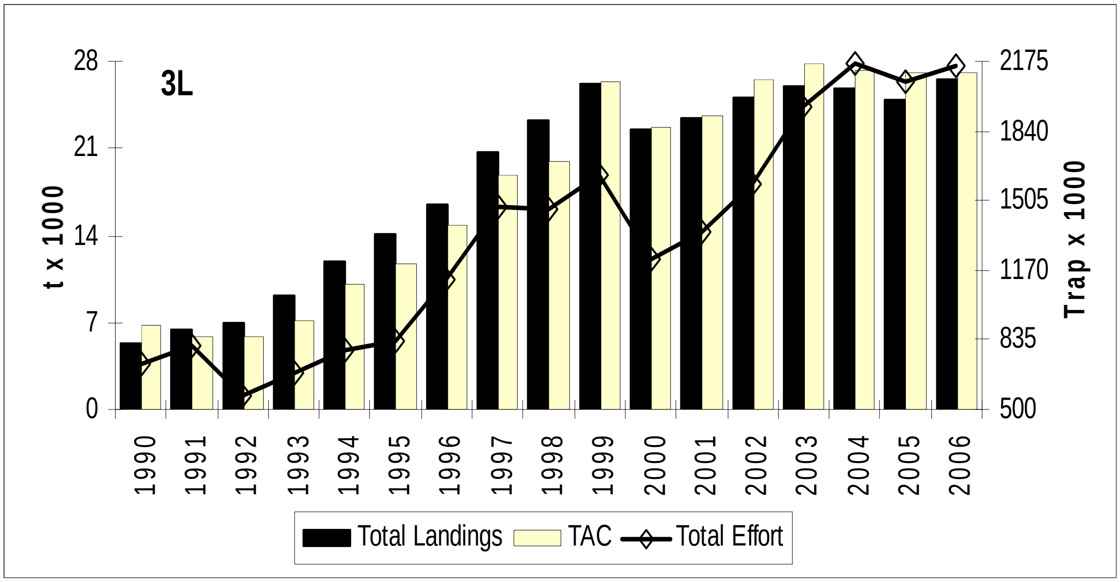


Figure 67. Trends in Division 3L landings, TAC, and fishing effort.

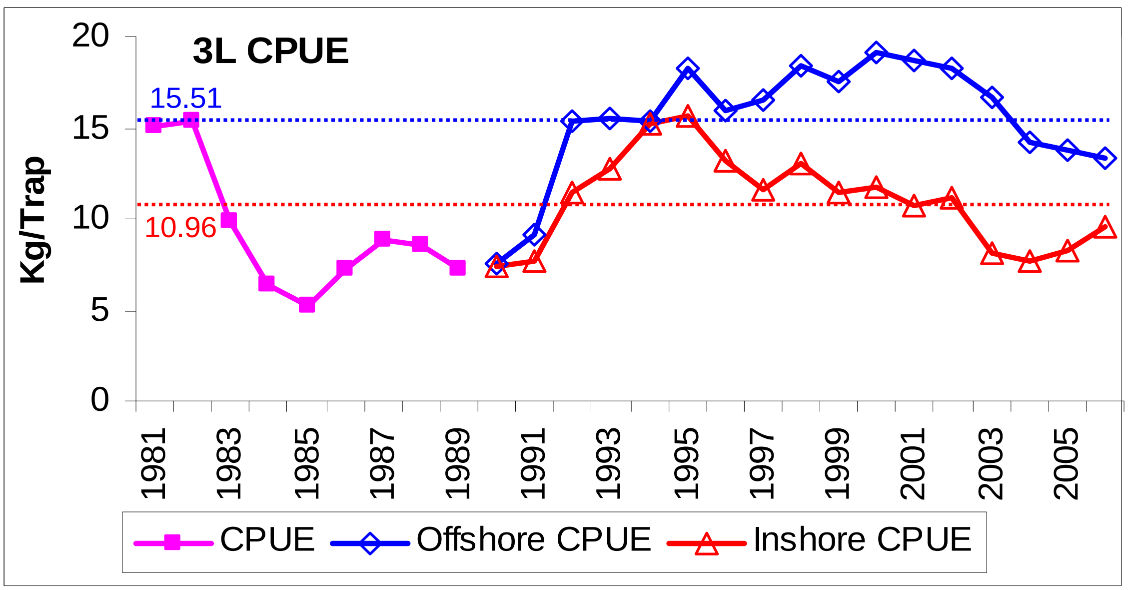


Figure 68. Trends in Division 3L inshore and offshore commercial CPUE in relation to their long-term averages (dotted lines).

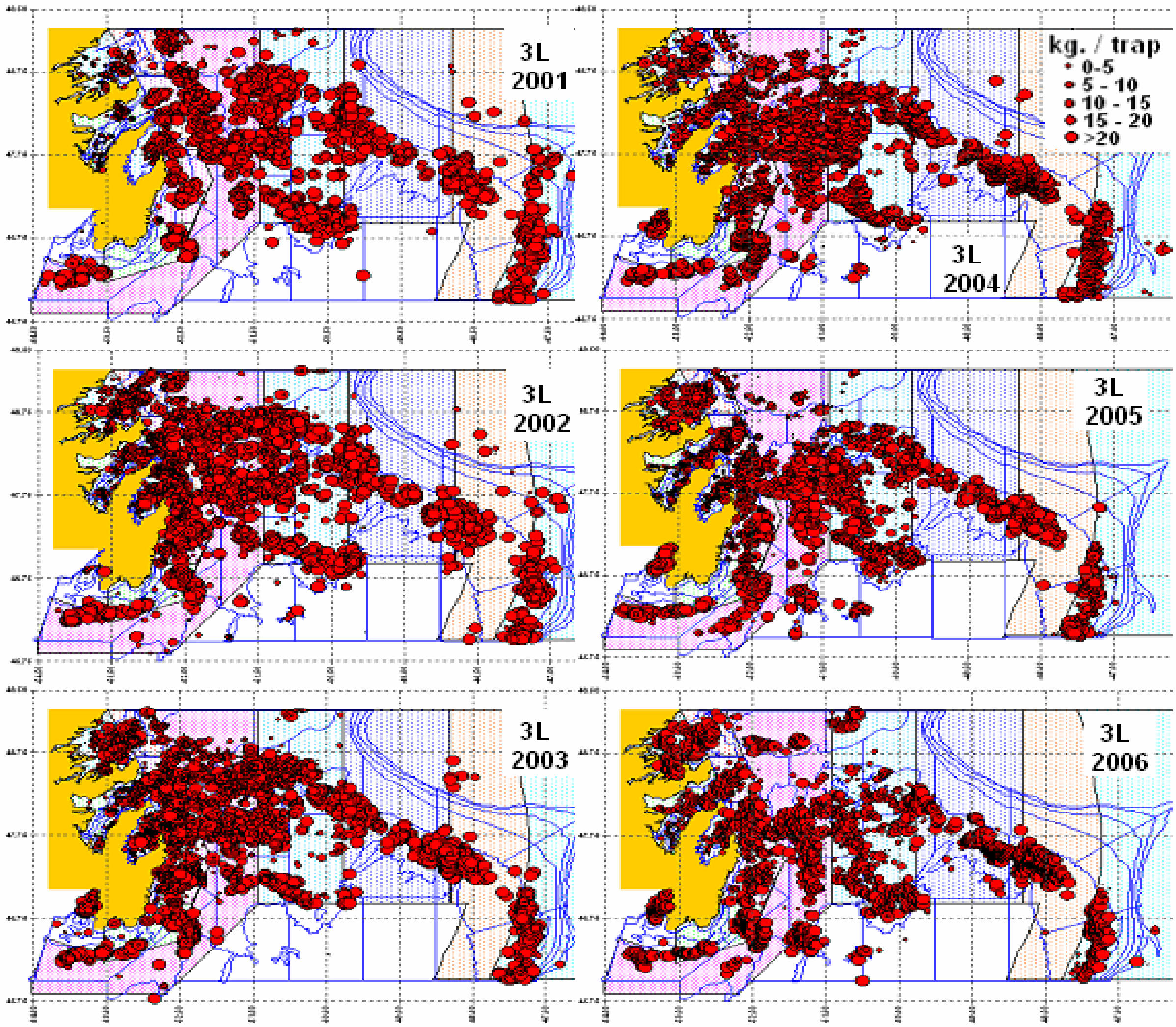


Figure 69. Spatial distribution of Division 3L commercial CPUE by year.

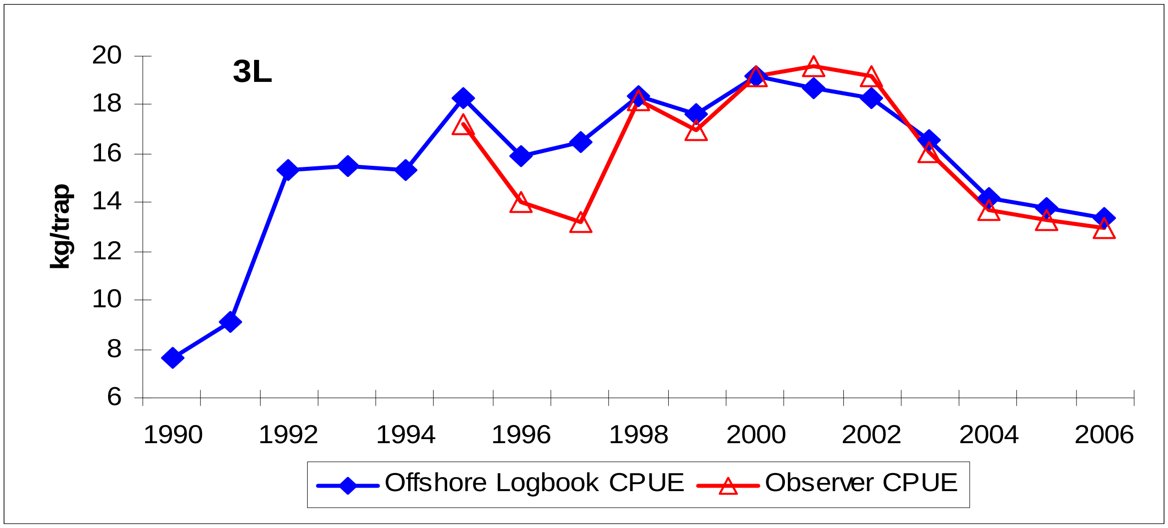


Figure 70. Trends in logbook-based CPUE vs. observer-based CPUE in the Division 3L fishery.

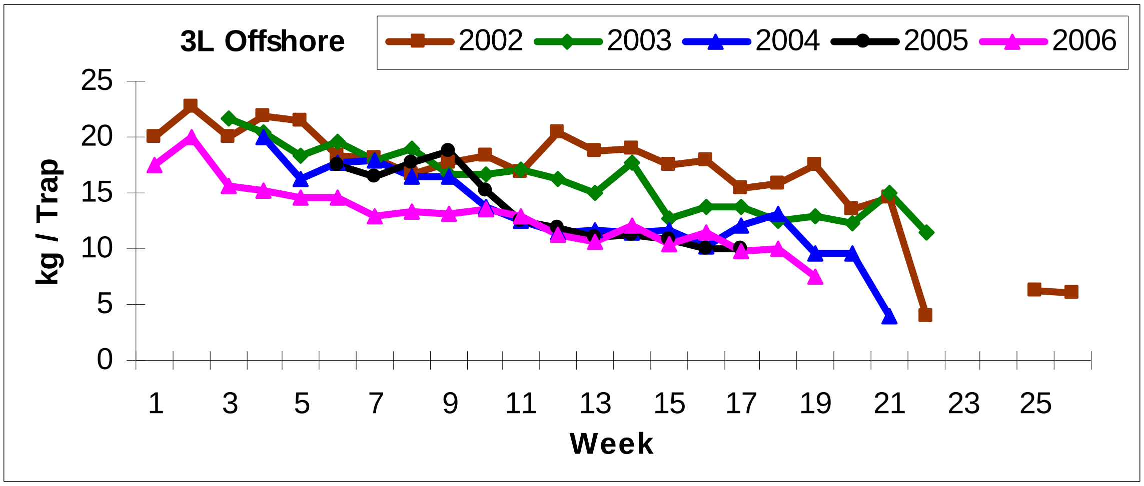


Figure 71. Seasonal trends in CPUE, by week, for Division 3L offshore during 2002-06.

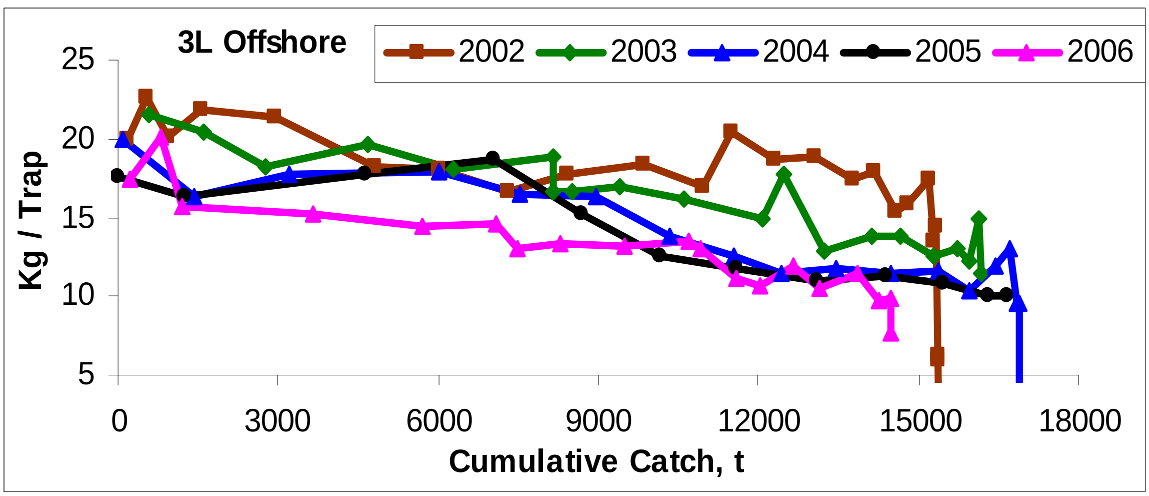


Figure 72. Seasonal trends in CPUE, in relation to cumulative catch, for Division 3L offshore during 2002-06.

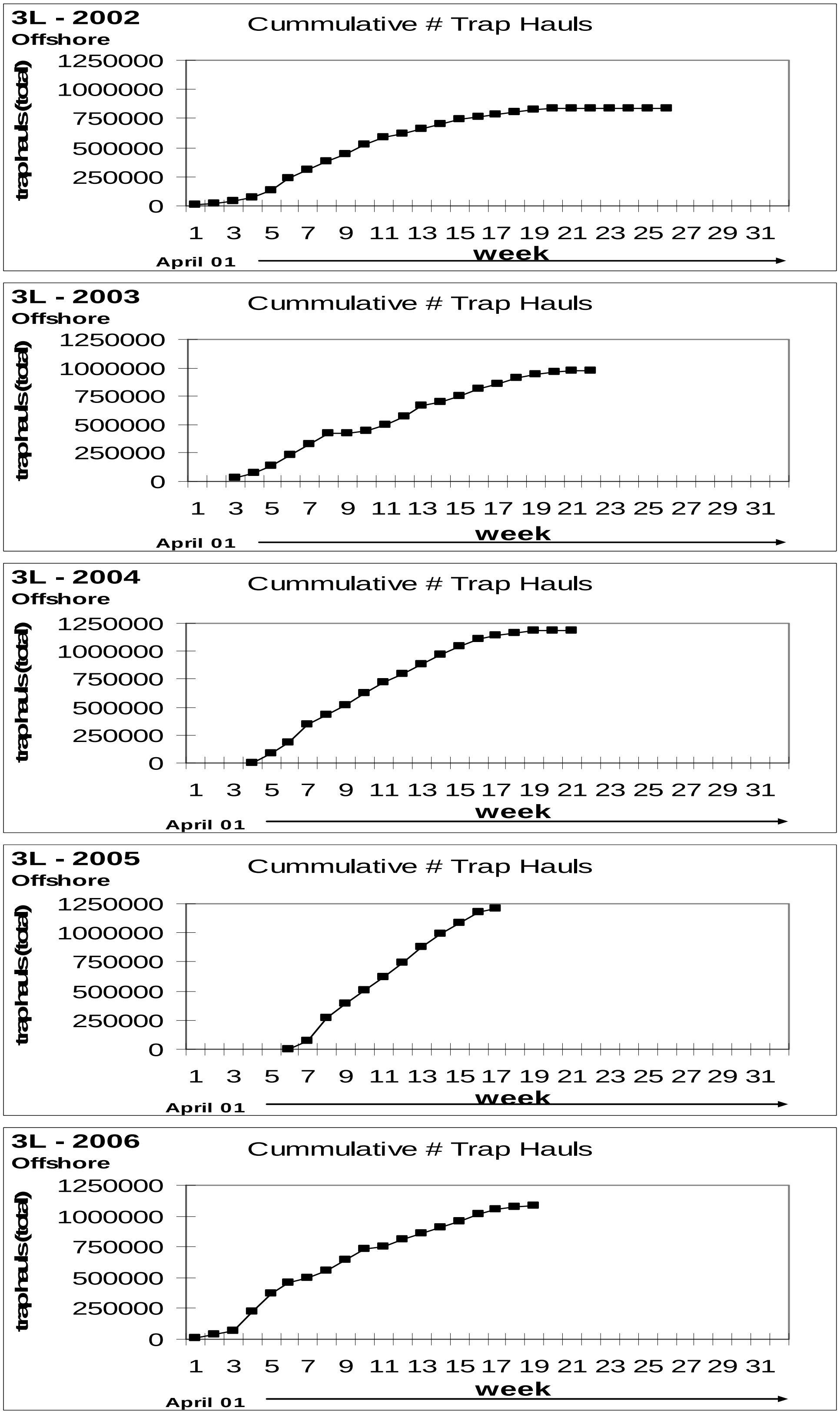


Figure 73. Seasonal trends in fishing effort, by week, for Division 3L offshore during 2002-06.

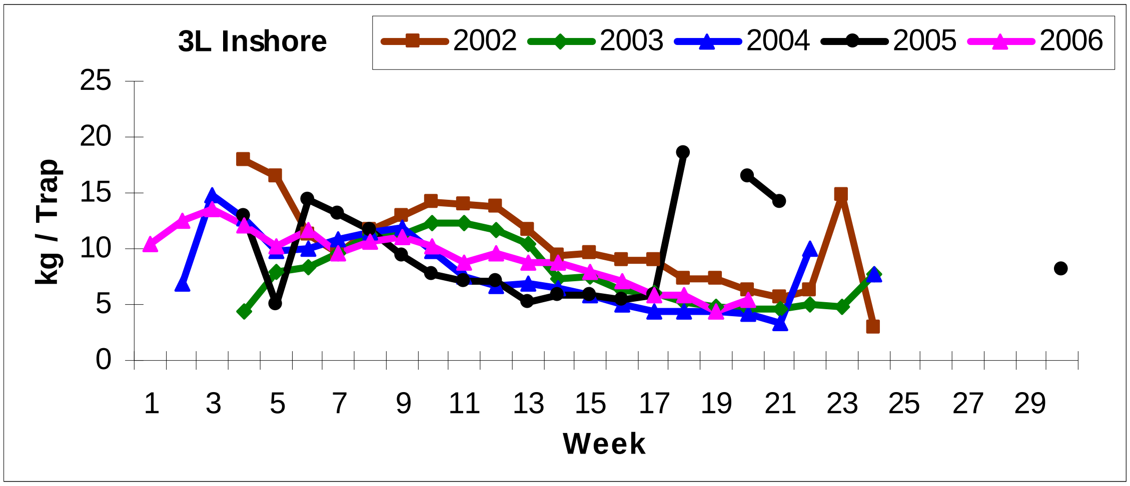


Figure 74. Seasonal trends in CPUE, by week, for Division 3L inshore during 2002-06.

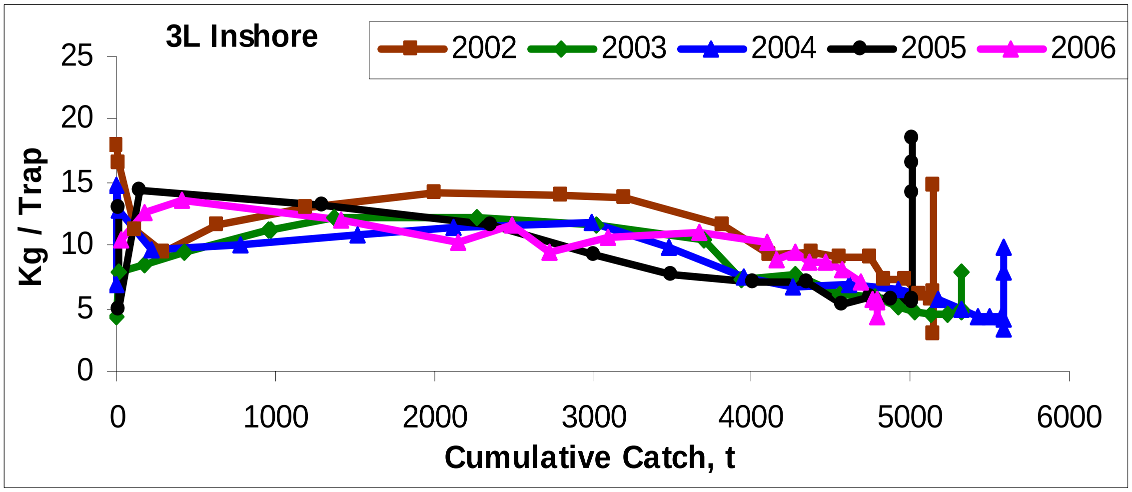


Figure 75. Seasonal trends in CPUE, in relation to cumulative catch, for Division 3L inshore during 2002-06.

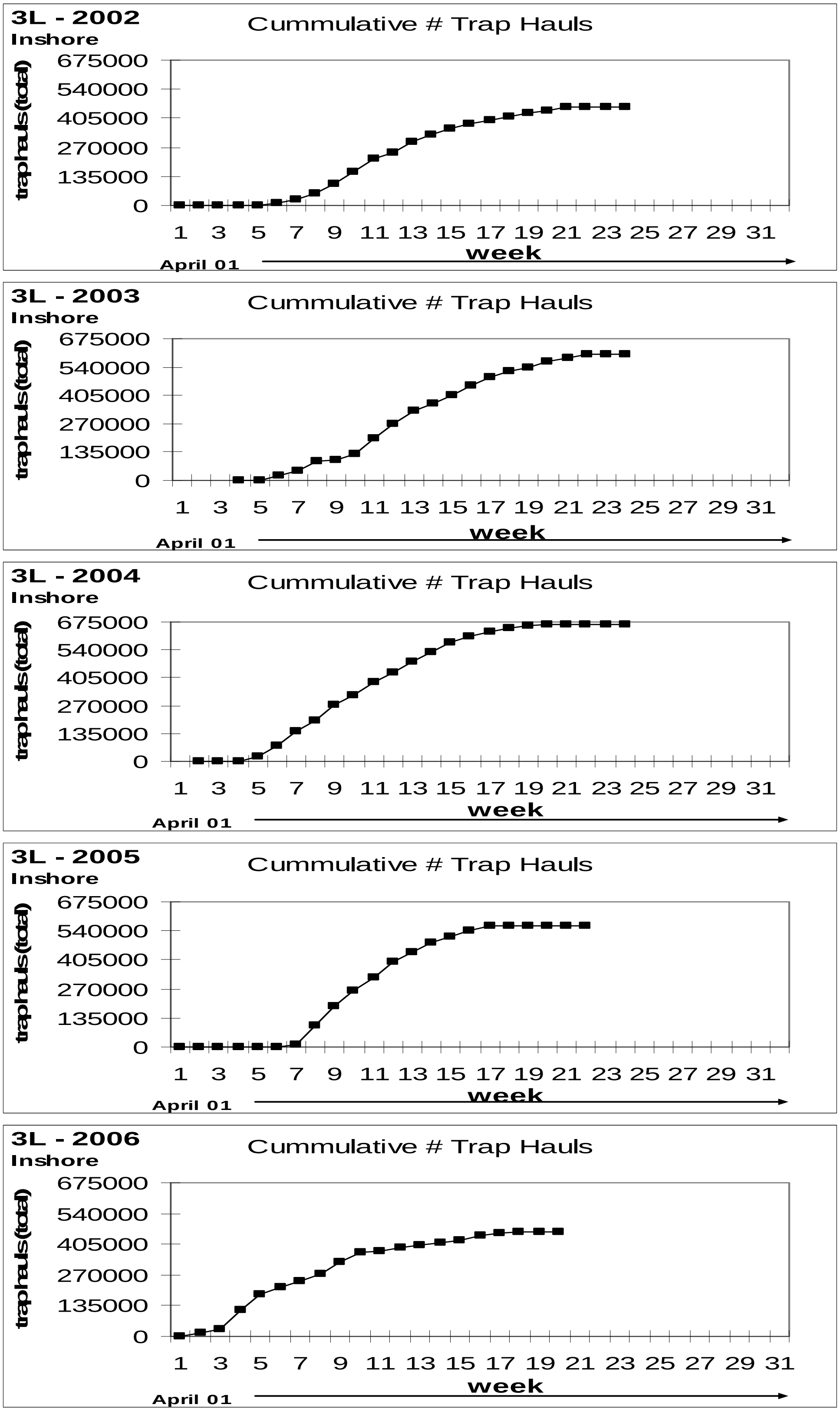


Figure 76. Seasonal trends in fishing effort, by week, for Division 3L inshore during 2002-06.

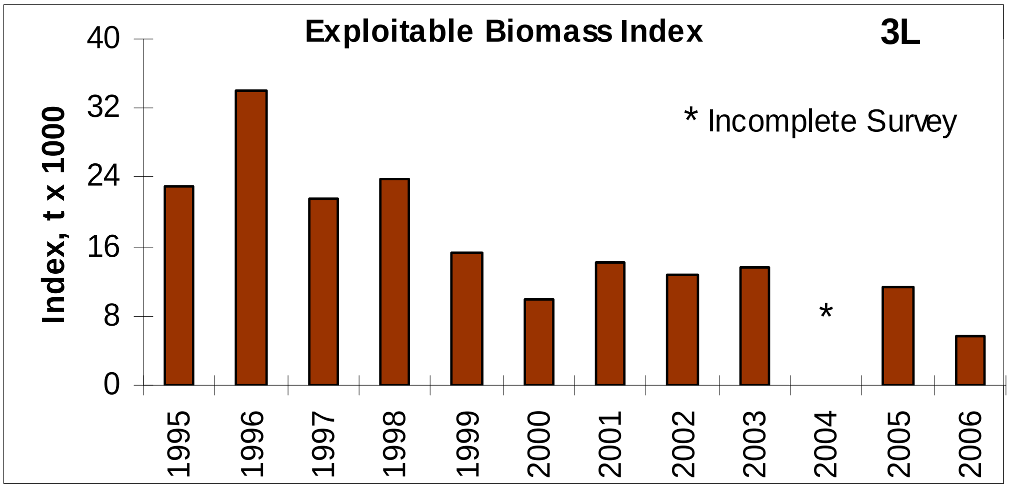


Figure 77. Trends in the Division 3L fall multi-species survey exploitable biomass index.

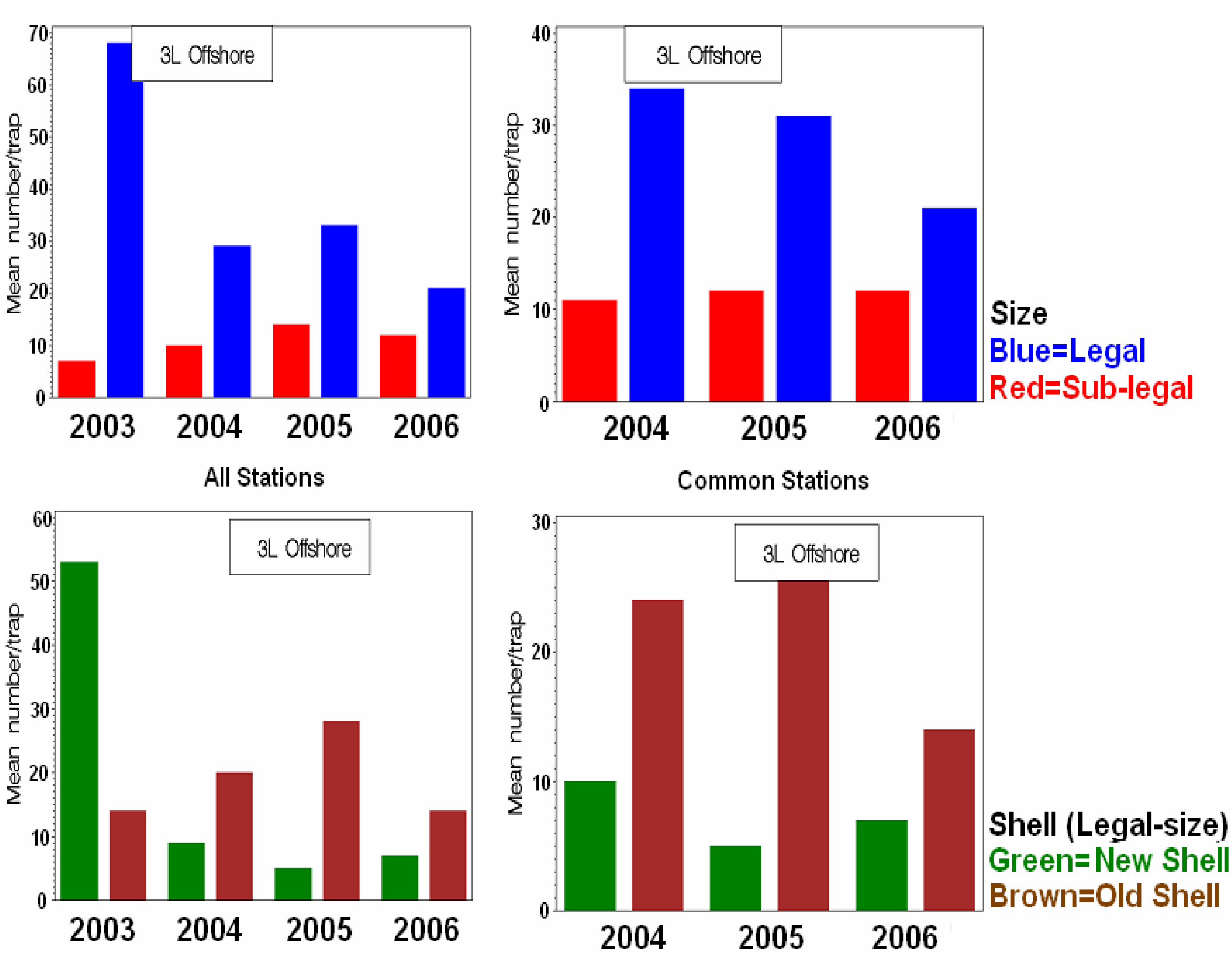


Figure 78 Trends in CPUE for size composition (above) and shell condition (below) from FSCP post-season trap surveys for Division 3L offshore from all stations (left) and common stations (right).

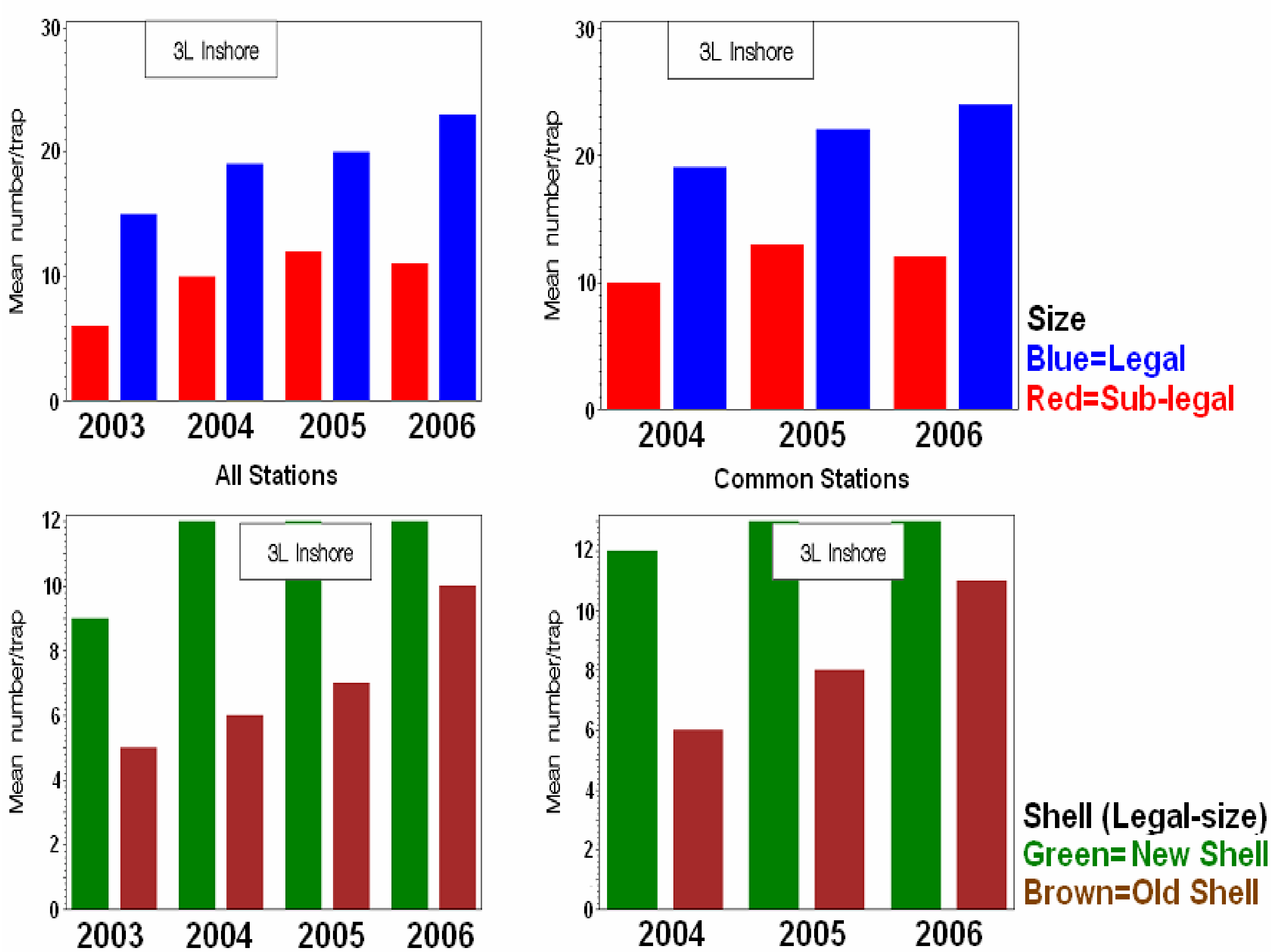


Figure 79. Trends in CPUE for size composition (above) and shell condition (below) from FSCP post-season trap surveys for Division 3K inshore from all stations (left) and common stations (right).

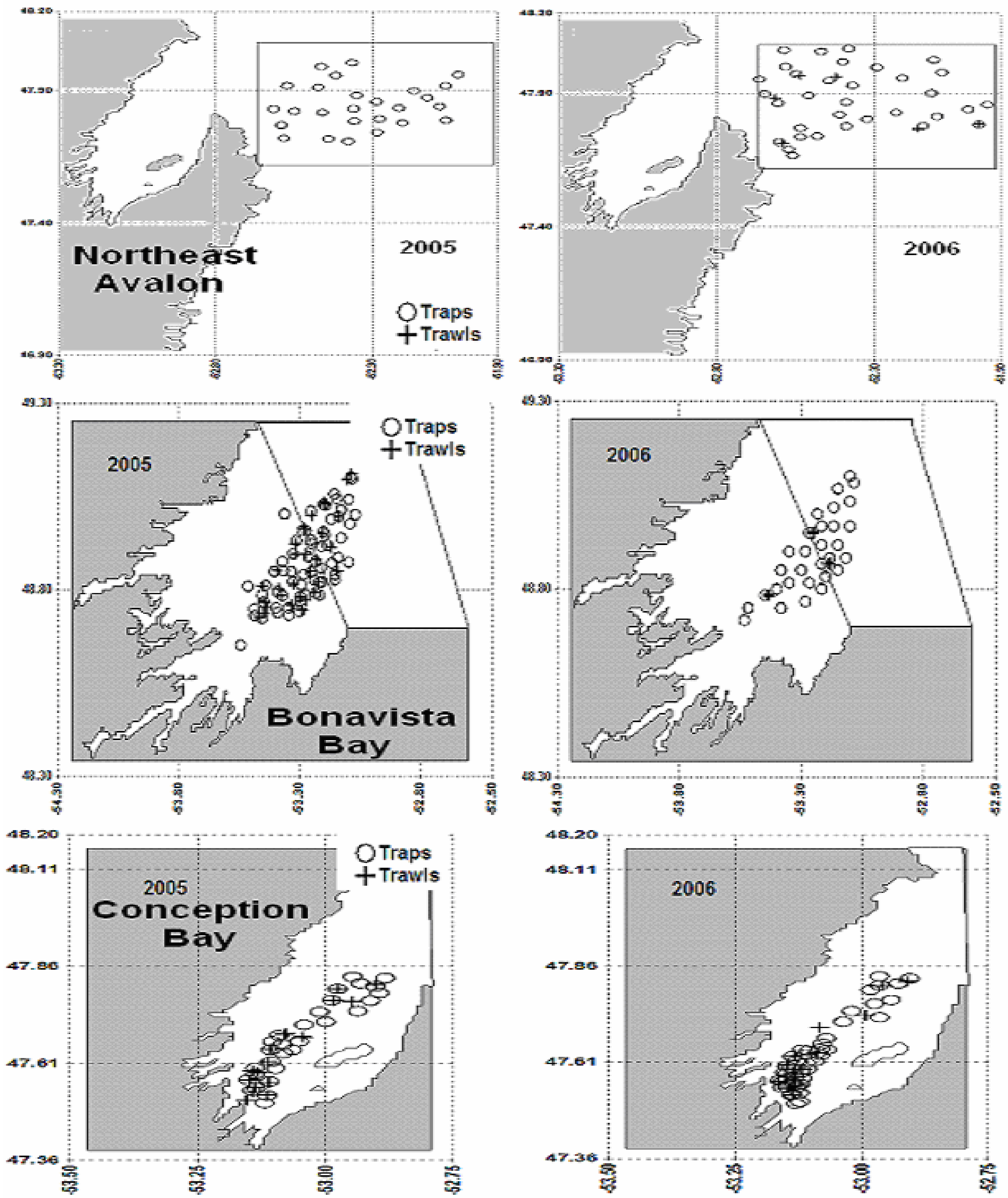


Figure 80. Location map showing inshore Division 3L stations sampled during Northeast Avalon (spring), Bonavista Bay (summer) and Conception Bay (autumn) surveys in 2005-06.

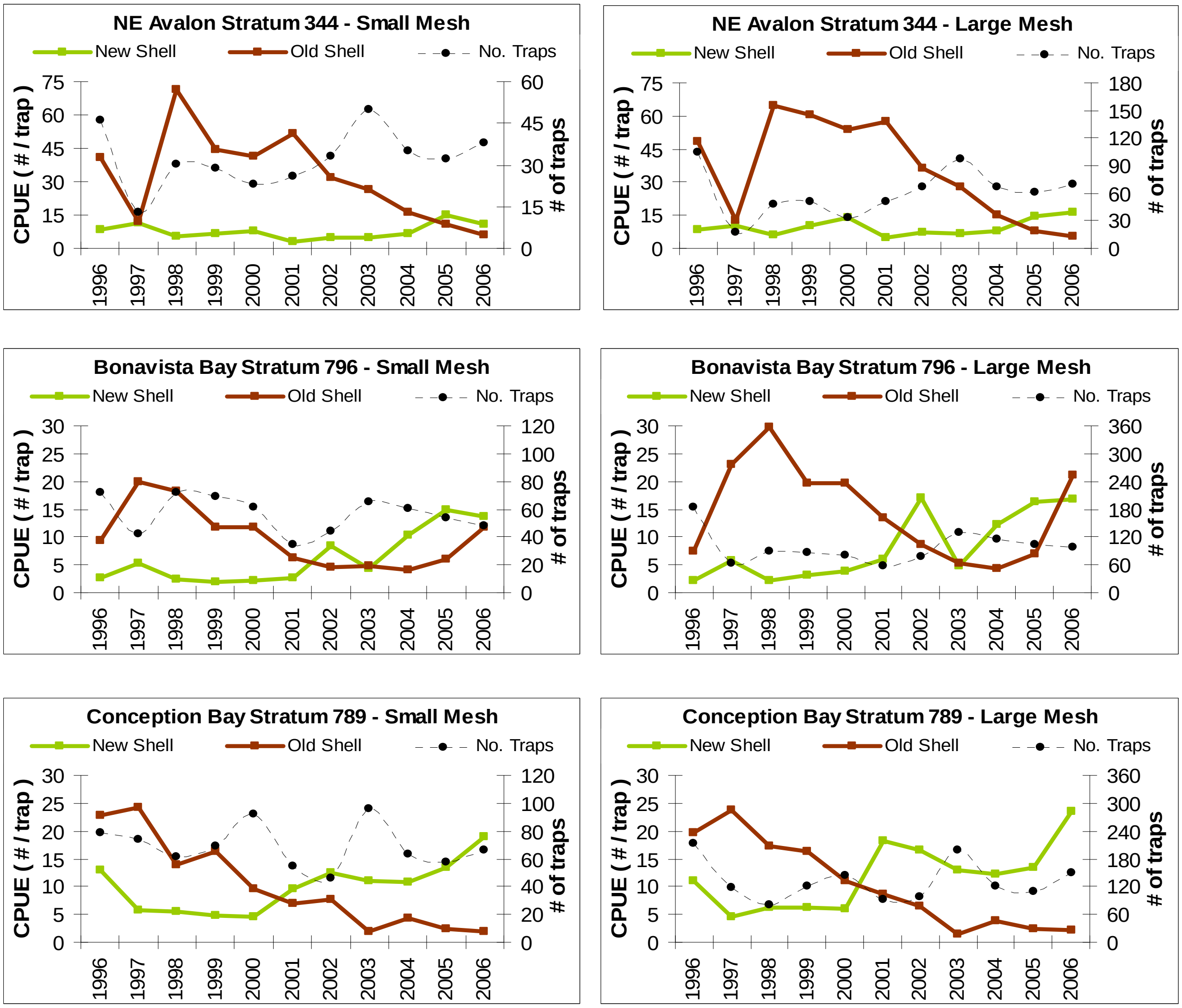


Figure 81. Trends in catch rates by shell category and stratum from inshore Division 3L trap surveys in Northeast Avalon (spring), Bonavista Bay (summer), and Conception Bay (autumn), 1996-2006.

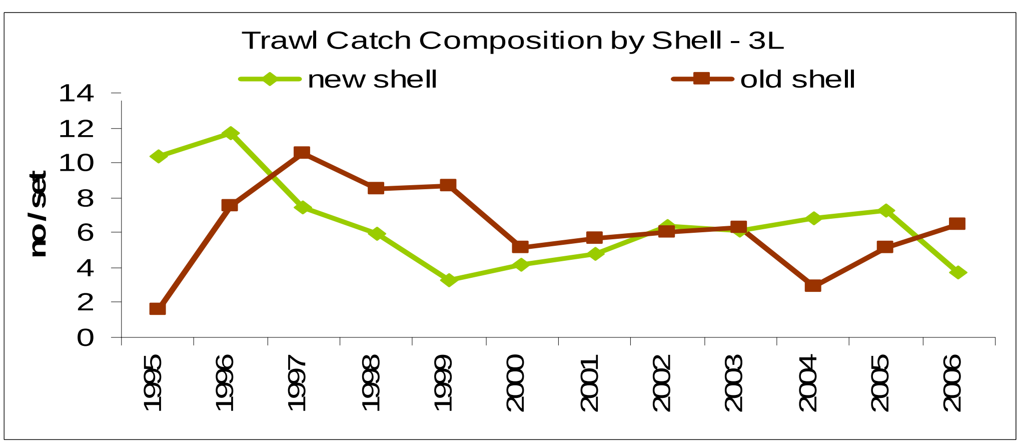


Figure 82. Trends, by shell condition, in abundance indices of legal-sized males for Division 3L from fall multi-species surveys.

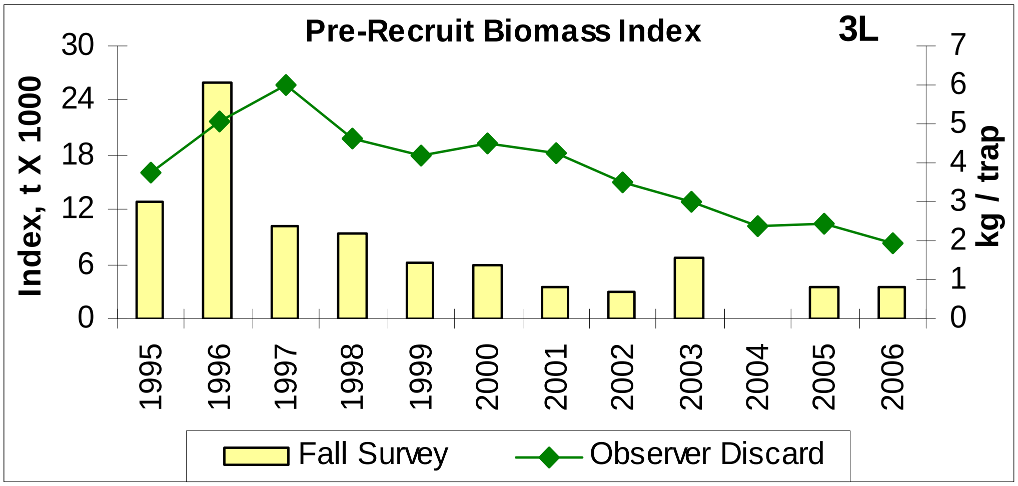


Figure 83. Trends in the Division 3L fall multi-species survey pre-recruit biomass index and the observer discard catch rate index.

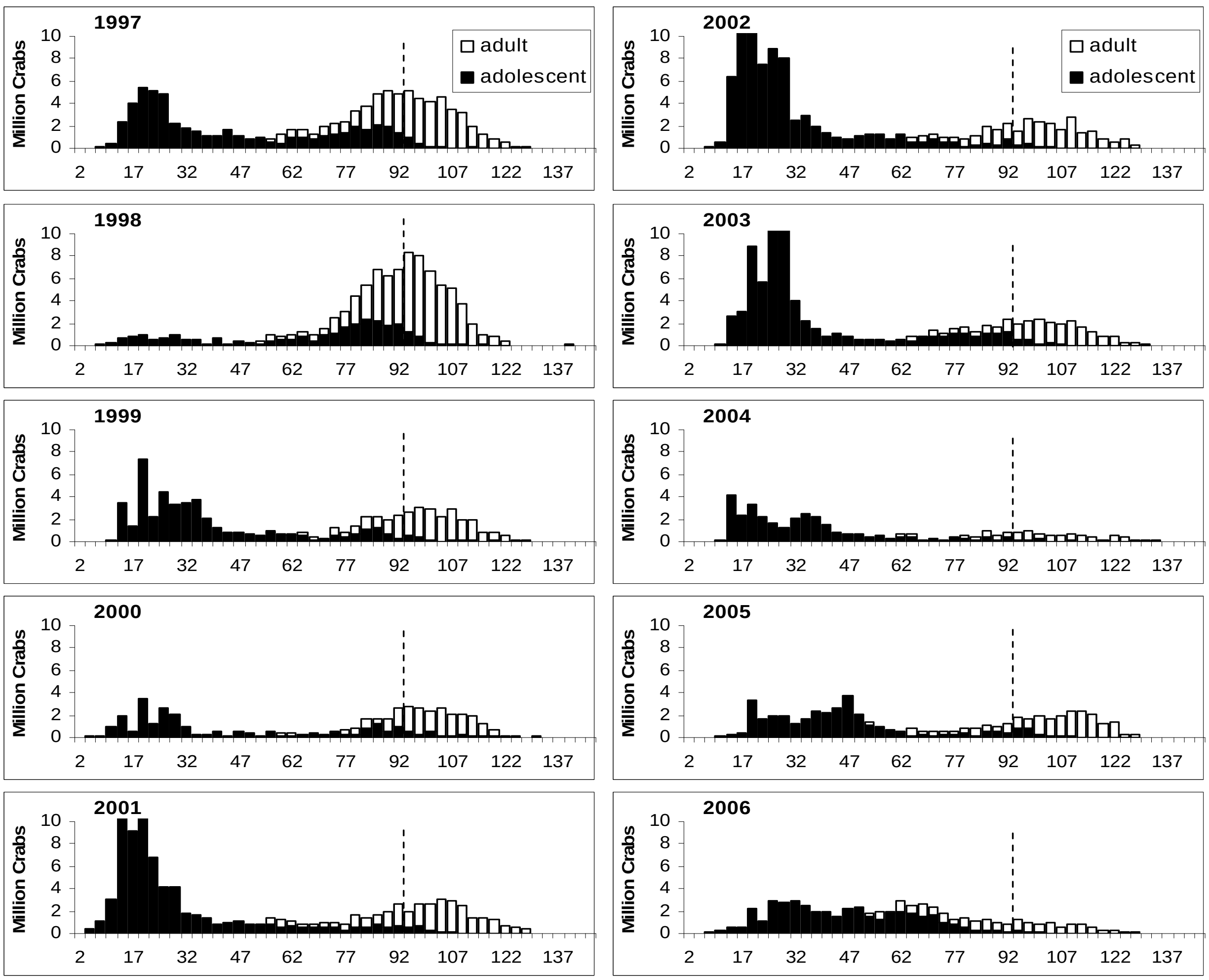


Figure 84. Truncated distribution of abundance (index) by carapace width for Division 3L juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

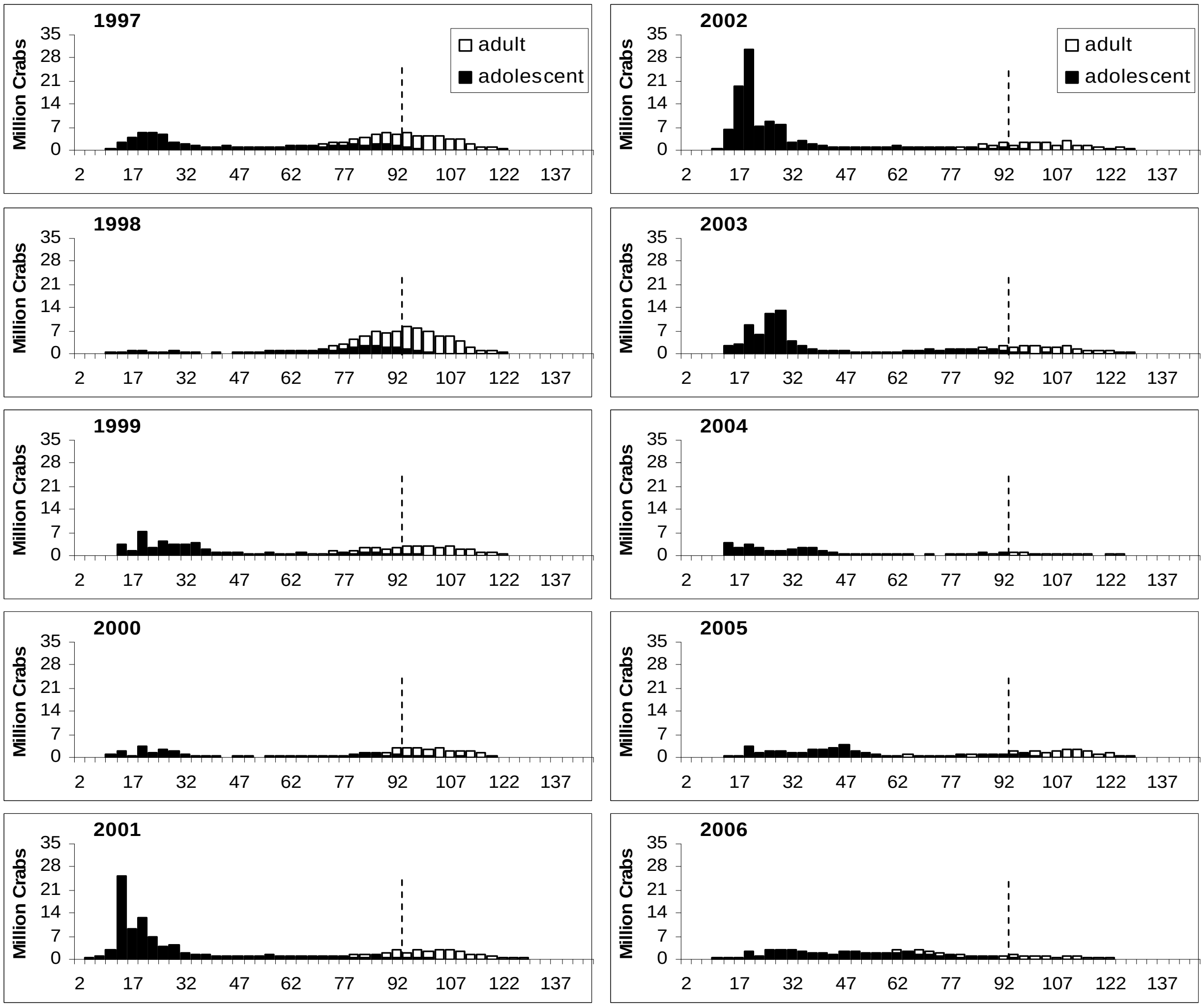


Figure 85. Distribution of abundance (index) by carapace width for Division 3L juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

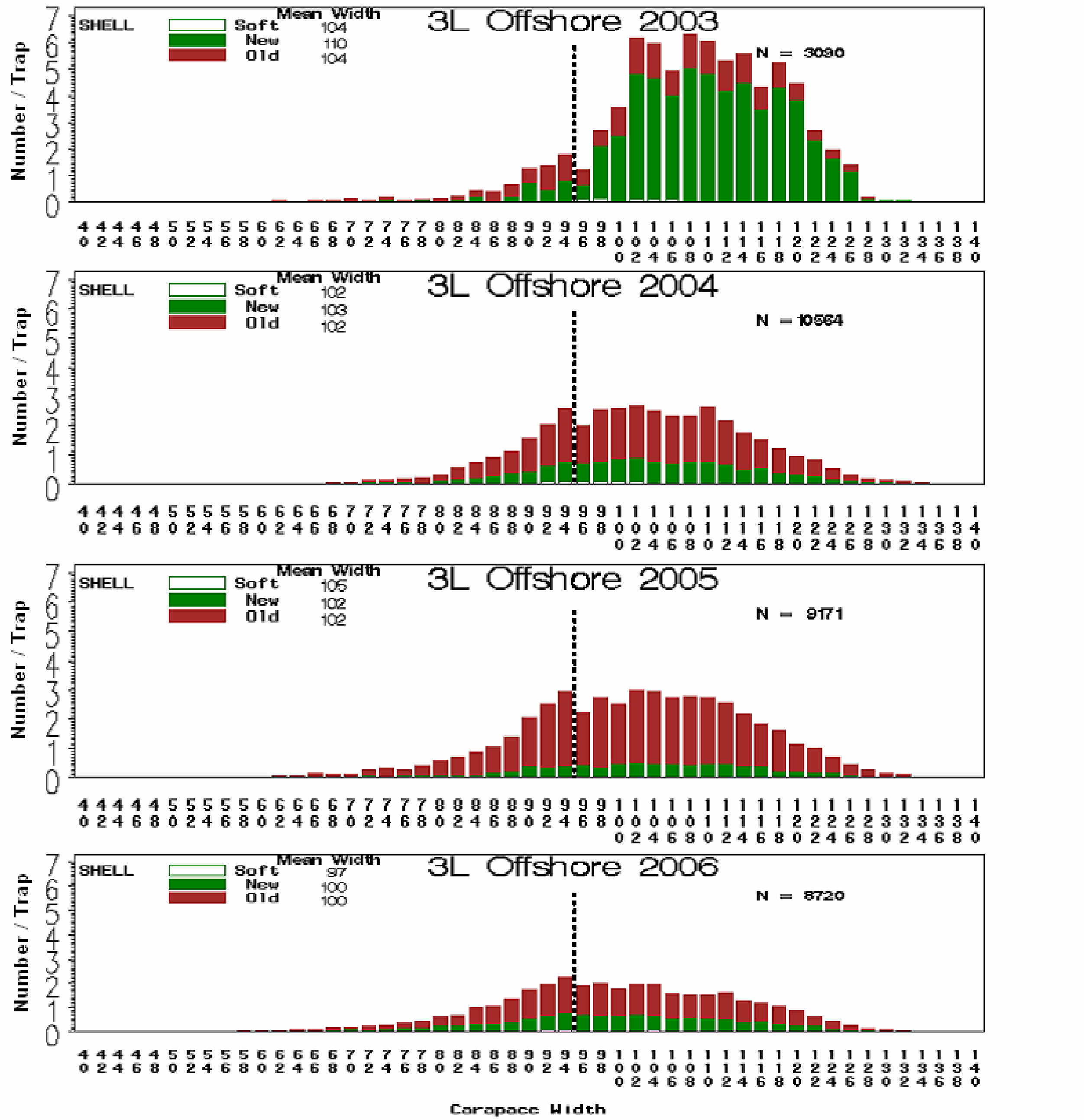


Figure 86. Trends in male carapace width distributions from FSCP post-season trap surveys for Division 3L offshore.

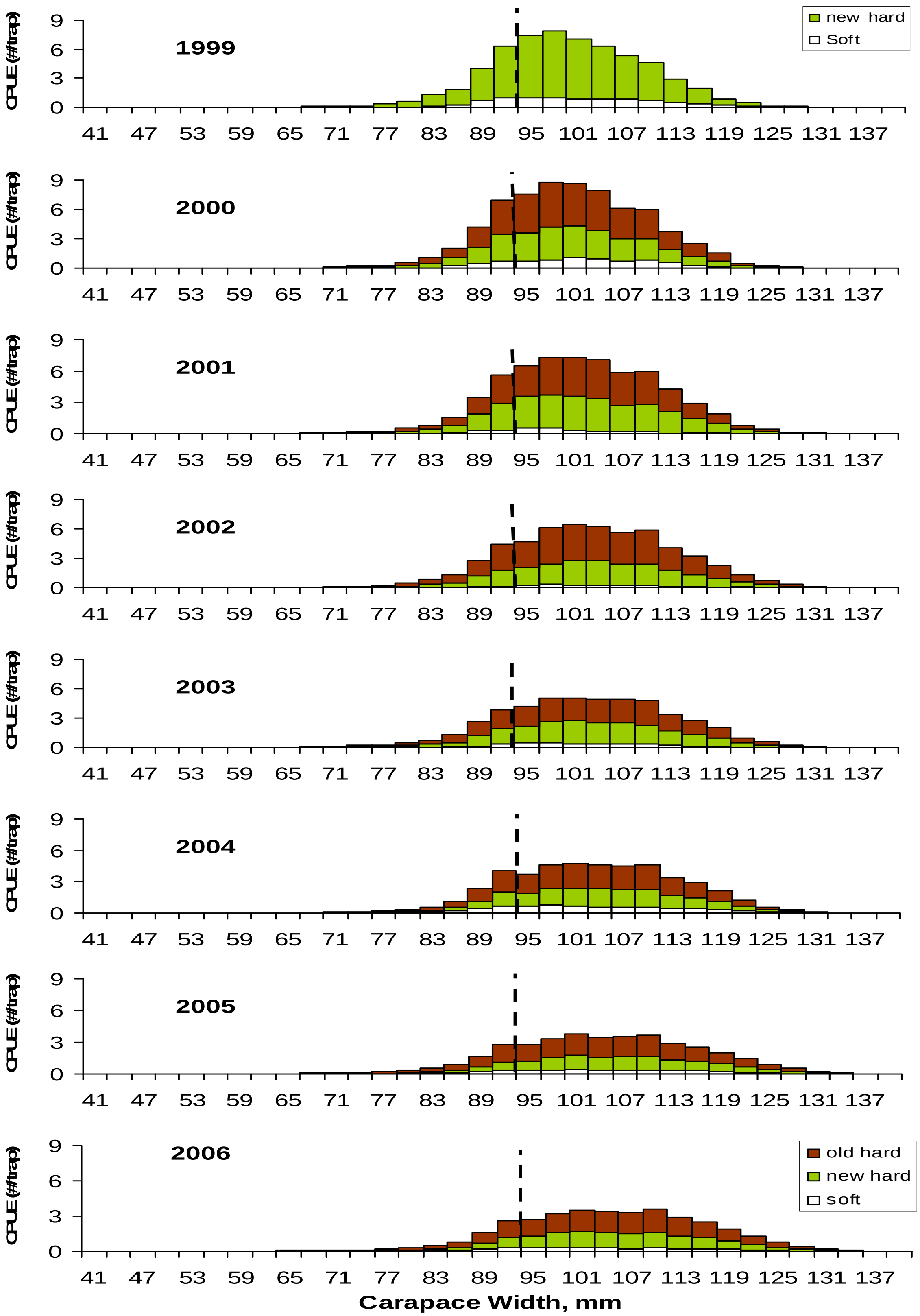


Figure 87. Trend in male carapace width distributions from observer at-sea sampling for Division 3L.

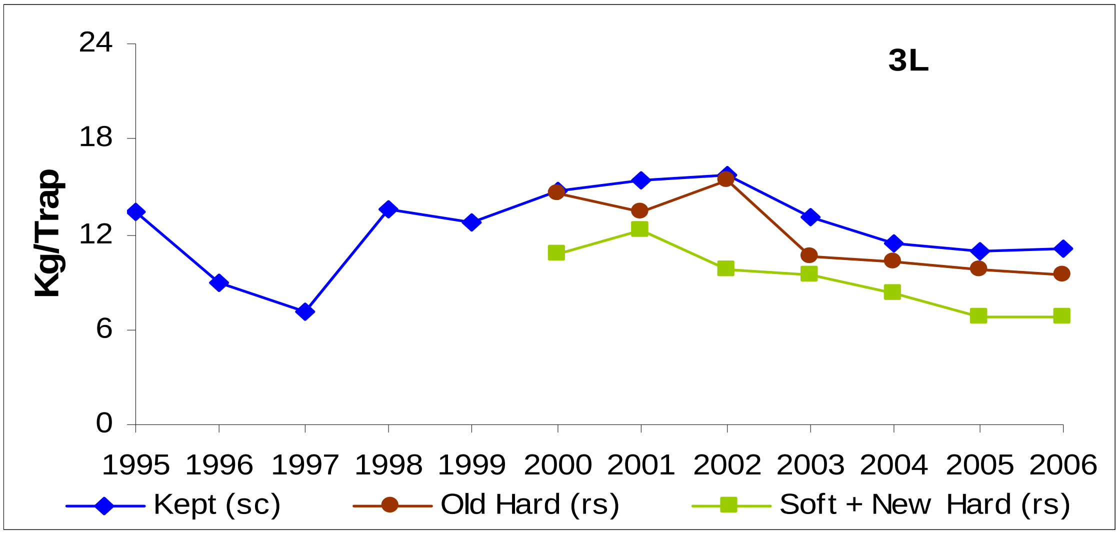


Figure 88. Trends in Division 3L observer catch rates of exploitable crabs since 1995 from set and catch records and of legal-sized crabs by shell category since 2000 from at-sea sampling.

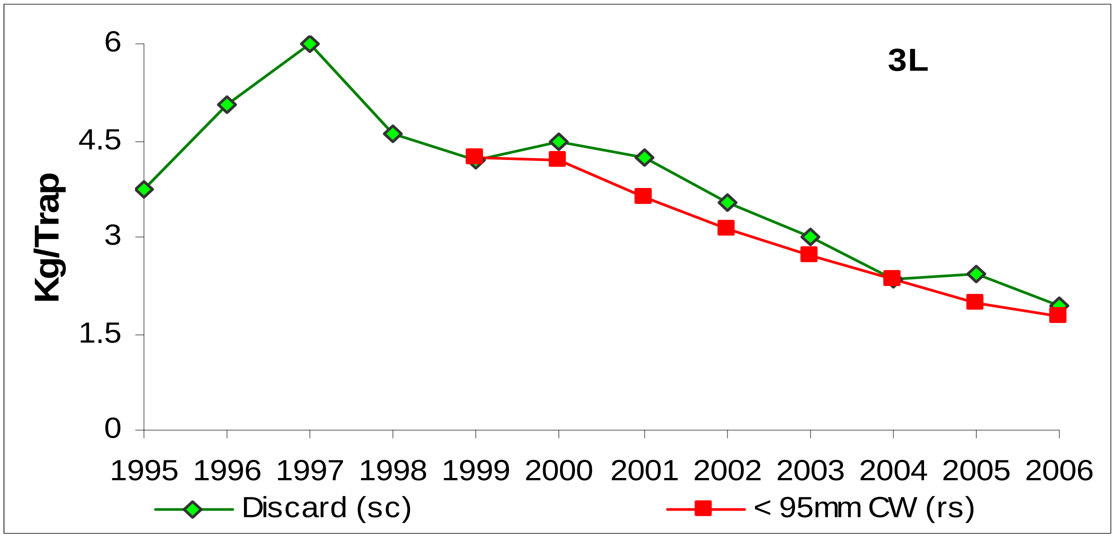


Figure 89. Trends in Division 3Lobserver catch rates of total discards since 1995 from set and catch records and of sub-legal sized crabs since 1999 from at-sea sampling.

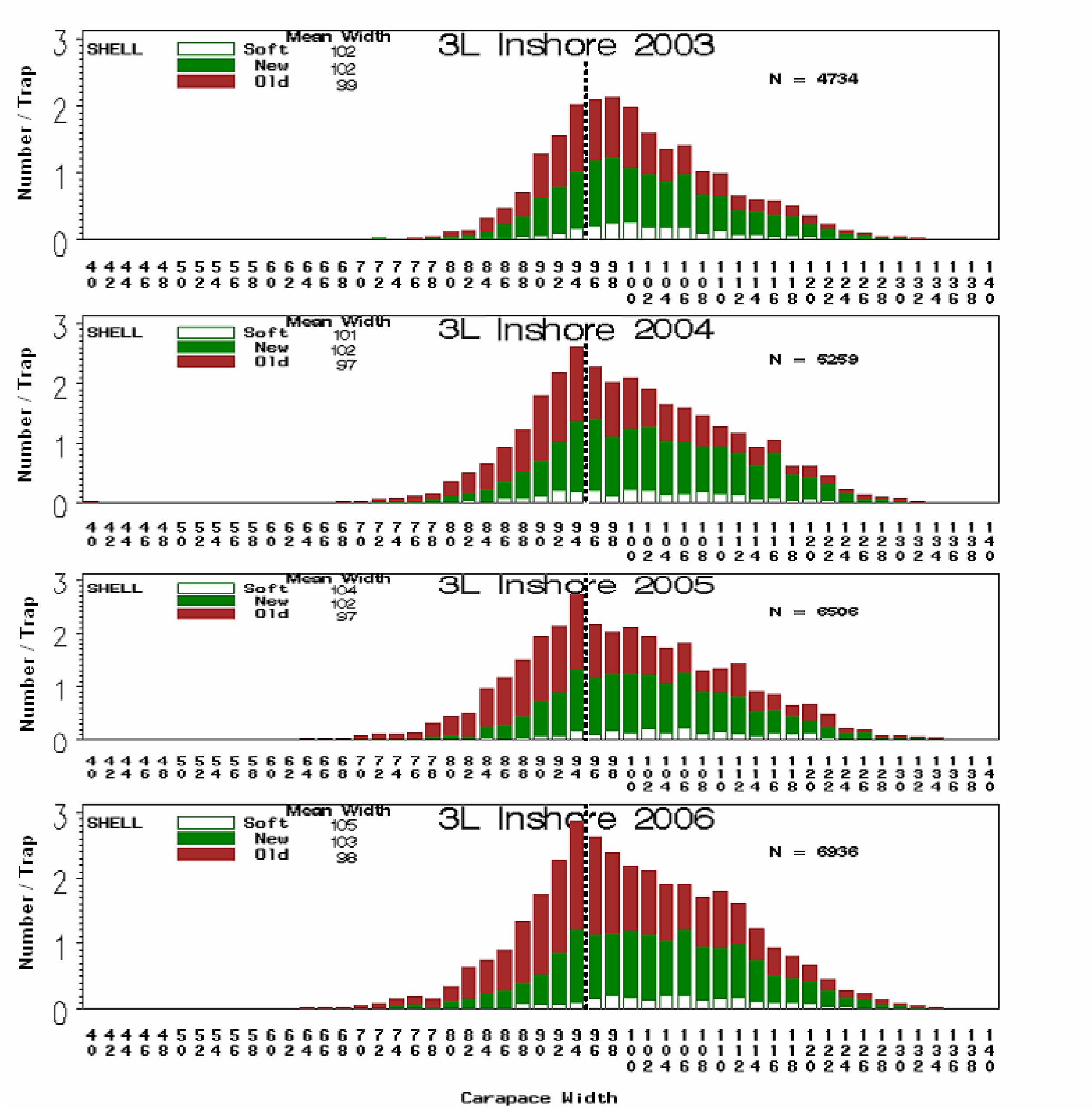


Figure 90. Trends in male carapace width distributions from FSCP post-season trap surveys for Division 3L inshore.

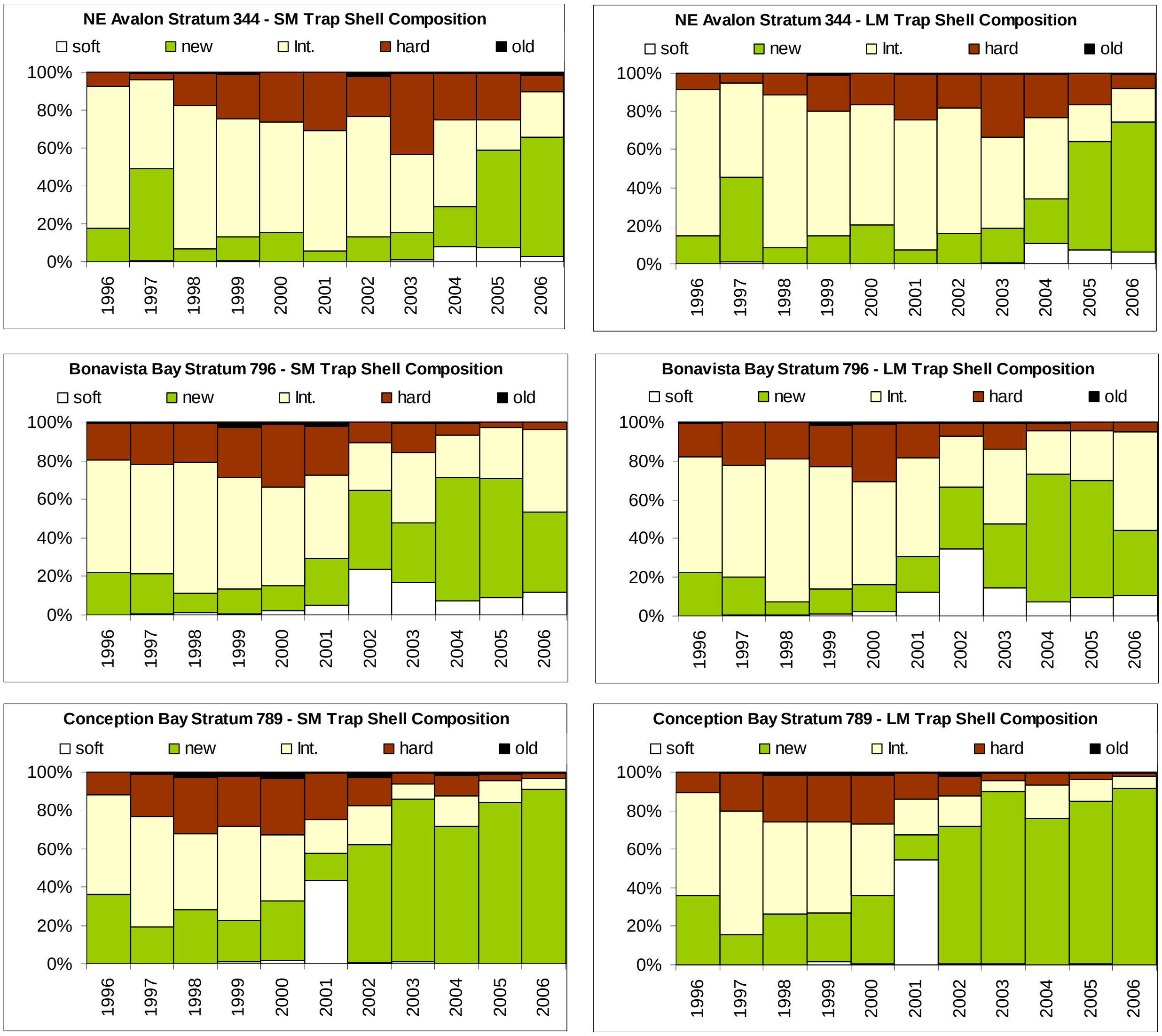


Figure 91. Trends in shell condition of catches by stratum from inshore Division 3L trap surveys in Northeast Avalon (spring), Bonavista Bay (summer), and Conception Bay (autumn), 1996-2006.

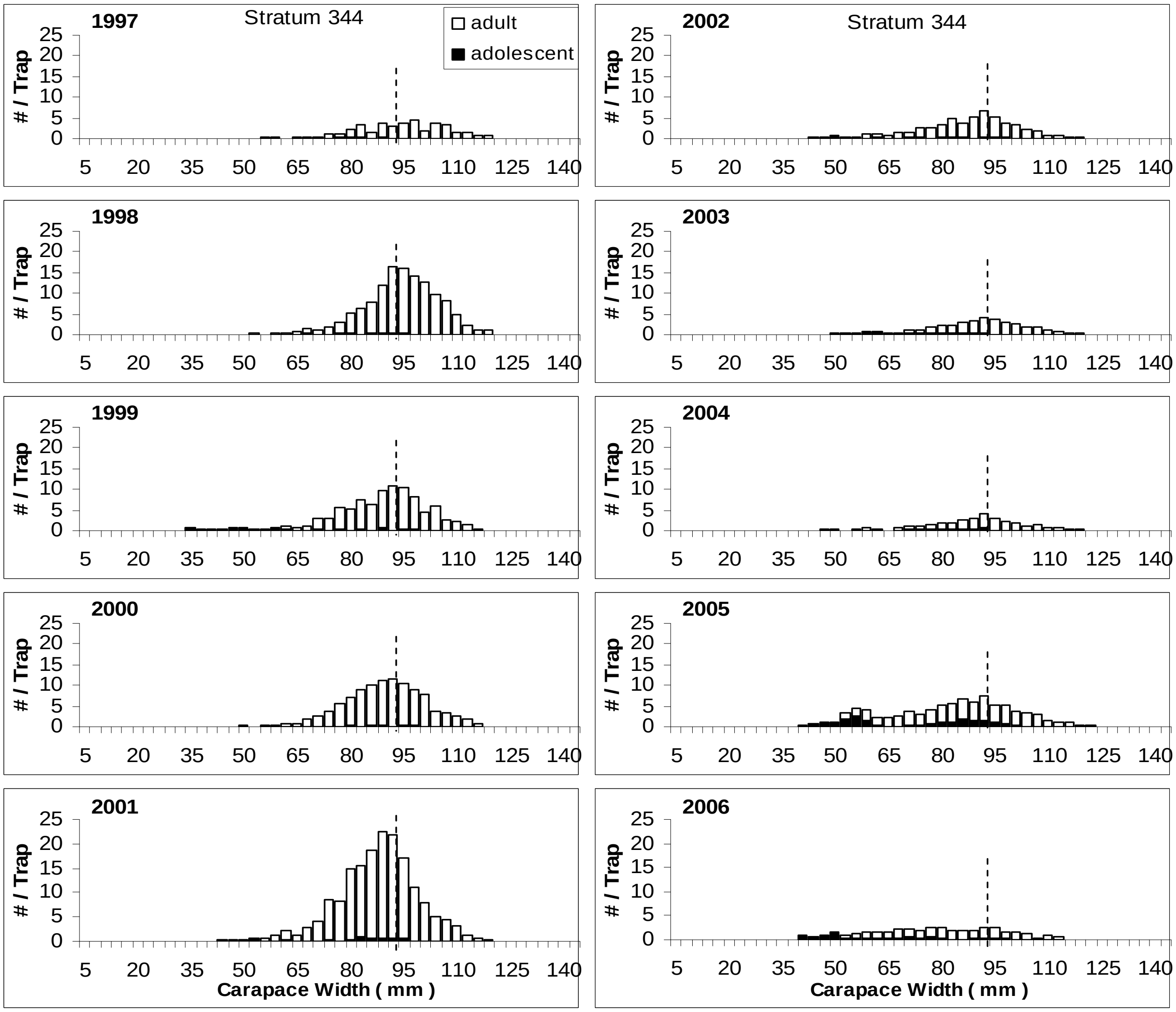


Figure 92. Male size composition from small-meshed traps by year from inshore spring trap surveys off Northeast Avalon; adolescents (small-clawed) in black vs. adults (large-clawed) in white.

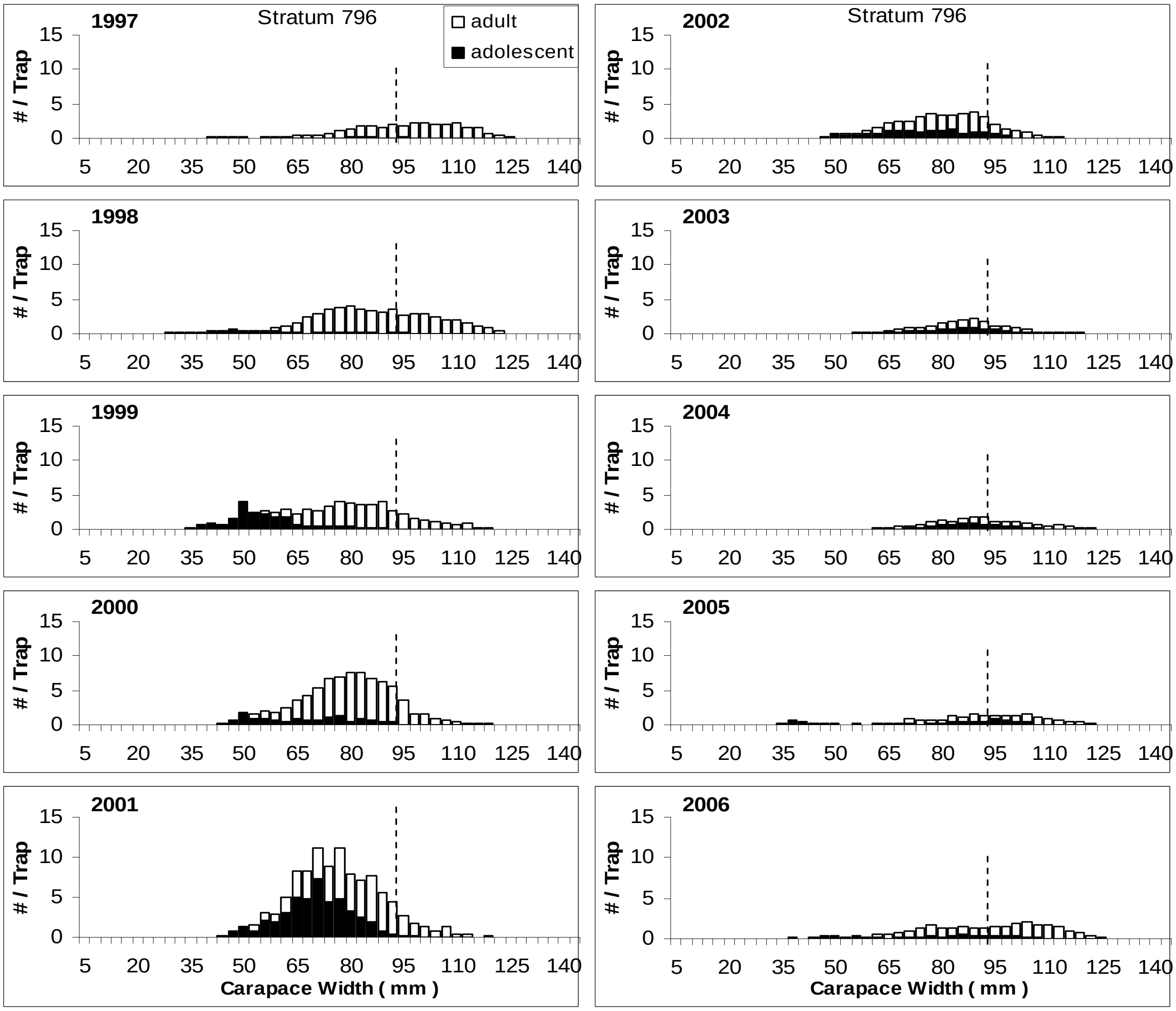


Figure 93. Male size composition from small-meshed traps by year from inshore summer trap surveys in Bonavista Bay; adolescents (small-clawed) in black vs. adults (large-clawed) in white.

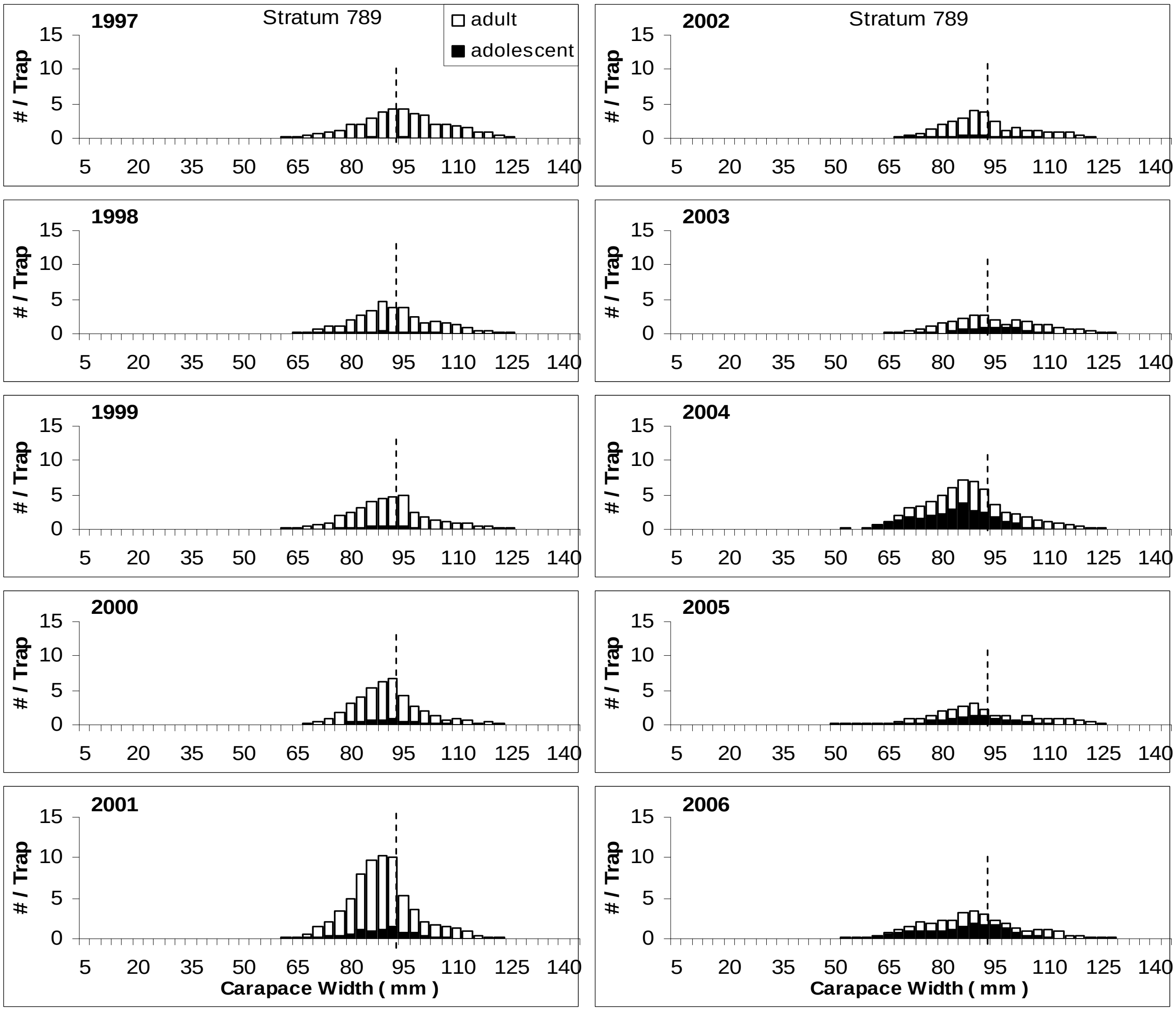


Figure 94. Male size composition from small-meshed traps by year from inshore fall trap surveys in Conception Bay; adolescents (small-clawed) in black vs. adults (large-clawed) in white.

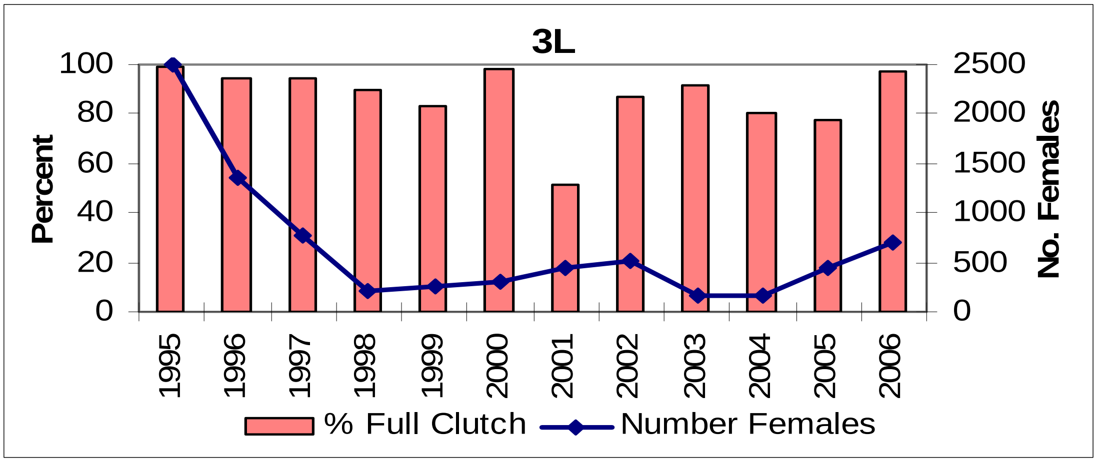


Figure 95. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3L from fall multi-species surveys.

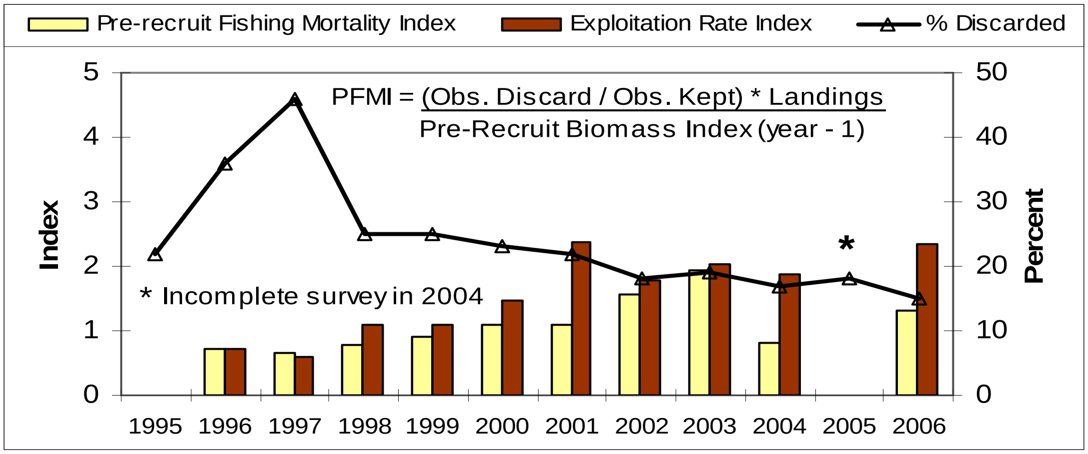


Figure 96. Trends in Division 3L mortality indices (the exploitation rate index and the pre-recruit mortality index) and in the percentage of the catch discarded in the fishery. (* incomplete survey in 2004)

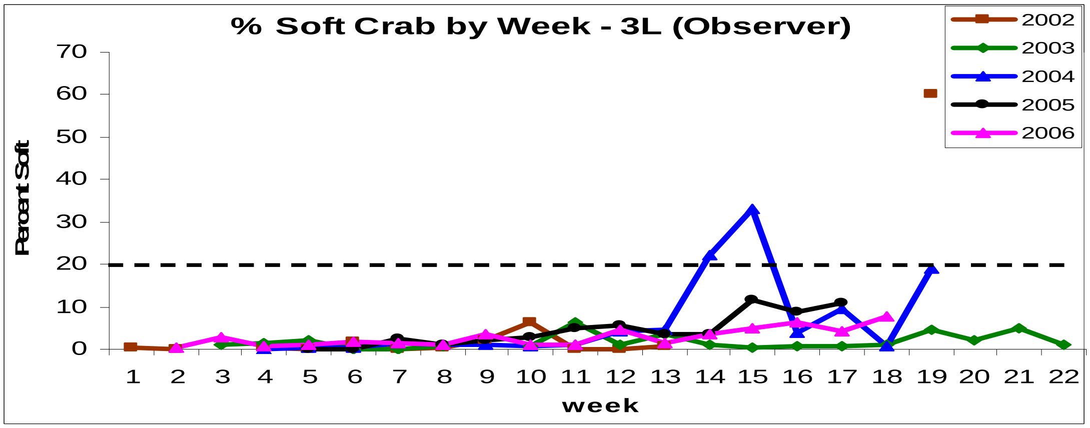


Figure 97. Seasonal trend (from April 1st) in the percentage of legal-sized crabs that are soft-shelled by year (2002-06), from at-sea sampling by observers in Division 3L. (Sample sizes of <10 observed sets/week removed)

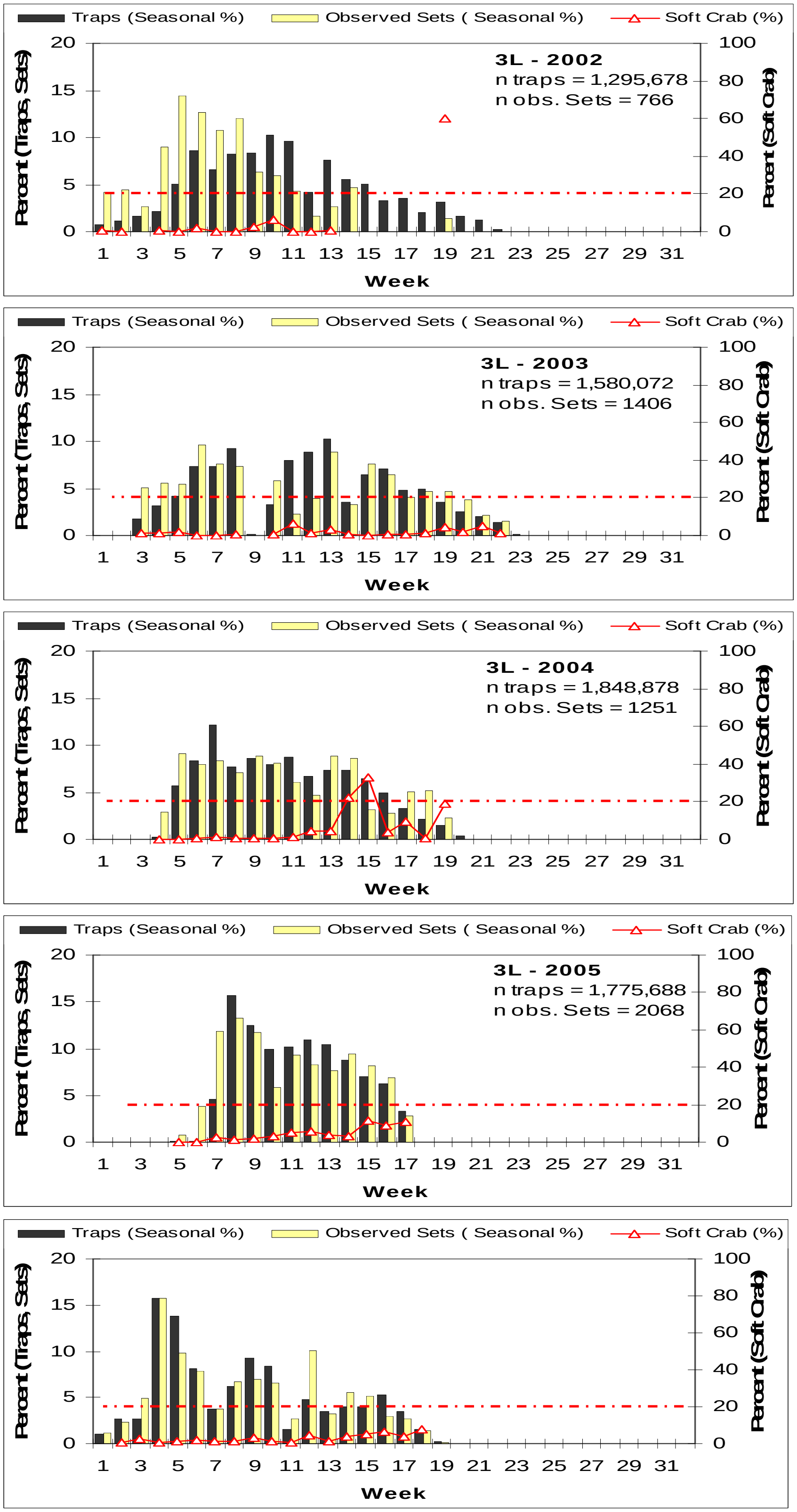
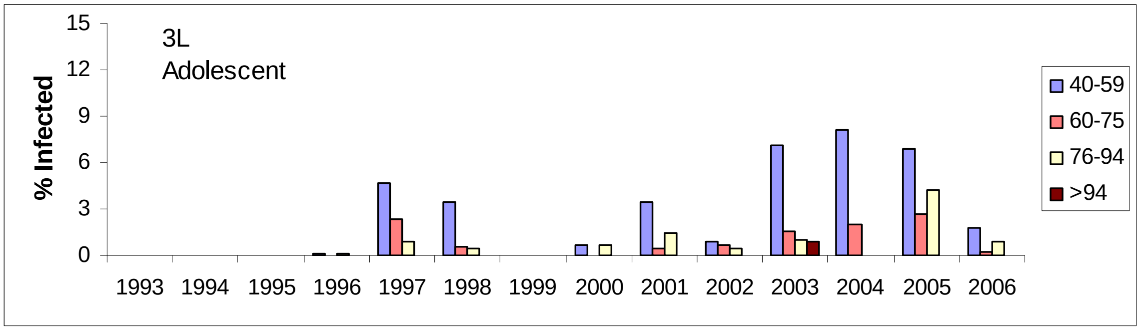


Figure 98. Trends in percentages of weekly effort by trap hauls in Division 3L versus percentages of weekly sets observed and soft shell (shell type 1) discards. (Sample sizes of <10 observed sets/week removed)



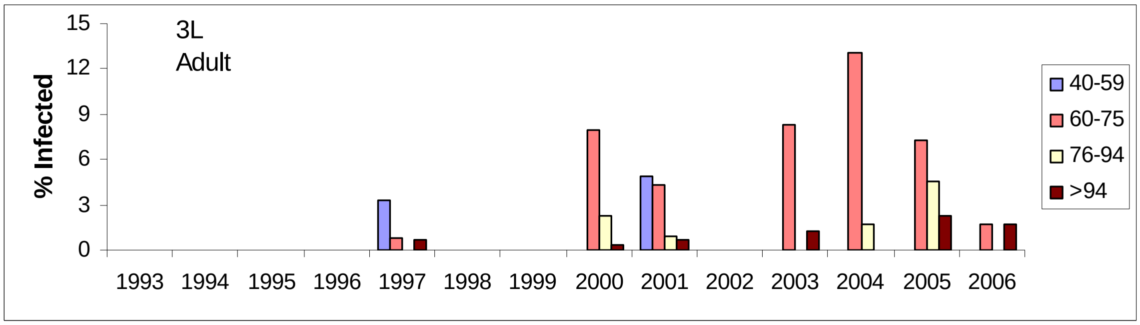


Figure 99. Trends in prevalence of BCD in Division 3L by male size group from multi-species surveys in new-shelled adolescent males (above) and adult males (below).

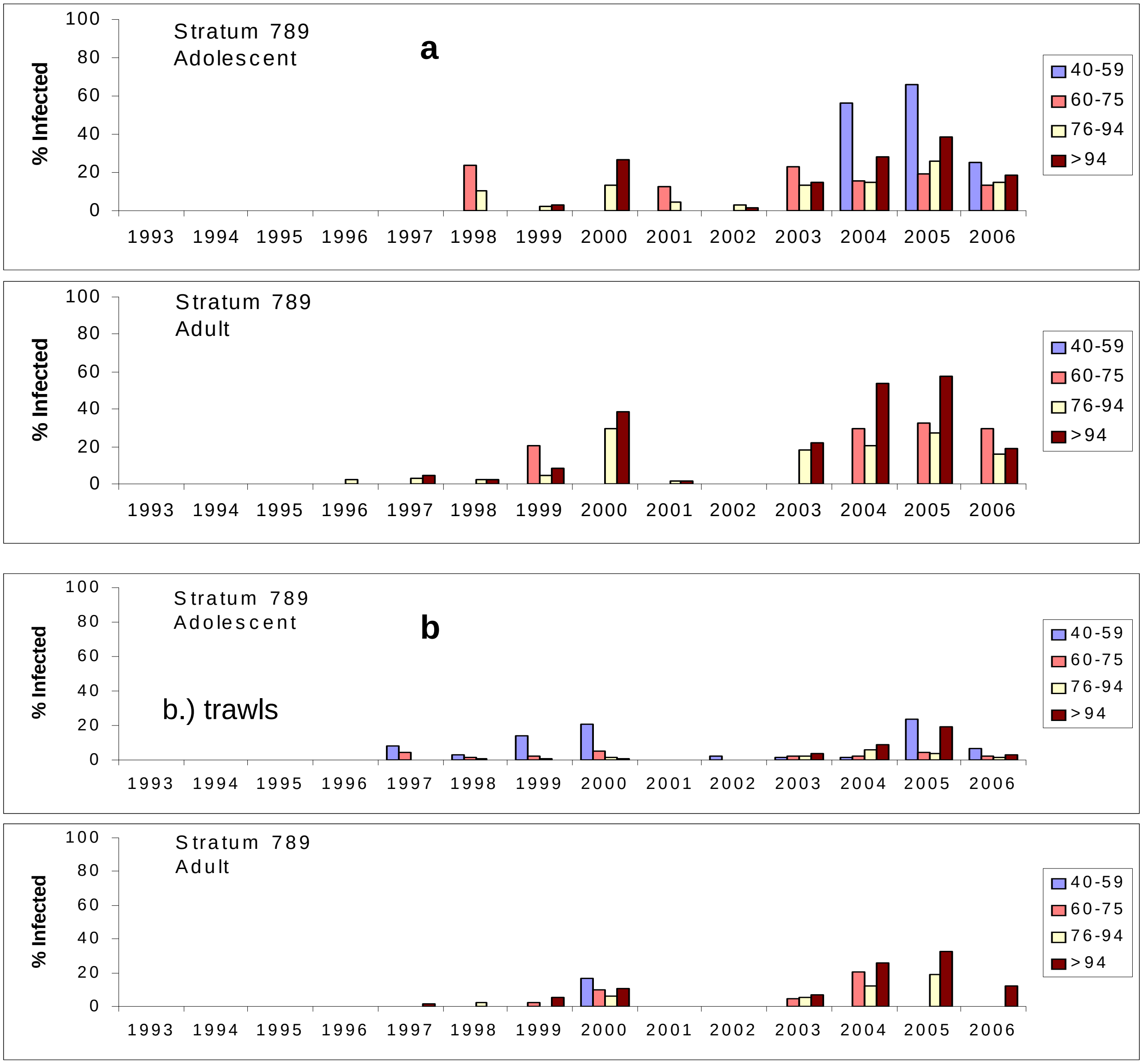


Figure 100. Trends in prevalence of BCD in annual Division 3L Conception Bay research trap (a) and trawl (b) surveys by male size group in new-shelled adolescents (above) and adults (below). (sample sizes <10 crab/size group removed).

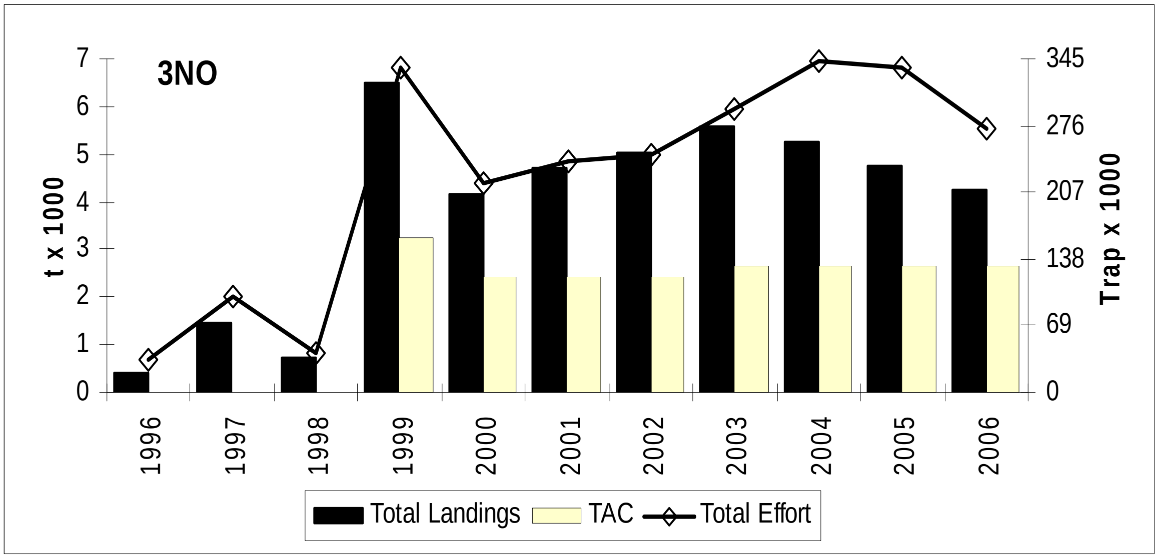


Figure 101. Trends in Division 3NO landings, TAC, and fishing effort.

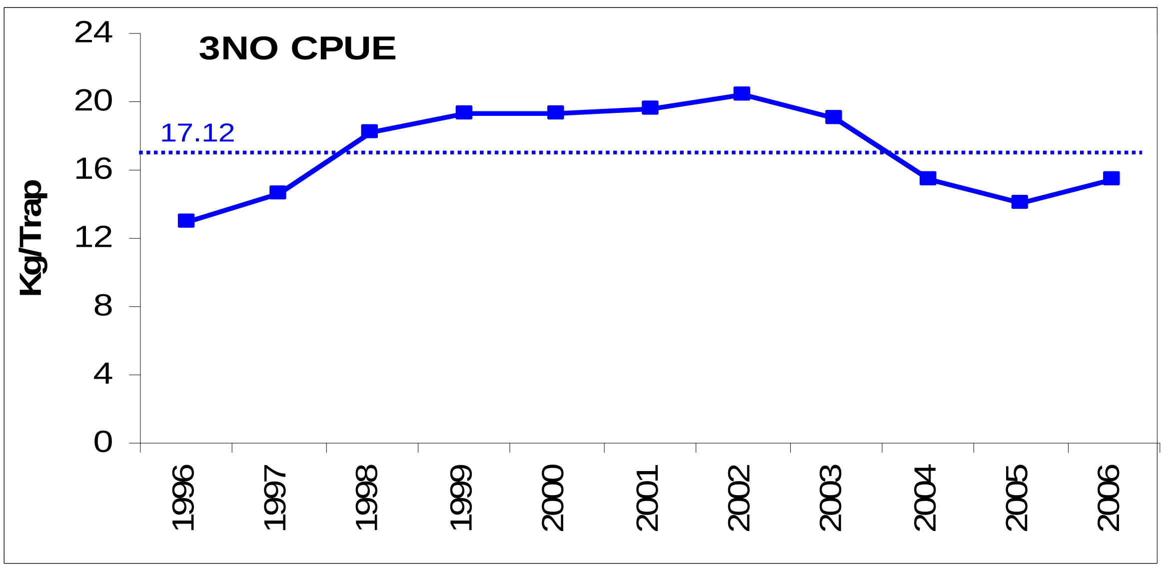


Figure 102. Trend in Division 3NO commercial CPUE in relation to the long-term average (dotted line).

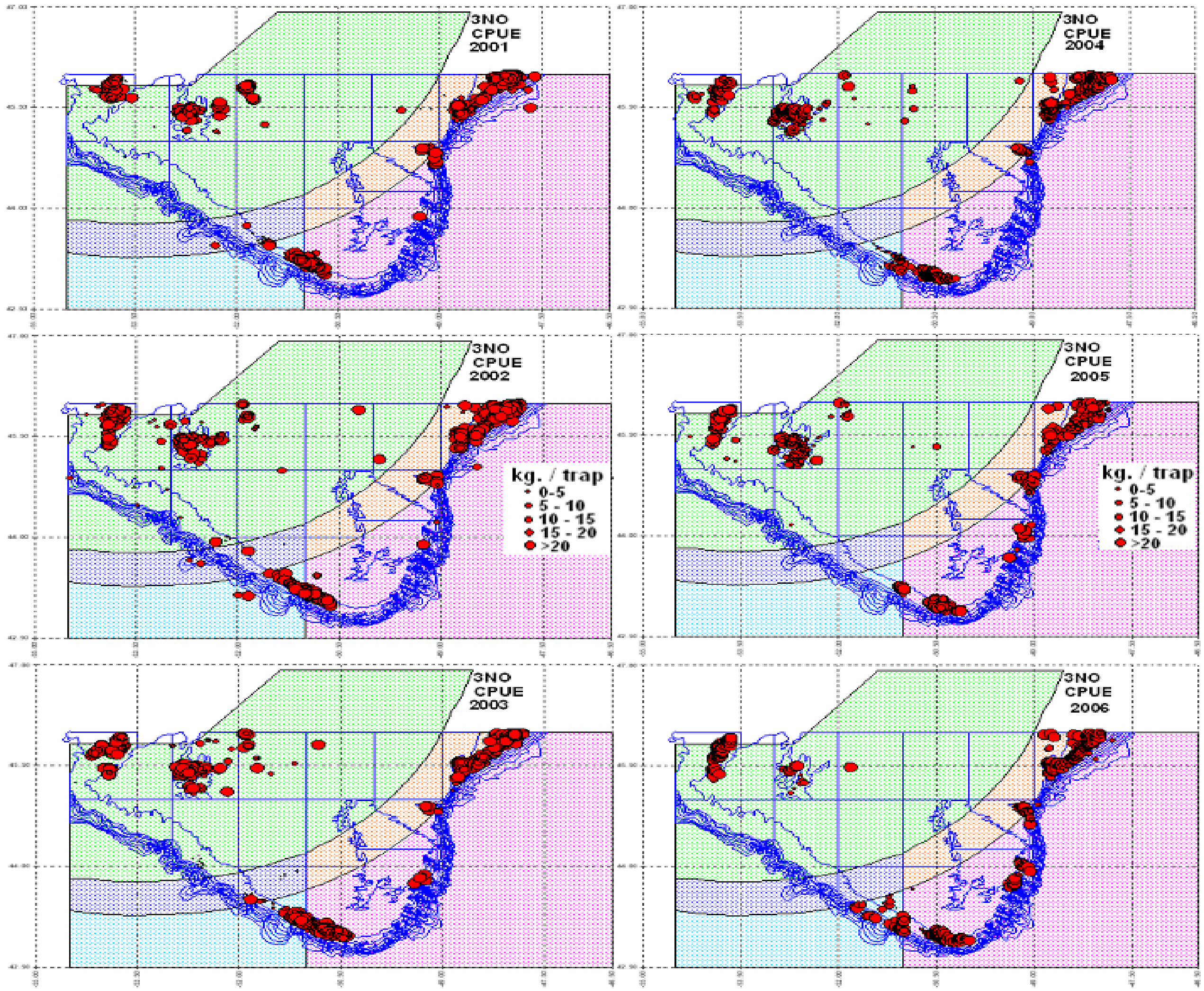


Figure 103. Spatial distribution of Division 3NO commercial CPUE by year.

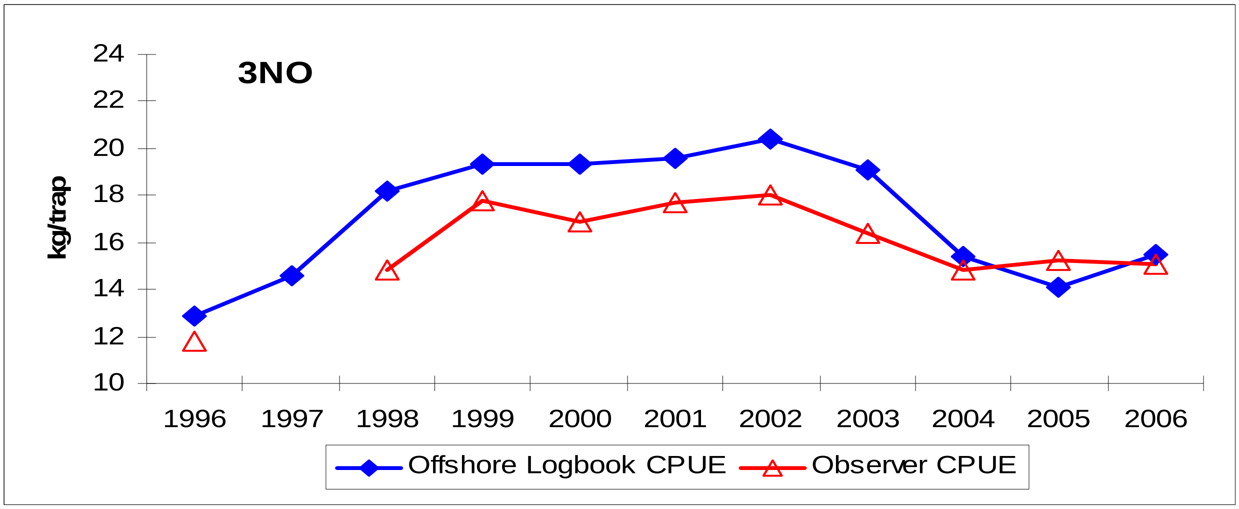


Figure 104. Trends in logbook-based CPUE vs. observer-based CPUE in the Division 3NO fishery.

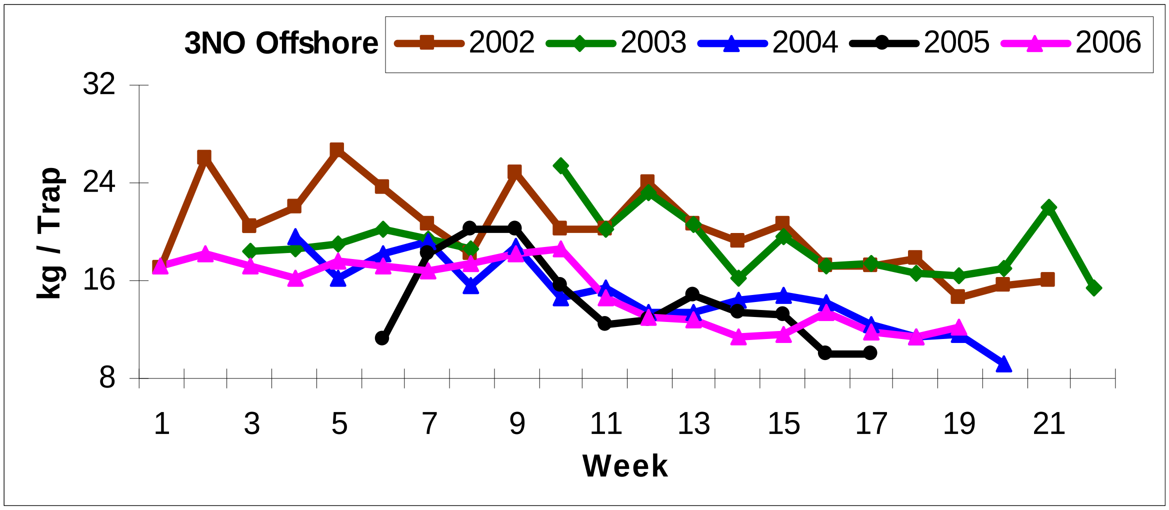


Figure 105. Trends in CPUE, by week, for Division 3NO during 2002-06.

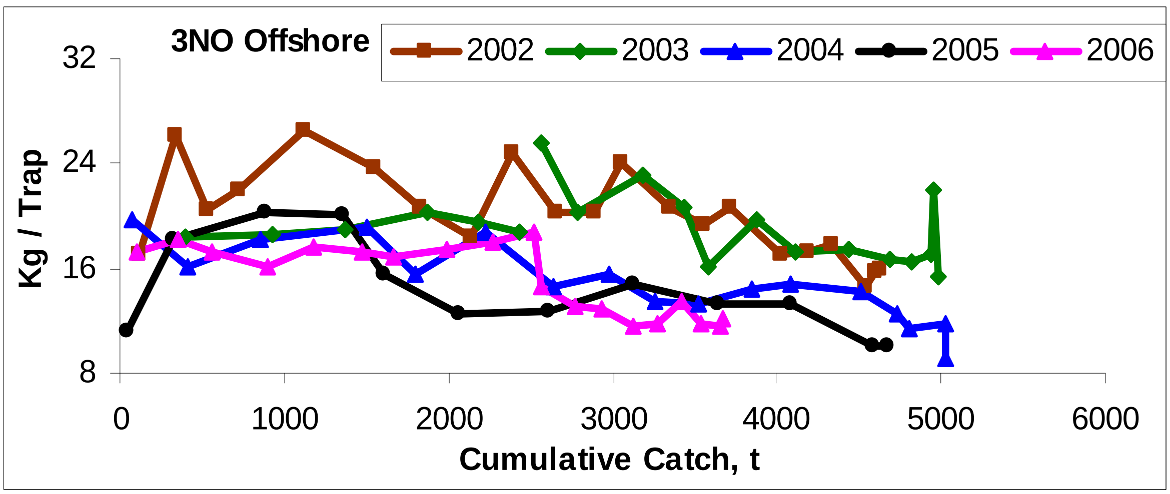


Figure 106. Seasonal trends in CPUE, in relation to cumulative catch, for Division 3NO during 2002-06.

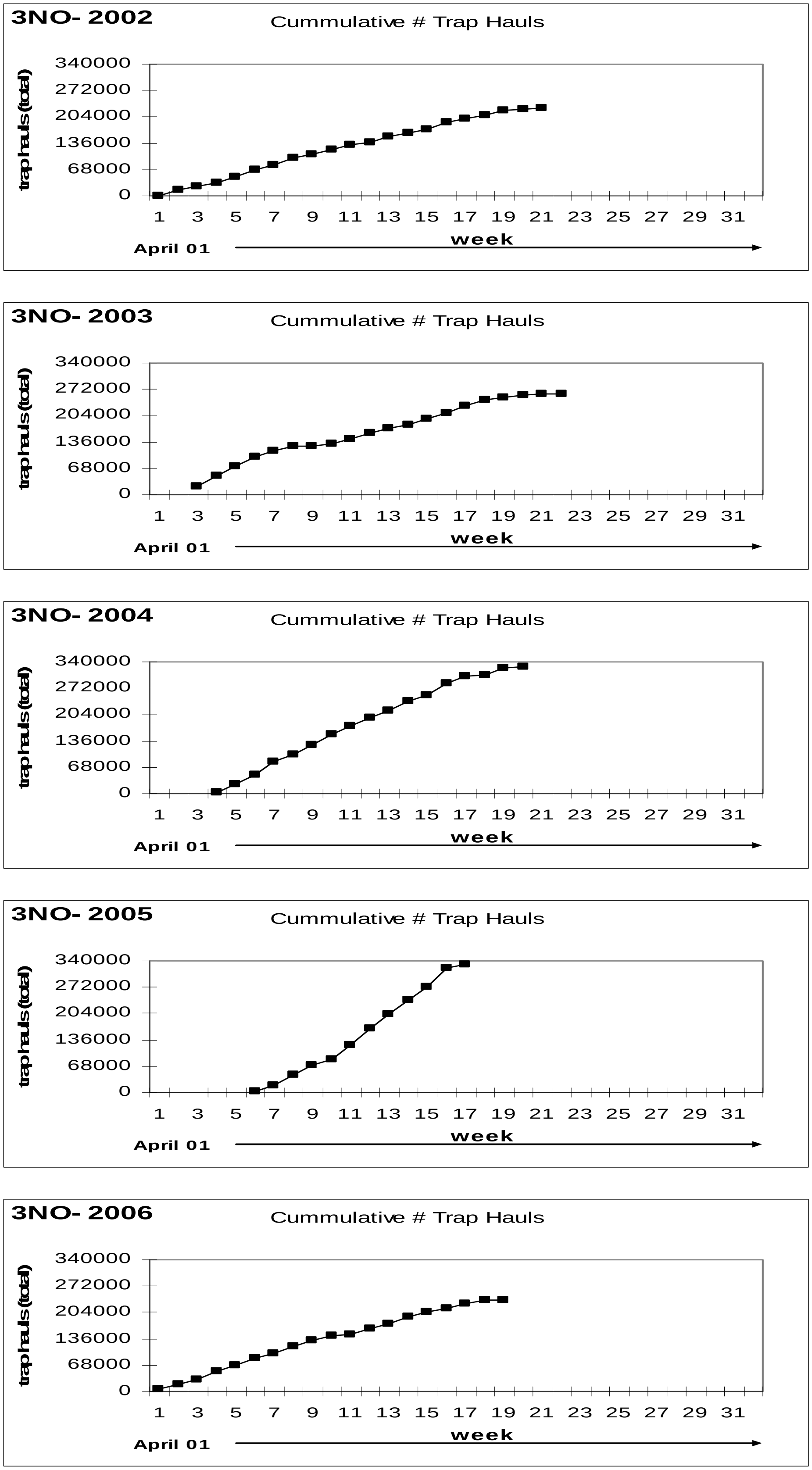


Figure 107. Seasonal trends in fishing effort, by week, for Division 3NO during 2002-06.

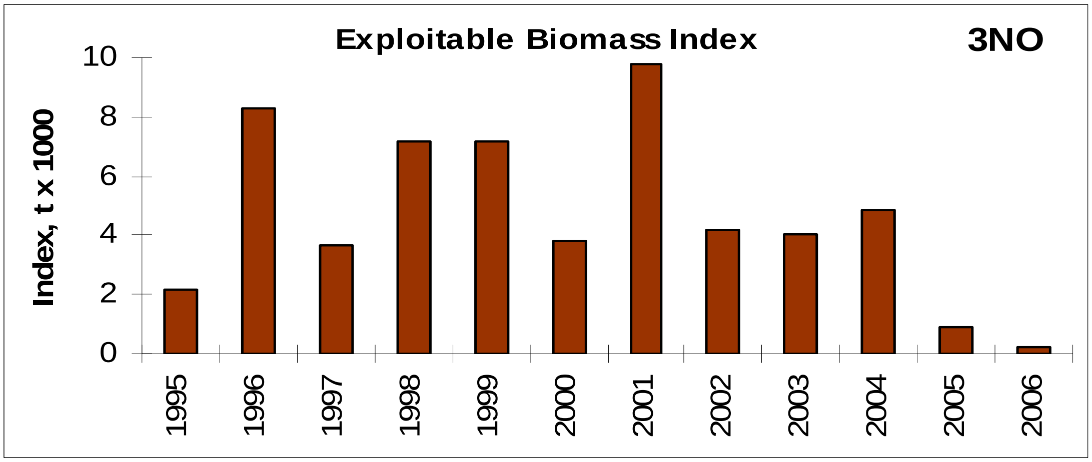


Figure 108. Trends in the Division 3NO fall multi-species survey exploitable biomass index.

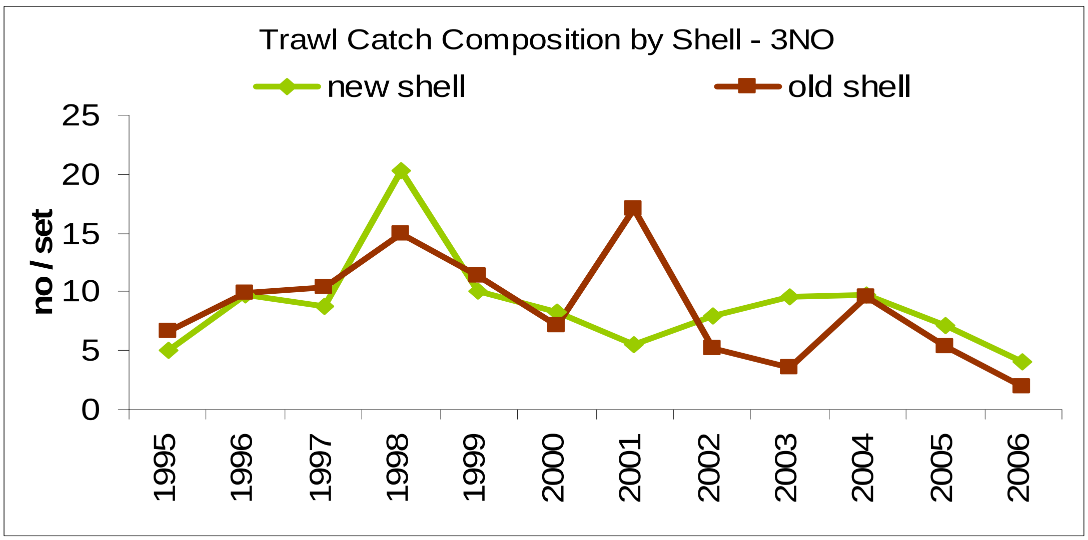


Figure 109. Trends, by shell condition, in abundance indices of legal-sized males for Division 3NO from fall multi-species surveys.

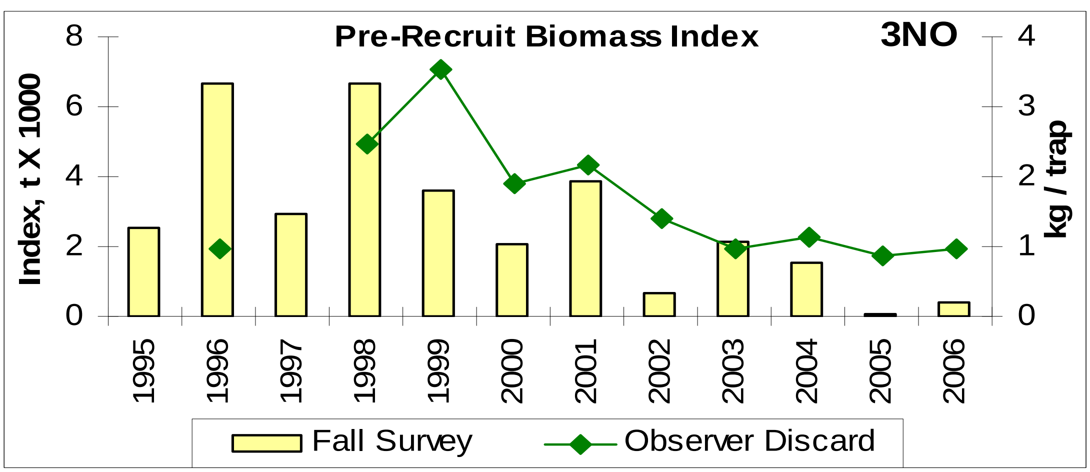


Figure 110. Trends in the Division 3NO fall multi-species survey pre-recruit biomass index and the observer discard catch rate index.

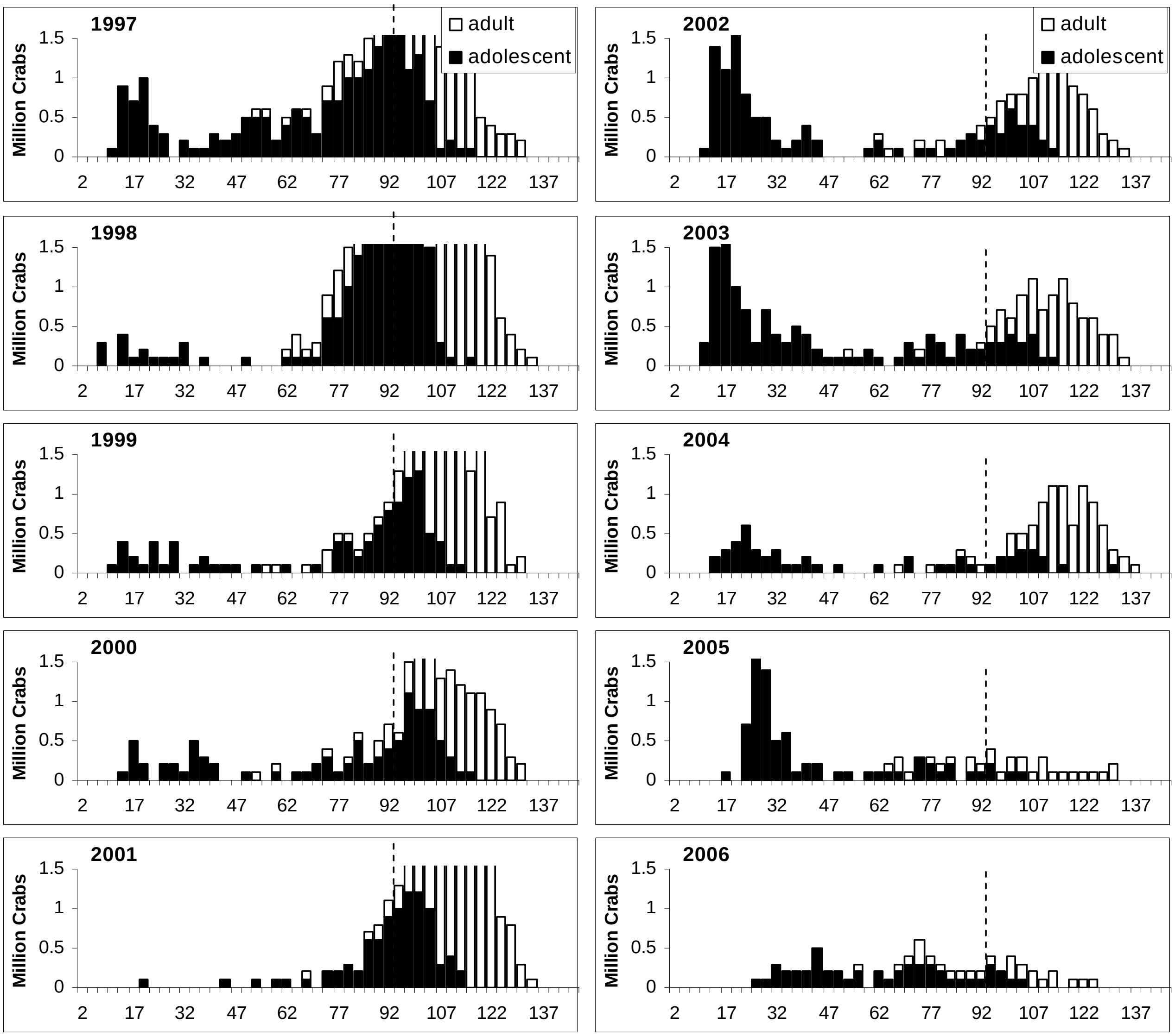


Figure 111. Truncated distribution of abundance (index) by carapace width for Division 3NO juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

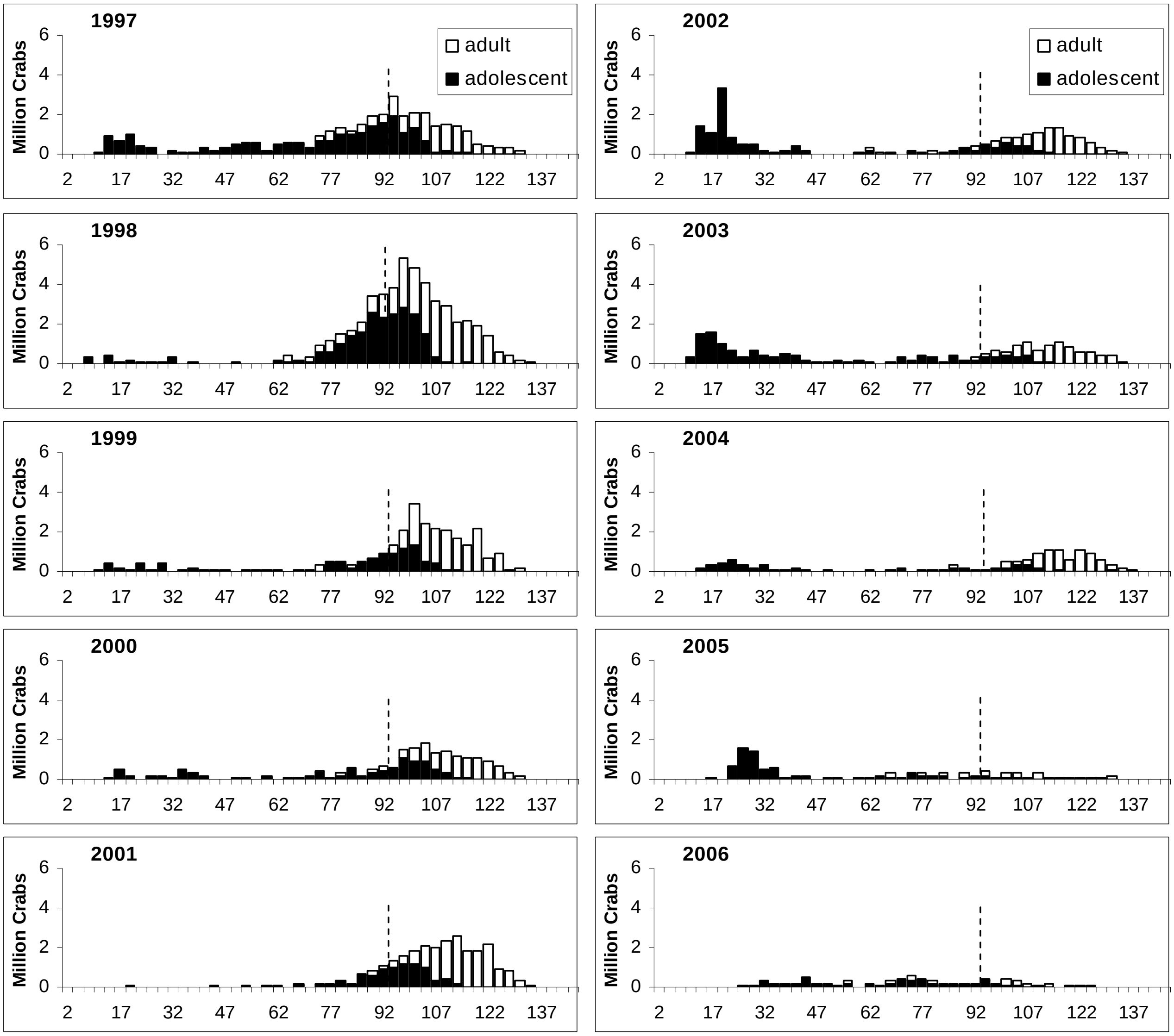


Figure 112. Distribution of abundance (index) by carapace width for Division 3NO juveniles plus adolescents (dark bars) versus adults (open bars) from fall multi-species surveys.

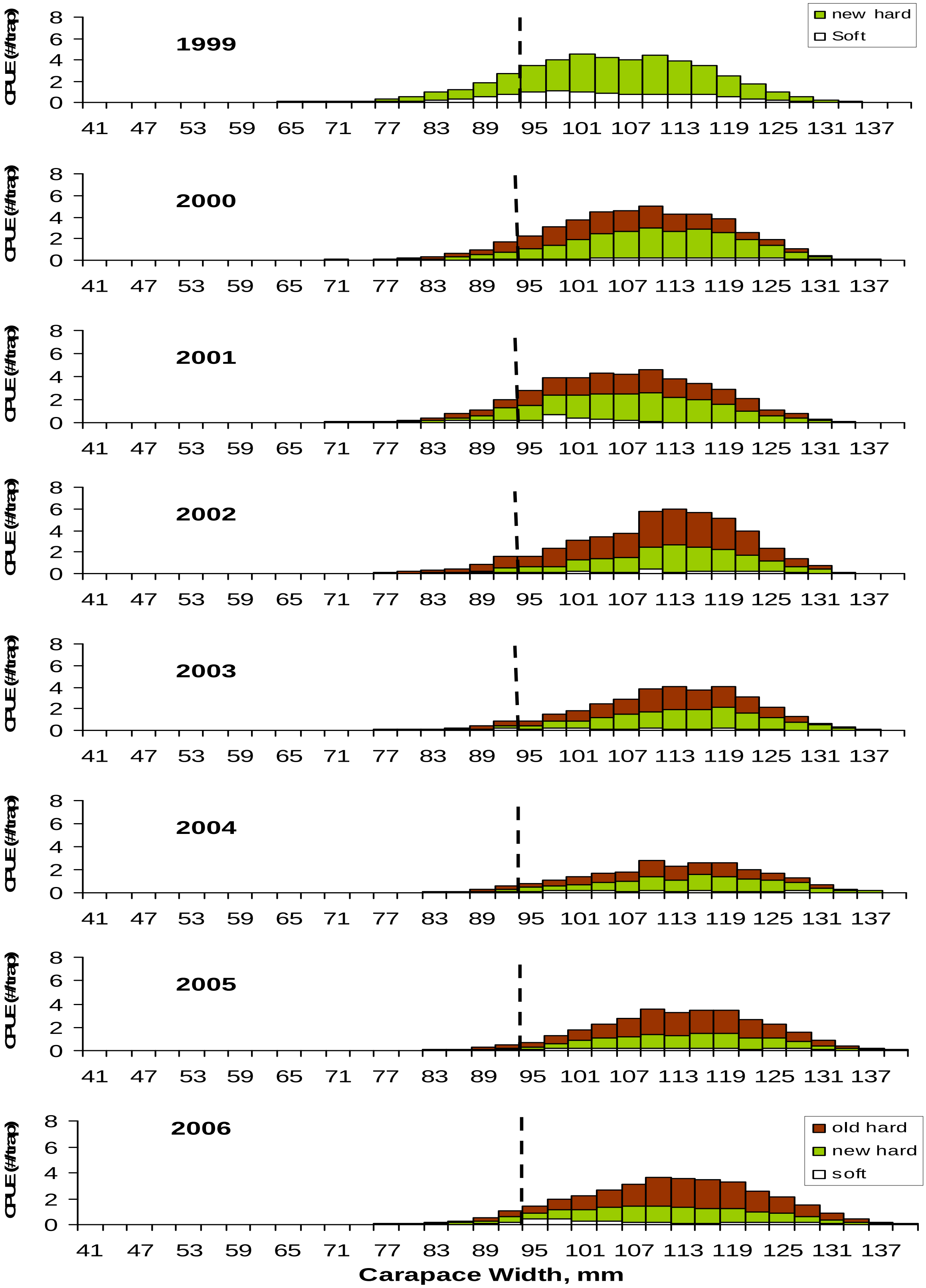


Figure 113. Trends in male carapace width distributions from observer at-sea sampling for Division 3NO.

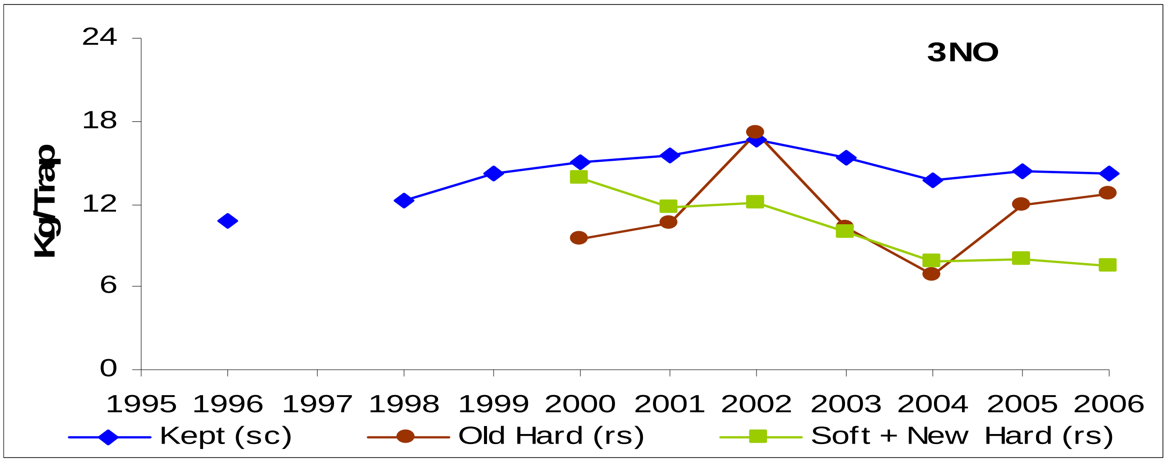


Figure 114. Trends in Division 3NO observer catch rates of exploitable crabs since 1996 from set and catch records and of legal-sized crabs by shell category since 2000 from at-sea sampling

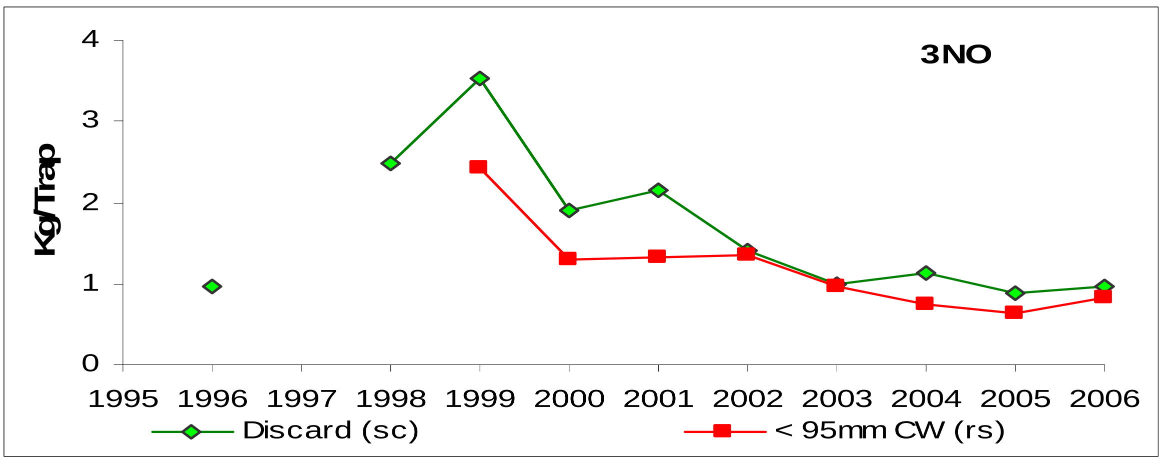


Figure 115. Trends in Division 3NO observer catch rates of total discards since 1996 from set and catch records and of sub-legal sized crabs since 1999 from at-sea sampling.

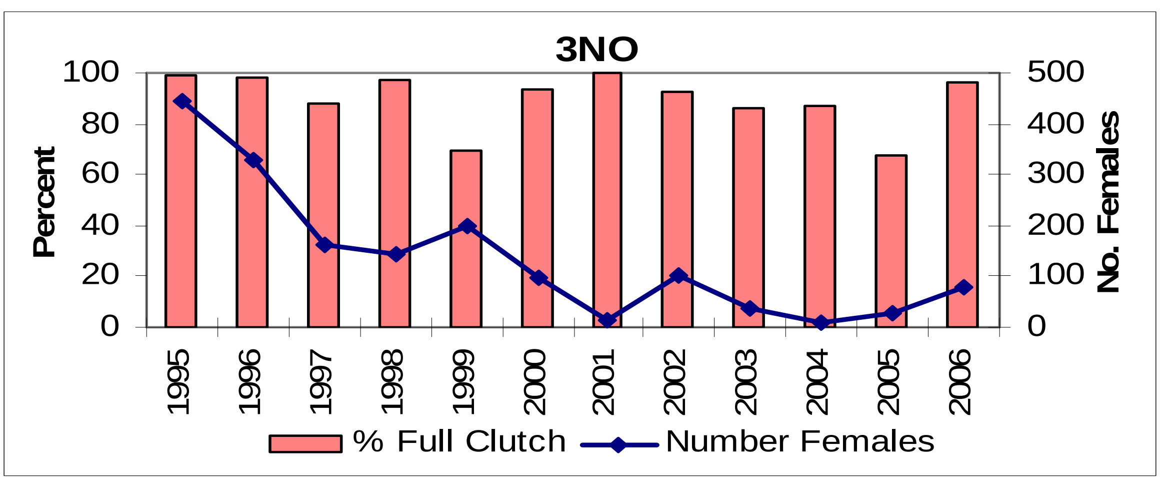


Figure 116. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3NO from fall multi-species surveys.

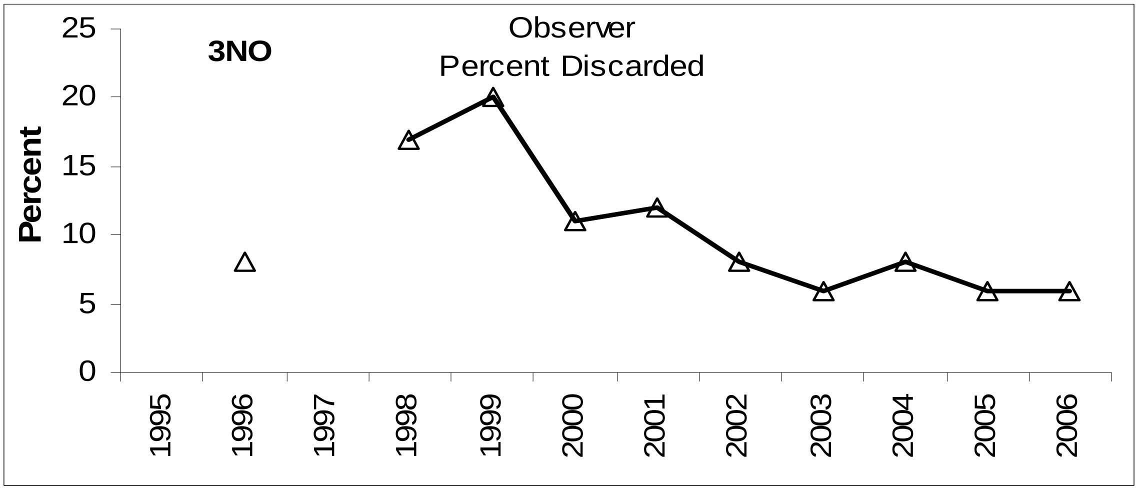


Figure 117. Trends in percentage of the catch discarded in the Division 3NO fishery.

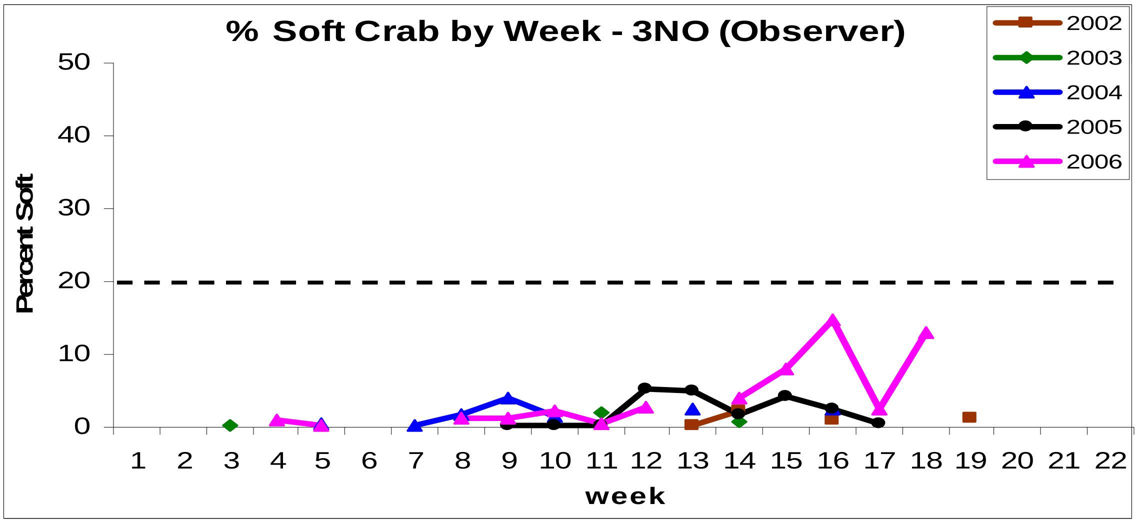


Figure 118. Seasonal trends (from April 01) in the percentage of legal-sized crabs that are soft-shelled by year (2001-06), from at-sea sampling by observers in Division 3NO. (Sample sizes of <10 observed sets/week removed)

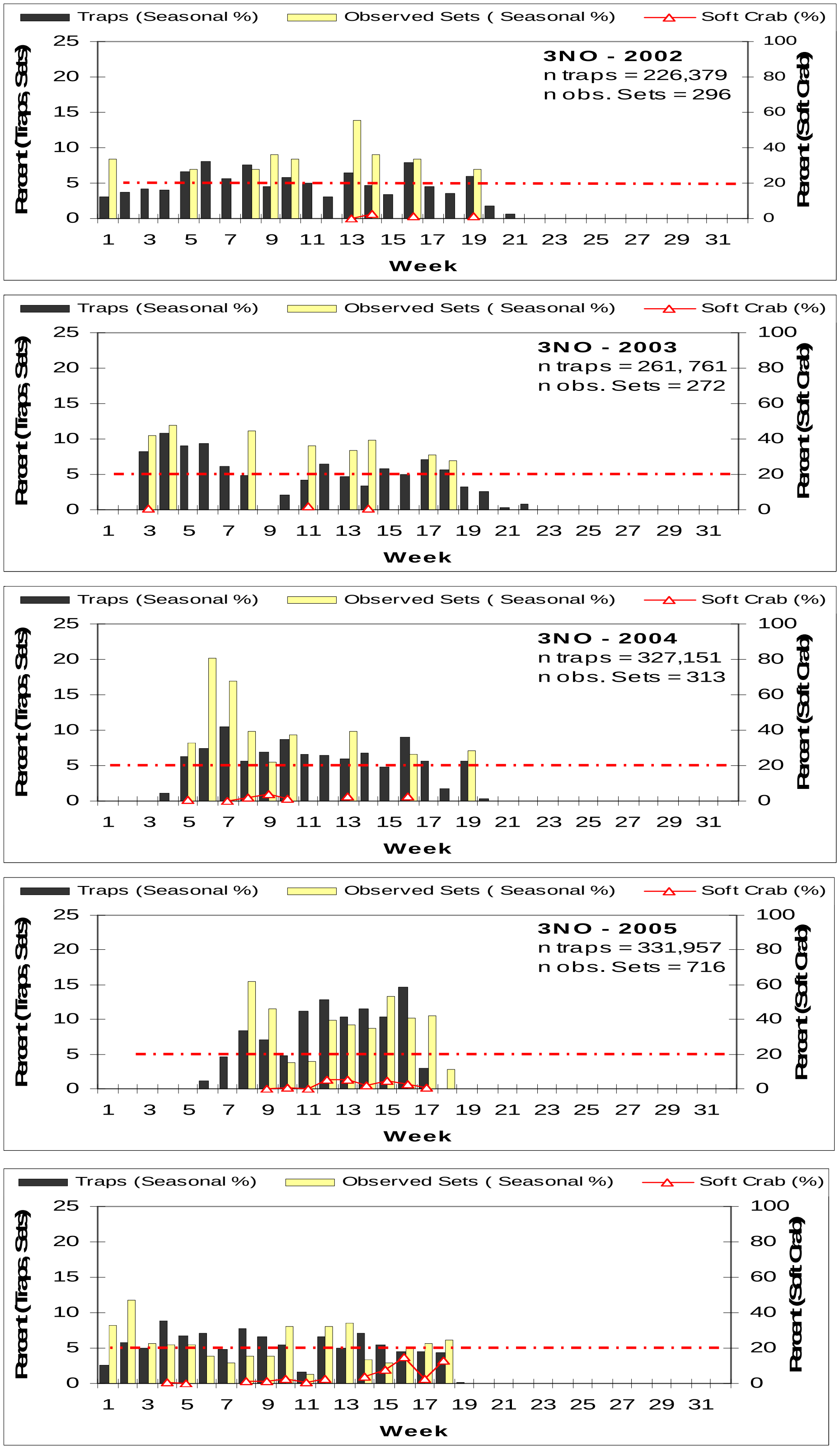


Figure 119. Trends in percentages of weekly effort by trap hauls in Division 3NO versus percentages of weekly sets observed and soft shell (shell type 1) discards. (Sample sizes of <10 observed sets/week removed)

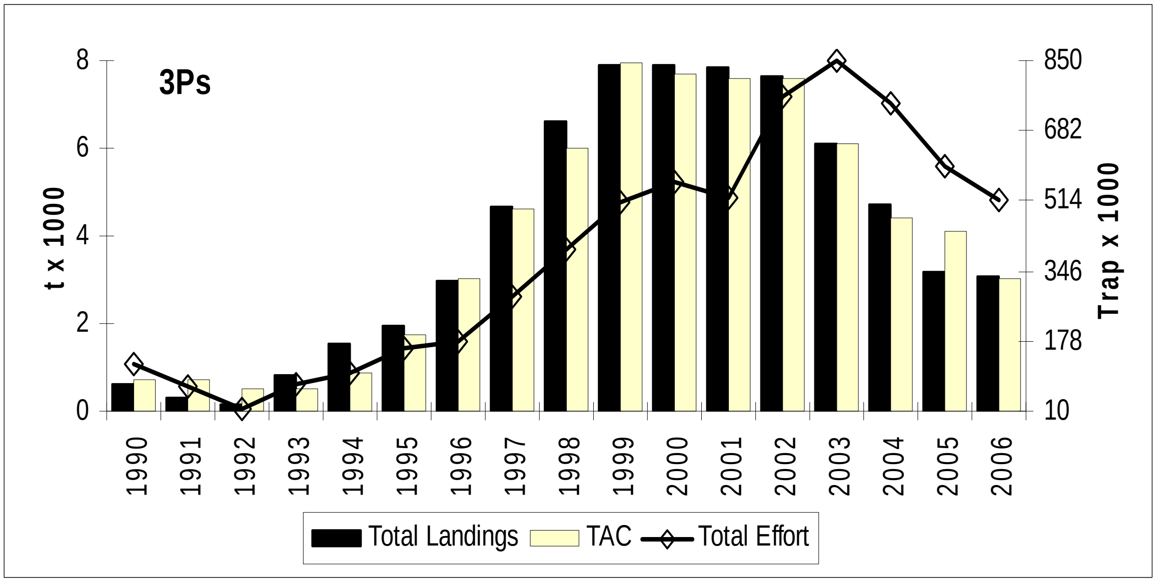


Figure 120. Trends in Subdivision 3Ps landings, TAC, and fishing effort.

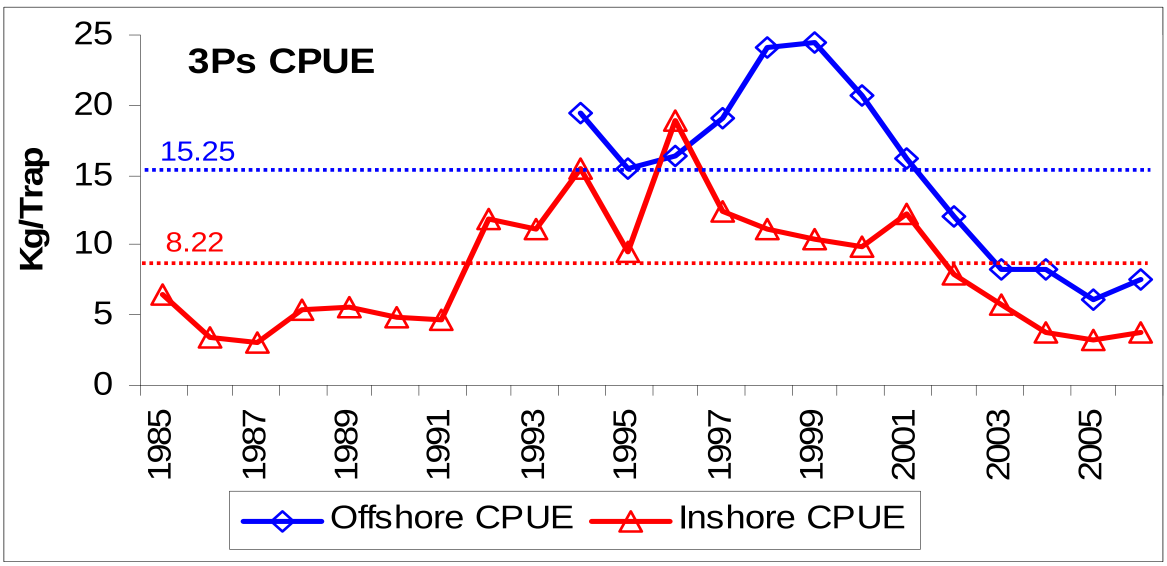


Figure 121. Trends in Subdivision 3Ps commercial CPUE in relation to their long-term averages (dotted lines).

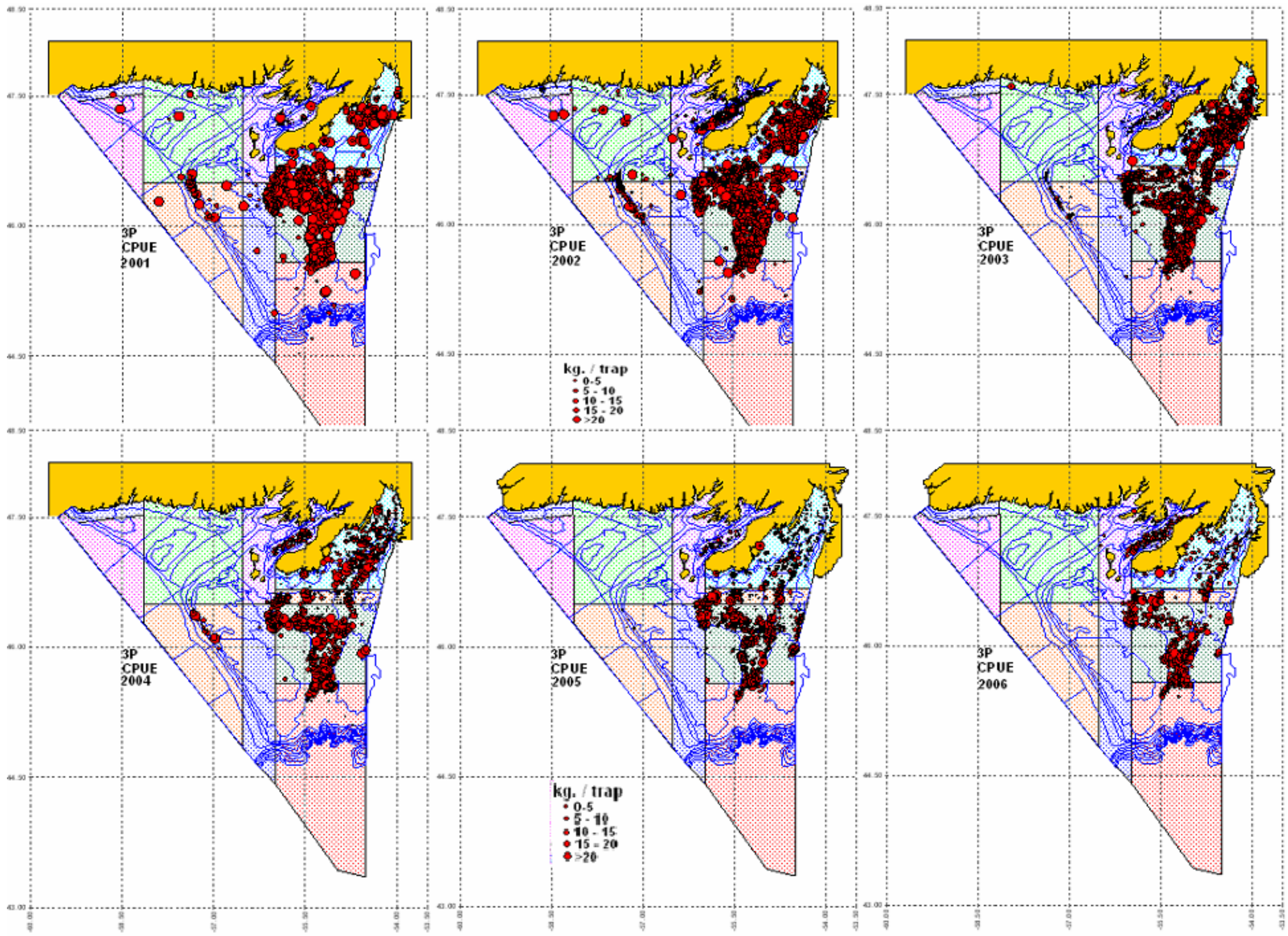


Figure 122. Spatial distribution of Subdivision 3Ps commercial CPUE by year.

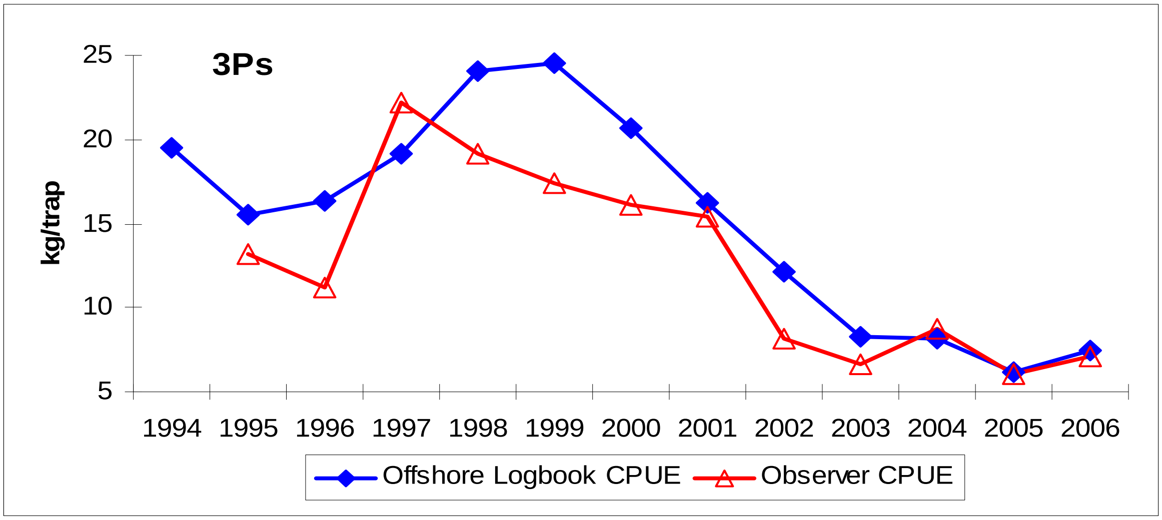


Figure 123. Trends in logbook-based CPUE vs. observer-based CPUE in the Subdivision 3Ps fishery.

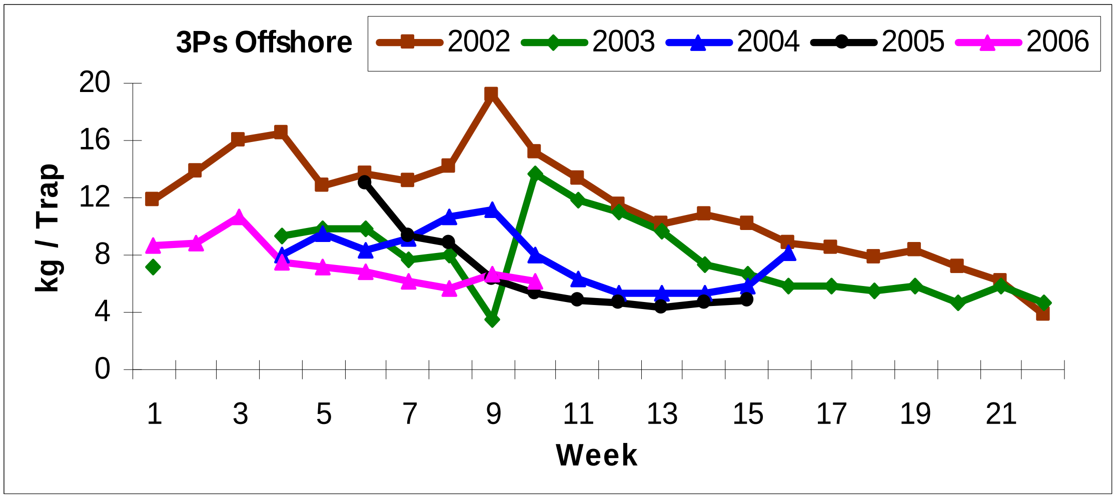


Figure 124. Seasonal trends in CPUE, by week, for Subdivision 3Ps offshore during 2002-06.

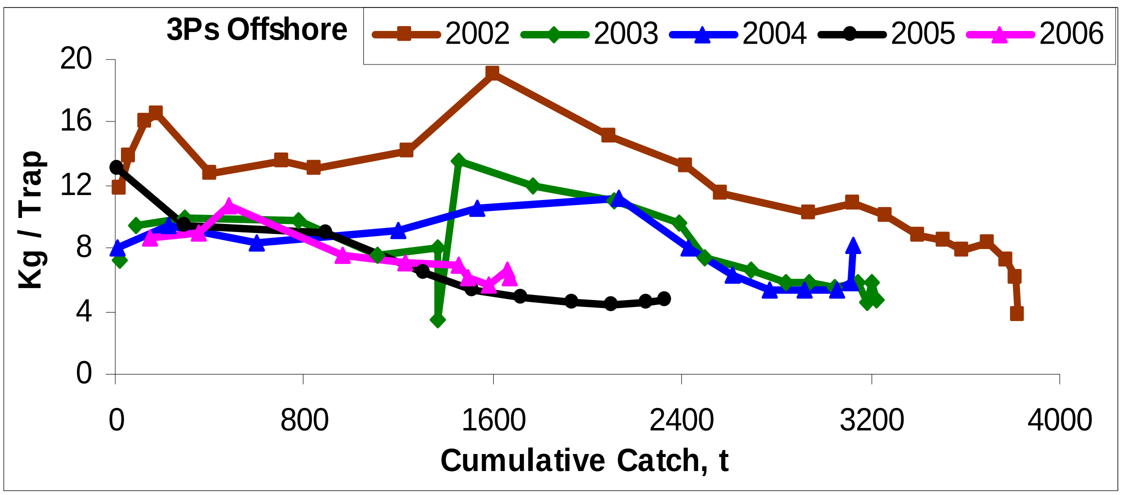


Figure 125. Seasonal trends in CPUE, in relation to cumulative catch, for Subdivision 3Ps offshore during 2002-06.

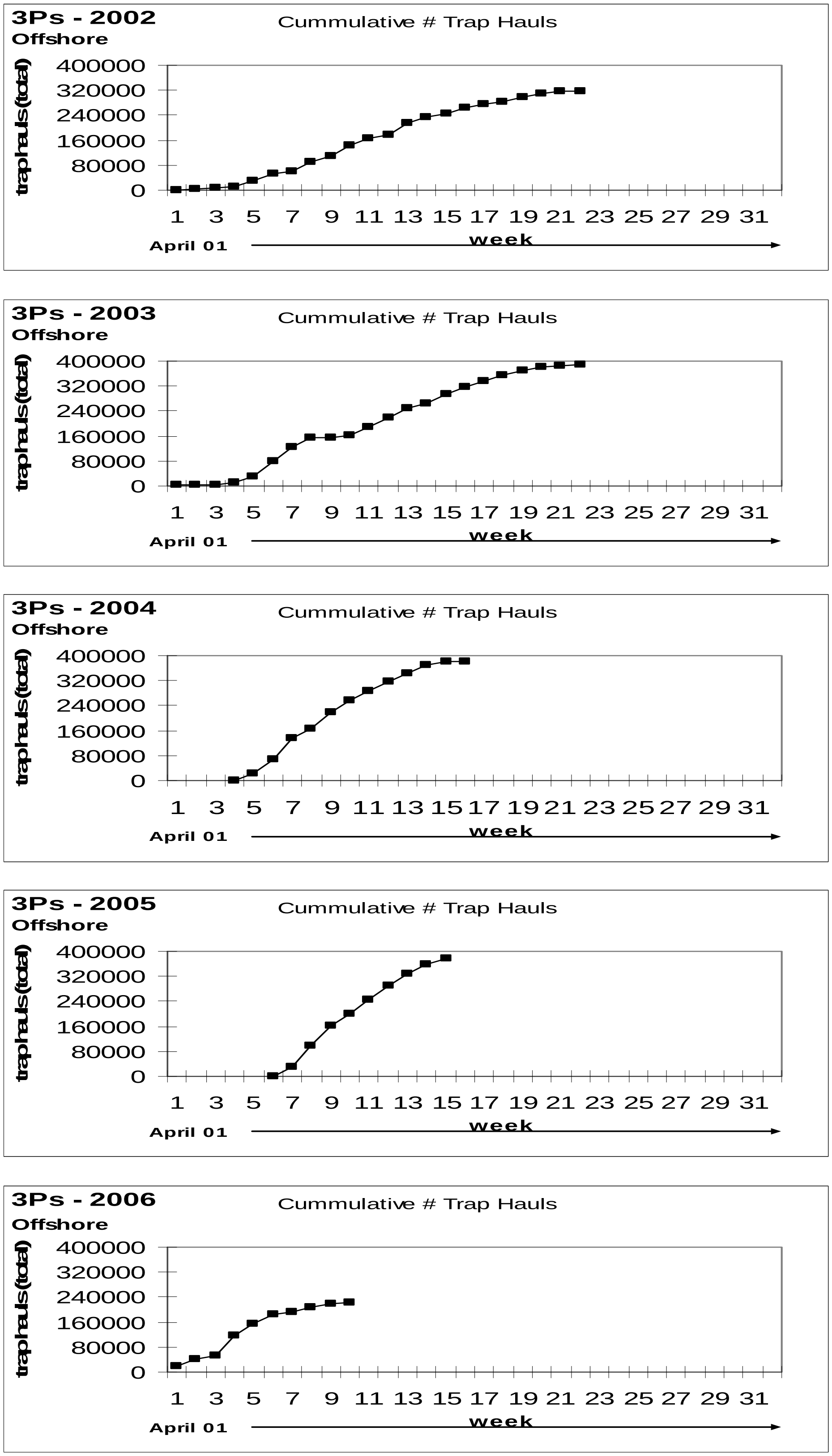


Figure 126. Seasonal trends in fishing effort, by week, for Subdivision 3Ps offshore during 2002-06.

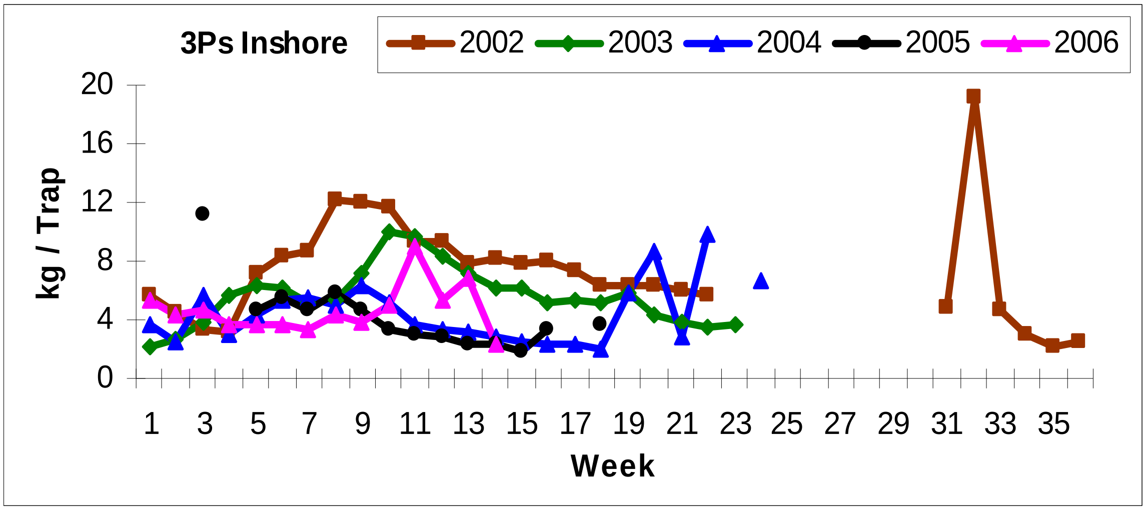


Figure 127. Seasonal trend in CPUE, by week, for Subdivision 3Ps inshore during 2002-06.

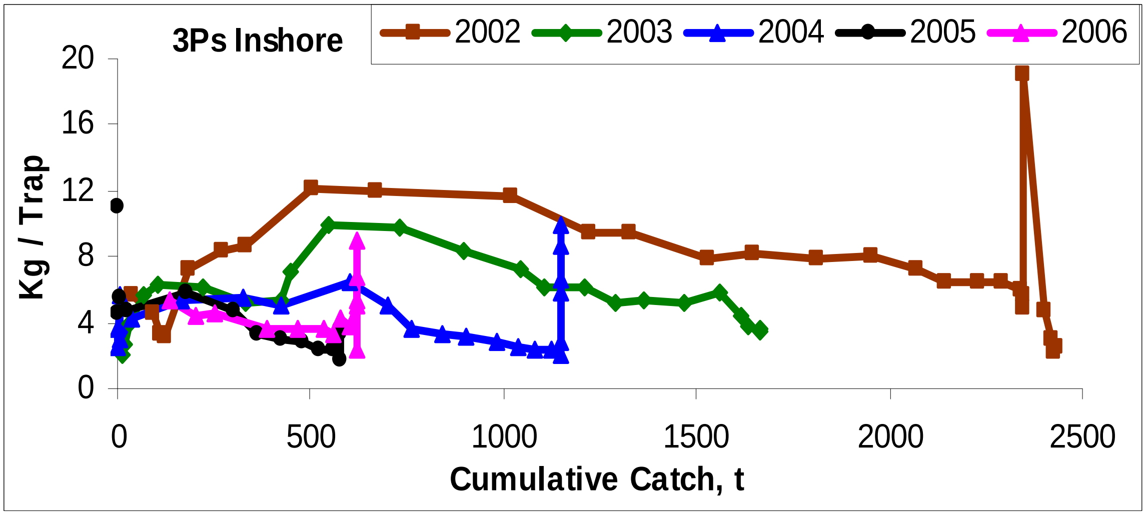


Figure 128. Seasonal trend in CPUE, in relation to cumulative catch, for Subdivision 3Ps inshore during 2002-06.

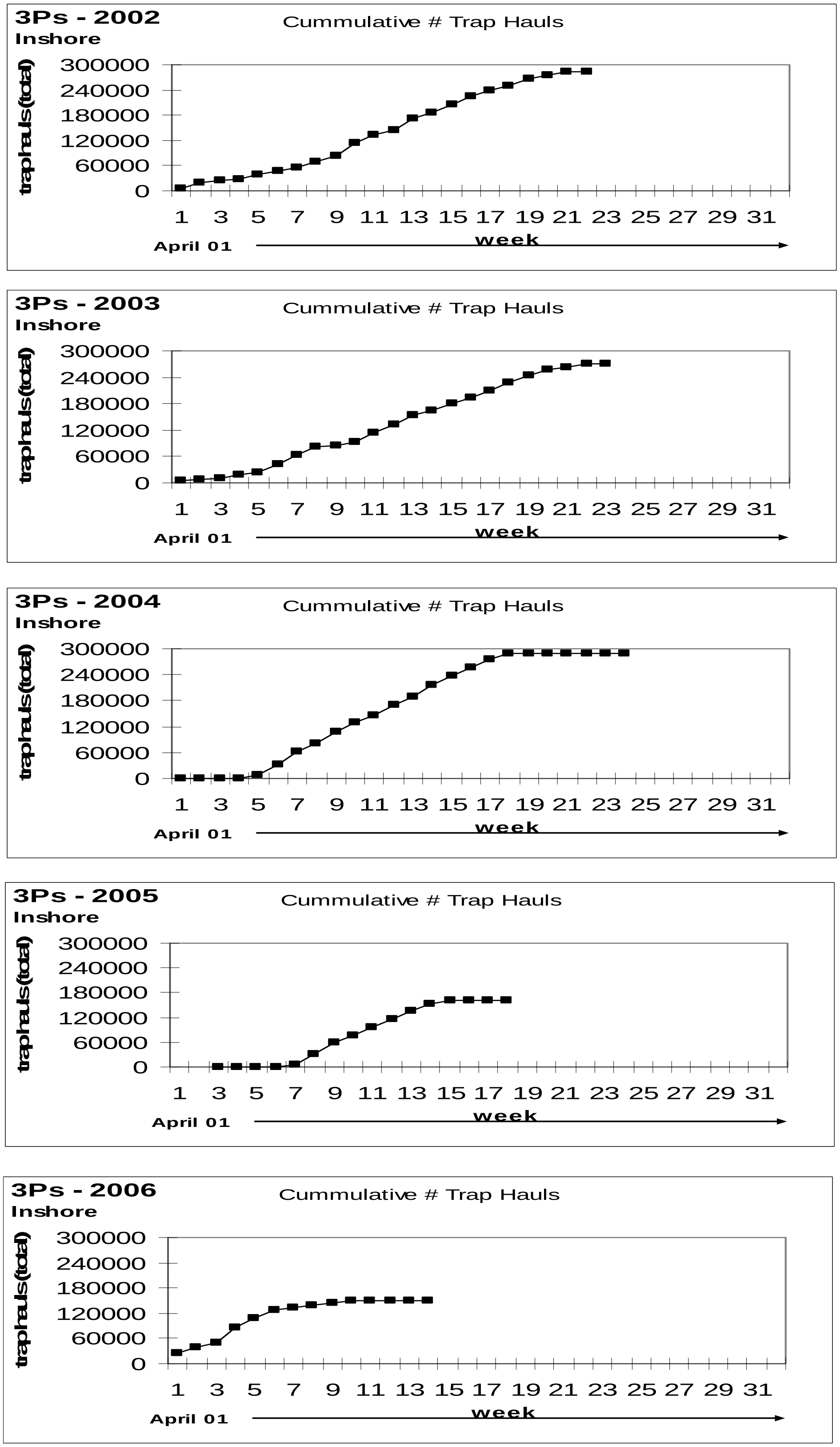


Figure 129. Seasonal trends in fishing effort, by week, for Subdivision 3Ps inshore during 2002-06.

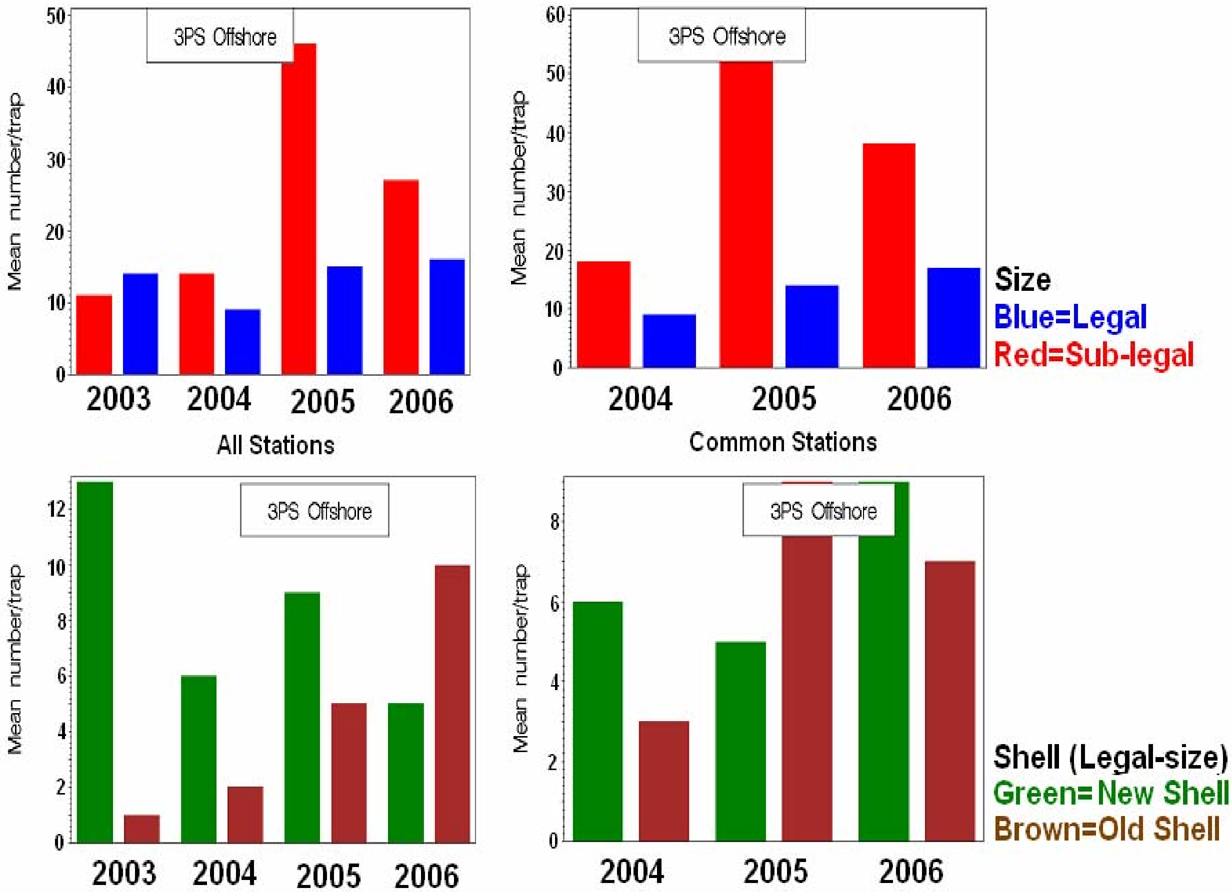


Figure 130. Trends in CPUE for size composition (above) and shell condition (below) from FSCP post-season trap surveys for Subdivision 3Ps offshore from all stations (left) and common stations (right).

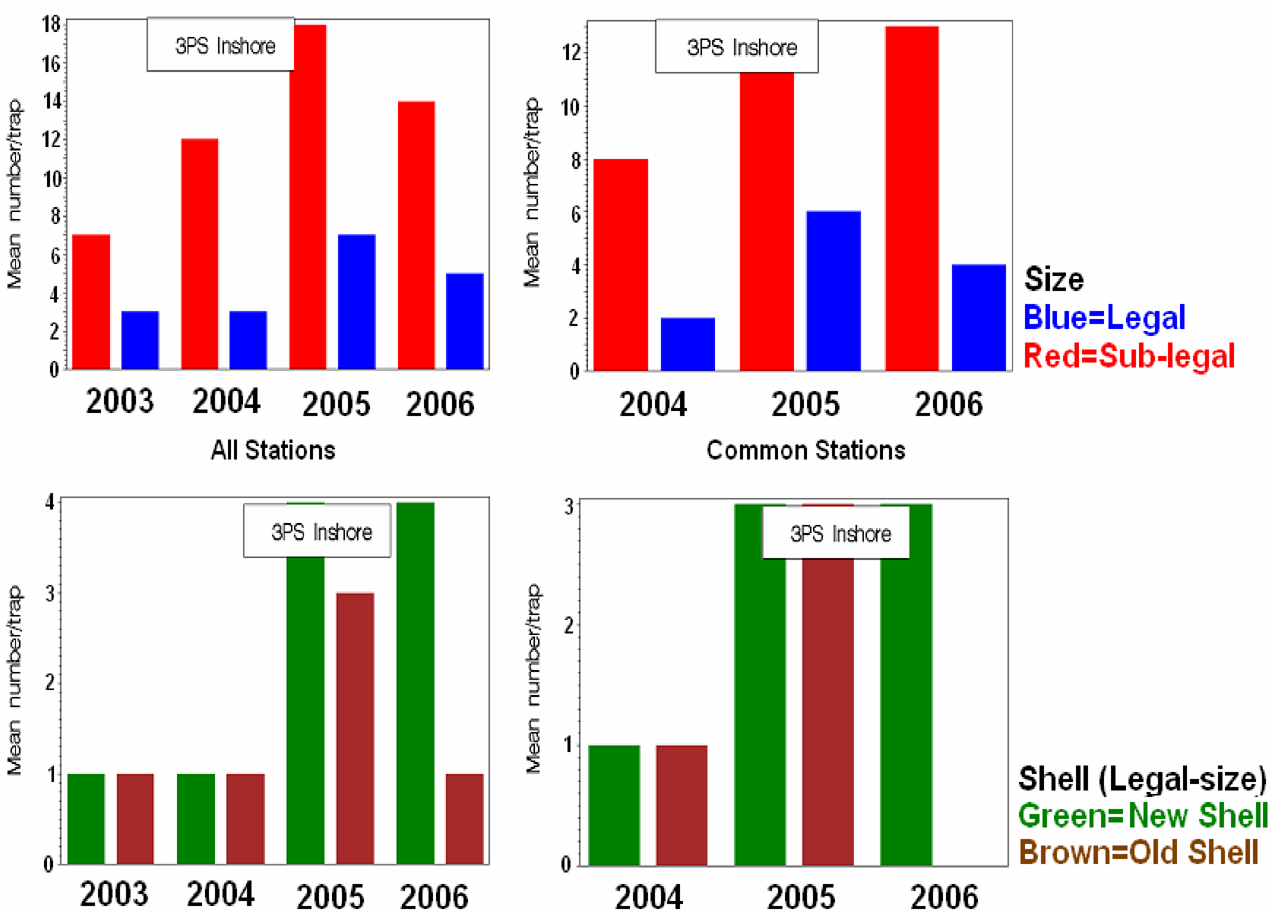


Figure 131. Trends in CPUE for size composition (above) and shell condition (below) from FSCP post-season trap surveys for Subdivision 3Ps inshore from all stations (left) and common stations (right).

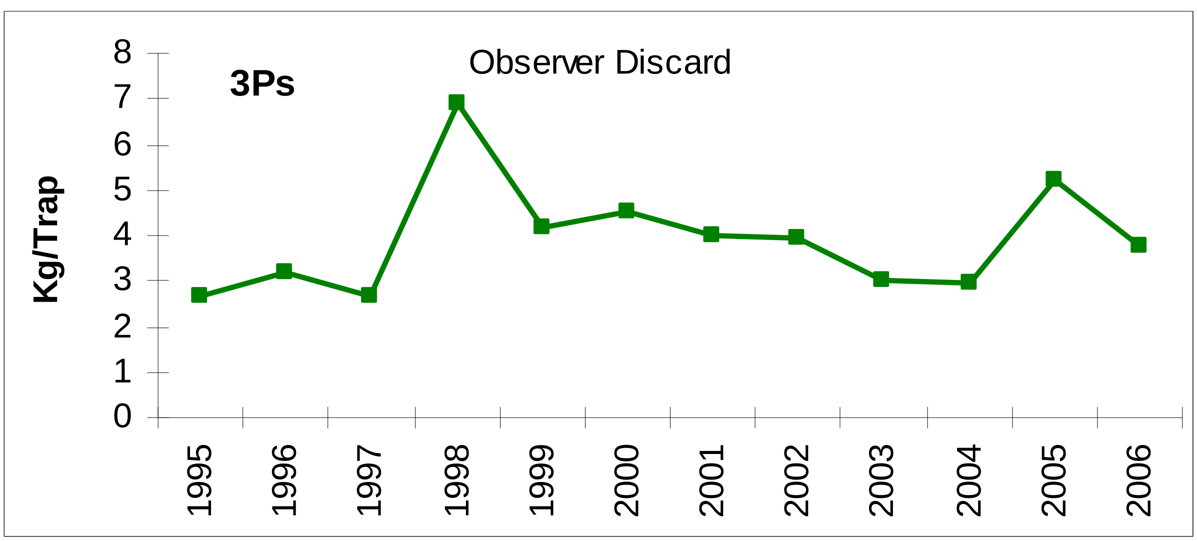


Figure 132. Trends in the Subdivision 3Ps observer discard catch rate index.

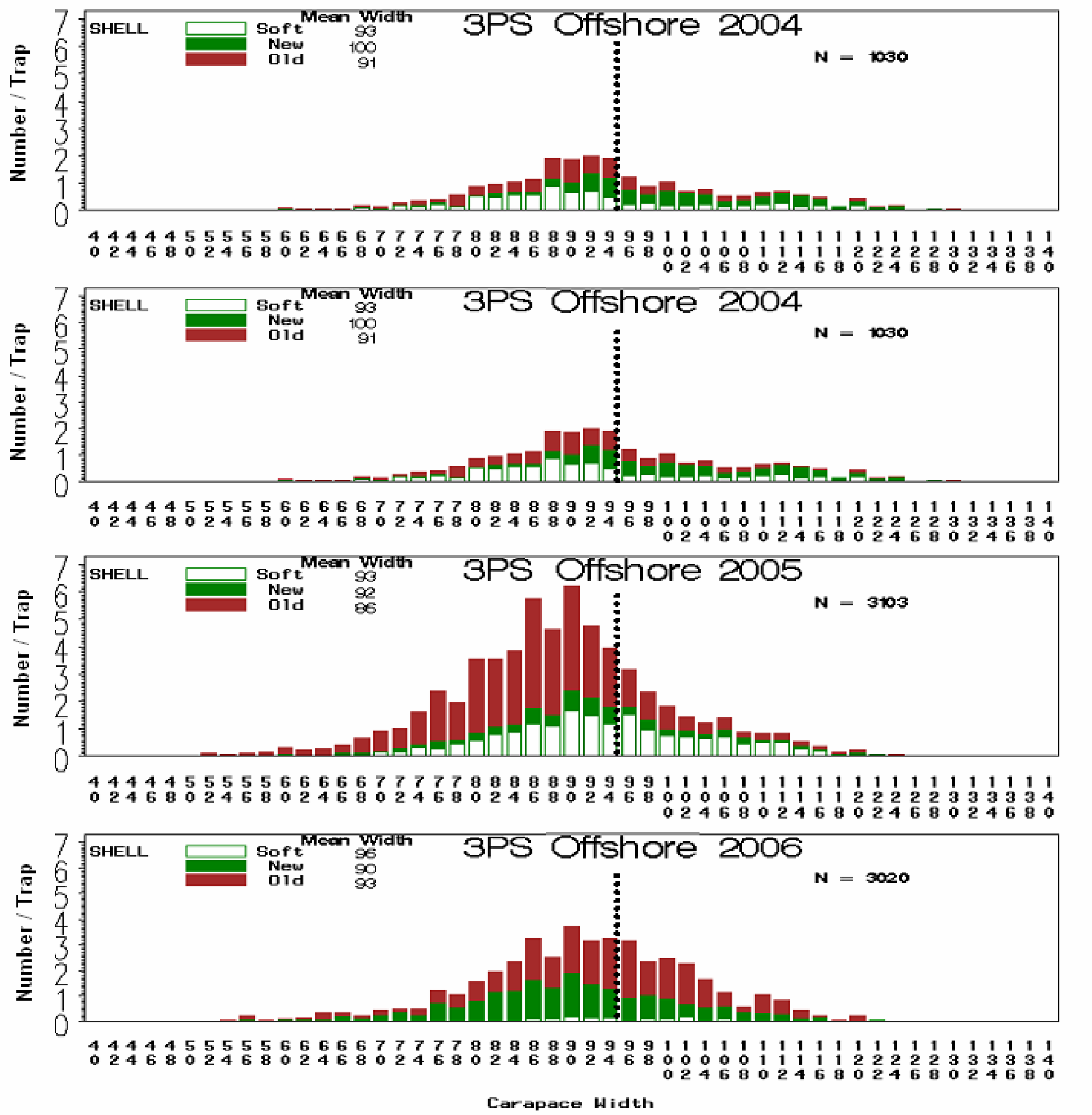


Figure 133. Trends in male carapace width distributions from FSCP post-season trap surveys for Subdivision 3Ps offshore.

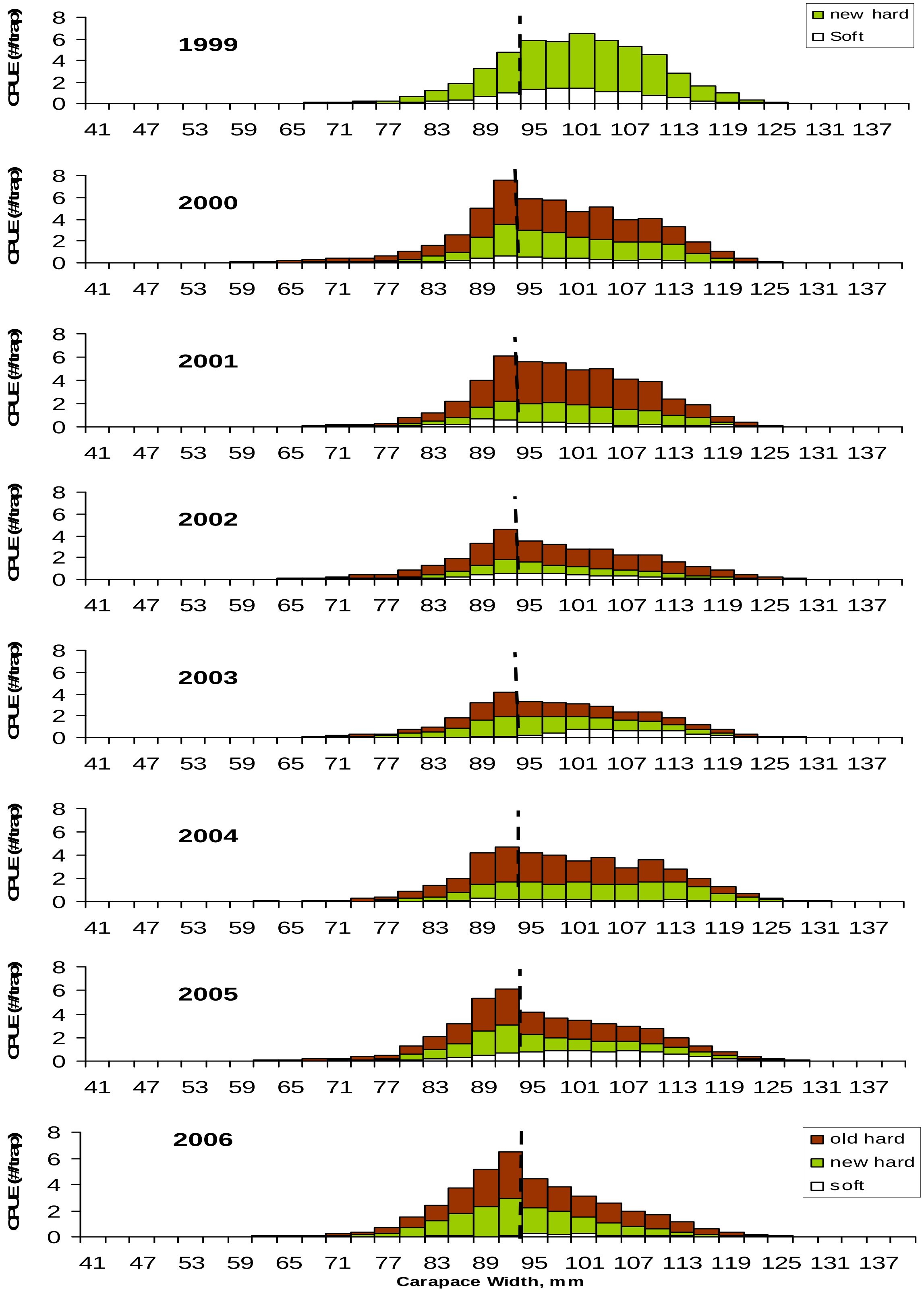


Figure 134. Trends in male carapace width distributions from observer at-sea sampling for Subdivision 3Ps.

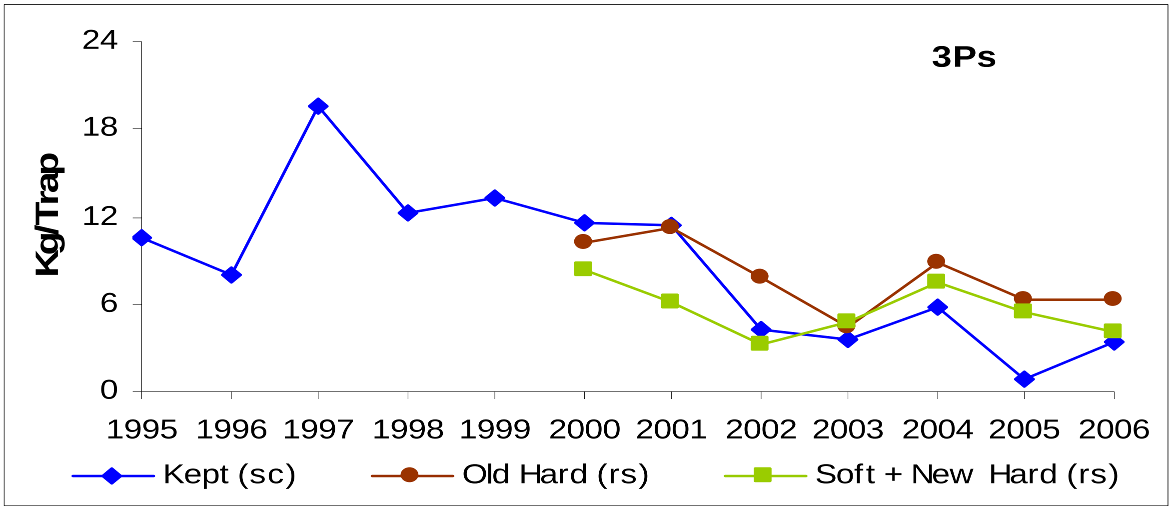


Figure 135. Trends in Subdivision 3Ps observer catch rates of exploitable crabs since 1995 from set and catch records and of legal-sized crabs by shell category since 2000 from at-sea sampling.

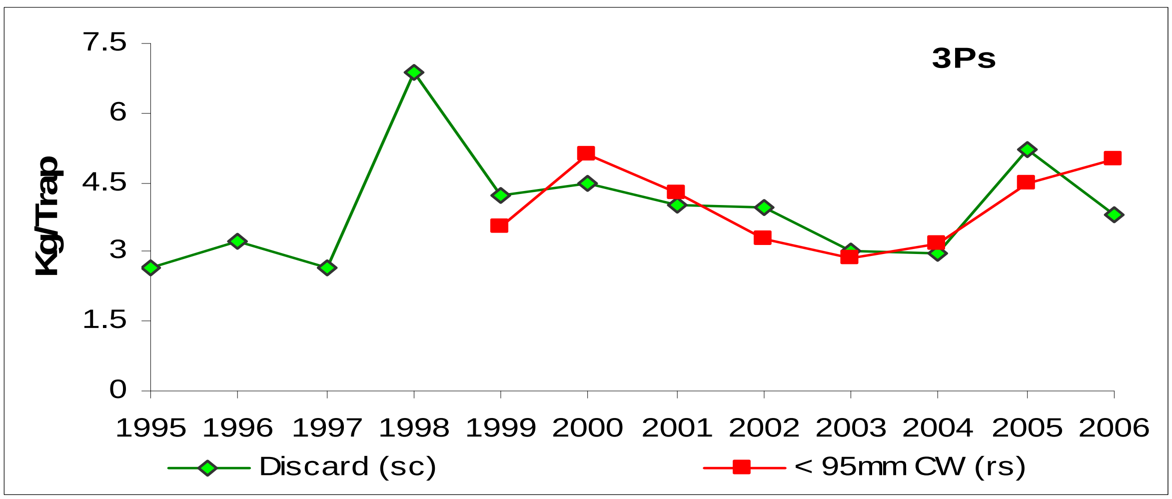


Figure 136. Trends in Subdivision 3Ps observer catch rates of total discards since 1995 from set and catch records and of sub-legal sized crabs since 1999 from at-sea sampling.

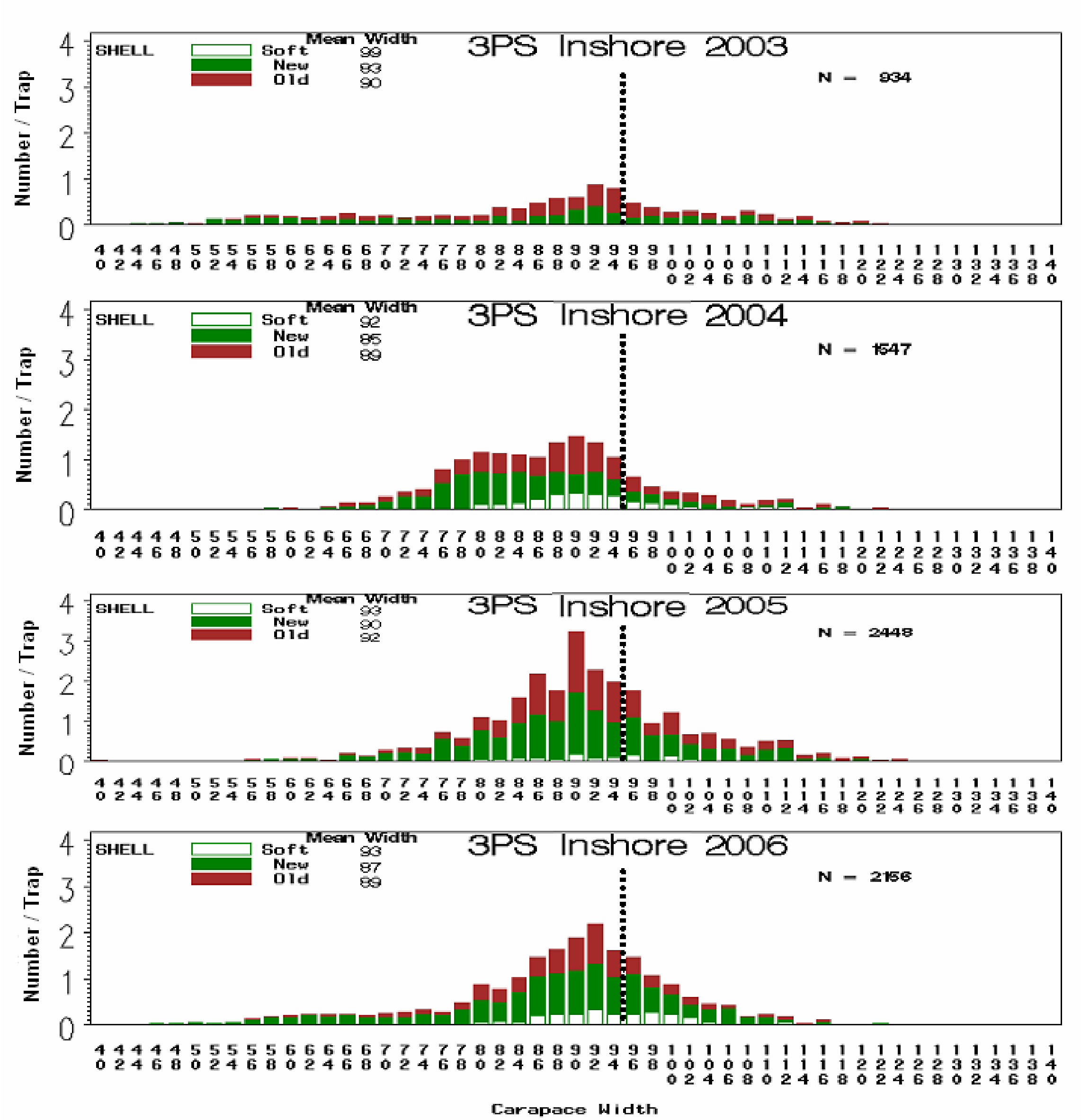


Figure 137. Trends in male carapace width distributions from FSCP post-season trap surveys for Subdivision 3Ps inshore.

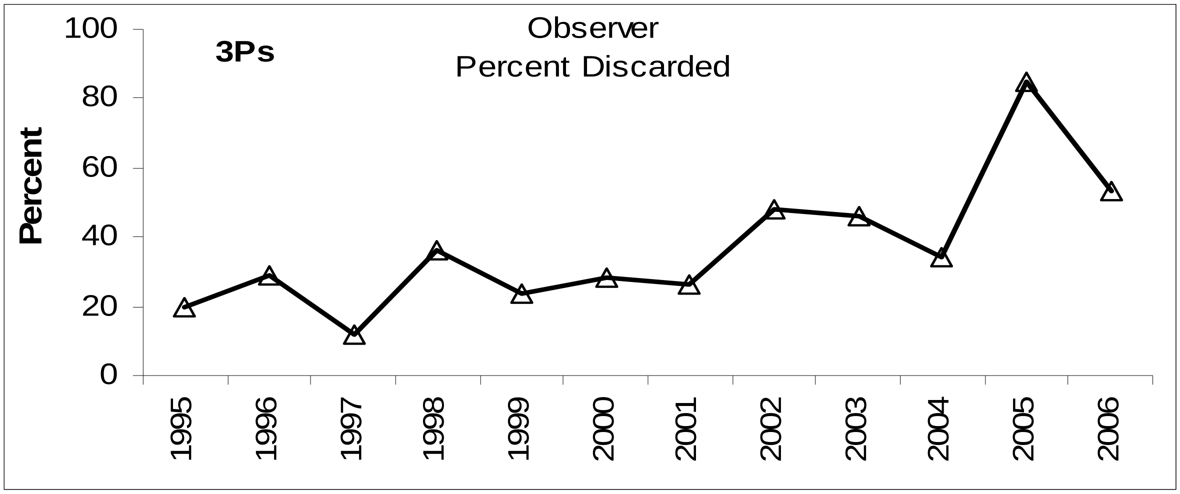


Figure 138. Trend in the percentage of the catch discarded in the Subdivision 3Ps fishery.

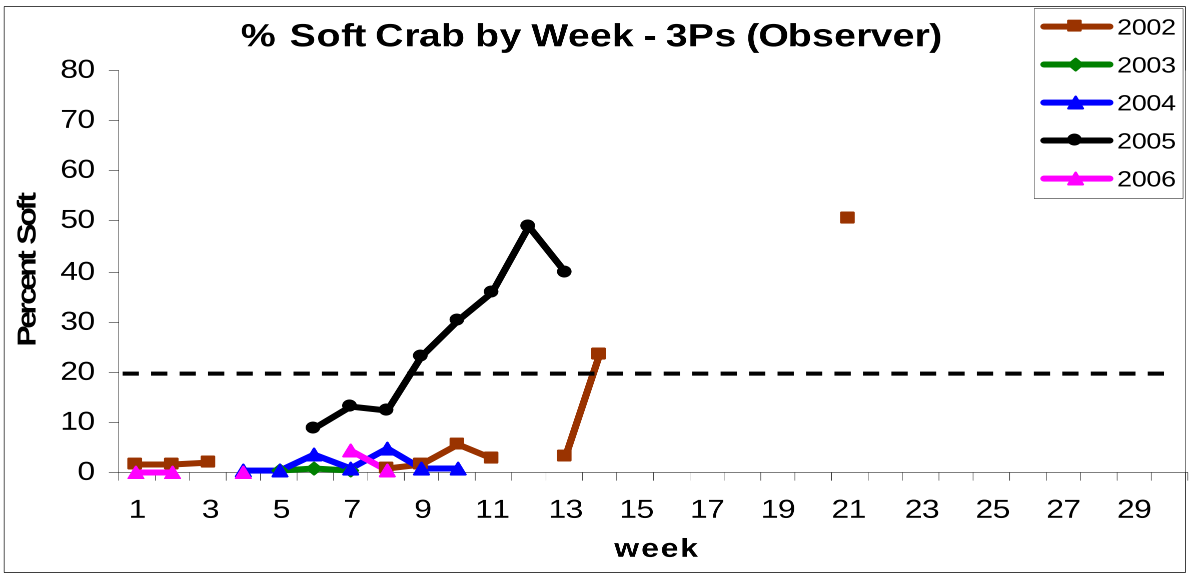


Figure 139. Seasonal trend (from April 01) in the percentage of legal-sized crabs that are soft-shelled by year (2001-06), from at-sea sampling by observers in Subdivision 3Ps. (Sample sizes of <10 observed sets/week removed)

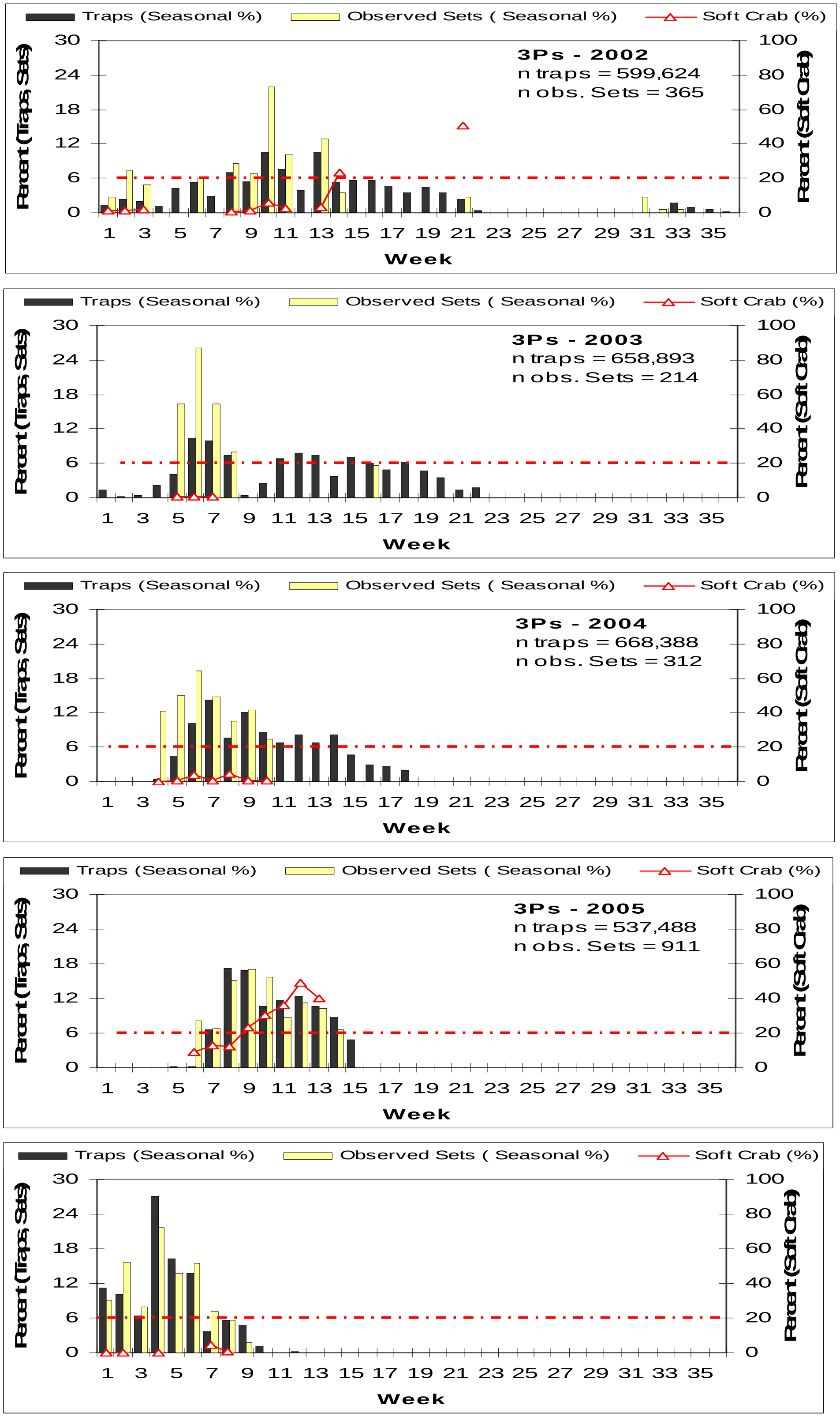


Figure 140. Trends in percentages of weekly effort by trap hauls in Subdivision 3Ps versus percentages of weekly sets observed and soft shell (shell type 1) discards. (Sample sizes of <10 observed sets/week removed)

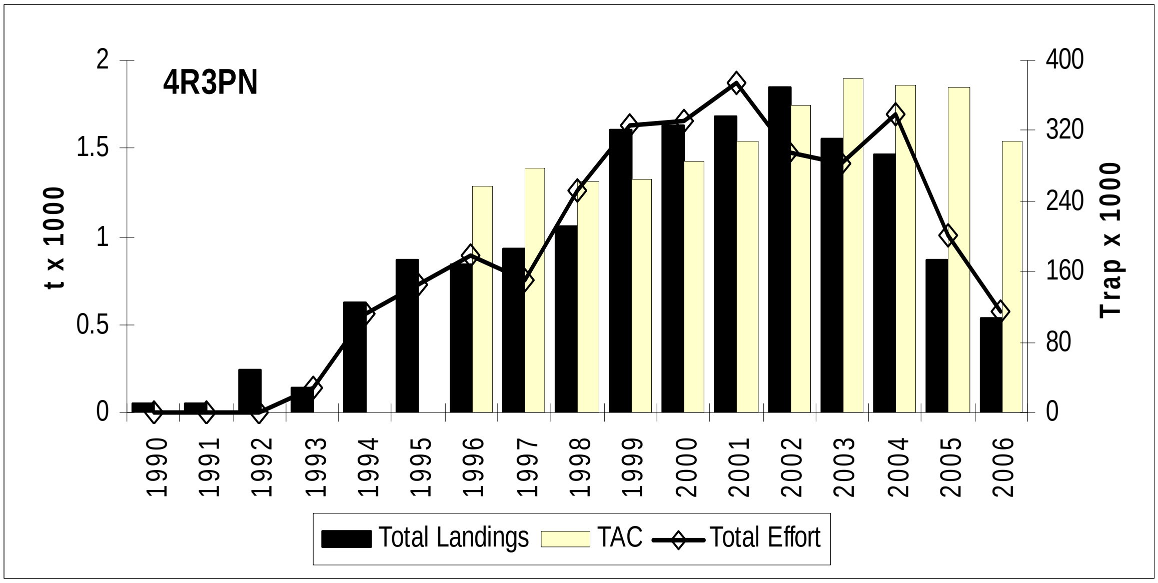


Figure 141. Trends in Division 4R and Subdivision 3Pn Landings, TAC and fishing effort.

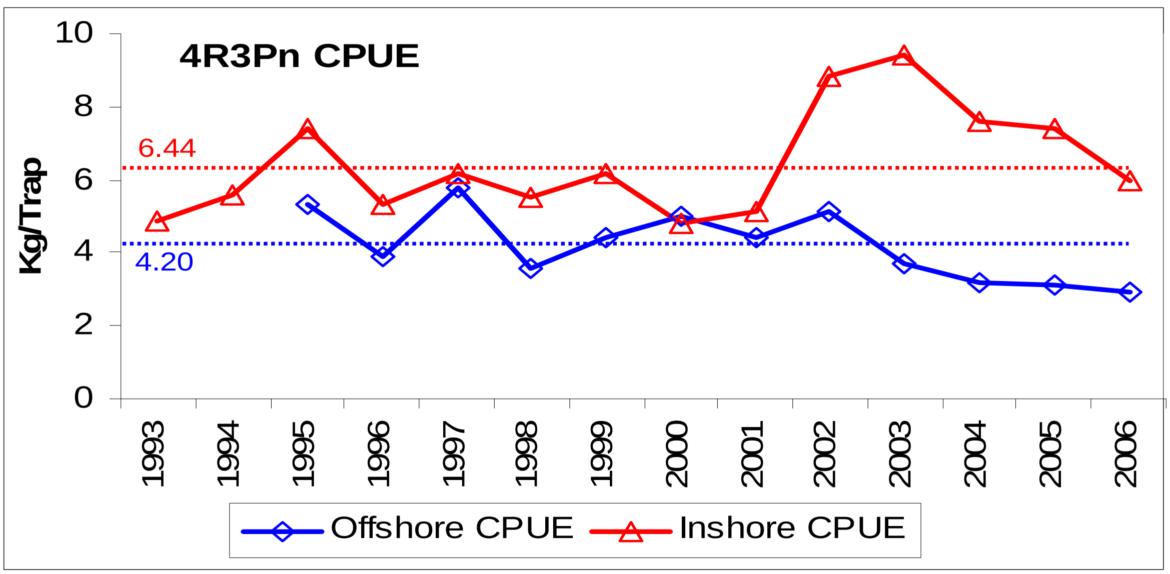


Figure 142. Trends in Division 4R and Subdivision 3Pn commercial CPUE in relation to their long-term averages (dotted lines).

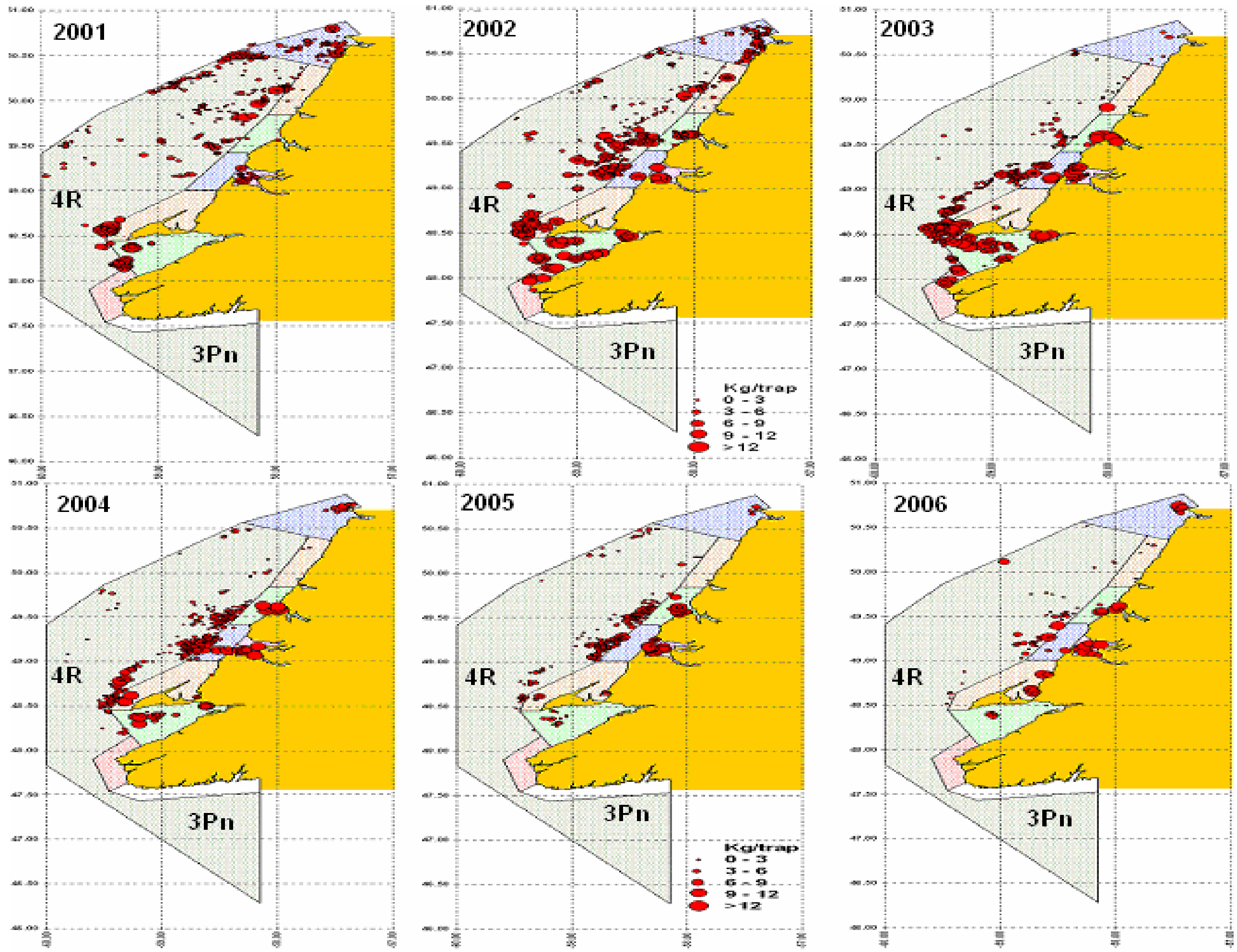


Figure 143. Division 4R and Subdivision 3Pn biomass. Commercial CPUE for 1999-2006.

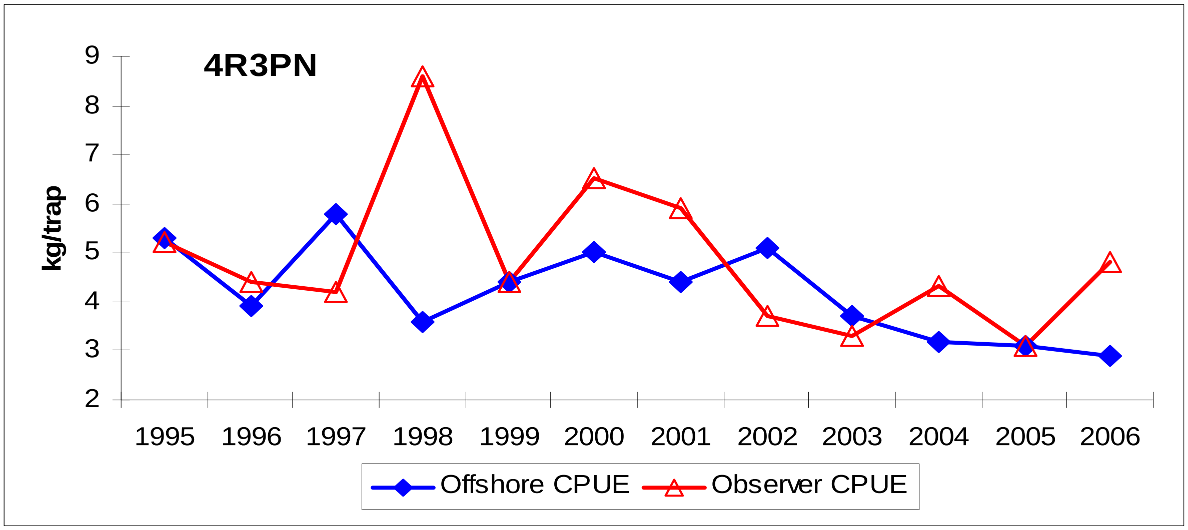


Figure 144. Trends in logbook- based offshore CPUE vs. observer - based CPUE in the Division 4R and Subdivision 3Pn fishery.

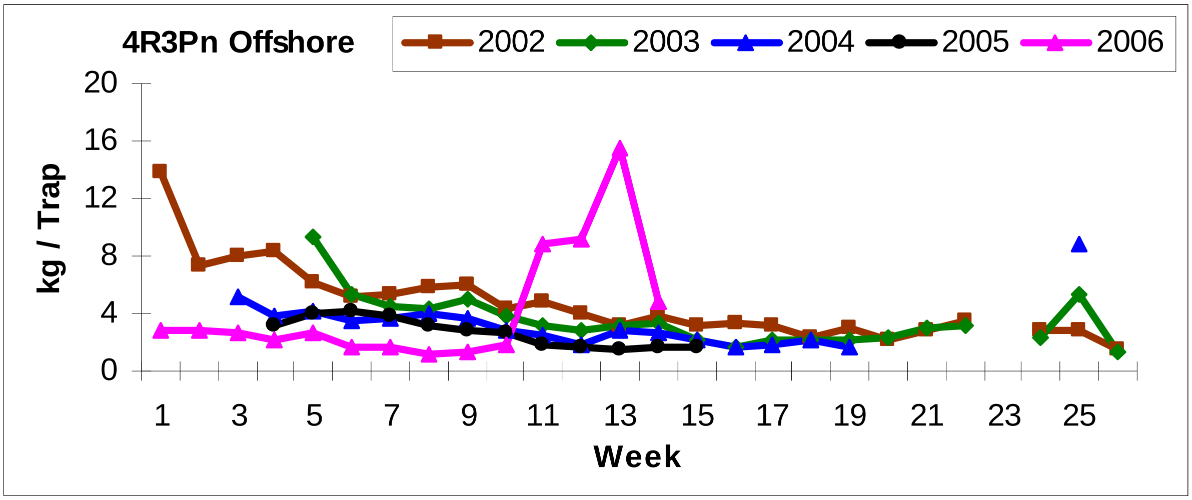


Figure 145. Seasonal trends in CPUE, by week, for Division 4R offshore during 2002-06.

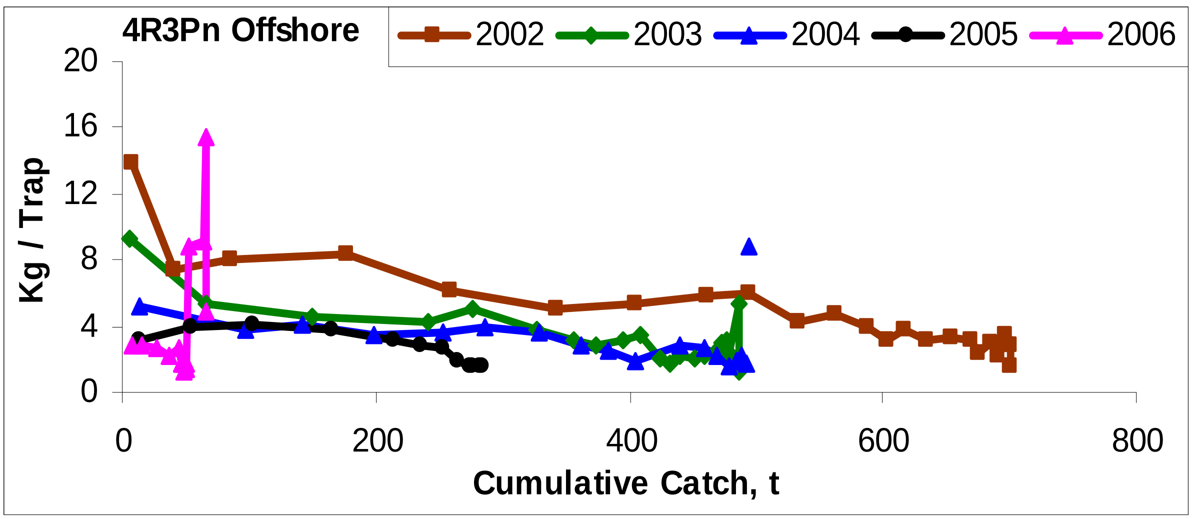


Figure 146. Seasonal trends in CPUE, in relation to cumulative catch, for Division 4R offshore during 2002-06.

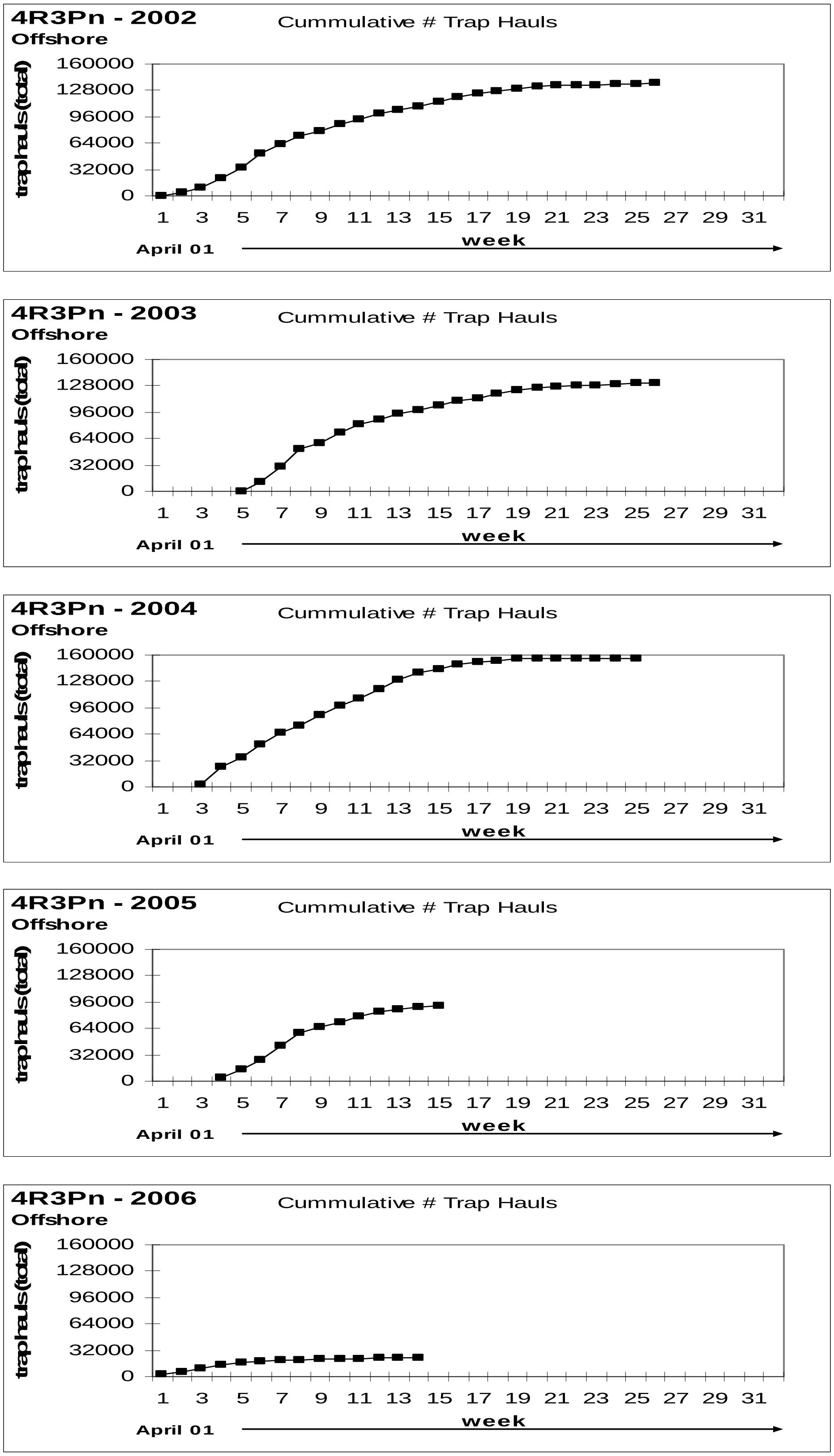


Figure 147. Seasonal trends in fishing effort, by week, for Division 4R offshore during 2002-06.

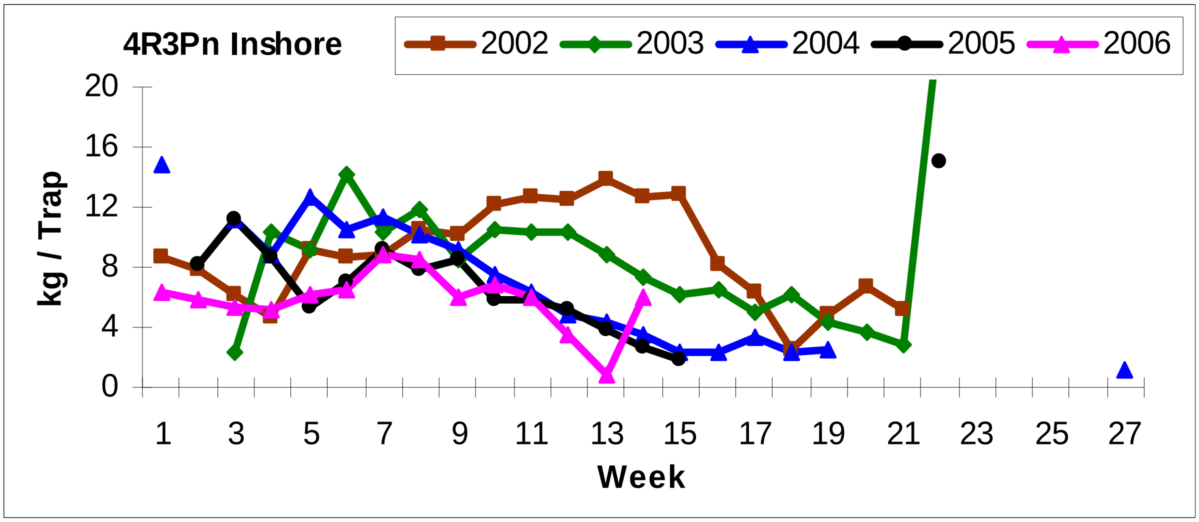


Figure 148. Seasonal trends in CPUE, by week, for Division 4R inshore during 2002-06.

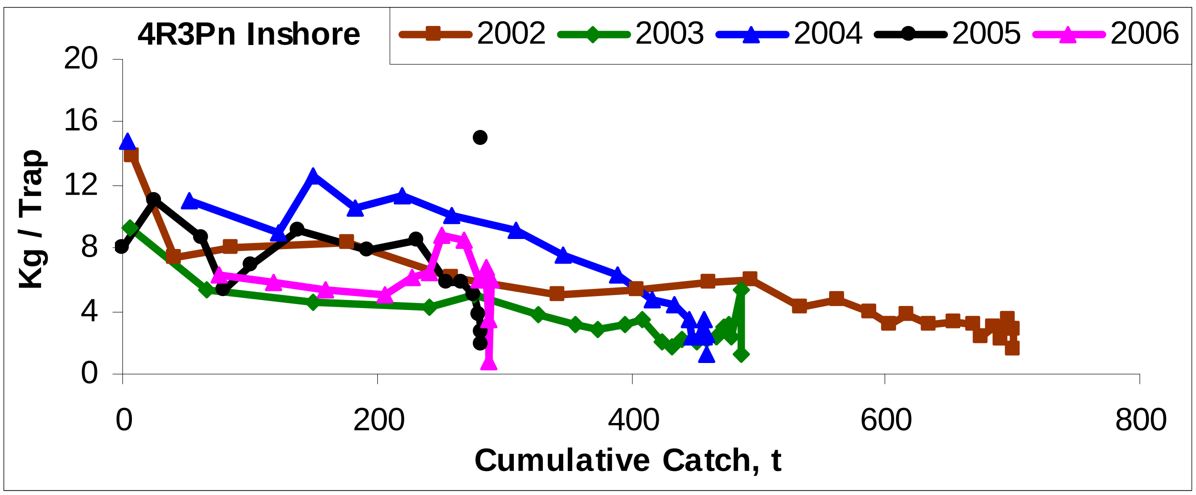


Figure 149. Seasonal trends in CPUE, in relation to cumulative catch, for Division 4R inshore during 2002-06.

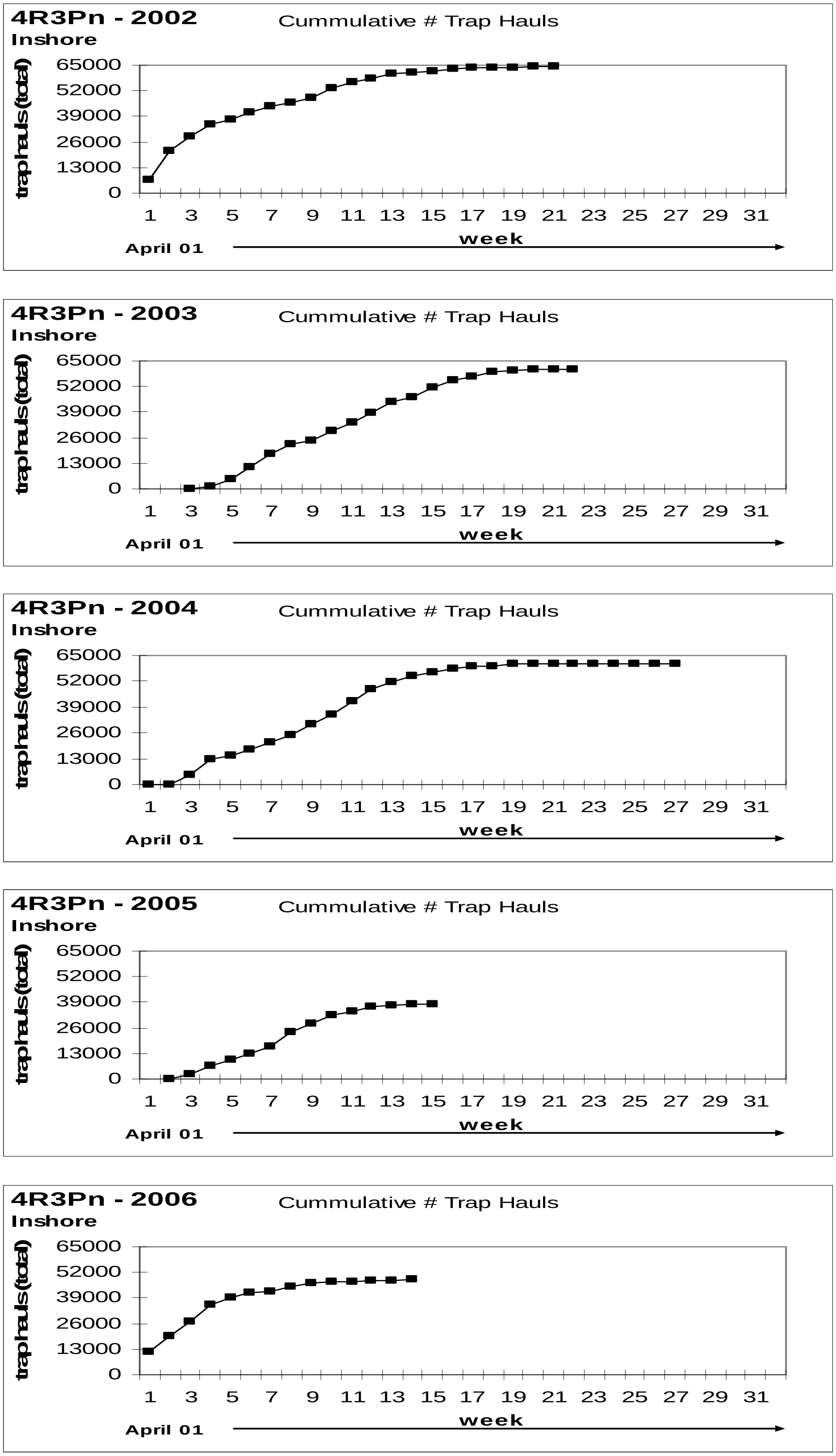


Figure 150. Seasonal trends in fishing effort, by week, for Division 4R inshore during 2002-06.

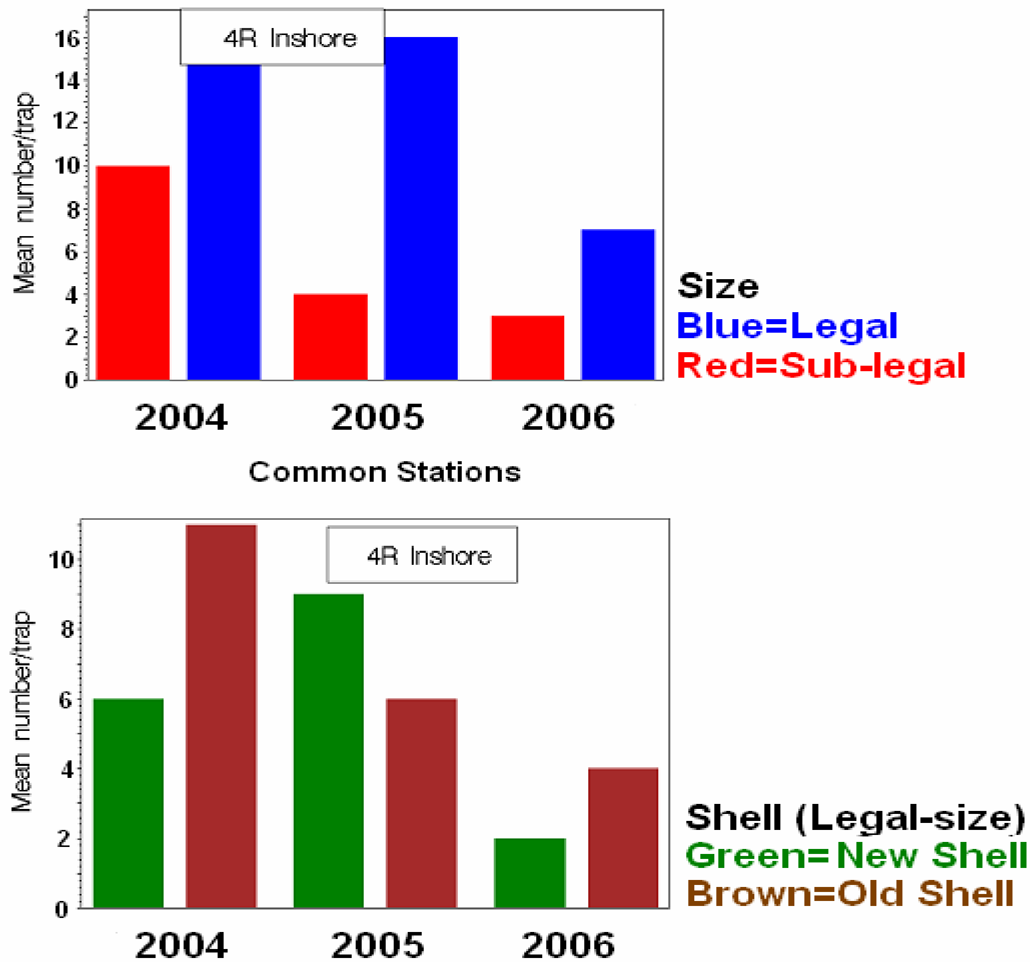


Figure 151. Trends in CPUE for size composition (above) and shell condition (below) from FSCP post-season trap surveys for Division 4R from inshore common stations.